# Specification Handbook

Afton® CHEMICAL
Passion for Solutions™

Specification Handbook

Passion for Solutions™

# Specification Handbook

This handbook, compiled by Afton Chemical, is a collection of widely used Industry Specifications. We aim to provide a single source for specifications for Engine Oils, Industrial, Driveline and Off Road, together with the associated bench, rig and engine test procedures.

Afton Chemical hopes you find this handbook a useful reference tool and source of information. The handbook is also available electronically from our website, **www.aftonchemical.com** and on Afton's **Spec-Stik™**, a portable memory stick that will allow you to access the information when and wherever you want.

If you require information about our products and services please contact your local Afton Chemical representative.

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# Specification Handbook

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## Section List


01 Viscosity
02 Engine Oils
03 Driveline
04 Industrial
05 Off Road
06 Engine Tests
07 Rig Tests


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# Offices

## Regional Offices

**EMEAI**
Afton Chemical Limited
London Road, Bracknell
Berkshire RG12 2UW
England
T | 44 (0)1344 304141
F | 44 (0)1344 420666

**North America**
Afton Chemical Corporation
500 Spring Street
Richmond, VA 23219
USA
T | 804 788 5800
F | 804 788 5184

**Asia Pacific**
Afton Chemical Asia Pacific LLC
111 Somerset Road #09-05
Singapore
238164
T | 65 6732 0822
F | 65 6737 4123

**Latin America**
Afton Chemical Indústria de Aditivos LTDA
Avenida Rio de Janeiro 901 (Parte)
CEP-20931-675
Brazil
T | (55 21) 3295 4050
F | (55 21) 2580 8647 & 2589 0531

## EMEAI Sales Offices

**Brussels**
Afton Chemical Sprl
Alma Court
Lenneke Marelaan, 8
BE -1932 St Stevens, Woluwe
T | 32 (0) 2 715 22 11
F | 32 (0) 2 715 22 10

**Dubai**
Afton Chemical Middle East
PO Box 37660
Dubai, UAE
Office 0202, Jafza View 19
Jebel Ali Free Zone (South)
T | 971 4 886 5707
F | 971 4 886 5708

**Hamburg**
Afton Chemical GmbH
Strassenbahnring 3
20251 Hamburg
Germany
T | 49 40 429 2900
F | 49 40 429 29032

**Moscow**
Afton Chemical Limited
World Trade Center
Krasnopresnenskaya nab. 12
Entrance 6, Floor 6
Office 620-622
123610 Moscow
Russia
T | 7 495 258 2034
F | 7 495 258 2036

**Mumbai**
Afton Chemical India Private Limited
101 Hyde Park
Saki Vihar Road
Andheri-East
Mumbai 400 072
India
T | 91 22 2858 1962 / 63
F | 91 22 2857 6920

**Paris**
Afton Chemical France
Succursale de Afton Chemical Sprl
5 Rue Salomon De Rothschild
92150 Suresnes
France
T | 33 1 469 39180
F | 33 1 477 88717

Specification Handbook

# Viscosity

# Contents

SAE J300 Viscosity Grades For Engine Oils ..... 2
ISO Viscosity Grade Conversions ..... 3
Viscosity Ranges For AGMA Lubricant Numbers ..... 4
Axle and Manual Transmission Lubricant Viscosity Classifications
SAE J306 Automotive Gear Viscosity Classifications ..... 5
SAE J2360 Specifications ..... 5
Comparison of Viscosity Classifications ..... 6
Viscosity Equivalents at Same Temperature ..... 7
Two Components Viscosity Blending Chart (cSt) ..... 8
Base Stocks Viscosities ..... 9
Conversion Factors ..... 10

## SAE J300 Viscosity Grades For Engine Oils (1) (2)

January 2009

| SAE Viscosity Grade | Low Temperature (°C) Cranking Viscosity(3), mPa.s Max. | Low Temperature (°C) Pumping Viscosity(4), mPa.s Max. with No Yield Stress(4) | Low-Shear-Rate Kinematic Viscosity(5) (mm²/s) at 100°C Min. | Low-Shear-Rate Kinematic Viscosity(5) (mm²/s) at 100°C Max. | High-Shear-Rate Viscosity(6) (mPa.s) at 150°C 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 | 13 000 at -10 | 60 000 at -15 | 9.3 | - | - |
| 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, and 10W-40 grades) |
| 40 | - | - | 12.5 | < 16.3 | 3.7 (15W-40, 20W-40, 25W-40, 40 grades) |
| 50 | - | - | 16.3 | < 21.9 | 3.7 |
| 60 | - | - | 21.9 | < 26.1 | 3.7 |

**Note:**

(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 (See text, Section 3).

(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, CEC L-36-A-90 (ASTM D4741), or ASTM D5481.



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## ISO Viscosity Grade Conversions

| ISO Viscosity Grade | Mid-point Kinematic Viscosity | Kinematic Viscosity Limits cSt at 40°C (104°F) | | ASTM, Saybolt Viscosity Number | Saybolt Viscosity SUS 100°F (37.8°C) | |
|---|---|---|---|---|---|---|
| | | Min. | Max. | | Min. | Max. |
| 2 | 2.2 | 1.98 | 2.42 | 32 | 34.0 | 35.5 |
| 3 | 3.2 | 2.88 | 3.52 | 36 | 36.5 | 38.2 |
| 5 | 4.6 | 4.14 | 5.06 | 40 | 39.9 | 42.7 |
| 7 | 6.8 | 6.12 | 7.48 | 50 | 45.7 | 50.3 |
| 10 | 10 | 9.00 | 11.0 | 60 | 55.5 | 62.8 |
| 15 | 15 | 13.5 | 16.5 | 75 | 72 | 83 |
| 22 | 22 | 19.8 | 24.2 | 105 | 96 | 115 |
| 32 | 32 | 28.8 | 35.2 | 150 | 135 | 164 |
| 46 | 46 | 41.4 | 50.6 | 215 | 191 | 234 |
| 68 | 68 | 61.2 | 74.8 | 315 | 280 | 345 |
| 100 | 100 | 90.0 | 110 | 465 | 410 | 500 |
| 150 | 150 | 135 | 165 | 700 | 615 | 750 |
| 220 | 220 | 198 | 242 | 1000 | 900 | 1110 |
| 320 | 320 | 288 | 352 | 1500 | 1310 | 1600 |
| 460 | 460 | 414 | 506 | 2150 | 1880 | 2300 |
| 680 | 680 | 612 | 748 | 3150 | 2800 | 3400 |
| 1000 | 1000 | 900 | 1100 | 4650 | 4100 | 5000 |
| 1500 | 1500 | 1350 | 1650 | 7000 | 6100 | 7500 |



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## Viscosity Ranges for AGMA Lubricant Numbers

| Rust and Oxidation Inhibited Gear Oils | Viscosity Range | Equivalent ISO Grade | Extreme Pressure Gear Lubricants |
|---|---|---|---|
| **AGMA Lubricant No.** | **cSt ($mm^2/s$) at 40°C** | | **AGMA Lubricant No.** |
| 1 | 41.4 to 50.6 | 46 | |
| 2 | 61.2 to 74.8 | 68 | 2 EP |
| 3 | 90 to 110 | 100 | 3 EP |
| 4 | 135 to 165 | 150 | 4 EP |
| 5 | 198 to 242 | 220 | 5 EP |
| 6 | 288 to 352 | 320 | 6 EP |
| 7 Compounded | 414 to 506 | 460 | 7 EP |
| 8 Compounded | 612 to 748 | 680 | 8 EP |
| 8A Compounded | 900 to 1100 | 1000 | 8A EP |

**Note:**
Viscosity ranges for AGMA Lubricant Numbers will henceforth be identical with those of the ASTM system
Oils compounded with 3% to 10% fatty or synthetic fatty oils.

## SAE J306 Automotive Gear Viscosity Classifications

Axle and Manual Transmission Lubricant Viscosity Classifications

| | | 70W | 75W | 80W | 85W | 80 | 85 | 90 | 110 | 140 | 190 | 250 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Viscosity at 100°C | min, mm²/s | 4.1 | 4.1 | 7.0 | 11.0 | 7.0 | 11.0 | 13.5 | 18.5 | 24.0 | 32.5 | 41.0 |
| | max, mm²/s | No requirement | | | | 11.0 | 13.5 | 18.5 | 24.0 | 32.5 | 41.0 | No req |
| Viscosity of 150,000 mPa.s, max. temp °C | | -55 | -40 | -26 | -12 | No requirement | | | | | | |
| 20 hr. KRL Shear (CRC L-45-T-93), KV100 after Shear, mm²/s, min. | | 4.1 | 4.1 | 7.0 | 11.0 | 7.0 | 11.0 | 13.5 | 18.5 | 24.0 | 32.5 | 41.0 |

## SAE J2360 Specifications

| | | 75W | 80W-90 | 85W-140 |
|---|---|---|---|---|
| Viscosity at 100°C | min, mm²/s | 4.1 | 13.5 | 24.0 |
| | max, mm²/s | - | 18.5 | 32.5 |
| Viscosity of 150,000 mPa.s, max. temp °C | | -40 | -26 | -12 |
| Channel Point, min, °C | | -45 | -35 | -20 |
| Flash Point, min, °C | | 150 | 165 | 180 |



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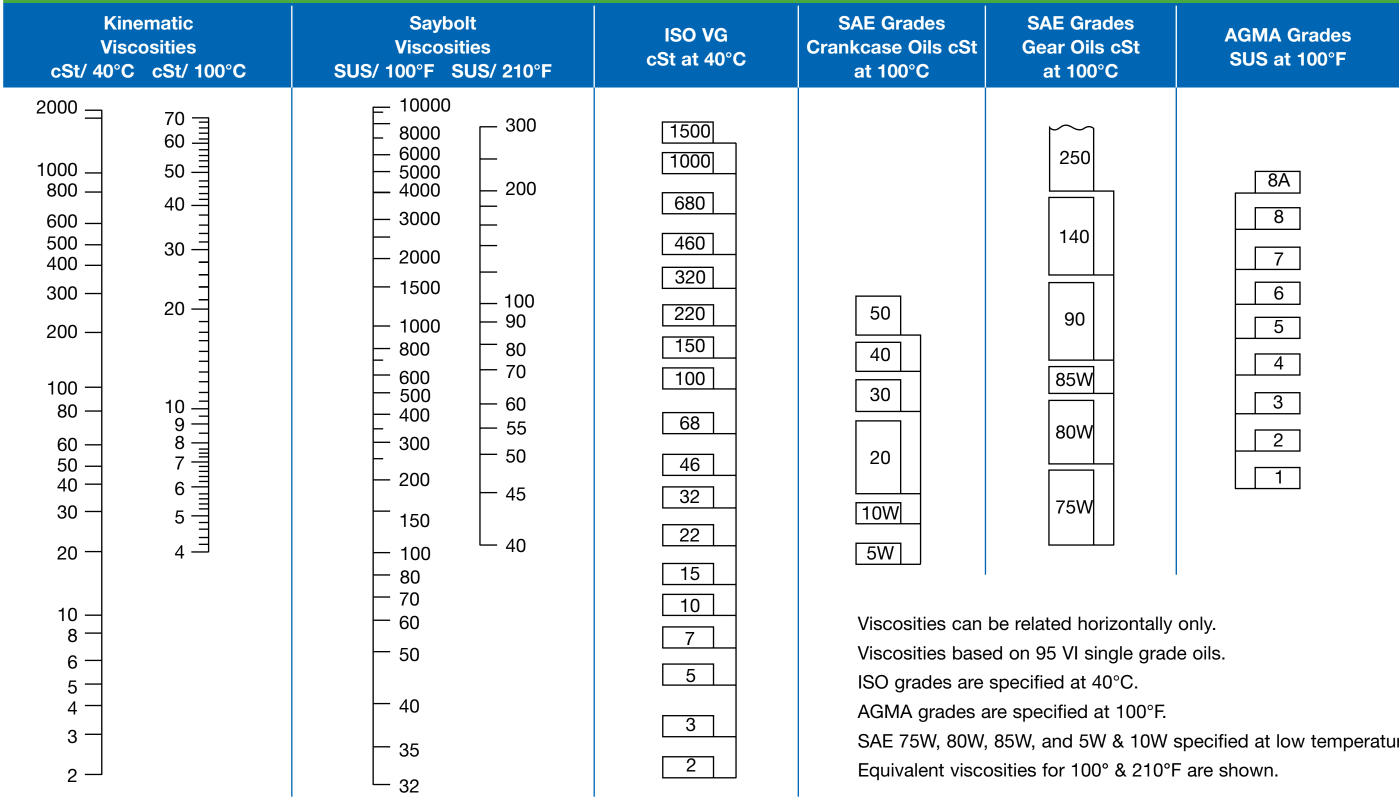
## Comparison of Viscosity Classifications

Approximate Equivalents




Viscosities can be related horizontally only.

Viscosities based on 95 VI single grade oils.

ISO grades are specified at 40°C.

AGMA grades are specified at 100°F.

SAE 75W, 80W, 85W, and 5W & 10W specified at low temperature.

Equivalent viscosities for 100° & 210°F are shown.

## Viscosity Equivalents at Same Temperature

Approximate Equivalents

| Kinematic (Centistokes) | Saybolt Universal (Seconds) | Redwood No.1 (Seconds) | Engler (Degrees) | Saybolt Furol (Seconds) | Redwood No.2 (Seconds) |
|---|---|---|---|---|---|
| 1.8 | 32 | 30.8 | 1.14 | - | - |
| 2.7 | 35 | 32.2 | 1.18 | - | - |
| 4.2 | 40 | 36.2 | 1.32 | - | - |
| 5.8 | 45 | 40.6 | 1.46 | - | - |
| 7.4 | 50 | 44.9 | 1.60 | - | - |
| 8.9 | 55 | 49.1 | 1.75 | - | - |
| 10.3 | 60 | 53.5 | 1.88 | - | - |
| 11.7 | 65 | 57.9 | 2.02 | - | - |
| 13.0 | 70 | 62.3 | 2.15 | - | - |
| 14.3 | 75 | 67.6 | 2.31 | - | - |
| 15.6 | 80 | 71.0 | 2.42 | - | - |
| 16.8 | 85 | 75.1 | 2.55 | - | - |
| 18.1 | 90 | 79.6 | 2.68 | - | - |
| 19.2 | 95 | 84.2 | 2.81 | - | - |
| 20.4 | 100 | 88.4 | 2.95 | - | - |
| 22.8 | 110 | 97.1 | 3.21 | - | - |
| 25.0 | 120 | 105.9 | 3.49 | - | - |
| 27.4 | 130 | 114.8 | 3.77 | - | - |
| 29.6 | 140 | 123.6 | 4.04 | - | - |
| 31.8 | 150 | 132.4 | 4.32 | - | - |
| 34.0 | 160 | 141.1 | 4.59 | - | - |
| 36.0 | 170 | 150.0 | 4.88 | - | - |
| 38.4 | 180 | 158.8 | 5.15 | - | - |
| 40.6 | 190 | 167.5 | 5.44 | - | - |
| 42.8 | 200 | 176.4 | 5.72 | 23.0 | - |
| 47.2 | 220 | 194.0 | 6.28 | 25.3 | - |
| 51.8 | 240 | 212 | 6.85 | 27.0 | - |
| 55.9 | 260 | 229 | 7.38 | 28.7 | - |
| 60.2 | 280 | 247 | 7.95 | 30.5 | - |
| 64.5 | 300 | 265 | 8.51 | 32.5 | - |
| 69.9 | 325 | 287 | 9.24 | 35.0 | - |
| 75.3 | 350 | 309 | 9.95 | 37.2 | - |
| 80.7 | 375 | 331 | 10.70 | 39.5 | - |
| 86.1 | 400 | 353 | 11.40 | 42.0 | - |
| 91.5 | 425 | 375 | 12.10 | 44.2 | - |
| 96.8 | 450 | 397 | 12.8 | 47.0 | - |
| 102.2 | 475 | 419 | 13.5 | 49 | - |
| 107.6 | 500 | 441 | 14.2 | 51 | - |
| 118.4 | 550 | 485 | 15.6 | 56 | - |
| 129.2 | 600 | 529 | 17.0 | 61 | - |
| 140.3 | 650 | 573 | 18.5 | 66 | - |
| 151 | 700 | 617 | 19.8 | 71 | - |
| 162 | 750 | 661 | 21.3 | 76 | - |
| 173 | 800 | 705 | 22.7 | 81 | - |
| 183 | 850 | 749 | 24.2 | 86 | - |
| 194 | 900 | 793 | 25.6 | 91 | - |
| 205 | 950 | 837 | 27.0 | 96 | - |
| 215 | 1,000 | 882 | 28.4 | 100 | - |
| 259 | 1,200 | 1,058 | 34.1 | 121 | 104 |
| 302 | 1,400 | 1,234 | 39.8 | 141 | 122 |
| 345 | 1,600 | 1,411 | 45.5 | 160 | 138 |
| 388 | 1,800 | 1,587 | 51 | 180 | 153 |
| 432 | 2,000 | 1,763 | 57 | 200 | 170 |
| 541 | 2,500 | 2,204 | 71 | 250 | 215 |
| 650 | 3,000 | 2,646 | 85 | 300 | 255 |
| 758 | 3,500 | 3,087 | 99 | 350 | 300 |
| 866 | 4,000 | 3,526 | 114 | 400 | 345 |
| 974 | 4,500 | 3,967 | 128 | 450 | 390 |
| 1,082 | 5,000 | 4,408 | 142 | 500 | 435 |
| 1,190 | 5,500 | 4,849 | 156 | 550 | 475 |
| 1,300 | 6,000 | 5,290 | 170 | 600 | 515 |
| 1,405 | 6,500 | 5,730 | 185 | 650 | 580 |
| 1,515 | 7,000 | 6,171 | 199 | 700 | 600 |
| 1,625 | 7,500 | 6,612 | 213 | 750 | 645 |
| 1,730 | 8,000 | 7,053 | 227 | 800 | 690 |
| 1,840 | 8,500 | 7,494 | 242 | 850 | 730 |
| 1,950 | 9,000 | 7,934 | 256 | 900 | 770 |
| 2,055 | 9,500 | 8,375 | 270 | 950 | 815 |
| 2,165 | 10,000 | 8,816 | 284 | 1,000 | 855 |



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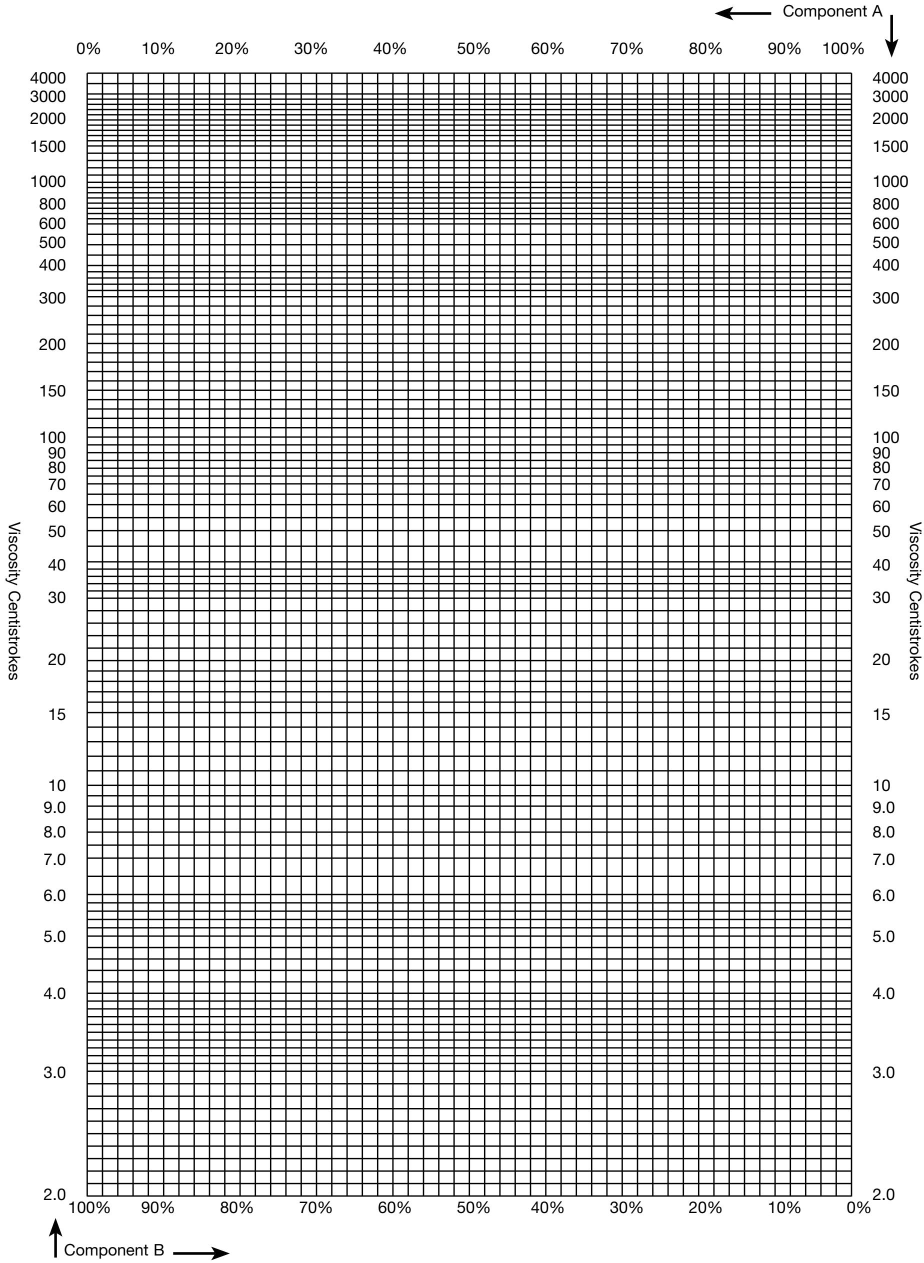
# Two Components Viscosity Blending (cSt)



## Base Stock Viscosities

Approximate Equivalents

| | Neutrals | | | |
|---|---|---|---|---|
| | 40°C | | 100°C | |
| | cSt | SUS | cSt | SUS |
| 70N | 13.3 | 70.8 | 3.0 | 37.0 |
| 80N | 15.6 | 80.3 | 3.35 | 37.3 |
| 90N | 18.0 | 89.0 | 3.4 | 37.5 |
| 100N | 21.5 | 104.0 | 4.0 | 39.0 |
| 140N | 30.7 | 144.0 | 4.5 | 41.0 |
| 150N | 31.6 | 148.0 | 4.9 | 42.4 |
| 160N | 33.7 | 158.0 | 5.2 | 43.3 |
| 170N | 34.0 | 159.0 | 5.4 | 44.0 |
| 180N | 38.5 | 181.0 | 5.7 | 44.9 |
| 200N | 44.5 | 204.0 | 6.2 | 46.0 |
| 250N | 56.1 | 257.0 | 6.5 | 47.0 |
| 300N | 61.3 | 285.0 | 7.0 | 49.0 |
| 315N | 70.0 | 315.0 | 7.9 | 52.0 |
| 330N | 70.9 | 328.0 | 8.4 | 53.7 |
| 350N | 76.0 | 358.0 | 8.8 | 55.0 |
| 400N | 86.0 | 398.6 | 9.8 | 58.0 |
| 450N | 98.0 | 454.0 | 10.5 | 61.0 |
| 500N | 107.0 | 496.0 | 11.0 | 64.0 |
| 600N | 130.4 | 604.0 | 12.1 | 66.0 |
| 650N | 141.0 | 665.0 | 13.8 | 71.0 |
| 700N | 151.0 | 668.0 | 14.0 | 73.0 |

| | Brights | | | |
|---|---|---|---|---|
| | 40°C | | 100°C | |
| | cSt | SUS | cSt | SUS |
| 135 Brt | 413.2 | 1875.0 | 28.6 | 135.0 |
| 145 Brt | 523.3 | 2425.0 | 30.9 | 145.0 |
| 150 Brt | 568.0 | 2632.0 | 33.0 | 155.0 |
| 160 Brt | 600.0 | 2800.0 | 35.2 | 166.0 |
| 175 Brt | 616.0 | 2855.0 | 36.0 | 169.7 |
| 185 Brt | 654.7 | 3034.0 | 37.6 | 177.0 |
| 225 Brt | 1030.0 | 4800.0 | 49.3 | 229.0 |

# Conversion Factors

| | |
|---|---|
| 1 yd | = 0.9144 m |
| 1 m | = 1.0936 yd |
| 1 ft | = 0.3048 m |
| 1 m | = 3.28 ft |
| 1 in | = 2.54 cm |
| 1 cm | = 0.3937 in |
| 1 mile | = 1.6093 km |
| 1 km | = 0.6214 mile |
| | |
| 1 sq yd | = 0.8361 sq m |
| 1 sq m | = 1.1960 sq yd |
| 1 sq in | = 6.452 sq cm |
| 1 sq cm | = 0.155 sq in |
| | |
| 1 cu in | = 16.3872 cc |
| 1 cc | = 0.0610 cu in |
| 1 cu ft | = 0.02832 cu m |
| 1 cu m | = 35.314 cu ft |
| 1 cu yd | = 0.7646 cu m |
| 1 cu m | = 1.3079 cu yd |
| | |
| 1 imp gall | = 4.54596 litre |
| 1 litre | = 0.21998 imp gall |
| 1 imp gall | = 1.201 US gall |
| 1 litre | = 1.76 pints |
| | |
| 1 oz | = 28.3495 g |
| 1 g | = 0.03527 oz |
| 1 lb | = 453.59 g |
| 1 kg | = 2.20462 lbs |
| | |
| 1 g/litre | = 0.16035 oz/imp gall |
| 1 oz/imp gall | = 6.236 g/litre |
| 1 g/litre | = 0.01002 lb/imp gall |
| 1 lb/imp gall | = 99.8003 g/litre |
| | |
| °C | = (°F - 32) x 5/9 |
| °F | = (°C x 9/5) + 32 |
| | |
| API gravity, deg | = (141.5/sp.gr. at 60/60°F) - 131.5 |

% volume of additive $= \dfrac{\text{\% weight of additive x density of finished oil}}{\text{density of additive}}$

(typical finished oil density = 0.88 g/ml)

Specification Handbook

# Engine Oils

# Contents Engine Oils


API Service Classifications........................................................................5
API Gasoline Engine Performance Criteria ...........................................................8
ILSAC Specifications
GF-1........................................................................................18
GF-2........................................................................................19
GF-3........................................................................................20
GF-4........................................................................................21
GF-5........................................................................................23
API Commercial Classifications ..................................................................26
API Diesel Engine Performance Criteria.........................................................31
ACEA 2007 Service Fill Oils For:
Gasoline and Diesel Engines ..........................................................40
Gasoline and Diesel Engines - Engine Tests ....................................41
Gasoline and Diesel Engines With After Treatment Devices.............44
Heavy Duty Diesel Engines.............................................................48
ACEA 2008 Service Fill Oils For:
Gasoline and Diesel Engines ..........................................................52
Gasoline and Diesel Engines - Engine Tests ....................................53
Gasoline and Diesel Engines With After Treatment Devices.............55
Heavy Duty Diesel Engines.............................................................59
ACEA 2010 Service Fill Oils For:
Gasoline and Diesel Engines ..........................................................63
Gasoline and Diesel Engines - Engine Tests ....................................64
Gasoline and Diesel Engines With After Treatment Devices.............66
Heavy Duty Diesel Engines.............................................................70
ACEA 2012 Service Fill Oils For:
Gasoline and Diesel Engines ..........................................................75
Gasoline and Diesel Engines - Engine Tests ....................................78
Gasoline and Diesel Engines With After Treatment Devices.............81
Heavy Duty Diesel Engines.............................................................86

## Contents Engine Oils


US Military Specifications: Engine Test Requirements ........ 89
- Additional Test Requirements For MIL-L-2104E ........ 90
- MIL-L-2104F Engine Test Requirements ........ 91
- MIL-L-2104F Transmission Test Requirements ........ 92
- MIL-PRF-2104H Requirements ........ 93
- Diesel Engine Oil Standards ........ 98
- Diesel Engine Oil Standards ........ 99

Japanese Automotive Diesel Engine Oil Standards
- JASO 2008 Diesel Engine Oil Standards ........ 100
- JASO 2008 Diesel Engine Oil Standards ........ 101

Laboratory Tests
- Global Engine Oil Specifications DHD-1 ........ 102

Engine Tests
- Global Engine Oil Specifications DHD-1 ........ 103

Two-Stroke Classifications
- API TC ........ 104
- ISO/JASO ........ 105
- TISI 1040 ........ 106
- NMMA TC-W3 ........ 107

Four-Stroke Classifications
- JASO T903: 2006, 2011 ........ 108
- NMMA FCW, 2006 ........ 109

OEM Specifications: General Motors
dexos 1™ (Gasoline engines) ... 110
dexos 2™ (Diesel engines) ... 110
OEM Specifications:
Mercedes Benz Sheets For Passenger Car Engine Oils v.2009.1
MB 229.1 ... 115
MB 229.3 ... 115
MB 229.31 ... 115
MB 229.5 ... 115
MB 229.51 ... 115
OEM Specifications:
Mercedes Benz Sheets For Passenger Car Engine Oils v.2012.2
MB 226.5 ... 121
MB 226.51 ... 121
MB 229.1 ... 121
MB 229.3 ... 121
MB 229.31 ... 121
MB 229.5 ... 121
MB 229.51 ... 121
MB 229.52 ... 121
OEM Specifications: BMW
BMW Longlife-01 ... 129
BMW Longlife-01 FE ... 129
BMW Longlife-04 ... 129
OEM Specifications: Volkswagen
VW 501.01 ... 130
VW 502.00 ... 130
VW 504.00 ... 130
VW 505.00 ... 130
VW 505.01 ... 130
VW 507.00 ... 130
OEM Specifications: Renault Service Fill
RN0700 ... 134
RN0710 ... 137
RN0720 ... 141
OEM Specifications: PSA First Fill ... 145
OEM Specifications: PSA Service Oils ... 146
OEM Specifications: PSA Service Oils Low SAPs ... 149

**Contents** Engine Oils


OEM Specifications:
Mercedes Benz Sheets For Heavy Duty Diesel Engine Oils V.2012.2
- MB 226.9 ... 152
- MB 228.0/.1 ... 152
- MB 228.2/.3 ... 152
- MB 228.31 ... 152
- MB 228.5 ... 152
- MB 228.51 ... 152

OEM Specifications: MAN
- 270/271 ... 159
- M 3275 ... 161
- M 3277 ... 165
- M 3477 ... 167
- M 3575 ... 169

OEM Specifications: Volvo Drain Specifications
- VDS ... 171
- VDS-2 ... 172
- VDS-3 ... 173
- VDS-4 ... 174

OEM Category: MTU MTL 5044 ... 178
OEM Specifications: Scania LDF-1&2 ... 182
OEM Specifications: Caterpillar
- ECF-1a ... 183
- ECF-2 ... 183
- ECF-3 ... 183

OEM Specifications: Cummins
- 20078 ... 187
- 20081 ... 187

OEM Specifications: DDC
- 93K214 ... 190
- 93K215 ... 190
- 93K218 ... 190

OEM Specifications: Mack
- EO-N PP 03 ... 294
- EO-O VDS-4 ... 294

European OEM Seal Test Requirements For Automotive Engine Oils ... 197

# API Service Classifications

## "S" Spark

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

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

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

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

**SB** **For Minimum Duty Gasoline Engine Service**

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

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

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

**SD** **For Gasoline Engine Warranty Maintenance Service**

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

**SE** **For 1972 Gasoline Engine Warranty Service**

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

## "S" Spark

**SF**

### For 1980 Gasoline Engine Warranty Maintenance Service

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

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

**SG**

### For 1989 Gasoline Engine Warranty Maintenance Service

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

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

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

- The IID gasoline engine test has been correlated with vehicles used in short-trip service prior to 1978, particularly with regard to rusting.
- The IIIE gasoline engine test has been correlated with vehicles used in high-temperature service prior to 1988, particularly with regard to oil thickening and valve train wear.
- The VE gasoline engine test has been correlated with vehicles used in stop-and-go service prior to 1988, particularly with regard to sludge and valve train wear.
- The L-38 gasoline engine test requirement provides a measurement of copper-lead bearing weight loss and piston varnish under high temperature operating conditions.
- The 1-H2 diesel engine test requirement provides a measurement of high-temperature deposits.

## "S" Spark

**SH** **For 1992 Gasoline Engine Warranty Maintenance Service**
Category SH covers the performance requirements of SG oils tested to the latest CMA protocol on engine testing. In addition, SH oils must meet various bench test requirements including volatility, filterability and foaming tests.

**SJ** **For 1997 Gasoline Engine Warranty Maintenance Service**
API Service Category SJ was adopted for use in describing engine oils available in 1996. These oils are for use in service typical of gasoline engines in current and earlier passenger-car, sport utility vehicle, van, and light truck operations under vehicle manufacturers' recommended maintenance procedures. Engine oils that meet API Service Category SJ designation may be used where API Service Category SH and earlier Categories have been recommended. Engine oils that meet the API Service Category SJ designation have been tested in accordance with the CMA Code, may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing. Engine oils that meet these requirements may display API Service Category SJ in the upper portion of the API Service Symbol.

**SL** **For 2001 Gasoline Engine Warranty Maintenance Service**
API Service Category SL was adopted for use in describing engine oils available in 2001. These oils are for use in service typical of gasoline engines in current and earlier passenger cars, sport utility vehicles, vans, and light-duty trucks operating under vehicle manufacturers' recommended maintenance procedures. Engine oils that meet API Service Category SL designation may be used where API Service Category SJ and earlier Categories have been recommended. Engine oils that meet the API Service Category SL designation have been tested in accordance with the ACC Code and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing. First licence date was July 1, 2001, engine oils that meet these requirements may display API Service Category SL in the upper portion of the API Service Symbol.

**SM** For all automotive engines currently in use. Introduced in 2004, SM oils are designed to provide improved oxidation resistance, improved deposit protection, better wear protection, and better low-temperature performance over the life of the oil. Some SM oils may also meet the latest ILSAC specifications and/or quality as Energy Conserving. Suitable for use where API SJ or SL have been recommended. The first license date for API SM was November 30th 2004. Engine oil that meet these requirements may display API Service Category SM in the upper portion of the API Service Symbol.

**SN** API Service Category SN was adopted for use in describing engine oils available in 2011. These oils are for use in service typical of gasoline engines in current and earlier passenger cars, sport utility vehicles, vans, and light-duty trucks operating under vehicle manufacturers' recommended maintenance procedures. Vehicle owners and operators should follow their vehicle manufacturer's recommendations on engine oil viscosity and performance standard.

Engine oils that meet the API Service Category SN designation may be used where API Service Category SM and earlier S categories have been recommended. Engine oils that meet the API Service Category SN designation have been tested in accordance with the ACC Code and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing. Starting October 1, 2010, oils that have passed the tests for API Service Category SN and are properly licensed by API may display API Service SN in the upper portion of the API Service Symbol.

API SN engine oils designated as Resource Conserving are formulated to help improve fuel economy and protect vehicle emission system components in passenger cars, sport utility vehicles, vans, and light-duty trucks powered by gasoline engines. The requirements are aligned with ILSAC GF-5

## API Gasoline Engine Performance Criteria

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

## API Gasoline Engine Performance Criteria

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

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

## API Gasoline Engine Performance Criteria

| | Test | Primary Performance Criteria | Limits |
|---|---|---|---|
| SG | Sequence IID | Avg. Engine Rust Rating, min. | 8.5 |
| | | Lifter Sticking | None |
| | Sequence IIIE | Viscosity Increase at 40°C. and 64 test hrs, %. max. | 375 |
| | | Avg. Piston Skirt Varnish Rating, min. | 8.9 |
| | | Avg. Sludge Rating, min. | 9.2 |
| | | Ring Land Face Varnish Rating, min. | 3.5 |
| | | Ring Sticking | None |
| | | Lifter Sticking | None |
| | | Cam & Lifter Scuffing | None |
| | | Cam & Lifter Wear, mm. average | 30 |
| | | Cam & Lifter Wear, mm. max. | 64 |
| | Sequence VE | Avg. Engine Sludge Rating, min. | 9.0 |
| | | Rocker Arm Cover Sludge Rating, min. | 7.0 |
| | | Avg. Piston Skirt Varnish Rating, min. | 6.5 |
| | | Avg. Engine Varnish Rating, min. | 5.0 |
| | | Oil Ring Clogging, %. max. | 15 |
| | | Oil Screen Plugging, %. max. | 20 |
| | | Compression Ring Sticking | None |
| | | Cam Wear, mm. average | 122 |
| | | Cam Wear, mm. max. | 381 |
| | CRC L-38 | Bearing Weight Loss, mg. max. | 40 |
| | 1H2 | Top Groove Filling, % vol. max. | 45 |
| | | Weighted Total Demerits | 140 |
| SH | Sequence IID | API SG limits apply<br>Tested according to CMA Code of Practice | |
| | Sequence IIIE or IIIF or IIIG | | |
| | Sequence VE or IVA + VG | | |
| | CRC L-38 | | |

| | **SAE (J300)** | **5W30** | **10W30** | **15W40** | **All Others** |
|---|---|---|---|---|---|
| SH | CEC-L-40-A-93/<br>L-40-T-87 (NOACK), % | 25 max. | 20 max. | 18 max. | - |
| | Phosphorus, % m. | 0.12 max. | 0.12 max. | - | - |
| | Flash Point<br>(ASTM D92), °C. | 200 min. | 205 min. | 215 min. | - |
| | Foaming<br>(Tendency/Stability) | | | | |
| | Sequence I, max. | 10/0 | 10/0 | 10/0 | - |
| | Sequence II, max. | 50/0 | 50/0 | 50/0 | - |
| | Sequence III, max. | 10/0 | 10/0 | 10/0 | - |
| | Sequence IV | Report | Report | Report | - |
| | Homogeneity/Miscibility | Pass | Pass | Pass | - |
| | GM EOFT Filterability,<br>Flow Reduction, % | 50 max. | 50 max. | - | - |

## API Gasoline Engine Performance Criteria

| | Test | Primary Performance Criteria | |
|---|---|---|---|
| SJ | BRT | Average gray value, min. | 100 |
| | Sequence IIIF | Viscosity increase, % max. | 325 |
| | | Avg. piston skirt varnish, min. | 8.5 |
| | | Weighted piston deposit, min. | 3.2 |
| | | Avg. cam-plus-lifter wear µm. max. | 20 |
| | | Hot stuck rings | None |
| | Sequence VG (1) | Avg. engine sludge rating, min. | 7.8 |
| | | Rocker arm cover sludge rating, min. | 8.0 |
| | | Avg. piston skirt varnish rating, min. | 7.5 |
| | | Avg. engine varnish rating, min. | 8.9 |
| | | Oil screen clogging, % max. | 20 |
| | | Hot stuck compression rings | None |
| | Sequence IVA (1) | Avg. cam wear µm. max. | 120 |
| | Sequence VIII (2) | Bearing weight loss, mg max. | 26.4 |
| | | Sheer stability | Stay-in-grade |
| | **SAE (J300)** | **0W-20, 5W-20, 5W-30, 10W-30** | **All Others** |
| | CEC-L-40-A-93/ L-40-T-87 (NOACK), % | 22 max. | 20 max. |
| | Phosphorus, % m. | 0.10 max. | - |
| | Flash Point (ASTM D92), °C. | 200 min.<br>205 min. (10W-30) | - |
| | Foaming (Tendency/Stability) | | |
| | Sequence I, max. | 10/0 | 10/0 |
| | Sequence II, max. | 50/0 | 50/0 |
| | Sequence III, max. | 10/0 | 10/0 |
| | High Temp. (ASTM D6082), max. | 200/50 | 200/50 |
| | Homogeneity/Miscibility | Pass | Pass |
| | GM EOFT Filterability, Flow Reduction, % | 50 max. | 50 max. |
| | High Temp. Deposits (TEOST) mg. | 60 max. | 60 max. |
| | Gelation Index | 12 max. | - |

**Note:**

(1) Sequence IVA + VG in lieu of Sequence VE.

(2) Sequence VIII to API SL limits may be used.

## API Gasoline Engine Performance Criteria

| | Test | Primary Performance Criteria | Limits |
|---|---|---|---|
| SL | ASTM Ball Rust Test | Avg. Grey Value, min. | 100 |
| | Sequence IIIF (2) | Viscosity Increase (KV 40°C), %. max. | 275 |
| | | Avg. Piston Skirt Varnish, min. | 9.0 |
| | | Weighted Piston Demerit Rating, min. | 4.0 |
| | | Hot Stuck Piston Rings | None |
| | | Avg. Cam and Lifter Wear, μm. max. | 20 |
| | | Oil Consumption | 5.2 |
| | | Low Temp. Viscosity | Report (1) |
| | Sequence VE (3) | Cam Wear Average μm. max. | 127 |
| | | Cam Wear Average μm. max. | 380 |
| | Sequence IVA | Avg. Cam Wear μm, max. | 120 |
| | Sequence VG | Avg. Engine Sludge Rating, min. | 7.8 |
| | | Rocker Cover Sludge Rating, min. | 8.0 |
| | | Average Engine Varnish Rating, min. | 8.9 |
| | | Average Piston Skirt Varnish, min. | 7.5 |
| | | Oil Screen Clogging, max. | 20 |
| | | Hot Stuck Compression Ring | None |
| | | Cold Stuck Rings | Rate & Report |
| | | Oil Screen Debris (%) | Rate & Report |
| | | Oil Ring Clogging | Rate & Report |
| | **SAE (J300)** | **0W-20, SW-20, SW-30, 10W-30** | **All Others** |
| | Volatility Loss ASTM D5800, %. max. | 15 | 15 |
| | Volatility Loss at 37 °C ASTM D6417, %. max. | 10 | 10 |
| | Sequence VIII | Bearing % wt. Loss, mg. max. | 26.4 |
| | Phosphorus, % m. | 0.10 max. | - |
| | Flash Point (ASTM D92), °C. | 200 min.<br>205 min. (10W-30) | - |
| | Foaming (Tendency/Stability) | | |
| | Sequence I, max. | 10/0 | 10/0 |
| | Sequence II, max. | 50/0 | 50/0 |
| | Sequence III, max. | 10/0 | 10/0 |
| | High Temp. (ASTM D6082), max. | 100/0 | 100/0 |
| | Homogeneity/Miscibility | Pass | Pass |
| | GM EOFT Filterability, Flow Reduction, %. max. | 50 | 50 |
| | High Temp. Deposits (TEOST) mg. max. | 45 | 45 |
| | Gelation Index, max. | 12 | - |
| | Shear Stability - Seq. VIII 10 hr. Stripped KV100°C. | Stay-in-grade | Stay-in-grade |

**Note:**

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

(2) Sequence IIIG at API SM performance accepted as alternative to Sequence IIIF.

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



Afton CHEMICAL

## API Gasoline Engine Performance Criteria

| | Test | Primary Performance Criteria | Limits | |
|---|---|---|---|---|
| | | | SAE 0W-20, SAE 5W-20 SAE 0W-30, SAE 5W-30, SAE 10W-30 | All Others |
| SM | ASTM Ball Rust Test | Avg. Grey Value, min | 100 | 100 |
| | Sequence IIIG | Viscosity Increase (KV 40°C), %, max. | 150 | 150 |
| | | Weighted Piston Demerit rating, min. | 3.5 | 3.5 |
| | | Hot Stuck Piston Rings | None | None |
| | | Avg. Cam and Lifter Wear, µm, max. | 60 | 60 |
| | | Oil Consumption | Report | Report |
| | Sequence IIIGA | Used oil MRV (1) | Pass | - |
| | Sequence IVA | Avg. Cam Wear µm, max | 90 | 90 |
| | Sequence VG | Avg. Engine Sludge rating, min. | 7.8 | 7.8 |
| | | Rocker Cover Sludge rating, min. | 8.0 | 8.0 |
| | | Average Engine Varnish rating, min. | 8.9 | 8.9 |
| | | Average Piston Skirt Varnish, min. | 7.5 | 7.5 |
| | | Oil Screen Clogging, max. | 20 | 20 |
| | | Hot Stuck Compression Ring | None | None |
| | | Cold Stuck Rings | Rate & Report | Rate & Report |
| | | Oil Screen Debris (%) | Rate & Report | Rate & Report |
| | | Oil Ring Clogging | Rate & Report | Rate & Report |
| | Sequence VIII | Bearing Weight Loss, mg, max. | 26 | 26 |

**Note:**
(1) To be measured at 5°C greater than that specified by SAE J300 for the viscosity grade of the oil.

## API Gasoline Engine Performance Criteria

| Bench Tests | Primary Performance Criteria | Limits | |
|---|---|---|---|
| | | SAE 0W-20, SAE 5W-20 SAE 0W-30, SAE 5W-30, SAE 10W-30 | All Others |
| SM | Phosphorus % mass, max.[2] | 0.08[3] | - |
| | Phosphorus % mass, min.[2] | 0.06[3] | 0.06 [3] |
| | or D2622, sulphur mass, max.[2] | 0.5[3] | - |
| | SAE 0W-20, 0W-30, 5W-20, 5W-30, SAE 10W-30 | 0.7[3] | - |
| | Flash Point (ASTM D92), ˚C | 200 min. 205 min. (10W-30) | - |
| | Foaming (Tendency / Stability) | | |
| | Sequence I, max. | 10/0 | 10/0 |
| | Sequence II, max. | 50/0 | 50/0 |
| | Sequence III, max. | 10/0 | 10/0 |
| | High Temp. (ASTM D6082), max. | 100/0 | 100/0 |
| | Homogeneity / Miscibility | Pass | Pass |
| | GM EOFT Filterability Flow reduction, %, max. | 50 | 50 |
| | EOWTT, % flow reduction, max. | | |
| | with 0.6% $H_2O$ | 50 | 50 |
| | with 1.0% $H_2O$ | 50 | 50 |
| | with 2.0% $H_2O$ | 50 | 50 |
| | with 3.0% $H_2O$ | 50 | 50 |
| | High temp. deposits (TEOST) mg, max | 35 | 45 |
| | Gelation Index, max.[4] | 12 | - |
| | Shear Stability - Seq. VIII 10 hr. Stripped KV 100˚C | Stay-in-grade | Stay-in-grade |
| | Volatility Loss ASTM D5800, %, max. | 15 | 15 |
| | Volatility Loss at 37˚C ASTM D6417, %, max. | 10 | 10 |

**Note:**

(2) 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, sulphur, 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.

(3) This is a non-critical specification as described in ASTM D3244.

(4) To be evaluated 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 J300), whichever occurs first.

## API Gasoline Engine Performance Criteria

| | Engine Tests | Primary Performance Criteria | Limits | |
|---|---|---|---|---|
| | | | SAE 0W-20, 5W-20, 0W-30, 5W-30, 10W-30 | All Others |
| SN | Sequence IIIG (ASTM D7320) | Kinematic viscosity increase @ 40°C, %, max. | 150 | |
| | | Average Weighted Piston Deposits, merits, min. | 4.0 | |
| | | Hot Stuck Rings | None | |
| | | Average Cam plus Lifter Wear, µm, max. | 60 | |
| | Sequence IVA (ASTM D6891) | Average Cam Wear (7 positions average), µm, max. | 90 | |
| | Sequence VG (ASTM D6593) | Average Engine Sludge, merits, min. | 8.0 | |
| | | Average Rocker Cover Sludge, merits, min. | 8.3 | |
| | | Average Engine Varnish, merits, min. | 8.9 | |
| | | Average Piston Skirt Varnish, merits, min. | 7.5 | |
| | | Oil Screen Sludge, % area, max. | 15 | |
| | | Oil Screen Debris, % area | Rate & Report | |
| | | Hot Stuck Compression Rings | none | |
| | | Cold Stuck Rings | Rate & Report | |
| | | Oil Ring Clogging, % area | Rate & Report | |
| | Sequence VID (ASTM D7589) | SAE xW-20 Viscosity grade | | |
| | | FEI SUM | 2.6% min. | |
| | | FEI 2 | 1.2% min. after 100 hrs. aging | |
| | | SAE xW-30 viscosity grade | | |
| | | FEI SUM | 1.9% min. | |
| | | FEI 2 | 0.9% min. after 100 hrs. aging | |
| | | SAE 10W-30 and all others viscosity grades not listed above: | | |
| | | FEI SUM | 1.5% min. | |
| | | FEI 2 | 0.6% min. after 100 hrs. aging | |
| | Sequence VIII (ASTM D6709) | Bearing weight loss, mg, max. | 26 | |

## API Gasoline Engine Performance Criteria

| | Bench Test and Measured Parameters | Primary Performance Criteria | Limits | |
|---|---|---|---|---|
| | | | SAE 0W-20, 5W-20, 0W-30, 5W-30, 10W-30 | All Others |
| SN | Aged oil Low Temp Viscosity, ASTM Sequence IIIGA test, ASTM D7320 | Measure CCS viscosity of the EOT Sequence IIIGA sample at the CCS temperature corresponding to original viscosity grade | (1) a) b) c) | |
| | Aged oil Low Temperature Viscosity, ROBO Test, ASTM D7528 | Measure CCS viscosity of the EOT ROBO sample at the CCS temperature corresponding to original viscosity grade | (2) a) b) c) | |
| | Sequence IIIGB, ASTM D7320 | Phosphorous volatility, % min. | 79 | |
| | Ball Rust Test, ASTM D6557 | Average gray value, % min. | 100 | |
| | Evaporation loss, ASTM D5800 | 1 hr at 250°C, max. (3) | 15.0 | |
| | Simulated distillation, ASTM D6417 | % max at 371°C | 10 | |
| | EOFT, ASTM D6795 | Maximum Flow reduction, % | 50 | |
| | EOWTT, ASTM D6794 | with 0.6% H2O, maximum flow reduction, % | 50 | |
| | | with 1.0% H2O, maximum flow reduction, % | 50 | |
| | | with 2.0% H2O, maximum flow reduction, % | 50 | |
| | | with 3.0% H2O, maximum flow reduction, % | 50 | |
| | Phosporous content, ASTM D4951 | % mass | ≥ 0.06 and ≤ 0.08 | ≥ 0.06 |
| | Sulphur content, ASTM D4951 or D2622 | 0W-XX, 5W-XX, % mass max. | 0.5 | |
| | | 10W-30, % mass, max. | 0.6 | |
| | | All other grades, % mass max. | 0.6 | |
| | Fresh Oil Foaming Characteristics ASTM D892 (option A) | | Tendency/ Stability (after 10 min ) | Tendency/ Stability (after 10 min ) |
| | | Sequence I, ml max. | 10/0 | 10/0 |
| | | Sequence II, ml max. | 50/0 | 50/0 |
| | | Sequence III, ml max. | 10/0 | 10/0 |

**Note:**

(1) a) If CCS Viscosity measured is less than or equal to the maximum CCS viscosity for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade.
b) If CCS Viscosity measured is higher than the maximum viscosity specified for the original grade in J300, 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).
c) The EOT IIIGA sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity as outlined in a) or b) above.

(2) a) Same as above.
b) Same as above.
c) The EOT ROBO sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity as outlined in a) or b) above.

(3) Calculated conversions specified in D5800 are allowed.

## API Gasoline Engine Performance Criteria

| | Bench Test and Measured Parameters | Primary Performance Criteria | Limits | |
|---|---|---|---|---|
| | | | SAE 0W-20, 5W-20, 0W-30, 5W-30, 10W-30 | All Others |
| SN | Fresh Oil High Temperature Foaming Characteristics, ASTM D6082 (Option A) | ml, max. | Tendency/ Stability (after 10 min ) | Tendency/ Stability (after 10 min ) |
| | | | 100/0 | 100/0 |
| | Homogeneity and Miscibility, ASTM D6922 | Shall remain homogeneous and, when mixed with ASTM Test Monitoring Centre (TMC) reference oils, shall remain miscible | Pass | |
| | Shear stability, Sequence VIII, ASTM D6709 | 10 hr stripped KV @ 100°C | Kinematic viscosity must remain in original SAE viscosity grade | |
| | High Temperature Deposits, TEOST MHT, ASTM D7097 | Deposit weight, mg, max. | 35 | 45 |
| | Gelation Index, ASTM D5133 (4) | Max. | 12 | - |
| | Emulsion Retention, ASTM D7563 | 0°C, 24 hrs | No water separation | |
| | | 25°C, 24 hrs | No water separation | |

**Elastomer Compatibility**

Candidate oil 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 Material (SAE J2643) | Test Procedure | Material property | Units | Limits |
|---|---|---|---|---|
| Polyacrylate Rubber (ACM-1) | ASTM D471 | Volume | % Δ | -5, 9 |
| | ASTM D2240 | Hardness | pts | -10, 10 |
| | ASTM D412 | Tensile Strength | % Δ | -40, 40 |
| Hydrogenated Nitrile Rubber (HNBR-1) | ASTM D471 | Volume | % Δ | -5, 10 |
| | ASTM D2240 | Hardness | pts | -10, 5 |
| | ASTM D412 | Tensile Strength | % Δ | -20, 15 |
| Silicone Rubber (VMQ-1) | ASTM D471 | Volume | % Δ | -5, 40 |
| | ASTM D2240 | Hardness | pts | -30, 10 |
| | ASTM D412 | Tensile Strength | % Δ | -50, 5 |
| Fluorocarbon Rubber (FKM-1) | ASTM D471 | Volume | % Δ | -2, 3 |
| | ASTM D2240 | Hardness | pts | -6, 6 |
| | ASTM D412 | Tensile Strength | % Δ | -65, 10 |
| Ethylene Acrylic Rubber (AEM-1) | ASTM D471 | Volume | % Δ | -5, 30 |
| | ASTM D2240 | Hardness | pts | -20, 10 |
| | ASTM D412 | Tensile Strength | % Δ | -30, 30 |

**Note:**

(4) To be evaluated 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 J300), whichever occurs first.

## ILSAC Specifications: GF-1

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

## ILSAC Specifications: GF-2

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

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

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

| Test | | | Limits |
|---|---|---|---|
| Viscosity Requirements | SAE 0W-XX, 5W-XX, 10W-XX | | As defined by SAE J300 |
| Engine Test Requirements | Sequence IID, Sequence IIIE, Sequence VE, CRC L-38 | | API SG Limits apply. Tested according to CMA Code of Practice |
| Bench Test Requirements | CEC-L-40-A-93/L-40-T-87 (NOACK), % | | 22 max. |
| | Phosphorus, % m. | | 0.10 max. |
| | Flash Point (ASTM D92), °C. | | 200 min. |
| | Foaming (Tendency/Stability) | | |
| | | D892 Sequence I, max. | 10/0 |
| | | D892 Sequence II, max. | 50/0 |
| | | D892 Sequence III, max. | 10/0 |
| | | D6082 High temp. (ASTM D1392), max. | 200/50 |
| | Homogeneity/Miscibility | | Pass |
| | GM EOFT Filterability | | |
| | | Flow reduction, % | 50 max. |
| | GM EOFT Modified | | |
| | | 0.6/1.0% water | Rate & Report |
| | | 2.0/3.0% water | Rate & Report |
| | High Temp. Deposits (TEOST) | | |
| | | Deposit % wt. mg. | 60 max. |
| | Gelation Index | | 12.0 max. |
| Additional Requirements | Sequence VI-A Fuel Economy | | |
| | | SAE 0W-20, 5W-20 | 1.4% min. |
| | | Other SAE 0W-X, 5W-X | 1.1% min. |
| | | SAE 10W-X | 0.5% min. |



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## ILSAC Specifications: GF-3

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

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

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

| Test | | | Limits | | |
|---|---|---|---|---|---|
| Viscosity Requirements | SAE 0W-XX, 5W-XX, 10W-XX | | As defined by SAE J300 | | |
| Engine Test Requirements | Sequence IIIF, Sequence IVA, Sequence VG, Sequence VIII, BRT | | API SL Limits apply. Tested according to ACC Code of Practice | | |
| Bench Test Requirements | Evaporation Loss (ASTM D5800) | | 15% max. 1 hr at 250°C. | | |
| | Simulated Distillation (ASTM D6417) | | 10% max. at 371°C. | | |
| | Phosphorus, % m. | | 0.10 max. | | |
| | Foaming Tendency/Stability (Option A) | | | | |
| | | Sequence I, max. | 10/0 | | |
| | | Sequence II, max. | 50/0 | | |
| | | Sequence III, max. | 10/0 | | |
| | | High temp. (ASTM D6082), max. | 100/0 | | |
| | Homogeneity/Miscibility | | Pass | | |
| | GM EOFT Filterability | | | | |
| | | Flow reduction, % | 50 max. | | |
| | GM EOFT Modified (EOWTT) (1) | | | | |
| | | 0.6/1.0% water | 50 max. | | |
| | | 2.0/3.0% water | 50 max. | | |
| | High Temp. Deposits (TEOST-MHT-4) | | | | |
| | | Deposit % wt. mg. | 45 max. | | |
| | Gelation Index | | 12.0 max. | | |
| Additional Requirements | Sequence VI-B Fuel Economy | | FE1 (16 hr) | FE2 (96 hr) | Sum FE1/FE2 |
| | | SAE 0W-20, 5W-20 | 2.0 min | 1.7 min. | - |
| | | Other SAE 0W-30, 5W-30 | 1.6 min. | 1.3 min. | 3.0 min. |
| | | SAE 10W-30 & all other viscosity grades | 0.9 min. | 0.6 min. | 1.6 min. |

**Note:**

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



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## ILSAC Specifications: GF-4

ILSAC GF-4 is applicable to SAE viscosity grades 0W-XX, 5W-XX and 10W-XX grades only. Oils can be licensed with the API Engine Oil Licensing and Certification System (EOLCS) from 14 January 2004.

Three categories of fuel economy improvement are possible with ILSAC GF-4.

ILSAC GF-4 oils have a phosphorus limitation of 0.08% maximum compared with 0.10% maximum for GF-3 and a sulphur limit dependent on the viscosity grade, to maintain acceptable catalyst protection.

| Test | | Limits |
|---|---|---|
| Viscosity Requirements | SAE 0W-XX, 5W-XX, 10W-XX | As defined by SAE J300 |
| Engine Test Requirements | Sequence IIIG | |
| | Kinematic Viscosity Increase @ 40ºC, % | 150 max. |
| | Average Weighted Piston Deposits, merits | 3.5 min. |
| | Hot Stuck Rings | none |
| | Average Cam plus Lifter Wear, μm | 60 max. |
| | Sequence IIIGA<br>Evaluate the EOT oil from the ASTM Sequence IIIGA test with ASTM D4684 (MRV TP-1) | The D4684 viscosity of the EOT sample must meet the requirements of the original grade or the next higher grade. |
| | Sequence VG | |
| | Average Engine Sludge, merits | 7.8 min. |
| | Average Rocker Cover Sludge, merits | 8.0 min. |
| | Average Engine Varnish, merits | 8.9 min. |
| | Average Piston Skirt Varnish, merits | 7.5 min. |
| | Oil Screen Sludge, % area | 20 max. |
| | Oil Screen Debris, % area | Rate & Report |
| | Hot Stuck Compression Rings | None |
| | Cold Stuck Rings | Rate & Report |
| | Oil Ring Clogging, % area | Rate & Report |
| | Follower Pin Wear, cyl #8, avg., μm | Rate & Report (1) |
| | Ring Gap Increase, cyl #1 & #8, avg., μm | Rate & Report (1) |
| | Sequence IVA | |
| | Average Cam Wear (7 position average), μm | 90 maximum |
| | Sequence VIII | |
| | Bearing Weight Loss, mg | 26 maximum |
| | Sequence VIB (2) | |
| | SAE 0W-20 and 5W-20 viscosity grades: | 2.3% FEI 1 min. after 16 hrs. aging<br>2.0% FEI 2 min. after 96 hrs. aging |
| | SAE 0W-30 and 5W-30 viscosity grades: | 1.8% FEI 1 min. after 16 hrs. aging<br>1.5% FEI 2 min. after 96 hrs. aging |
| | SAE 10W-30 and all other viscosity grades not listed above | 1.1% FEI 1 min. after 16 hrs. aging<br>0.8% FEI 2 min. after 96 hrs. aging |

**Note:**

(1) ASTM Surveillance Panel will review statistics annually.

(2) All FEI 1 and FEI 2 values determined relative to ASTM Reference Oil BC.

## ILSAC Specifications: GF-4

| Test | | Limits | |
|---|---|---|---|
| Bench Test Requirements | Evaporation Loss (ASTM D5800) | 15% max. 1 hr at 250ºC | |
| | Simulated Distillation (ASTM D6417) | 10% max. at 371ºC | |
| | Phosphorous, % mass | 0.06 min. - 0.08 max. | |
| | Sulphur, % mass, | | |
| | SAE 0W and 5W multigrades | 0.5% max. | |
| | SAE 10W multigrades | 0.7% max. | |
| | Shear Stability, Sequence VIII (ASTM D6709) 10 hr stripped KV @ 100ºC | Kinematic viscosity must remain in original SAE viscosity | |
| | Ball Rust test (ASTM D6557) | | |
| | Average Grey value | 100 min. | |
| | Foaming (Tendency/Stability) | | |
| | Sequence I, max. | 10/0 | |
| | Sequence II, max. | 50/0 | |
| | Sequence III, max. | 10/0 | |
| | High temp. (ASTM D6082), max. | 100/0 | |
| | Homogeneity/Miscibility | Pass | |
| | GM EOFT Filterability | | |
| | Flow reduction, % | 50 max. | |
| | GM EOFT Modified (EOWTT) (3) | | |
| | 0.6/1.0% water | 50 max. | |
| | 2.0/3.0% water | 50 max. | |
| | High Temp. deposits (TEOST MHT-4) | | |
| | Deposit wt. mg. | 35 max. | |
| Additional Requirements | Sequence VI-B Fuel Economy (2) | FE1 (16 hr) | FE2 (96 hr) |
| | SAE 0W-20, 5W-20 | 2.3 min. | 2.0 min. |
| | SAE 0W-30, 5W-30 | 1.8 min. | 1.5 min. |
| | SAE 10W-30 & all other viscosity grades | 1.1 min. | 0.8 min. |

**Note:**

(2) All FEI 1 and FEI 2 values determined relative to ASTM Reference Oil BC.

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

## ILSAC Specifications: GF-5

| Test | Performance Criteria | Limits |
|---|---|---|
| Viscosity requirements | SAE 0W-XX, 5W-XX, 10W-XX | As defined by SAE J300 |
| Gelation Index | ASTM D5133 To be evaluated from -5°C at which 40,000 cP is attained or -40°C, or 2°C below the appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first | |
| Engine Test Requirements | Sequence IIIG (ASTM D7320) | |
| | Kinematic viscosity increase @ 40°C, % | 150 max. |
| | Average Weighted Piston Deposits, merits | 4.0 min. |
| | Hot Stuck Rings | none |
| | Average Cam plus Lifter Wear, μm | 60 max. |
| | Sequence VG (ASTM D6593) | |
| | Average Engine Sludge, merits | 8.0 min. |
| | Average Rocker Cover Sludge, merits | 8.3 min. |
| | Average Engine Varnish, merits | 8.9 min. |
| | Average Piston Skirt Varnish, merits | 7.5 min. |
| | Oil Screen Sludge, % area | 15 max. |
| | Oil Screen Debris, % area | Rate & Report |
| | Hot Stuck Compression Rings | none |
| | Cold Stuck Rings | Rate & Report |
| | Oil Ring Clogging, % area | Rate & Report |
| | Sequence IVA (ASTM D6891) | |
| | Average Cam Wear (7 positions average), μm | 90 max. |
| | Sequence VIII (ASTM D6709) | |
| | Bearing weight loss, mg | 26 max. |
| | Sequence VID (ASTM D7589) | |
| | SAE xW-20 Viscosity grade | |
| | FEI SUM | 2.6% min. |
| | FEI 2 | 1.2% min. after 100 hrs. ageing |
| | SAE xW-30 viscosity grade | |
| | FEI SUM | 1.9% min. |
| | FEI 2 | 0.9% min. after 100 hrs. aging |
| | SAE 10W-30 and all others viscosity grades not listed above: | |
| | FEI SUM | 1.5% min. |
| | FEI 2 | 0.6% min. after 100 hrs. aging |
| | Catalyst compatibility | |
| | Phosphorus Content, ASTM D4951 | 0.08% (mass) max. |
| | Phosphorus Volatility ASTM D7320 (Sequence IIIGB, Phosphorus retention) | 79% min |
| | Sulphur content, ASTM D4951 or D2622 | |
| | SAE 0W-XX, 5W-XX | 0.5% (mass) max. |
| | SAE 10W-30 | 0.6% (mass) max. |
| | Wear | |
| | Phosphorous content, ASTM D4951 | 0.06% (mass ) min. |



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## ILSAC Specifications: GF-5

| Test | Performance Criteria | Limits | |
|---|---|---|---|
| Engine Test Requirements | Volatility | | |
| | Evaporation loss, ASTM D5800 | 15% max 1 hr at 250°C (1) | |
| | Simulated distillation, ASTM D6417 | 10% max at 371°C | |
| | High Temperature Deposits, TEOST MHT-4 ASTM D7097 | | |
| | Deposit weight, mg | 35 max | |
| | High Temperature Deposits, TEOST 33C, ASTM D6335 | | |
| | Total deposit weight, mg | 30 max (2) | |
| | Filterability | | |
| | EOWTT, ASTM D6794 | | |
| | with 0.6% H2O | 50% maximum flow reduction | |
| | with 1.0% H2O | 50% maximum flow reduction | |
| | with 2.0% H2O | 50% maximum flow reduction | |
| | with 3.0% H2O | 50% maximum flow reduction | |
| | EOFT, ASTM D6795 | 50% maximum flow reduction | |
| | Fresh Oil Foaming Characteristics (ASTM D6082 option A and excluding paragraph 11) | Tendency | Stability (after 1 min settling period) |
| | Sequence I | 10 ml max | 0 ml max |
| | Sequence II | 50 ml max | 0 ml max |
| | Sequence III | 10 ml max | 0 ml max |
| | Fresh Oil High Temperature Foaming Characteristics, ASTM D6082 (Option A) | Tendency | Stability (after 1 min settling period) |
| | | 100ml max | 0 ml max |
| | Aged oil Low Temperature Viscosity, ROBO Test, ASTM D7528 | | |
| | Measure CCS viscosity of the EOT ROBO sample at the CCS temperature corresponding to original viscosity grade | See (3) a) b) c) | |

**Note:**

(1) Calculated conversions specified in D5800 are allowed.

(2) No TEOST 33C limit for SAE 0W-20.

(3) a) If CCS Viscosity measured is less than or equal to the maximum CCS viscosity for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade

b) If CCS Viscosity measured is higher than the maximum viscosity specified for the original grade in J300, 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).

c) The EOT ROBO sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity as outlined in a) or b) above.

## ILSAC Specifications: GF-5

| Test | Performance Criteria | Limits |
|---|---|---|
| | Aged oil Low Temperature Viscosity, ASTM Sequence IIIGA test, ASTM D7320 | |
| | Measure CCS viscosity of the EOT Sequence IIIGA sample at the CCS temperature corresponding to original viscosity grade | See [(4) a) b) c)] |
| | Shear stability, Sequence VIII, ASTM D6709 | |
| | 10 hr stripped KV @ 100°C | Kinematic viscosity must remain in original SAE viscosity grade |
| | Homogeneity and Miscibility, ASTM D6922 | Shall remain homogeneous and, when mixed with ASTM Test Monitoring Center (TMC) reference oils, shall remain miscible |
| | Engine Rusting, Ball Rust Test, ASTM D6557 | |
| | Average gray value | 100 min |
| | Emulsion Retention, ASTM D7563 | |
| | 0°C, 24 hrs | No water separation |
| | 25°C, 24 hrs | No water separation |

Elastomer compatibility

Candidate oil 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 Material (SAE J2643) | Test Procedure | Material property | Units | Limits |
|---|---|---|---|---|
| Polyacrylate Rubber (ACM-1) | ASTM D471 | Volume | % Δ | -5, 9 |
| | ASTM D2240 | Hardness | pts | -10, 10 |
| | ASTM D412 | Tensile Strength | % Δ | -40, 40 |
| Hydrogenated Nitrile Rubber (HNBR-1) | ASTM D471 | Volume | % Δ | -5, 10 |
| | ASTM D2240 | Hardness | pts | -10, 5v |
| | ASTM D412 | Tensile Strength | % Δ | -20, 15 |
| Silicone Rubber (VMQ-1) | ASTM D471 | Volume | % Δ | -5, 40 |
| | ASTM D2240 | Hardness | pts | -30, 10 |
| | ASTM D412 | Tensile Strength | % Δ | -50, 5 |
| Fluorocarbon Rubber (FKM-1) | ASTM D471 | Volume | % Δ | -2, 3 |
| | ASTM D2240 | Hardness | pts | -6, 6 |
| | ASTM D412 | Tensile Strength | % Δ | -65, 10 |
| Ethylene Acrylic Rubber (AEM-1) | ASTM D471 | Volume | % Δ | -5, 30 |
| | ASTM D2240 | Hardness | pts | -20, 10 |
| | ASTM D412 | Tensile Strength | % Δ | -30, 30 |

**Note:**

(4) a) If CCS Viscosity measured is less than or equal to the maximum CCS viscosity for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade.

b) If CCS Viscosity measured is higher than the maximum viscosity specified for the original grade in J300, 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).

c) The EOT IIIGA sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity as outlined in a) or b) above.

## "C" Compression

**"C" Compression** - (Fleets, Contractors, Farmers, etc.)

**CA**

### For Light Duty Diesel Engine Service

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

**CB**

### For Moderate Duty Diesel Engine Service

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

**CC**

### For Moderate Duty Diesel and Gasoline Engine Service

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

**CD**

### For Severe Duty Diesel Engine Service

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

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

# API Compression Classifications

## "C" Compression

**CD-II**

### For Severe Duty two-Stroke Diesel Engine Service

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

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

**CE**

### For High Performance Diesel Engine Service

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

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

## API Compression Classifications

### "C" Compression

**CF**

**For Indirect Injected Diesel Engine Service**

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

**CF-2**

**For Two-Stroke Cycle Diesel Engine Service**

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

**CF-4**

**For High Performance Diesel Engine Service**

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

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

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

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

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

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

# API Compression Classifications

## "C" Compression

**CG-4**

### For Severe Duty Diesel Engine Service

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

**CH-4**

### For 1998 Severe Duty Diesel Engine Service

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

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

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

**CI-4**

### For 2004 Severe Duty Diesel Engine Service

API Service Category CI-4 describes oils for use in high-speed, four-stroke cycle diesel engines designed to meet 2004 exhaust emission standards implemented in 2002. These oils are intended for use in all applications with diesel fuels ranging in sulphur content up to 0.5% weight.

These oils are specifically formulated to sustain engine durability where Exhaust Gas Recirculation (EGR) is used and the impact of these oils on other supplemental exhaust emission devices has not been determined. Optimum protection is provided against corrosive and soot-related wear tendencies, piston deposits, degradation of low- and high-temperature viscometric properties due to soot accumulation, oxidative thickening, loss of oil consumption control, foaming, degradation of seal materials, and viscosity loss due to shear.

Engine oils that meet the API Service Category CI-4 designation have been tested in accordance with the ACC Code and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscocity-Grade Engine Testing.

CI-4 oils are superior in performance to those meeting API CH-4, CG-4, and CF-4 and may be used in engines calling for those API Service Categories.
CI-4+ Introduced in 2006, with greater soot control over API CI-4 , Mack T-8E moving to Mack T-11

### CJ-4

**Diesel Engine Service**

API Service Category CJ-4 describes oils for use in high-speed four-stroke cycle diesel engines designed to meet 2007 model year on-highway exhaust emission standards as well as for previous model years.

These oils are compounded for use in all applications with diesel fuels ranging in sulphur content up to 500ppm (0.05% by weight). However, the use of these oils with greater than 15ppm (0.0015% by weight) sulphur fuel may impact after treatment system durability and/or oil drain interval.

These oils are especially effective at sustaining emission control system durability where particulate filters and other advanced after treatment systems are used. Optimum protection is provided for control of catalyst poisoning, particulate filter blocking, engine wear, piston deposits, low- and high-temperature stability, soot handling properties, oxidative thickening, foaming, and viscosity loss due to shear.

Engine oils that meet the API Service Category CJ-4 designation have been tested in accordance with the ACC Code and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing.

API CJ-4 oils exceed the performance criteria of API CI-4 with CI-4 PLUS, CI-4, CH-4, CG-4 and CF-4 and can effectively lubricate engines calling for those API Service Categories. When using CJ-4 oil with higher than 15 ppm sulphur fuel, consult the engine manufacturer for service interval.

The first licence date for API CJ-4 will be October 15, 2006.

Effective May 1, 2006, marketers may license products meeting API CJ-4 requirements as API CI-4 with CI-4 PLUS, CI-4, CH-4, CG-4, and CF-4.

## API Diesel Engine Performance Criteria

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

## API Diesel Engine Performance Criteria

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

## API Diesel Engine Performance Criteria

| | Test | Primary Performance Criteria | Number of Test Runs | | |
|---|---|---|---|---|---|
| | | | 1 | 2 | 3 |
| CF | 1M-PC | Top Groove Filling (TGF), % vol. max. | 70 | 70 | 70 |
| | | Weighted Total Demerits (WTD), max. | 240 | 240 | 240 |
| | | Ring Side Clearance Loss, mm. max. | 0.013 | 0.013 | 0.013 |
| | | Piston Ring Sticking | None | None | None |
| | | Piston, Ring and Liner Scuffing | None | None | None |
| | Seq. VIII | Bearing Weight Loss, mg. max. | 29.3 | 31.9 | 33.0 |
| CF-2 | 1M-PC | Weighted Total Demerits (WTD), max. | 100 | 100 | 100 |
| | 6V-92TA | Cylinder Line Scuffing, %. max. | 45.0 | 48.0 | 50.0 |
| | | Port Plugging, %. max. | | | |
| | | Average | 2 | 2 | 2 |
| | | Single Cylinder | 5 | 5 | 5 |
| | | Piston Ring Face Distress Demerits, max. | | | |
| | | No. 1 (Fire Ring) | 0.23 | 0.24 | 0.26 |
| | | Avg. No. 2 & 3 | 0.20 | 0.21 | 0.22 |
| | Seq. VIII | Bearing Weight Loss, mg. max. | 29.3 | 31.9 | 33.0 |
| CF-4 | 1-K | A 1-K test programme with a minimum of two tests, acceptable to the limits shown in the columns to the right, is required to demonstrate performance for this category | **Number of Test Runs** | | |
| | | | **2** | **3** | **4** |
| | | Weighted Demerits (WDK), max. | 332 | 339 | 342 |
| | | Top Groove Carbon Fill (TGF), % vol. max. | 24 | 26 | 27 |
| | | Top Land Heavy Carbon (TLHC), %. max. | 4 | 4 | 5 |
| | | Avg. Oil Consumption, g/kW-h. (0-252 hrs.) max. | 0.5 | 0.5 | 0.5 |
| | | Final Oil Consumption, g/kW-h. (228-252 hrs.) max. | 0.27 | 0.27 | 0.27 |
| | | Scuffing, (piston-rings-liner) | None | None | None |
| | | | **Limits (1 test)** | | |
| | T6 | Merit Rating (*), min. | 90 | | |
| | or T10 (D6987) | or Top Piston Ring % wt. loss, avg. mg. max. | 180 | | |
| | | Linear Wear, µm. max. | 47 | | |
| | T7 | Average rate of KV inc. during last 50 hrs. max. | 0.040 | | |
| | or T8A (D5967) | or Average rate of KV inc. 100-150 hrs. max. | 0.20 | | |
| | Seq. VIII | Bearing Weight Loss, mg. max. | 33 | | |
| | CBT (D5968) | Copper, mg/kg. (ppm) increase, max. | 20 | | |
| | | Lead, mg/kg. (ppm) increase, max. | 60 | | |
| | | Tin, mg/kg. (ppm) increase, max. | Report | | |
| | | Copper Corrosion, max. | 3 | | |

**Note:**

* Requires greater than zero unit on all individual rating.

## API Diesel Engine Performance Criteria

| | Test | Primary Performance Criteria | Number of Test Runs | | |
|---|---|---|---|---|---|
| | | | 1 | 2 | 3 |
| CG-4 | 1N | WDN (Weighted Demerits-1N), avg. max. | 286.2 | 311.7 | 323.0 |
| | | TGF (Top Groove Fill), % vol. avg. max. | 20 | 23 | 25 |
| | | TLHC (Top Land Heavy Carbon), % avg. max. | 3 | 4 | 5 |
| | | Oil Consumption, g/kW-h. avg. max. | 0.5 | 0.5 | 0.5 |
| | | Scuffing, Piston-Rings-Liner | | | |
| | | Number of Tests Allowed | None | None | None |
| | | Stuck Rings | None | None | None |
| | T-8 | Viscosity Increase at 3.8% soot, cSt. avg. max. | 11.5 | 12.5 | 13.0 |
| | | Filter Plugging, Differential Pressure, kPa. avg. max. | 138 | 138 | 138 |
| | | Oil Consumption, g/kW-h. avg. max. | 0.304 | 0.304 | 0.304 |
| | Seq. IIIF or | 60 hr viscosity (at 40°C) | 325 | 349 | 360 |
| | IIIG | Kinematic viscosity % increase @ 40°C, max | 150 | 173 | 184 |
| | Seq. VIII | Bearing Weight Loss, mg. avg. max. | 29.3 | 31.9 | 33.0 |
| | | Used Oil Viscosity, cSt. greater than SAE J300 lower limit for Grade, avg. min. | 0.5 | 0.5 | 0.5 |
| | RFWT | Wear, µm. (mils), avg. max. | 11.4 (0.45) | 12.4 (0.49) | 12.7 (0.50) |
| | Foam Option A not allowed | Foaming/Settling, ml. max. | | | |
| | | Sequence I | 10/0 | | |
| | | Sequence II | 20/0 | | |
| | | Sequence III | 10/0 | | |
| | Bench Corrosion Test | ppm. Increase, max. | | | |
| | | Copper | 20 | | |
| | | Lead | 60 | | |
| | | Tin | 50 | | |
| | | Copper Corrosion, max. D130 | 3 | | |

**Note:**
Limits do not apply to monograde oils.

## API Diesel Engine Performance Criteria

| | Test | Primary Performance Criteria | Number of Test Runs | | |
|---|---|---|---|---|---|
| | | | 1 | 2 | 3 |
| CH-4 | 1P | WDP (Weighted Demerits - 1P), max. | 350 | 378 | 390 |
| | | TGC (Top Groove carbon), %, vol. max. | 36 | 39 | 41 |
| | | TLC (Top land Carbon), %, max. | 40 | 46 | 49 |
| | | Avg. Oil Consumption, 0-360 hrs. | 11.0 max./test | | |
| | | Final oil Consumption, 336-360 hrs. | 10.0 max./test | | |
| | M-11/ ISM[1] | Crosshead Weight Loss, 4.5% soot, mg, max. | 6.5/7.5 | 7.5/7.8 | 8.0/7.9 |
| | | Sludge, min. | 8.7/8.1 | 8.6/8.0 | 8.5/8.0 |
| | | Differential Pressure/Oil Filter, kPa, max. | 79/79 | 93/95 | 100/103 |
| | T-12 [2] | Avg. Liner wear, µm, max. | 25.4/30.0 | 26.6/30.8 | 27.1/31.1 |
| | | Top Ring Weight Loss, mg, max. | 120/120 | 136/132 | 144/137 |
| | | Increase in Lead Content, ppm, max. | 25/65 | 32/75 | 36/79 |
| | T8-E | Viscosity Increase, 3.8% soot cSt, max. | 11.5 | 12.5 | 13.0 |
| | | Relative Viscosity, 4.8% soot, max. | 2.1 | 2.2 | 2.3 |
| | 1K | WDK (Weighted Demerits - 1K), max. | 332 | 347 | 353 |
| | | TGF (Top Groove Fill), % vol, max. | 24 | 27 | 29 |
| | | TLHC (Top Land Heavy Carbon), %, max. | 4 | 5 | 5 |
| | | Oil Consumption, g/bhp-hr, max. | 0.5 | 0.5 | 0.5 |
| | | Piston, Ring and Liner Scuffing | None | None | None |
| | RFWT | Pin Wear, mils, max. | 0.30 | 0.33 | 0.36 |
| | D6984 (Sequence IIIF) | 60 hr viscosity at 40˚C, increase from 10 min sample, %, max. | 295 | 295 (MTAC) | 295 (MTAC) |
| | or Sequence IIIG | Kinematic viscosity, % increase at 40˚C, max. | 150 | 150 (MTAC) | 150 (MTAC) |
| | D892 (Option A not allowed) | Foaming/Settling, mL, max. | | | |
| | | Sequence I | 10/0 | | |
| | | Sequence II | 20/0 | | |
| | | Sequence III | 10/0 | | |
| | D5800 or | % volatility loss at 250˚C, max. | SAE 10W-30 20 | | SAE 15W-40 18 |
| | D6417 | % volatility loss at 371˚C, max. | 17 | | 15 |
| | D6278 | Kinematic viscosity after shearing, cSt min. | SAE XW-30 9.3 | | SAE XW-40 12.5 |
| | EOAT | Aeration Volume, %, max. | 8.0 | 8.0 | 8.0 |
| | Bench Corrosion | Copper, ppm, Increase, max. | 20 | 20 | 20 |
| | | Lead, ppm, Increase, max. | 120 | 120 | 120 |
| | | Tin, ppm, Increase, max. | 50 | 50 | 50 |
| | | Copper Corrosion, ASTM D130, max. | 3 | 3 | 3 |

**Note:**

(1) Cummins ISM may be used as alternative for limits see ASTM D4485.

(2) Mack T-10 or Mack T-12 may be used as alternative for limits see ASTM D4485.

## API Diesel Engine Performance Criteria

| | Test | Primary Performance Criteria | Number of Test Runns 1 | 2 | 3 |
|---|---|---|---|---|---|
| CI-4 | D6923 (1R) or | Weighted demerits (WDP), max. | 382 | 396 | 402 |
| | | Top groove carbon (TGC), demerits, max. | 52 | 57 | 402 |
| | | Top land carbon (TLC), demerits, max. | 31 | 35 | 36 |
| | | Initial oil consumption (IOC), (0-252 hrs.), g/h, average | 13.1 | 13.1 | 13.1 |
| | D6681 (1P) | Weighted demerits (WDP), max. | 350 | 378 | 390 |
| | | Top groove carbon (TGC), demerits, max. | 36 | 39 | 41 |
| | | Top land carbon (TLC), demerits, max. | 40 | 46 | 49 |
| | | Average oil consumption, g/h (0-360 hrs.), max. | 12.4 | 12.4 | 12.4 |
| | | Final oil consumption, g/h (312-360 hrs.), max. | 14.6 | 14.6 | 14.6 |
| | | Piston, ring, and liner scuffing | none | none | none |
| | D6987 (T10) or D7422 (T12) | Merit rating, min. | 1000 | 1000 | 1000 |
| | D7468 (ISM) | Crosshead % wt. loss, mg, max. | 7.5 | 7.8 | 7.9 |
| | | Oil filter differential pressure at 250 hrs, kPa, max | 379 | 462 | 510 |
| | | Average engine sludge, CRC merits at EOT, min | 8.1 | 8.0 | 8.0 |
| | D5967 (T8-E) | Relative viscosity at 4.8% soot | 1.8 | 1.9 | 2.0 |
| | D6984 (Sequence IIIF) | kinematic viscosity (at 40˚C), % increase, max. | 275 | 275 (MTAC) | 275 (MTAC) |
| | or D7320 (Sequence IIIG) | Kinematic viscosity, % increase at 40˚C, max. | 150 | 150 (MTAC) | 150 (MTAC) |
| | D6750 (1K) | Weighted demerits (WDK), max. | 332 | 347 | 353 |
| | | Top groove fill (TGF), %, max. | 24 | 27 | 29 |
| | | Top land heavy carbon, (TLHC), %, max. | 4 | 5 | 5 |
| | | Average oil consumption, g/kW-h, (0-252 hrs.), max | 0.5 | 0.5 | 0.5 |
| | | Piston, ring and liner scuffing | none | none | none |
| | D5966 (RFWT) | Average pin wear, mils, max. or µm, max. | 0.30<br>(7.6) | 0.33<br>(8.4) | 0.36<br>(9.1) |
| | D6894 (EOAT) | Aeration, volume %, max. | 8.0 | 8.0 | 8.0 |
| | D4683 (High temperature / High shear) | Viscosity after shear, mPa.s, min. | - | 3.5 | - |
| | D4684 (MRV TP-1) | The following limits are applied to SAE viscosity grades 0W, 5W, 10W and 15W: Viscosity of 75 hrs. used oil sample from T-10 test tested at -20˚C, mPa-s, max. | | 25,000 | |
| | | If yield stress is detected, use modified D4684 (external preheat), then mPa-s, max. and yield stress, Pa | | 25,000<br><35 | |
| | D5800 (NOACK) | Evaporative loss at 250˚C, %, max | | 15 | |



Afton Chemical

## API Diesel Engine Performance Criteria

| | Test | Primary Performance Criteria | Limits |
|---|---|---|---|
| CI-4 | D6594 (135°C HTCBT) | Copper, mg/kg (ppm) increase, max. | 20 |
| | | Lead, mg/kg (ppm) increase, max. | 120 |
| | | Tin, mg/kg (ppm) increase, max. | 50 |
| | | Copper strip rating, max. | 3 |
| | D6278 | Kinematic viscosity after shearing, cSt, min. | SAE XW-30 / SAE XW-40<br>9.3 / 12.5 |
| | D892 | Foaming/settling, ml. max. | |
| | | Sequence I | 10/0 |
| | | Sequence II | 20/0 |
| | | Sequence III | 10/0 |

**Elastomer Compatibility**

| Elastomer | Volume Change | Limits Hardness | Tensile Strength | Elongation |
|---|---|---|---|---|
| Nitrile | +5/-3 | +7/-5 | +10/-TMC 1006 | +10/-TMC 1006 |
| Silicone | + TMC 1006/-3 | +5/-TMC 1006 | +10/-45 | +20/-30 |
| Polyacrylate | +5/-3 | +8/-5 | +18/-15 | +10/-35 |
| Fluoroelastomer | +5/-2 | +7/-5 | +10/-TMC 1006 | +10/-TMC 1006 |

## API Diesel Engine Performance Criteria

| | Test | Primary Performance Criteria | Number of Test Runns 1 | 2 | 3 |
|---|---|---|---|---|---|
| CJ-4 | D7422 (T-12) | Merit rating, min. | 1000 | 1000 | 1000 |
| | D7468 (ISM) | Merit rating, min. | 1000 | 1000 | 1000 |
| | | Top ring weight loss, mg, max. | 100 | 100 | 100 |
| | D7549 (C-13) | Merit rating, min. | 1000 | 1000 | 1000 |
| | | Hot-stuck piston ring. | none | none | none |
| | D7156 (T-11) | TGA % Soot at 4.0 cSt increase, at 100˚C, min. | 3.5 | 3.4 | 3.3 |
| | | TGA % Soot at 12.0 cSt increase, at 100˚C min. | 6.0 | 5.9 | 5.9 |
| | | TGA % Soot at 15.0 cSt increase, at 100˚C min. | 6.7 | 6.6 | 6.5 |
| | D7484 (ISB) | Slider tappet weight loss, mg, average, max. | 100 | 108 | 112 |
| | | Cam lobe wear, μm, average, max. | 55 | 59 | 61 |
| | | Crosshead weight loss, mg, avg | Report | Report | Report |
| | D6750 (1N) | Weighted demerits (WDN), max. | 286.2 | 311.7 | 323.0 |
| | | Top groove fill (TGF), %, max. | 20 | 23 | 25 |
| | | Top land heavy carbon (TLHC), %, max. | 3 | 4 | 5 |
| | | Oil consumption, g/kW-h, (0-252 hrs.), max. | 0.5 | 0.5 | 0.5 |
| | | Piston, ring, and liner scuffing | none | none | none |
| | | Piston ring sticking | none | none | none |
| | D5966 (RFWT) | Average pin wear, mils, max. | 0.30 | 0.33 | 0.36 |
| | | (μm, max), | (7.6) | (8.4) | (9.1) |
| | D6984 (Seq. IIIF) | Kinematic viscosity (at 40˚C) % increase, max. | 275 | 275 (MTAC) | 275 (MTAC) |
| | Or, alternately, Sequence IIIG | Kinematic viscosity (at 40˚C), % increase, max. | 150 | 150 (MTAC) | 150 (MTAC) |
| | D6894 (EOAT) | Aeration, volume, %, max. | 8.0 | 8.0 (MTAC) | 8.0 (MTAC) |
| | D4683 (High temperature/ High shear) | Viscosity at 150˚C, mPa-s, min. | 3.5 | | |
| | D6594 (135˚C HTCBT) | Copper, mg/kg (ppm) increase, max. | 20 | | |
| | | Lead, mg/kg (ppm) increase, max. | 120 | | |
| | | Copper strip rating, max. | 3 | | |
| | D7109 | Kinematic viscosity after 90 pass, | SAE XW-30 / SAE XW-40 | | |
| | | shearing, cSt at 100˚C, min. | 9.3 / 12.5 | | |
| | D5800 (NOACK) | Evaporative loss at 250˚C, %, max, (Viscosities other than SAE 10W-30) | 13 | | |
| | | Evaporative loss at 250˚C, %, max. (SAE 10W-30 viscosity) | 15 | | |
| | D892 | Foaming/settling, ml. max. | | | |
| | | Sequence I | 10/0 | | |
| | | Sequence II | 20/0 | | |
| | | Sequence III | 10/0 | | |
| | D6896 (MRV TP-1) | Viscosity of the 180 hr used oil drain sample from a T-11 test, tested at -20˚C mPa-s, max. | 25,000 | | |
| | | If yield stress is detected, use the modified test method (external preheat), then measure the viscosity, mPa-s, max. | 25,000 | | |
| | | Measure the yield stress, Pa | <35 | | |

## API Diesel Engine Performance Criteria

| | Test | Primary Performance Criteria | | Limits | |
|---|---|---|---|---|---|
| CJ-4 | D874 | Sulfated ash, weight %, max. | | 1.0 | |
| | D4951 | Phosphorus, weight %, max. | | 0.12 | |
| | D4951 | Sulphur, weight %, max. | | 0.4 | |
| | Seal Compatibility | | | | |
| | Elastomer | Volume Change, % | Hardness Change, Points | Tensile Strength Change, % | Elongation at Break Change, % |
| | Nitrile (NBR) | (+5, -3) | (+7, -5) | (+10, -TMC 1006) | (+10, -TMC 1006) |
| | Silicone (VMQ) | (+TCM 1006, -3) | (+5, -TMC 1006) | (+10, -45) | (+20, -30) |
| | Polyacrylate (ACM) | (+5, -3) | (+8, -5) | (+18, -15) | (+10, -35) |
| | Fluoroelastomer (FKM) | (+5, -2) | (+7, -5) | (+10, -TMC 1006) | (+10, -TMC 1006) |
| | Vamac G (Seal Test) | | | | |
| | Evaluate the Vamac G elastomer using the procedures specified in D7216 and Annex A10. Unadjusted specifications limits for Vamac G follow: | | | | |
| | Volume Change % | | | +TMC 1006/-3 | |
| | Hardness Change, Points | | | +5/-TMC 1006 | |
| | Tensile Strength Change, % | | | +10/-TMC 1006 | |
| | Elongation at Break Change, % | | | +10/-TMC 1006 | |

# ACEA 2007 Service-Fill Oils For Gasoline And Diesel Engines

| Requirements | Method | Properties | Unit | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1-04 | A3 / B3-04 | A3 / B4-04 | A5 / B5-04 |
| Viscosity grades | | SAE J300 Latest active issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear stability | CEC-L-14-A-93 or ASTM D6278 | 100°C Viscosity after 30 cycles | mm²/s | xW-20 stay in grade xW-30 ≥ 8.6 xW-40 ≥ 12.0 | All grades to be Stay-in-grade | All grades to be Stay-in-grade | All grades to be Stay-in-grade |
| Viscosity at high temp. & high shear rate | CEC-L-36-A-90 (2nd Edition) (Ravenfield) | Viscosity at 150°C and $10^6 s^{-1}$ shear rate | mPa.s | max. 3.5. xW -20 2.6. min All others 2.9 min. | ≥ 3.5 | ≥ 3.5 | min 2.9 max. 3.5 |
| Evaporative loss | CEC-L-40-A-93 (NOACK) | Max. weight loss after 1 hr at 250°C | % | ≤ 15 | ≤ 13 | ≤ 13 | ≤ 13 |
| NOTE: The following sections apply to all sequences | | | | | | | |
| Sulphated ash | ASTM D874 | | % m/m | ≤ 1 .3 (1) | ≤ 1.5 (1) | ≤ 1.6 (1) | ≤ 1.6 (1) |
| Sulphur | ASTM D5185 | (2) | % m/m | Report | | | |
| Phosphorous | ASTM D5185 | (2) | % m/m | Report | | | |
| Chlorine | ASTM D6443 | | ppm m/m | Report | | | |

| Requirements | Method | Properties | Unit | Elastomer type | | | | |
|---|---|---|---|---|---|---|---|---|
| Oil / elastomer compatibility | CEC-L-39-T-96 (3) | Max variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | RE1 | RE2-99 | RE3-04 | RE4 | AEM VAMAC As per Daimler Chrysler |
| | | Hardness DIDC | points | -1/+5 | -5/+8 | -22/+1 | -5/+5 | |
| | | Tensile strength | % | -40/+10 | -15/+18 | -30/+10 | -20/+10 | |
| | | Elongation at rupture | % | -50/+10 | -35/+10 | -20/+10 | -50/+10 | |
| | | Volume variation | % | -1/+5 | -7/+5 | -1/+22 | -5/+5 | |

| Requirements | Method | Properties | Unit | Limits |
|---|---|---|---|---|
| Foaming tendency | ASTM D892 without option A | Tendency - stability | ml | Sequence I (24°C) 10 - nil |
| | | | | Sequence II (94°C) 50 - nil |
| | | | | Sequence III (24°C) 10 - nil |
| High temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency - stability | ml | Sequence IV (150°C) 100 - nil |

**Note:**
(1) Maximum limits. Values take into account method and production tolerances.
(2) The internal standard method has to be used.
(3) Use either complete DaimlerChrysler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR: NBR34 DIN 53538 T3 (100°C +/- 2°C); FPM: AK6 (150 °C +/- 2°C); ACM: E7503

## ACEA 2007 Service-Fill Oils For Gasoline And Diesel Engines - Engine Tests

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1 -04 | A3 / B3 -04 | A3 / B4 -04 | A5 / B5 -04 |
| High temperature deposits<br>Ring sticking<br>Oil thickening | CEC-L-88-T-02 (TU5JP-L4)<br>72 hr test | Ring Sticking (each part) | merit, max. | 9.0 | 9.0 | 9.0 | 9.0 |
| | | Piston Varnish (6 elements, average of 4 pistons) | merit, min. | RL 216 | RL 216 | RL 216 | RL 216 |
| | | Absolute viscosity increase at 40°C between min. and max. values during test | $mm^2/s$, max. | RL 216 | 0.8 x RL 216 | 0.8 x RL 216 | 0.8 x RL 216 |
| | | Oil consumption | kg/test | Report | Report | Report | Report |
| Low temperature sludge | ASTM D6593-00 (Sequence VG) Under protocol & requirements for API (4) | Average engine sludge | merit, min. | 7.8 | 7.8 | 7.8 | 7.8 |
| | | Rocker cover sludge | merit, min. | 8.0 | 8.0 | 8.0 | 8.0 |
| | | Average piston skirt varnish | merit, min. | 7.5 | 7.5 | 7.5 | 7.5 |
| | | Average engine varnish | merit, min. | 8.9 | 8.9 | 8.9 | 8.9 |
| | | Compression ring (hot stuck) | | none | none | none | none |
| | | Oil screen clogging | %, max. | 20 | 20 | 20 | 20 |
| Valve train scuffing wear | CEC-L-38-A-94 (TU3M) | Average cam wear | µm, max. | 10 | 10 | 10 | 10 |
| | | Cam wear | µm, max. | 15 | 15 | 15 | 15 |
| | | Pad merit (avg. of 8 pads) | merit, min. | 7.5 | 7.5 | 7.5 | 7.5 |
| Black sludge | CEC-L-53-T-95 (M111) | Average engine sludge | merit, min. | RL 140 | RL 140 | RL 140 | RL 140 |

**Note:**

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

## ACEA 2007 Service-Fill Oils For Gasoline And Diesel Engines - Engine Tests

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1 -04 | A3 / B3 -04 | A3 / B4 -04 | A5 / B5 -04 |
| Fuel economy (5) | CEC-L-54-T-96 (M111) | Fuel economy improvement vs. Reference oil RL191 (15W-40) | %, min. | 2.5 | - | - | 2.5 |
| Ring sticking and piston cleanliness | CEC-L-46-T-93 (VW 1.6 TC D) (6) | Ring sticking | merit, min. | RL 148 | RL 148 | - | - |
| | | Piston cleanliness | merit, min. | RL 148 | RL 148 | - | - |
| Medium temperature dispersivity | CEC-L-093 (DV4TD) (7) | Absolute viscosity increase at 100˚C and 6% soot | $mm^2/s$, max. | 0.6 x RL223 result | 0.6 x RL223 result | 0.6 x RL223 result | 0.06 x RL223 result |
| | | Piston merit (8) | merit, min. | (RL223-2.5pts) | (RL223-2.5pts) | (RL223-2.5pts) | (RL223-2.5pts) |

**Note:**

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

(6) The test according to CEC-L-78-T-99 may be run instead of CEC-L-46-T-93 for A1/B1 and A3/B3. The limits shall be as A3/B4.

(7) XUD11 BTE passing results obtained before the end of 2005 can be used instead of the DV4.

(8) Piston merit is not yet an official CEC barometer.

## ACEA 2007 Service-Fill Oils For Gasoline And Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1 -04 | A3 / B3 -04 | A3 / B4 -04 | A5 / B5 -04 |
| Wear, Viscosity stability & Oil consumption | OM 602 A (9) | Average cam wear. (New tappet) | µm, max. | 50.0 | 50.0 | 50.0 | 50.0 |
| | | Viscosity increase at 40˚C | %, max. | 90 | 90 | 90 | 90 |
| | | Bore polishing | %, max. | 7.0 | 7.0 | 7.0 | 7.0 |
| | | Average cylinder wear | µm, max. | 20.0 | 20.0 | 20.0 | 20.0 |
| | | Oil consumption | kg/test, max. | 10.0 | 10.0 | 10.0 | 10.0 |
| DI diesel Piston cleanliness & Ring sticking | CEC-L-78-T-99 (VW TDI) | Piston cleanliness | merit, min. | - | - | RL 206 - 3pts | RL 206 |
| | | Ring sticking (rings 1 & 2) | | | | | |
| | | Average of all 8 rings | ASF, max. | - | - | 1.2 | 1.2 |
| | | Max. for any 1st ring | ASF, max. | - | - | 2.5 | 2.5 |
| | | Max. for any 2nd ring | ASF, max. | - | - | 0.0 | 0.0 |

**Note:**

(9) OM 646 LA results at an equivalent performance level can be used as soon as the test becomes available as a CEC test. In the event of OM 602 A and OM 646 are not available, ACEA will define an alternative.

## ACEA 2007 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1 -04 | C2 -04 | C3 -07 | C4 -07 |
| Viscosity grades | | SAE J300<br>Latest active issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear stability | CEC-L-14-A-93<br>or<br>ASTM D6278 | 100°C Viscosity after 30 cycles | $mm^2/s$ | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade |
| Viscosity at high temp.<br>& high shear rate | CEC-L-36-A-90<br>(2nd Edition)<br>(Ravenfield) | Viscosity at 150°C and $10^6\ s^{-1}$ shear rate | mPa.s, min. | 2.9 | 2.9 | 3.5 | 3.5 |
| Evaporative loss | CEC-L-40-A-93<br>(NOACK) | Max. weight loss after 1 hr at 250°C | %, max. | 13 | 13 | 13 | 11 |
| Sulphur | ASTM D5185 | (1) | % m/m, max. | 0.2 | 0.3 | 0.3 | 0.2 |
| Phosphorus | ASTM D5185 | (1) | % m/m, max. | 0.05 | 0.070 - 0.090 | 0.070 - 0.090 | 0.090 |
| Sulphated ash | ASTM D874 | | % m/m, max. | 0.5 (2) | 0.8 (2) | 0.8 (2) | 0.5 (2) |
| Chlorine | ASTM D6443 | | ppm - m/m. | Report | Report | Report | Report |
| TBN | ASTM D2896 | | mg KOH/g, min. | - | - | 6 | 6 |

**Note:**

(1) The internal standard method has to be used.

(2) Maximum limits. Values take into account method and production tolerances OM 646 are not available, ACEA will define an alternative.



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## ACEA 2007 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | C1 -04 | C2 -04 | C3 -07 | C4 -07 | |
| NOTE: The following sections apply to all sequences | | | | | | | | |
| Oil / elastomer compatibility (3) | CEC-L-39-T-96 | Max. variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | Elastomer type | | | | |
| | | | | RE1 | RE2-99 | RE3-04 | RE4 | AEM VAMAC |
| | | Hardness DIDC | points | -1/+5 | -5/+8 | -22/+1 | -5/+5 | As per Daimler Chrysler |
| | | Tensile strength | % | -40/+10 | -15/+18 | -30/+10 | -20/+10 | |
| | | Elongation at rupture | % | -50/+10 | -35/+10 | -20/+10 | -50/+10 | |
| | | Volume variation | % | -1/+5 | -7/+5 | -1/+22 | -5/+5 | |
| Foaming tendency | ASTM D892 without option A | Tendency - stability | ml | Sequence I (24˚C) 10 - nil | | | | |
| | | | | Sequence II (94˚C) 50 - nil | | | | |
| | | | | Sequence III (24˚C) 10 - nil | | | | |
| High temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency - stability | ml | Sequence IV (150˚C) 100 - nil | | | | |

**Note:**

(3) Use either complete DaimlerChrysler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR: NBR34 DIN 53538 T3 (100˚C +/-2˚C ); FPM: AK6 (150˚C +/- 2˚C); ACM: E7503 (150˚C +/-2˚C); AEM: D 8948/200.1 (150˚C +/-2˚C)) + RE3, or complete requirements as above + DC requirements for AEM.

## ACEA 2007 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1 -04 | C2 -04 | C3 -07 | C4 -07 |
| High temperature deposits<br><br>Ring sticking<br>Oil thickening | CEC-L-88-T-02 (TU5JP-L4) 72 hr test | Ring sticking (each part) | merit, min. | 9.0 | 9.0 | 9.0 | 9.0 |
| | | Piston varnish, (6 elements, average of 4 pistons) | merit, min. | RL 216 | RL 216 | RL 216 | RL 216 |
| | | Absolute viscosity increase at 40°C between min and max values during test | $mm^2/s$, max. | 0.8 x RL 216 | 0.8 x RL 216 | 0.8 x RL 216 | 0.8 x RL 216 |
| | | Oil consumption | kg/test | Report | Report | Report | Report |
| Low temperature sludge | ASTM D6593-00 (Sequence VG) Under protocol & requirements for API (4) | Average engine sludge | merit, min. | 7.8 | 7.8 | 7.8 | 7.8 |
| | | Rocker cover sludge | merit, min. | 8.0 | 8.0 | 8.0 | 8.0 |
| | | Average Piston skirt varnish | merit, min. | 7.5 | 7.5 | 7.5 | 7.5 |
| | | Average engine varnish | merit, min. | 8.9 | 8.9 | 8.9 | 8.9 |
| | | Comp. ring (hot stuck) | | none | none | none | none |
| | | Oil screen clogging | %, max. | 20 | 20 | 20 | 20 |
| Valve train scuffing wear | CEC-L-38-A-94 (TU3M) | Average cam wear | µm, max. | 10 | 10 | 10 | 10 |
| | | Cam wear, max | µm, max. | 15 | 15 | 15 | 15 |
| | | Pad merit (avg. of 8 pads) | merit, min. | 7.5 | 7.5 | 7.5 | 7.5 |
| Black sludge | CEC-L-53-T-95 (M111) | Average engine sludge | merit, min. | RL 140 | RL 140 | RL 140 | RL 140 + 4 or > 9.0 |
| Fuel economy (5) | CEC-L-54-T-96 (M111) | Fuel economy improvement vs. Reference oil RL 191 (15W-40) | %, min. | 2.5 | 2.5 | 1.0 for xW-30 grade | 1.0 for xW-30 grade |

**Note:**

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

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

## ACEA 2007 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1 -04 | C2 -04 | C3 -07 | C4 -07 |
| Medium temperature dispersivity | CEC-L-093 (DV4TD) | Absolute viscosity increase at 100˚C and 6% soot | $mm^2/s$, max. | 0.60 x RL223 result | 0.60 x RL223 result | 0.60 x RL223 result | 0.60 x RL223 result |
| | | Piston merit (6) | merit, min. | (RL223 - 2.5pts) | (RL223 - 2.5pts) | (RL223 - 2.5pts) | (RL223 - 2.5pts) |
| DI diesel Piston cleanliness & Ring sticking | CEC-L-78-T-99 (VW DI) | Piston cleanliness | merit, min. | RL206 | RL206 | RL206 | RL206 |
| | | | | | | | |
| | | Ring sticking (rings 1 & 2) | | | | | |
| | | Average of all 8 rings | (ASF), max. | 1.2 | 1.2 | 1.2 | 1.2 |
| | | Max. for any 1st ring | (ASF), max. | 2.5 | 2.5 | 2.5 | 2.5 |
| | | Max. for any 2nd ring | (ASF), max. | 0.0 | 0.0 | 0.0 | 0.0 |
| Wear, Viscosity stability & Oil consumption | OM 602 A (7) | Average Cam wear | µm, max. | 50.0 | 50.0 | 45.0 | 45.0 |
| | | Viscosity increase @ 40˚C | %, max. | 90 | 90 | 70.0 | 70.0 |
| | | Bore polishing | %, max. | 7.0 | 7.0 | 4.5 | 4.5 |
| | | Average cylinder wear | µm, max. | 20.0 | 20.0 | 15.0 | 15.0 |
| | | Oil consumption | kg/test, max. | 10.0 | 10.0 | 10.0 | 10.0 |

**Note:**

(6) Piston merit is not yet an official CEC parameter.

(7) OM 646 LA results at an equivalent performance level can be used as soon as the test becomes available as CEC test. In the event of OM 602 A and OM 646 are not available, ACEA will define an alternative.



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## ACEA 2007 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | **E2 -96 Issue 5** | **E4 -07** | **E6 -04 Issue 2** | **E7 -04 Issue 2** |
| Viscosity | | SAE J300 Latest Active Issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear stability | CEC-L-14-A-93 or ASTM D6278 | Viscosity after 30 cycles measured at 100°C | $mm^2/s$, min. | xW-30 9.0<br>xW-40 12.0<br>xW-50 15.0<br>mono grades no req. | Stay-in-grade | - | |
| | ASTM D6278 | Viscosity after 90 cycles measured at 100°C | $mm^2/s$ | - | - | Stay-in-grade | |
| Viscosity, High temperature, High shear rate | CEC-L-36-A-90 (2nd Edition) (Ravenfield) | Viscosity at 150°C and $10^6\ s^{-1}$ Shear rate | mPa.s, min. | 3.5 | | | |
| Evaporative loss | CEC-L-40-A-93 (NOACK) | Max. weight loss after 1 hrs. at 250°C | %, max. | 13 | | | |
| Sulphated ash | ASTM D874 | | % m/m, max. | 2.0 | 2.0 | 1.0 | 2.0 |
| Phosphorous | ASTM D5185 | | % m/m,max. | - | - | 0.08 | - |
| Sulphur | ASTM D5185 | | % m/m, max. | - | - | 0.3 | - |



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# ACEA 2007 Service-Fill Oils For Heavy Duty Diesel Engines

<table>
<tr><th>Requirements</th><th>Method</th><th>Properties</th><th>Units</th><th colspan="20">Limits</th></tr>
<tr><th></th><th></th><th></th><th></th><th colspan="5">E2 -96<br>Issue 5</th><th colspan="5">E4 -07</th><th colspan="5">E6 -04<br>Issue 2</th><th colspan="5">E7 -04<br>Issue 2</th></tr>
<tr><td rowspan="6">Oil elastomer compatibility (2)</td><td rowspan="6">CEC-L-39-T-96</td><td colspan="2"></td><td colspan="20">Elastomer Type</td></tr>
<tr><td colspan="2">Max. variation of characteristics after immersion for 7 days in fresh oil without pre-aging</td><td colspan="4">RE1</td><td colspan="4">RE2-99</td><td colspan="4">RE3-04</td><td colspan="4">RE4</td><td colspan="4">AEM VAMAC</td></tr>
<tr><td>Hardness DIDC</td><td>points</td><td colspan="4">-1/+5</td><td colspan="4">-5/+8</td><td colspan="4">-25/+1</td><td colspan="4">-5/+5</td><td colspan="4" rowspan="4">As per Daimler-Chrysler</td></tr>
<tr><td>Tensile strength</td><td>%</td><td colspan="4">-50/+10</td><td colspan="4">-15/+18</td><td colspan="4">-45/+10</td><td colspan="4">-20/+10</td></tr>
<tr><td>Elongation rupture</td><td>%</td><td colspan="4">-60/+10</td><td colspan="4">-35/+10</td><td colspan="4">-20/+10</td><td colspan="4">-50/+10</td></tr>
<tr><td>Volume variation</td><td>%</td><td colspan="4">-1/+5</td><td colspan="4">-7/+5</td><td colspan="4">-1/+30</td><td colspan="4">-5/+5</td></tr>
<tr><td rowspan="3">Foaming tendency</td><td rowspan="3">D892<br>without option A</td><td rowspan="3">Tendency - stability</td><td>ml</td><td colspan="20">Sequence I (24˚C) 10 - nil</td></tr>
<tr><td>ml</td><td colspan="20">Sequence II (94˚C) 50 - nil</td></tr>
<tr><td>ml</td><td colspan="20">Sequence III (24˚C) 10 - nil</td></tr>
<tr><td>High temperature foaming tendency</td><td>D6082</td><td>Tendency - stability</td><td>ml</td><td colspan="20">Sequence IV (150˚C) 200-50</td></tr>
<tr><td>Oxidation</td><td>(CEC-L-85-T-99)<br>(PDSC)</td><td>Oxidation induction time</td><td>mins, min.</td><td colspan="5">-</td><td colspan="5">-</td><td colspan="5">-</td><td colspan="5">35</td></tr>
<tr><td>Corrosion</td><td>D6594</td><td>Lead Increase</td><td>ppm, max.</td><td colspan="5">-</td><td colspan="5">-</td><td colspan="5">-</td><td colspan="5">100</td></tr>
<tr><td>TBN</td><td>D2896</td><td>mg KOH/g, min.</td><td></td><td colspan="5">-</td><td colspan="5">12</td><td colspan="5">-</td><td colspan="5">-</td></tr>
</table>

**Note:**

(2) Use either complete DaimlerChrysler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR: NBR34 DIN 53538 T3 (100˚C +/-2˚C ); FPM: AK6 (150˚C +/- 2˚C); ACM: E7503 (150˚C +/-2˚C); AEM: D 8948/200.1 (150˚C +/-2˚C)) + RE3, or complete requirements as above + DC requirements for AEM.



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## ACEA 2007 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | E2 -96 Issue 5 | E4 -07 | E6 -04 Issue 2 | E7 -04 Issue 2 |
| Bore Polishing / Piston Cleanliness (3) | CEC-L-42-T-99 (OM 364 LA) | Bore polishing | %, max. | 3.5 | - | - | - |
| | | Piston cleanliness | merit, max. | 40.0 | - | - | - |
| | | Average cylinder wear | µm, max. | 3.5 | - | - | - |
| | | Sludge | merit, max. | 9.4 | - | - | - |
| | | Oil consumption | kg/test, max. | 16.0 | - | - | - |
| Wear (4) | CEC-L-51-A-97 (OM 602 A) | Cam wear | µm, max. | 50.0 | 50.0 | 50.0 | 50.0 |
| | | Viscosity increase at 40°C | %, max. | - | 90 | 90 | 90 |
| | | Bore polishing | %, max. | - | 7.0 | 7.0 | 7.0 |
| | | Cylinder wear | µm, max. | - | 20.0 | 20.0 | 20.0 |
| | | Oil consumption | kg/test, max. | - | 10 | 10 | 10 |
| Soot in oil (5) | ASTM D5967 (Mack T-8E) ASTM D4485 (Mack T-8) | Test duration: (hrs.) | | - | 300 | 300 | 300 |
| | | Relative viscosity at 1 test/2 test/3 test average | | - | 4.8% soot | | |
| | | | $mm^2/s$, max. | - | 2.1/2.2/2.3 | 2.1/2.2/2.3 | 2.1/2.2/2.3 |
| | | Relative viscosity at 1 test/2 test/3 test average | | - | 3.8% soot | | |
| | | | $mm^2/s$, max. | - | 11.5/12.5/13.0 | 11.5/12.5/13.0 | 11.5/12.5/13.0 |
| | | Filter plugging, Diff, Pressure | kPa, max. | - | 138 | 138 | 138 |
| | | Oil consumption | g/kWh, max. | - | 0.304 | 0.304 | 0.304 |
| Bore polishing Piston cleanliness Turbocharger deposits (6) | CEC-L-52-T-97 (OM 441 LA) | Bore polishing | %, max. | - | 2.0 | 2.0 | 2.0 |
| | | Piston cleanliness | merit, max. | - | 40.0 | 40.0 | 40.0 |
| | | Boost pressure loss at 400 hrs | %, max. | - | 4 | 4 | 4 |
| | | Oil consumption | kg/test, max | - | 40 | 40 | 40 |

**Note:**

(3) Results from a CEC-L-52-T-97 (OM 441 LA) test as part of a DaimlerChrysler sheet 228.1 approval can be used as an alternative. Only tests according to CEC-L-52-T-97 are acceptable.

(4) OM 646 LA results at an equivalent performance level can be used as soon as the test becomes available as a CEC test. In the event the OM 602 A and the OM 646 are not available, then ACEA will define an alternative.

(5) Mack T11 (ASTM D7156) 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.

(6) OM 501 LA results at an equivalent performance level can be used as soon as the test becomes available as a CEC test.



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## ACEA 2007 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | E2 -96 Issue 5 | E4 -07 | E6 -04 Issue 2 | E7 -04 Issue 2 |
| Soot induced wear [7] | Cummins ISM | Rocker pads average weight loss at 3.9% soot. 1 test/2 test/3 test average | mg, max. | - | - | - | 7.5/7.8/7.9 |
| | | Oil filter diff. press @ EOT 1 test/2 test/3 test average | kPa, max. | - | - | - | 55/67/74 |
| | | Engine sludge 1 test/2 test/3 test average | merit, max. | - | - | - | 8.1/8.0/8.0 |
| Wear (liner ring-bearings) [8] | Mack T10 | Merit | | | | 1000 | 1000 |
| | ASTM D6987 | Average. liner wear | µm, max. | | | 32 (26) | 32 (26) |
| | (Mack T12) | Average top ring weight loss | mg, max. | | | 158 (117) | 158 (117) |
| | | End of test lead | ppm, max. | | | 35 (42) | 35 (42) |
| | | Delta lead 250-300 hrs | ppm, max. | | | 14 (918) | 14 (918) |
| | | Oil consumption (Phase II) | g/hr, max. | | | 65 (95) | 65 (95) |

**Note:**

(7) Results from Cummins a M11 HST (ASTM D6838) at API CH-4 or M11 EGR test (ASTM D6975) at API CI-4 or CI-4. Plus can be used in place of the Cummins ISM test.

(8) Mack T12 results can be used in place of Mack T10. In this case the merit scale for CI-4 plus approvals must be applied to the Mack T12 results. Maximum allowable values for the Mack T12 test are given in parentheses.

# ACEA 2008 Service-Fill Oils For Gasoline And Diesel Engines

<table>
<tr><th rowspan="2">Requirements</th><th rowspan="2">Method</th><th rowspan="2">Properties</th><th rowspan="2">Unit</th><th colspan="20">Limits</th></tr>
<tr><th colspan="5">A1 / B1-08</th><th colspan="5">A3 / B3-08</th><th colspan="5">A3 / B4-08</th><th colspan="5">A5 / B5-08</th></tr>
<tr><td>Viscosity grades</td><td></td><td>SAE J300 Latest active issue</td><td></td><td colspan="20">No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature.</td></tr>
<tr><td>Shear stability</td><td>CEC-L-14-A-93 or ASTM D6278</td><td>100°C Viscosity after 30 cycles</td><td>$mm^2/s$</td><td colspan="5">xW-20 Stay-in-grade xW-30 ≥ 9.3 xW-40 ≥ 12.0</td><td colspan="5">All grades to be Stay-in-grade</td><td colspan="5">All grades to be Stay-in-grade</td><td colspan="5">All grades to be Stay-in-grade</td></tr>
<tr><td>Viscosity at high temp. & high shear rate</td><td>CEC-L-36-A-90 (2nd Edition) (Ravenfield)</td><td>Viscosity at 150°C and $10^6 s^{-1}$ shear rate</td><td>mPa.s</td><td colspan="5">max. 3.5. xW-20 2.6. min All others 2.9 min.</td><td colspan="5">≥ 3.5</td><td colspan="5">≥ 3.5</td><td colspan="5">min 2.9 max. 3.5</td></tr>
<tr><td>Evaporative loss</td><td>CEC-L-40-A-93 (NOACK)</td><td>Max. weight loss after 1 hr at 250°C</td><td>%</td><td colspan="5">≤ 15</td><td colspan="5">≤ 13</td><td colspan="5">≤ 13</td><td colspan="5">≤ 13</td></tr>
<tr><td colspan="24">NOTE: The following sections apply to all sequences</td></tr>
<tr><td>Sulphated ash</td><td>ASTM D874</td><td></td><td>% m/m</td><td colspan="5">≤ 1 .3 (2)</td><td colspan="5">≤ 1.5 (2)</td><td colspan="5">≤ 1.6 (2)</td><td colspan="5">≤ 1.6 (2)</td></tr>
<tr><td>Sulphur (1)</td><td>ASTM D5185</td><td></td><td>% m/m</td><td colspan="20">Report</td></tr>
<tr><td>Phosphorous (1)</td><td>ASTM D5185</td><td></td><td>% m/m</td><td colspan="20">Report</td></tr>
<tr><td>Chlorine</td><td>ASTM D6443</td><td></td><td>ppm m/m</td><td colspan="20">Report</td></tr>
<tr><td rowspan="6">Oil / elastomer compatibility</td><td rowspan="6">CEC-L-39-T-96 (3)</td><td rowspan="2">Max variation of characteristics after immersion for 7 days in fresh oil without pre-aging</td><td rowspan="2"></td><td colspan="20">Elastomer type</td></tr>
<tr><td colspan="4">RE1</td><td colspan="4">RE2-99</td><td colspan="4">RE3-04</td><td colspan="4">RE4</td><td colspan="4" rowspan="5">AEM VAMAC As per Daimler Chrysler</td></tr>
<tr><td>Hardness DIDC</td><td>points</td><td colspan="4">-1/+5</td><td colspan="4">-5/+8</td><td colspan="4">-22/+1</td><td colspan="4">-5/+5</td></tr>
<tr><td>Tensile strength</td><td>%</td><td colspan="4">-40/+10</td><td colspan="4">-15/+18</td><td colspan="4">-30/+10</td><td colspan="4">-20/+10</td></tr>
<tr><td>Elongation at rupture</td><td>%</td><td colspan="4">-50/+10</td><td colspan="4">-35/+10</td><td colspan="4">-20/+10</td><td colspan="4">-50/+10</td></tr>
<tr><td>Volume variation</td><td>%</td><td colspan="4">-1/+5</td><td colspan="4">-7/+5</td><td colspan="4">-1/+22</td><td colspan="4">-5/+5</td></tr>
<tr><td rowspan="3">Foaming tendency</td><td rowspan="3">ASTM D892 without option A</td><td rowspan="3">Tendency - stability</td><td rowspan="3">ml</td><td colspan="20">Sequence I (24°C) 10 - nil</td></tr>
<tr><td colspan="20">Sequence II (94°C) 50 - nil</td></tr>
<tr><td colspan="20">Sequence III (24°C) 10 - nil</td></tr>
<tr><td>High temperature foaming tendency</td><td>ASTM D6082 High temperature foam test</td><td>Tendency - stability</td><td>ml</td><td colspan="20">Sequence IV (150°C) 100 - nil</td></tr>
</table>

**Note:**

(1) The internal standard method has to be used.

(2) Maximum limits. Values take into account method and productions tolerances.

(3) Use either complete Daimler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR : NBR34 DIN 53538 T3 (100°C +/- 2°C); FPM: AK6 (150°C +/- 2°C); ACM: E7503 (150°C +/- 2°C ; AEM: D8948/200.1 (150°C +/- 2°C)) + RE3, or complete requirements above + Daimler requirements for AEM.

## ACEA 2008 Service-Fill Oils For Gasoline And Diesel Engines - Engine Tests

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1 -08 | A3 / B3 -08 | A3 / B4 -08 | A5 / B5 -08 |
| High temperature deposits<br>Ring sticking<br>Oil thickening | CEC-L-88-T-02 (TU5JP-L4)<br><br>72 hr test | Ring Sticking (each part) | merit, max. | 9.0 | 9.0 | 9.0 | 9.0 |
| | | Piston Varnish (6 elements, average of 4 pistons) | merit, min. | RL 216 | RL 216 | RL 216 | RL 216 |
| | | Absolute viscosity increase at 40˚C between min. and max. values during test | $mm^2/s$, max. | ≤ 0.8 x RL 216 | ≤ 0.8 x RL 216 | ≤ 0.8 x RL 216 | ≤ 0.8 x RL 216 |
| | | Oil consumption | kg/test | Report | Report | Report | Report |
| Low temperature sludge | ASTM D6593-00 (Sequence VG) Under protocol & requirements for API [(4)] | Average engine sludge | merit | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 |
| | | Rocker cover sludge | merit | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 |
| | | Average piston skirt varnish | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| | | Average engine varnish | merit | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 |
| | | Compression ring (hot stuck) | | none | none | none | none |
| | | Oil screen clogging | % | ≤ 20 | ≤ 20 | ≤ 20 | ≤ 20 |
| Valve train scuffing wear | CEC-L-38-A-94 (TU3M) | Average cam wear | µm | ≤ 10 | ≤ 10 | ≤ 10 | ≤ 10 |
| | | Cam wear | µm | ≤ 15 | ≤ 15 | ≤ 15 | ≤ 15 |
| | | Pad merit (avg. of 8 pads) | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| Black Sludge | CEC-L-53-T-95 (M111) | Average engine sludge | ≥ RL 140 | ≥ RL 140 + 4σ or ≥ 9.0 | ≥ RL 140 + 4σ or ≥ 9.0 | ≥ RL 140 + 4σ or ≥ 9.0 | ≥ RL 140 + 4σ or ≥ 9.0 |

**Note:**

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

## ACEA 2008 Service-Fill Oils For Gasoline And Diesel Engines - Engine Tests

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1 -04 | A3 / B3 -04 | A3 / B4 -04 | A5 / B5 -04 |
| Fuel economy (5) | CEC-L-54-T-96 (M111) | Fuel economy improvement vs. reference oil RL191 (15W-40) | % | ≥ 2.5 | - | - | ≥ 2.5 |
| Medium temperature dispersivity | CEC-L-093 (DV4TD) | Absolute viscosity increase at 100˚C and 6% soot | $mm^2/s$ | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result |
| | | Piston merit | merit | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) |
| Wear (6) | CEC-L-099-08 (OM 646 LA) | Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 140 | ≤ 140 | ≤ 120 | ≤ 120 |
| | | Cam wear inlet (avg. max. wear 8 cam) (8) | µm | ≤ 110 | ≤ 110 | ≤ 100 | ≤ 100 |
| | | Cylinder wear (avg. 4 cyl) (8) | µm | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 |
| | | Bore polishing (13 mm) max. value of 4 cylinders (8) | % | ≤ 3.5 | ≤ 3.5 | ≤ 3.0 | ≤ 3.0 |
| | | Tappet wear inlet (avg. max. wear 8 cams) | µm | Report | Report | Report | Report |
| | | Tappet wear outlet (avg. max. wear 8 cams) | µm | Report | Report | Report | Report |
| | | Piston cleanliness (avg. 4 pistons) | merit | Report | Report | Report | Report |
| | | Average Engine sludge | merit | Report | Report | Report | Report |
| DI diesel Piston cleanliness & Ring sticking (9) | CEC-L-078-99 (VW TDI) | Piston cleanliness | merit | ≥ RL 206 - 4 pts | ≥ RL 206 - 4 pts | ≥ RL 206 | ≥ RL 206 |
| | | Ring sticking (rings 1 & 2) | | | | | |
| | | Avg of all 8 rings | ASF | ≤ 1.2 | ≤ 1.2 | ≤ 1.0 | ≤ 1.0 |
| | | Max. for any 1st ring | ASF | ≤ 2.5 | ≤ 2.5 | ≤ 1.0 | ≤ 1.0 |
| | | Max. for any 2nd ring | ASF | 0.0 | 0.0 | 0.0 | 0.0 |
| | | EOT TBN (ISO 3771) (7) (8) | mgKOH/g | ≥ 4.0 | ≥ 4.0 | ≥ 4.0 | ≥ 4.0 |
| | | EOT TAN (ASTM D664) (7) | mgKOH/g | Report | Report | Report | Report |

**Note:**

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

(6) For A1/B1 claims OM 602 A passing results obtained before the end of 2008 can be used instead of OM 646 LA results.

(7) The report has to give measured values before and after the test, all measurements to be taken in the same lab.

(8) These parameters are not yet official CEC parameters.

(9) Test results from tests performed before the publishing of the 2008 ACEA oil sequences are allowed to be used without passing the EOT TBN.



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## ACEA 2008 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1 -08 | C2 -08 | C3 -08 | C4 -08 |
| Viscosity grades | | SAE J300<br>Latest active issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear stability | CEC-L-14-A-93<br>or<br>ASTM D6278 | 100°C Viscosity after 30 cycles | $mm^2/s$ | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade |
| Viscosity at high temp. & high shear rate | CEC-L-36-A-90 (2nd Edition) (Ravenfield) | Viscosity at 150°C and $10^6\ s^{-1}$ shear rate | mPa.s | ≥ 2.9 | ≥ 2.9 | ≥ 3.5 | ≥ 3.5 |
| Evaporative loss | CEC-L-40-A-93 (NOACK) | Max. weight loss after 1 hr at 250°C | % | ≤ 13 | ≤ 13 | ≤ 13 | ≤ 11 |
| Sulphur | ASTM D5185 | (1) | % m/m | ≤ 0.2 | ≤ 0.3 | ≤ 0.3 | ≤ 0.2 |
| Phosphorus | ASTM D5185 | (1) | % m/m | ≤ 0.05 | ≥0.070 and ≤0.090 (2) | ≥0.070 and ≤0.090 (2) | ≤ 0.090 (2) |
| Sulphated ash | ASTM D874 | | % m/m | ≤ 0.5 (2) | ≤ 0.8 (2) | ≤ 0.8 (2) | ≤ 0.5 (2) |
| Chlorine | ASTM D6443 | | ppm - m/m, | Report | Report | Report | Report |
| TBN | ASTM D2896 | | mg KOH/g | - | - | ≥ 6.0 | ≥ 6.0 |

**Note:**
(1) The internal standard method has to be used.
(2) Maximum limits, values take into account method and productions tolerances.



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## ACEA 2008 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | C1 -08 | C2 -08 | C3 -08 | C4 -08 | |
| | | | | NOTE: The following sections apply to all sequences | | | | |
| Oil / elastomer compatibility | CEC-L-39-T-96 (3) | Max. variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | Elastomer type | | | | |
| | | | | RE1 | RE2-99 | RE3-04 | RE4 | AEM VAMAC |
| | | Hardness DIDC | points | -1/+5 | -5/+8 | -22/+1 | -5/+5 | As per Daimler |
| | | Tensile strength | % | -40/+10 | -15/+18 | -30/+10 | -20/+10 | |
| | | Elongation at rupture | % | -50/+10 | -35/+10 | -20/+10 | -50/+10 | |
| | | Volume variation | % | -1/+5 | -7/+5 | -1/+22 | -5/+5 | |
| Foaming tendency | ASTM D892 without option A | Tendency - stability | ml | Sequence I (24°C) 10 - nil | | | | |
| | | | | Sequence II (94°C) 50 - nil | | | | |
| | | | | Sequence III (24°C) 10 - nil | | | | |
| High temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency - stability | ml | Sequence IV (150°C) 100 - nil | | | | |

**Note:**

(3) Use either complete Daimler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR : NBR34 DIN 53538 T3 (100°C +/- 2°C); FPM: AK6 (150°C +/- 2°C); ACM: E7503 (150°C +/- 2°C); AEM: D8948/200.1 (150°C +/- 2°C)) + RE3, or complete requirements above + Daimler requirements for AEM.

## ACEA 2008 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1 -08 | C2 -08 | C3 -08 | C4 -08 |
| High temperature deposits<br><br>Ring sticking<br>Oil thickening | CEC-L-88-T-02<br>(TU5JP-L4)<br>72 hr test | Ring sticking (each part) | merit | ≥ 9.0 | ≥ 9.0 | ≥ 9.0 | ≥ 9.0 |
| | | Piston varnish (6 elements, average of 4 pistons) | merit | ≥ RL 216 | ≥ RL 216 | ≥ RL 216 | ≥ RL 216 |
| | | Absolute viscosity increase @ 40°C between min. and max. values during test | $mm^2/s$ | ≤ 0.8 x RL 216 | ≤ 0.8 x RL 216 | ≤ 0.8 x RL 216 | ≤ 0.8 x RL 216 |
| | | Oil consumption | kg/test | Report | Report | Report | Report |
| Low temperature sludge | ASTM D6593-00<br>(Sequence VG)<br>Under protocol & requirements for API (4) | Average engine sludge | merit | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 |
| | | Rocker cover sludge | merit | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 |
| | | Average piston skirt varnish | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| | | Average engine varnish | merit | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 |
| | | Comp. Ring (hot stuck) | | none | none | none | none |
| | | Oil screen clogging | % | ≤ 20 | ≤ 20 | ≤ 20 | ≤ 20 |
| Valve train scuffing wear | CEC-L-38-A-94<br>(TU3M) | Cam wear average | µm | ≤ 10 | ≤ 10 | ≤ 10 | ≤ 10 |
| | | Cam wear max. | µm | ≤ 15 | ≤ 15 | ≤ 15 | ≤ 15 |
| | | Pad merit (avg. of 8 pads) | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| Black Sludge | M111SL<br>CEC-L-53-T-95 | Average engine sludge | merit | ≥ RL 140 + 4σ or ≥ 9.0 | ≥ RL 140 + 4σ or ≥ 9.0 | ≥ RL 140 + 4σ or ≥ 9.0 | ≥ RL 140 + 4σ or ≥ 9.0 |
| Fuel economy (5) | CEC-L-54-T-96<br>(M111) | Fuel economy improvement vs. reference oil RL 191 (15W40) | % | ≥ 3.0 | ≥ 2.5 | ≥ 1.0 for xW30 grades | ≥ 1.0 for xW30 grades |

**Note:**

(4) The limits shown are based upon those applied in U.S. market requirements. ACEA will continuously review the situation to ensure that these limits.

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



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## ACEA 2008 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1 -08 | C2 -08 | C3 -08 | C4 -08 |
| Medium temperature dispersivity | CEC-L-093-04 (DV4TD) | Absolute viscosity increase @ 100°C and 6% of soot | $mm^2/s$ | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result |
| | | Piston merit | merit | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) |
| DI diesel<br><br>Piston cleanliness & Ring sticking (10) | CEC-L-78-T-99 (VW TDI) | Piston cleanliness | merit | ≥ RL 206 | ≥ RL 206 | ≥ RL 206 | ≥ RL 206 |
| | | Ring sticking (rings 1 & 2) | | | | | |
| | | Average of all 8 rings | (ASF), max. | 1.0 | 1.2 | 1.0 | 1.0 |
| | | Max. for any 1st ring | (ASF), max. | 1.0 | 2.5 | 1.0 | 1.0 |
| | | Max. for any 2nd ring | (ASF), max. | 0.0 | 0.0 | 0.0 | 0.0 |
| | | EOT TBN (ISO 3771) (7) | mgKOH/g | Report | Report | Report | Report |
| | | EOT TAN (ASTM D664) (7) | mgKOH/g | Report | Report | Report | Report |
| Wear (6) | CEC-L-099-08 (OM 646 LA) | Cam wear outlet (avg. max. wear 8 cams ) | µm | ≤ 120 | ≤ 120 | ≤ 120 | ≤ 120 |
| | | Cam wear inlet (avg. max. wear 8 cam) (9) | µm | ≤ 100 | report, (8) | ≤ 100 | ≤ 100 |
| | | Cylinder wear (avg. 4 cyl) (9) | µm | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 |
| | | Bore polishing (13 mm) max. value of 4 cylinders (9) | % | ≤ 3.0 | ≤ 3.0 | ≤ 3.0 | ≤ 3.0 |
| | | Tappet wear inlet (avg. max. wear 8 cams) | µm | Report | Report | Report | Report |
| | | Tappet wear outlet (avg. max. wear 8 cams) | µm | Report | Report | Report | Report |
| | | Piston cleanliness (avg. 4 pistons) | merit | Report | Report | Report | Report |
| | | Average engine sludge | merit | Report | Report | Report | Report |

**Note:**

(6) Limits for C1 might be revised if needed. For C1 claims OM 602 A passing results obtained before the end of 2008 can be used instead of OM 646 LA results.

(7) Test report has to give measured values before and after the test, all measurements to be taken in the same lab.

(8) Limit under definition.

(9) These parameters are not yet official CEC parameters.

(10) Test results from tests performed before the publishing of the 2008 ACEA oil sequences are allowed to be used without reporting EOT TBN & TAN.



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## ACEA 2008 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | **E4** -08 | **E6** -08 | **E7** -08 | **E9** -08 |
| Viscosity | | SAE J300<br>Latest Active Issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear stability | CEC-L-14-A-93<br>or<br>ASTM D6278 | Viscosity after 30 cycles measured at 100˚C | $mm^2/s$ | Stay-in-grade | - | | |
| | ASTM D6278 | Viscosity after 90 cycles measured at 100˚C | $mm^2/s$ | - | -<br>Stay-in-grade | | |
| Viscosity, High temperature, High shear rate | CEC-L-36-A-90<br>($2^{nd}$ Edition)<br>(Ravenfield) | Viscosity at 150˚C and $10^6$ $s^{-1}$ shear rate | mPa.s | ≥ 3.5 | | | |
| Evaporative loss | CEC-L-40-A-93<br>(NOACK) | Max. weight loss after 1 hr at 250˚C | % | ≤ 13 | | | |
| Sulphated ash | ASTM D874 | | % m/m | ≤ 2.0 | ≤ 1.0 | ≤ 2.0 | ≤ 1.0 |
| Phosphorous (1) | ASTM D5185 | | % m/m | | ≤ 0.08 | | ≤ 0.12 |
| Sulphur (1) | ASTM D5185 | | % m/m | | ≤ 0.3 | | ≤ 0.4 |

**Note:**

(1) The internal standard method has to be used.

## ACEA 2008 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | E4 -08 | E6 -08 | E7 -08 | E9 -08 | |
| Oil elastomer compatibility [2] | CEC-L-39-T-96 [3] | | | Elastomer Type | | | | |
| | | Max. variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | RE1 | RE2-99 | RE3-04 | RE4 | AEM VAMAC As per Daimler-Chrysler |
| | | Hardness DIDC | points | -1 /+ 5 | -5/+8 | -25 / +1 | -5 / +5 | |
| | | Tensile strength | % | -50 / +10 | -15/+18 | -45 / +10 | -20 / +10 | |
| | | Elongation rupture | % | -60/+10 | -35/+10 | -20 / +10 | -50 / +10 | |
| | | Volume variation | % | -1/+5 | -7/+5 | -1 / +30 | -5 / +5 | |
| Foaming tendency | (D892) without option A | Tendency - stability | ml | Sequence I (24˚C) 10 - nil | | | Seq I 10/0 | |
| | | | ml | Sequence II (94˚C) 50 - nil | | | Seq II 20/0 | |
| | | | ml | Sequence III (24˚C) 10 - nil | | | Seq I 10/0 | |
| High temperature foaming tendency | (D6082) | Tendency - stability | ml | Sequence IV (150°C) 100-nil | | | | |
| Oxidation | CEC-L-085-99 (PDSC) | Oxidation induction time | min. | R&R | R&R | ≥ 65 | ≥ 65 | |
| Corrosion | (D6594) | Copper increase | ppm | R&R | R&R | R&R | ≤ 20 | |
| | | Lead increase | ppm | R&R | R&R | ≤ 100 | ≤ 100 | |
| | | Copper strip rating | max. | R&R | R&R | R&R | 3 | |
| Turbocharger performance [3] | | | | | | | | |
| TBN | (D2896) | mg KOH/g | | ≥ 12 | ≥ 7 | ≥9 [4] | ≥ 7 | |

**Note:**

(2) Use either the most recent complete Daimler requirements (VDA 675301, 7 days, 4 materials (NBR : NBR34 DIN 53538 T3 (100°C); FPM; AK6 (150°C); ACM: E7503 (150°C); AEM D 8948/200.1 (150°C)) + RE3 according to requirement above, or complete requirements above + Daimler requirements for AEM.

(3) Should a test become available before the next document update, ACEA reserves to set performance limits providing adequate data is available.

(4) Values < 9.00 are not accepted.

## ACEA 2008 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | E4 -08 | E6 -08 | E7 -08 | E9 -08 |
| Bore Polishing / Piston Cleanliness | CEC-L-101-08 (OM 501 LA) | Average Bore polishing | % | ≤ 1.0 | ≤ 1.0 | ≤ 2.0 | ≤ 2.0 |
| | | Average Piston cleanliness | merit | ≥ 26 | ≥ 26 | ≥ 17 | ≥ 17 |
| | | Oil consumption | kg/test | ≤ 9 | ≤ 9 | ≤ 9 | ≤ 9 |
| | | Average engine sludge (8) | merit | R&R (9) (10) | R&R (9) (10) | R&R (9) (10) | R&R (9) (10) |
| Wear | CEC-L-099-08 (OM 646 LA) | Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 140 (5) (6) | ≤ 140 (5) (6) | ≤ 155 (5) (6) | ≤ 155 (5) ( 6) |
| Soot in oil (7) | ASTM D5967 (Mack T-8E) | Test duration: 300 hrs<br>Relative viscosity at 4.8% soot<br>1 test/2 test/3 test average | $mm^2/s$ | ≤ 2.1 / 2.2 / 2.3 | ≤ 2.1 / 2.2 / 2.3 | ≤ 2.1 / 2.2 / 2.3 | |
| Soot in oil | Mack T11<br>ASTM D7159<br>(T-11) | 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 |

**Note:**

(5) OM 602 A data can be used instead of OM 646 LA data providing it meets the requirements as specified in the 2007 ACEA sequences

(6) Additional parameters may be included once approved by CEC.

(7) Mack T11 results obtained as part of an API CI-4, CI-4 plus or API CJ-4 program, can be used in place of Mack T-8E.

(8) Bore polish, oil consumption and engine sludge are non-approved CEC parameters.

(9) OM 441 LA data can be used instead of OM 501 LA data providing it meets the requirements as specified in the 2007 ACEA sequences

(10) Limits for the sludge parameter may be reconsidered when more data becomes available.

## ACEA 2008 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | E4 -08 | E6 -08 | E7 -08 | E9 -08 |
| Soot induced wear | Cummins ISM ASTM D7468 | Merit | | | | | ≥ 1000 |
| | | Rocker pad average weight loss at 3.9% soot | mg | | | ≤ 7.5 /7.8 / 7.9 | ≤ 7.1 |
| | | 1 test / 2 test / 3 test average Oil filter different pressure @150 hrs | kPa | - | - | ≤ 55/67/74 | ≤ 19 |
| | | 1 test / 2 test / 3 test average Engine sludge | merit | - | - | ≥ 8.1/8.0/8.0 (11) | ≥ 8.7 |
| | | 1 test / 2 test / 3 test average Adjust screw weight loss | mg | - | - | | ≤ 49 |
| Wear (liner ring-bearings) | ASTM D7422 (Mack T-12) | Merit | | | ≥ 1000 | ≥ 1000 | ≥ 1000 |
| | | Average liner wear | µm | | ≤ 26 | ≤ 26 | ≤ 24 |
| | | Average top ring weight loss | mg | | ≤ 117 | ≤ 117 | ≤ 105 |
| | | End of test lead | ppm | | ≤ 42 | ≤ 42 | ≤ 35 |
| | | Delta lead 250 - 300 hrs | ppm | | ≤ 18 | ≤ 18 | ≤ 15 |
| | | Oil consumption (Phase II) | g/hr | | ≤ 95 (12)(13) | ≤ 95 (12)(13) | ≤ 85 |

**Note:**

(11) Results from M11HST (ASTM D6838), at API CH-4, or M11EGR (ASTM D6975), at API CI-4 or CI-4 plus, can be used in place of Cummins ISM.

(12) Merit number shall be calculated according to the API CI-4 specification.

(13) 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.

## ACEA 2010 Service-Fill Oils For Gasoline And Diesel Engines

| Requirements | Method | Properties | Unit | Limits A1 / B1-10 | Limits A3 / B3-10 | Limits A3 / B4-10 | Limits A5 / B5-10 |
|---|---|---|---|---|---|---|---|
| Viscosity grades | | SAE J300 Latest active issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear stability | CEC-L-14-A-93 or ASTM D6278 | 100˚C Viscosity after 30 cycles | $mm^2/s$ | xW-20 Stay-in-grade xW-30 ≥ 9.3 xW-40 ≥ 12.0 | All grades to be Stay-in-grade | All grades to be Stay-in-grade | All grades to be Stay-in-grade |
| Viscosity at high temp. & high shear rate | CEC-L-36-A-90 | Viscosity at 150˚C and $10^6 s^{-1}$ shear rate | mPa.s | max. 3.5. xW -20 2.6. min All others 2.9 min. | ≥ 3.5 | ≥ 3.5 | min 2.9 max. 3.5 |
| Evaporative loss | CEC-L-40-A-93 (NOACK) | Max. weight loss after 1 hr at 250˚C | % | ≤ 15 | ≤ 13 | ≤ 13 | ≤ 13 |
| NOTE: The following sections apply to all sequences | | | | | | | |
| TBN. | ASTM D2896 | | mgKOH/g | ≥ 8.0 | ≥ 8.0 | ≥ 10.0 | ≥ 8.0 |
| Sulphated ash | ASTM D874 | | % m/m | ≤ 1.3 [2] | ≥ 0.9 and ≤ 1.5 [2] | ≥ 1.0 and ≤ 1.6 [2] | ≤ 1.6 [2] |
| Sulphur[1] | ASTM D5185 | | % m/m | Report | | | |
| Phosphorous[1] | ASTM D5185 | | % m/m | Report | | | |
| Chlorine | ASTM D6443 | | ppm m/m | Report | | | |

| Requirements | Method | Properties | Unit | Elastomer type RE1 | RE2-99 | RE3-04 | RE4 | AEM VAMAC As per Daimler Chrysler |
|---|---|---|---|---|---|---|---|---|
| Oil / elastomer compatibility | CEC-L-39-T-96 [3] | Max variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | | | | | |
| | | Hardness DIDC | points | -1/+5 | -5/+8 | -22/+1 | -5/+5 | |
| | | Tensile strength | % | -40/+10 | -15/+18 | -30/+10 | -20/+10 | |
| | | Elongation at rupture | % | -50/+10 | -35/+10 | -20/+10 | -50/+10 | |
| | | Volume variation | % | -1/+5 | -7/+5 | -1/+22 | -5/+5 | |

| Requirements | Method | Properties | Unit | Limits |
|---|---|---|---|---|
| Foaming tendency | ASTM D892 without option A | Tendency - stability | ml | Sequence I (24˚C) 10 - nil<br>Sequence II (94˚C) 50 - nil<br>Sequence III (24˚C) 10 - nil |
| High temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency - stability | ml | Sequence IV (150˚C) 100 - nil |

**Note:**

(1) The internal standard method has to be used.

(2) Maximum limits. Values take into account method and production tolerances.

(3) Use either complete Daimler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR : NBR34 DIN 53538 T3 (100°C +/- 2°C); FPM: AK6 (150°C +/- 2°C); ACM: E7503 (150°C +/- 2°C ; AEM: D8948/200.1 (150°C +/- 2°C)) + RE3, or complete requirements according to 1.10 above + Daimler requirements for AEM.

## ACEA 2010 Service-Fill Oils For Gasoline And Diesel Engines - Engine Tests

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1 -10 | A3 / B3 -10 | A3 / B4 -10 | A5 / B5 -10 |
| High temperature deposits<br>Ring sticking<br>Oil thickening | CEC-L-88-T-02 (TU5JP-L4)<br><br>72 hr test | Ring Sticking (each part) | merit, max. | 9.0 | 9.0 | 9.0 | 9.0 |
| | | Piston Varnish (6 elements, average of 4 pistons) | merit, min. | RL 216 | | | |
| | | Absolute viscosity increase at 40°C between min. and max. values during test | $mm^2/s$, max. | ≤ 0.8 x RL 216 | | | |
| | | Oil consumption | kg/test | Report | Report | Report | Report |
| Low temperature sludge | ASTM D6593-00 (Sequence VG) Under protocol & requirements for API (4) | Average engine sludge | merit | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 |
| | | Rocker cover sludge | merit | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 |
| | | Average piston skirt varnish | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| | | Average engine varnish | merit | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 |
| | | Compression ring (hot stuck) | | none | none | none | none |
| | | Oil screen clogging | % | ≤ 20 | ≤ 20 | ≤ 20 | ≤ 20 |
| Valve train scuffing wear | CEC-L-38-A-94 (TU3M) | Average cam wear | µm | ≤ 10 | ≤ 10 | ≤ 10 | ≤ 10 |
| | | Cam wear | µm | ≤ 15 | ≤ 15 | ≤ 15 | ≤ 15 |
| | | Pad merit (avg. of 8 pads) | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| Black Sludge | (10) (11) | Average engine sludge | ≥ RL 140 | ≥ RL 140 + 4σ or ≥ 9.0 | ≥ RL 140 + 4σ or ≥ 9.0 | ≥ RL 140 + 4σ or ≥ 9.0 | ≥ RL 140 + 4σ or ≥ 9.0 |

**Note:**

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

(10) Until a new CEC Test Method is developed, the gasoline sludge protection performance of engine oil formulations must be proofed by the M 271 sludge test procedure as described by Daimler AG. 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. Limits are based on the same reference oil as with the old M 111 sludge test.

(11) Existing results from tests with CEC-L-053 may be used where applicable. In this case limits for all ACEA A/B categories (including A1/B1) are: ≥ *RL 140 + 40 or* ≥ 9.0.

## ACEA 2010 Service-Fill Oils For Gasoline And Diesel Engines - Engine Tests

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1 -10 | A3 / B3 -10 | A3 / B4 - 10 | A5 / B5 -10 |
| Fuel economy (5) | CEC-L-54-T-96 (M111) | Fuel economy improvement vs. Reference oil RL191 (15W-40) | % | ≥ 2.5 | - | - | ≥ 2.5 |
| Medium temperature dispersivity | CEC-L-093-04 (DV4TD) | Absolute viscosity increase at 100˚C and 6% soot | $mm^2/s$ | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result |
| | | Piston merit | merit | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) |
| Wear (6) | CEC-L-099-08 (OM 646 LA) | Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 140 | ≤ 140 | ≤ 120 | ≤ 120 |
| | | Cam wear inlet (avg. max. wear 8 cam) (8) | µm | ≤ 110 | ≤ 110 | ≤ 100 | ≤ 100 |
| | | Cylinder wear (avg. 4 cyl) (8) | µm | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 |
| | | Bore polishing (13 mm) max. value of 4 cylinders (8) | % | ≤ 3.5 | ≤ 3.5 | ≤ 3.0 | ≤ 3.0 |
| | | Tappet wear inlet (avg. max. wear 8 cams) | µm | Report | Report | Report | Report |
| | | Tappet wear outlet (avg. max. wear 8 cams) | µm | Report | Report | Report | Report |
| | | Piston cleanliness (avg. 4 pistons) | merit | Report | Report | Report | Report |
| | | Average Engine sludge | merit | Report | Report | Report | Report |
| DI Diesel Piston cleanliness & Ring sticking (9) | CEC-L-078-99 (VW TDI) | Piston cleanliness | merit | ≥ RL 206 - 4 pts | ≥ RL 206 - 4 pts | ≥ RL 206 | ≥ RL 206 |
| | | Ring sticking (rings 1 & 2) | | | | | |
| | | Avg. of all 8 rings | ASF | ≤ 1.2 | ≤ 1.2 | ≤ 1.0 | ≤ 1.0 |
| | | Max. for any 1st ring | ASF | ≤ 2.5 | ≤ 2.5 | ≤ 1.0 | ≤ 1.0 |
| | | Max. for any 2nd ring | ASF | 0.0 | 0.0 | 0.0 | 0.0 |
| | | EOT TBN (ISO 3771) (7) (8) | mgKOH/g | ≥ 4.0 | ≥ 4.0 | ≥ 6.0 | ≥ 4.0 |
| | | EOT TAN (ASTM D664) (7) | mgKOH/g | Report | Report | Report | Report |

**Note:**

(5) ACEA considers the CEC-L-54-T-96 test the only valid comparator against which claims of lubricant fuel economy improvements should be made.
(6) For A1/B1 claims OM 602 A passing results obtained before the end of 2008 can be used instead of OM 646 LA results.
(7) The report has to give measured values before and after the test, all measurements to be taken in the same lab. Note: TAN is considered to become a future performance criteria.
(8) These parameters are not yet official CEC parameters.
(9) Test results from tests performed before the publishing of the 2008 ACEA oil sequences are allowed to be used without passing the EOT TBN criteria and reporting EOT TAN values.

## ACEA 2010 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1 -10 | C2 -10 | C3 -10 | C4 -10 |
| Viscosity grades | | SAE J300<br>Latest active issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear stability | CEC-L-14-A-93<br>or<br>ASTM D6278 | 100˚C Viscosity after 30 cycles | $mm^2/s$ | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade |
| Viscosity at high temp.<br>& high shear rate | CEC-L-36-A-90<br>(2nd Edition)<br>(Ravenfield) | Viscosity at 150˚C and $10^6$ $s^{-1}$ shear rate | mPa.s | ≥ 2.9 | ≥ 2.9 | ≥ 3.5 | ≥ 3.5 |
| Evaporative loss | CEC-L-40-A-93<br>(NOACK) | Max. weight loss after 1 hr at 250˚C | % | ≤ 13 | ≤ 13 | ≤ 13 | ≤ 11 |
| Sulphur | ASTM D5185 | see (1) | % m/m | ≤ 0.2 | ≤ 0.3 | ≤ 0.3 | ≤ 0.2 |
| Phosphorus | ASTM D5185 | see (1) | % m/m | ≤ 0.05 (2) | ≤0.090 (2) | ≥0.070 and ≤0.090 (2) | ≤ 0.090 (2) |
| Sulphated ash | ASTM D874 | | % m/m | ≤ 0.5 (2) | ≤ 0.8 (2) | ≤ 0.8 (2) | ≤ 0.5 (2) |
| Chlorine | ASTM D6443 | | ppm - m/m | Report | Report | Report | Report |
| TBN | ASTM D2896 | | mg KOH/g | - | - | ≥ 6.0 | ≥ 6.0 |

**Note:**

(1) The internal standard method has to be used.

(2) Maximum limits. Values take into account method and production tolerances.



Afton CHEMICAL

## ACEA 2010 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | C1 -10 | C2 -10 | C3 -10 | C4 -10 | |
| | | | | NOTE: The following sections apply to all sequences | | | | |
| Oil / elastomer compatibility | CEC-L-39-T-96 (3) | Max. variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | Elastomer Type | | | | |
| | | | | RE1 | RE2-99 | RE3-04 | RE4 | AEM VAMAC |
| | | Hardness DIDC | points | -1/+5 | -5/+8 | -22/+1 | -5/+5 | As per Daimler |
| | | Tensile strength | % | -40/+10 | -15/+18 | -30/+10 | -20/+10 | |
| | | Elongation at rupture | % | -50/+10 | -35/+10 | -20/+10 | -50/+10 | |
| | | Volume variation | % | -1/+5 | -7/+5 | -1/+22 | -5/+5 | |
| Foaming tendency | ASTM D892 without option A | Tendency - stability | ml | Sequence I (24˚C) 10 - nil | | | | |
| | | | | Sequence II (94˚C) 50 - nil | | | | |
| | | | | Sequence III (24˚C) 10 - nil | | | | |
| High temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency - stability | ml | Sequence IV (150˚C) 100 - nil | | | | |

**Note:**

(3) Use either complete Daimler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR : NBR34 DIN 53538 T3 (100°C +/- 2°C); FPM: AK6 (150°C +/- 2°C); ACM: E7503 (150°C +/- 2°C ; AEM: D8948/200.1 (150°C +/- 2°C)) + RE3, + Daimler requirements for AEM.

## ACEA 2010 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1 -10 | C2 -10 | C3 -10 | C4 -10 |
| High temperature deposits<br><br>Ring sticking<br>Oil thickening | CEC-L-88-T-02 (TU5JP-L4)<br>72 hr test | Ring sticking (each part) | merit | ≥ 9.0 | ≥ 9.0 | ≥ 9.0 | ≥ 9.0 |
| | | Piston varnish (6 elements, average of 4 pistons) | merit | ≥ RL 216 | ≥ RL 216 | ≥ RL 216 | ≥ RL 216 |
| | | Absolute viscosity increase @40°C between min. and max. values during test | $mm^2/s$ | ≤ 0.8 x RL 216 | ≤ 0.8 x RL 216 | ≤ 0.8 x RL 216 | ≤ 0.8 x RL 216 |
| | | Oil consumption | kg/test | Report | Report | Report | Report |
| Low temperature sludge | ASTM D6593-00 (Sequence VG)<br>Under protocol & requirements for API (4) | Average engine sludge | merit | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 |
| | | Rocker cover sludge | merit | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 |
| | | Average piston skirt varnish | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| | | Average engine varnish | merit | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 |
| | | Comp. ring (hot stuck) | | none | none | none | none |
| | | Oil screen clogging | % | ≤ 20 | ≤ 20 | ≤ 20 | ≤ 20 |
| Valve train scuffing wear | CEC-L-38-A-94 (TU3M) | Average Cam wear | µm | ≤ 10 | ≤ 10 | ≤ 10 | ≤ 10 |
| | | Cam wear max. | µm | ≤ 15 | ≤ 15 | ≤ 15 | ≤ 15 |
| | | Pad merit (avg. of 8 pads) | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| Sludge | (11) (12) | Average engine sludge | merit | ≥ RL 140 + 4σ | ≥ RL 140 + 4σ | ≥ RL 140 + 4σ | ≥ RL 140 + 4σ |
| Fuel economy (5) | CEC-L-54-T-96 (M111) | Fuel economy improvement vs. reference oil RL 191 (15W40) | % | ≥ 3.0 | ≥ 2.5 | ≥ 1.0 for xW-30 grades | ≥ 1.0 for xW-30 grades |

**Note:**

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

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

(11) Until a new CEC Test Method is developed, the gasoline sludge protection performance of engine oil formulations must be proofed by the M 271 sludge test procedure as described by Daimler AG. 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. Limits are based on the same reference oil as with the old M 111 sludge test.

(12) Existing results from tests with CEC-L-053 may be used where applicable. In this case limits for all ACEA C categories are: $^{3}$ RL 140 + 4σ or ≥ 9.0

## ACEA 2010 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1 -10 | C2 -10 | C3 -10 | C4 -10 |
| Medium temperature dispersivity | CEC-L-093-04 (DV4TD) | Absolute viscosity increase @ 100°C and 6% of soot | $mm^2/s$ | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result | ≤ 0.60 x RL223 result |
| | | Piston merit | merit | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) |
| DI diesel<br><br>Piston cleanliness & Ring sticking (10) | CEC-L-78-T-99 (VW TDI) | Piston cleanliness | merit | ≥ RL 206 | ≥ RL 206 | ≥ RL 206 | ≥ RL 206 |
| | | Ring sticking (rings 1 & 2) | | | | | |
| | | Average of all 8 rings | (ASF), max. | 1.0 | 1.2 | 1.0 | 1.0 |
| | | Max. for any $1^{st}$ ring | (ASF), max. | 1.0 | 2.5 | 1.0 | 1.0 |
| | | Max. for any $2^{nd}$ ring | (ASF), max. | 0.0 | 0.0 | 0.0 | 0.0 |
| | | EOT TBN (ISO 3771) (7) | mgKOH/g | Report | Report | Report | Report |
| | | EOT TAN (ASTM D 664) (7) | mgKOH/g | Report | Report | Report | Report |
| Wear (6) | CEC-L-099-08 (OM 646 LA) | Cam wear outlet (avg. max. wear 8 cams ) | µm | ≤ 120 | ≤ 120 | ≤ 120 | ≤ 120 |
| | | Cam wear inlet (avg. max. wear 8 cam) (9) | µm | ≤ 100 | report (8) | ≤ 100 | ≤ 100 |
| | | Cylinder wear (avg. 4 cyl) (9) | µm | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 |
| | | Bore polishing (13 mm) max. value of 4 cylinders (9) | % | ≤ 3.0 | ≤ 3.0 | ≤ 3.0 | ≤ 3.0 |
| | | Tappet wear inlet (avg. max. wear 8 cams) | µm | Report | Report | Report | Report |
| | | Tappet wear outlet (avg. max. wear 8 cams) | µm | Report | Report | Report | Report |
| | | Piston cleanliness (avg. 4 pistons) | merit | Report | Report | Report | Report |
| | | Average engine sludge | merit | Report | Report | Report | Report |

**Note:**

(6) Limits for C1 might be revised if needed. For C1 claims OM 602 A passing results obtained before the end of 2008 can be used instead of OM 646 LA results.

(7) Test report has to give measured values before & after the test, all measurements to be taken in the same lab.

(8) Limit under definition.

(9) These parameters are not yet official CEC parameters.

(10) Test results from tests performed before the publishing of the 2008 ACEA oil sequences are allowed to be used without reporting EOT TBN & TAN.



Afton CHEMICAL

## ACEA 2010 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | **E4 -08 (Issue 2)** | **E6 -08 (Issue 2)** | **E7 -08 (Issue 2)** | **E9 -08 (Issue 2)** |
| Viscosity | | SAE J300<br>Latest Active Issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear stability | CEC-L-14-A-93<br>or<br>ASTM D6278 | Viscosity after 30 cycles measured at 100°C | $mm^2/s$ | Stay-in-grade | - | | |
| | ASTM D6278 | Viscosity after 90 cycles measured at 100°C | $mm^2/s$ | - | -<br>Stay-in-grade | | |
| Viscosity, High temperature, High shear rate | CEC-L-36-A-90<br>(2nd Edition)<br>(Ravenfield) | Viscosity at 150°C and $10^6\ s^{-1}$ shear rate | mPa.s | ≥ 3.5 | | | |
| Evaporative loss | CEC-L-40-A-93<br>(NOACK) | Max. weight loss after 1 hr at 250°C | % | ≤ 13 | | | |
| Sulphated ash | ASTM D874 | | % m/m | ≤ 2.0 | ≤ 1.0 | ≤ 2.0 | ≤ 1.0 |
| Phosphorous (1) | ASTM D5185 | | % m/m | | ≤ 0.08 | | ≤ 0.12 |
| Sulphur (1) | ASTM D5185 | | % m/m | | ≤ 0.3 | | ≤ 0.4 |

**Note:**
(1) The internal standard method has to be used.

## ACEA 2010 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | E4 -08 (Issue 2) | E6 -08 (Issue 2) | E7 -08 (Issue 2) | E9 -08 (Issue 2) | |
| Oil elastomer compatibility [(2)] | CEC-L-39-T-96 | | | NOTE: The following sections apply to all sequences | | | | |
| | | | | Elastomer Type | | | | |
| | | Max. variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | RE1 | RE2-99 | RE3-04 | RE4 | AEM VAMAC As per Daimler-Chrysler |
| | | Hardness DIDC | points | -1 /+ 5 | -5/+8 | -25 / +1 | -5 / +5 | |
| | | Tensile strength | % | -50 / +10 | -15/+18 | -45 / +10 | -20 / +10 | |
| | | Elongation rupture | % | -60/+10 | -35/+10 | -20 / +10 | -50 / +10 | |
| | | Volume variation | % | -1/+5 | -7/+5 | -1 / +30 | -5 / +5 | |
| Foaming tendency | (ASTM D892) without option A | Tendency - stability | ml | Sequence I (24˚C) 10 - nil | | | Seq I 10/0 | |
| | | | ml | Sequence II (94˚C) 50 - nil | | | Seq II 20/0 | |
| | | | ml | Sequence III (24˚C) 10 - nil | | | Seq I 10/0 | |
| High temperature foaming tendency | (ASTM D6082) | Tendency - stability | ml | Sequence IV (150°C) 100-nil | | | | |
| Oxidation | CEC-L-085-99 (=DSC) | Oxidation induction time | min. | R&R | R&R | ≥ 65 | ≥ 65 | |
| Corrosion | (ASTM D6594) | Copper increase | ppm | R&R | R&R | R&R | ≤ 20 | |
| | | Lead increase | ppm | R&R | R&R | ≤ 100 | ≤ 100 | |
| | | Copper strip rating | max. | R&R | R&R | R&R | 3 | |
| Turbocharger performance [(3)] | | | | | | | | |
| TBN | (ASTM D2896) | mg KOH/g | | ≥ 12 | ≥ 7 | ≥9 [(4)] | ≥ 7 | |

**Note:**

(2) Use either the most recent complete Daimler requirements (VDA 675301, 7 days, 4 materials (NBR : NBR34 DIN 53538 T3 (100°C); FPM; AK6 (150°C); ACM: E7503 (150°C); AEM D 8948/200.1 (150°C)) + RE3 according to requirement 1.8 above, or complete requirements according to 1.8 above + Daimler requirements for AEM.

(3) Should a test become available before the next document update, ACEA reserves to set performance limits providing adequate data is available.

(4) Values < 9.00 are not accepted.



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## ACEA 2010 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | **E4 -08** (Issue 2) | **E6 -08** (Issue 2) | **E7 -08** (Issue 2) | **E9 -08** (Issue 2) |
| Bore Polishing / Piston Cleanliness | CEC-L-101-08 (OM 501 LA) | Average Bore polishing | % | ≤ 1.0 | ≤ 1.0 | ≤ 2.0 | ≤ 2.0 |
| | | Average Piston cleanliness | merit | ≥ 26 | ≥ 26 | ≥ 17 | ≥ 17 |
| | | Oil consumption | kg/test | ≤ 9.0 | ≤ 9.0 | ≤ 9.0 | ≤ 9.0 |
| | | Average engine sludge (8) | merit | R&R (9) (10) | R&R (9) (10) | R&R (9) (10) | R&R (9) (10) |
| Wear | CEC-L-099-08 (OM 646 LA) | Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 140 (5) (6) | ≤ 140 (5) (6) | ≤ 155 (5) (6) | ≤ 155 (5) ( 6) |
| Soot in oil (7) | ASTM D5967 (Mack T-8E) | Test duration: 300 hrs Relative viscosity at 4.8% soot 1 test/2 test/3 test average | $mm^2/s$ | ≤ 2.1 / 2.2 / 2.3 | ≤ 2.1 / 2.2 / 2.3 | ≤ 2.1 / 2.2 / 2.3 | |
| Soot in oil | ASTM D7156 (Mack T11) | 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 |

**Note:**

(5) OM 602 A data can be used instead of OM 646 LA data providing it meets the requirements as specified in the 2007 ACEA sequences.
(6) Additional parameters may be included once approved by CEC.
(7) Mack T11 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 T-8E.
(8) Bore polish, oil consumption and engine sludge are non-approved CEC parameters.
(9) OM 44 LA data can be used instead of OM 501 LA data providing it meets the requirements as specified in the 2007 ACEA sequences.
(10) Limits for the sludge parameter may be reconsidered when more data becomes available.

## ACEA 2010 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | **E4 -08** (Issue 2) | **E6 -08** (Issue 2) | **E7 -08** (Issue 2) | **E9 -08** (Issue 2) |
| Soot induced wear | Cummins ISM | Merit | | | | | ≥ 1000 |
| | | Rocker pad average weight loss at 3.9% soot | mg | | | ≤ 7.5 /7.8 / 7.9 | ≤ 7.1 |
| | | 1 test / 2 test / 3 test average Oil filter diff. pressure @150 hrs | kPa | - | - | ≤ 55/67/74 | ≤ 19 |
| | | 1 test / 2 test / 3 test average Engine sludge | merit | - | - | ≥ 8.1/8.0/8.0 (11) | ≥ 8.7 |
| | | 1 test / 2 test / 3 test average Adjust screw weight loss | mg | - | - | | ≤ 49 |

**Note:**

(11) Results from M11HST (ASTM D6838), at API CH-4, or M11EGR (ASTM D6975), at API CI-4 or CI-4 plus, can be used in place of Cummins ISM.

## ACEA 2010 Service-Fill Oils For Heavy Duty Diesel Engines

| Requirements | Method | Properties | Units | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | E4 -08 (Issue 2) | E6 -08 (Issue 2) | E7 -08 (Issue 2) | E9 -08 (Issue 2) |
| Wear (liner ring-bearings) | Mack T12 | Merit | | | ≥ 1000 | ≥ 1000 | ≥ 1000 |
| | | Average liner wear | µm | | ≤ 26 | ≤ 26 | ≤ 24 |
| | | Average top ring weight loss | mg | | ≤ 117 | ≤ 117 | ≤ 105 |
| | | End of test lead | ppm | | ≤ 42 | ≤ 42 | ≤ 35 |
| | | Delta lead 250-300 hrs | ppm | | ≤ 18 | ≤ 18 | ≤ 15 |
| | | Oil consumption (Phase II) | g/hr | | ≤ 95 (12)(13) | ≤ 95 (12)(13) | ≤ 85 |

**Note:**

(12) Merit number shall be calculated according to the API CI-4 specification.

(13) 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.

## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines

| Laboratory test | Method | Properties | Unit | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1-12 | A3 / B3-12 | A3 / B4-12 | A5 / B5-12 |
| Viscosity grades | | SAE J300<br>Latest active issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear (1) stability | CEC-L-014-93 or ASTM D6278 | Viscosity after 30 cycles at 100°C | $mm^2/s$ | xW-20 ≥ 5.6<br>xW-30 ≥ 9.3<br>xW-40 ≥ 12.0 | All grades to be Stay-in-grade | All grades to be Stay-in-grade | All grades to be Stay-in-grade |
| Viscosity at High temp. & high shear rate | CEC-L-036-90 | Viscosity at 150°C and $10^6 s^{-1}$ shear rate | mPa.s | ≥ 2.9 and ≤ 3.5; xW-20 : 2.6 min | ≥ 3.5 | ≥ 3.5 | ≥ 2.9 and ≤ 3.5 |
| Evaporative loss | CEC-L-040-93 (NOACK) | Max weight loss after 1 h at 250°C | % | ≤ 13 | | | |
| NOTE: The following sections apply to all sequences | | | | | | | |
| TBN. | ASTM D2896 | | mgKOH/g | ≥ 8.0 | ≥ 8.0 | ≥ 10.0 | ≥ 8.0 |
| Sulphated ash (2) | ASTM D874 | | % m/m | ≤ 1.3 | ≥ 0.9 and ≤ 1.5 | ≥ 1.0 and ≤ 1.6 | ≤ 1.6 |
| Sulphur (2) (3) | ASTM D5185 | | % m/m | Report | | | |
| Phosphorous (2) (3) | ASTM D5185 | | % m/m | Report | | | |
| Chlorine | ASTM D6443 | | ppm m/m | Report | | | |

**Note:**
(1) The minimum viscosity for xW-20 oils after shearing is 5,6 cSt.
(2) Maximum limits. Values take into account method and production tolerances.
(3) Internal standard method has to be used.

## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines - Cont'd

| Laboratory test | Method | Properties | Unit | Limits | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | A1 / B1-12 | A3 / B3-12 | | A3 / B4-12 | A5 / B5-12 |
| Oil / elastomer compatibility [4] | CEC-L-39-96 | Max variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | Elastomer type | | | | |
| | | | | RE1 | RE2-99 | RE3-04 | RE4 | DBL-AEM |
| | | Hardness DIDC | points | -1/+5 | -5/+8 | -22/+1 | -5/+5 | -5/+10 |
| | | Tensile strength | % | -40/+10 | -15/+18 | -30/+10 | -20/+10 | -35/- |
| | | Elongation at rupture | % | -50/+10 | -35/+10 | -20/+10 | -50/+10 | -50/- |
| | | Volume variation | % | -1/+5 | -7/+5 | -1/+22 | -5/+5 | -5/+15 |
| Foaming tendency | ASTM D892 without option A | Tendency - stability | ml | Sequence I (24˚C) 10 - nil | | | | |
| | | | | Sequence II (94˚C) 50 - nil | | | | |
| | | | | Sequence III (24˚C) 10 - nil | | | | |
| High temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency - stability | ml | Sequence IV (150˚C) 100 - nil | | | | |

**Note:**

(4) 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 D8948/200 are VDA 675301, 7 days ± 2 h, 150°C ± 2°C, closed cup test. RE1, RE2, RE3, RE4 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.

## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines - Cont'd

| Laboratory test | Method | Properties | Unit | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1-12 | A3 / B3-12 | A3 / B4-12 | A5 / B5-12 |
| Oxidation in presence of biodiesel (5) | GFC-Lu-43A-11 | Catalysed ageing test until 144 hrs at 170°C & with air bubbling:<br>1. on pure oil<br>2. with B10 added (B71 1892 GO B10 LUB) | | | | | |
| | | PAI at 144 hrs | % | | | | Report |
| | | Kin. Viscosity at 100°C variation:<br>- @ 72 hrs<br>- @ 96 hrs<br>- @ 120 hrs<br>- @ 144 hrs | cSt & %<br>cSt & %<br>cSt & %<br>cSt & % | | | | Report<br>Report<br>Report<br>Report and @ 144 hrs: < +200% (no solidification) |
| Low Temprature Pumpability | CEC-L-105 | MRV<br>Yield stress (MRV at SAE J300 temperatures applicable for the fresh oil viscosity grade) | mPa.s<br>Pa | Acc to SAE J300 for fresh oil | | Acc to SAE J300 for fresh oil | Acc to SAE J300 for fresh oil |

**Note:**

(5) Until a CEC Test Method is developed, the oxidation behavior of engine oil formulations must be proved by GFC-Lu-43A-11. 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.

## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines - Engine Tests

| Requirements | Method | Properties | Unit | ACEA Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1-12 | A3 / B3-12 | A3 / B4-12 | A5 / B5-12 |
| High temperature deposits<br>Ring sticking<br>Oil thickening | CEC L-088-02<br>(PSA TU5JP-L4)<br>72 hrs test | Ring sticking (each part) | merit | ≥ 9.0 | ≥ 9.0 | ≥ 9.0 | ≥ 9.0 |
| | | Piston varnish (5 elements, average of 4 pistons) | merit | ≥ RL 216 | ≥ RL 216 | ≥ RL 216 | ≥ RL 216 |
| | | Absolute viscosity increase @40°C between min and max values during test | $mm^2/s$ | ≤ 0.8 * RL 216 | ≤ 0.8 * RL 216 | ≤ 0.8 * RL 216 | ≤ 0.8 * RL 216 |
| | | Oil consumption | kg/test | Report | Report | Report | Report |
| Low temperature sludge (6) | ASTM D6593-00<br>(Sequence VG)<br>Under protocol and requirements for API | Average Engine sludge | merit | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 | ≥ 7.8 |
| | | Rocker cover sludge | merit | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 | ≥ 8.0 |
| | | Average piston skirt varnish | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| | | Average engine varnish | merit | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 | ≥ 8.9 |
| | | Comp. Ring (hot stuck) | | none | none | none | none |
| | | oil screen clogging | % | ≤ 20 | ≤ 20 | ≤ 20 | ≤ 20 |
| Valve train scuffing wear | CEC L-038-94<br>(TU3M) | Cam wear average | µm | ≤ 10 | ≤ 10 | ≤ 10 | ≤ 10 |
| | | Cam wear max | µm | ≤ 15 | ≤ 15 | ≤ 15 | ≤ 15 |
| | | Pad merit (avg. of 8 pads) | merit | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 | ≥ 7.5 |
| Black Sludge (7) | MB In-House Method (M271) | Average engine sludge | merit | ≥ RL 140 + 40 | | | |
| Fuel economy (8) | CEC L-54-96<br>(M 111FE) | Fuel economy improvement vs reference oil RL 191 (15W40) | % | ≥ 2.5 | - | - | ≥ 2.5 |

**Note:**

(6) 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.

(7) 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. 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. Limits are based on the same reference oil as with the old M 111 sludge test.

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



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## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines - Engine Tests - Cont'd

| Requirements | Method | Properties | Unit | ACEA Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1-12 | A3 / B3-12 | A3 / B4-12 | A5 / B5-12 |
| Medium temperature dispersivity | CEC L-093-04 (DV4TD) **to be replaced by DV6C** | Absolute viscosity increase @ 100°C and 6% of soot | mm²/s | ≤ 0.60 * RL223 result | ≤ 0.60 * RL223 result | ≤ 0.60 * RL223 result | ≤ 0.60 * RL223 result |
| | | Piston merit | merit | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) | ≥ (RL223 -2.5 pts) |
| Oil Dispersion at Medium Temperature for Passenger Car Direct Injection Diesel Engines (9) | CEC L-106 (DV6C) | Absolute viscosity increase at 100°C and 6% soot | mm²/s | limits to be defined | | | |
| | | Piston merit | merit | | | | |
| Wear (10) | CEC L-099-08 (OM 646 LA) | Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 120 | ≤ 140 | ≤ 120 | ≤ 120 |
| | | Cam wear inlet (avg. max. wear 8 cam) | µm | ≤ 100 | ≤ 110 | ≤ 100 | ≤ 100 |
| | | Cylinder wear (avg. 4 cyl) | µm | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 |
| | | Bore polishing (13 mm) max. value of 4 cylinders. | % | ≤ 3.0 | ≤ 3.5 | ≤ 3.0 | ≤ 3.0 |
| | | Tappet wear inlet (avg. max. wear 8 cams) | µm | Report | Report | Report | Report |
| | | Tappet wear outlet (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 |

**Note:**

(9) May be performed as soon as it becomes available as an alternative to the DV4 test. ACEA will decide when the DV4 test will be finally deleted from this specification. 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.

(10) Not all parameters are yet official CEC parameters. C2 limit for inlet cam wear under definition.

## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines - Engine Tests - Cont'd

| Requirements | Method | Properties | Unit | ACEA Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | A1 / B1-12 | A3 / B3-12 | A3 / B4-12 | A5 / B5-12 |
| DI Diesel Piston cleanliness & Ring sticking (11) | CEC-L-078-99 (VW TDI) | Piston cleanliness | merit | ≥ RL 206 | ≥ RL 206 - 4 pts | ≥ RL 206 | ≥ RL 206 |
| | | Ring sticking (Ring 1 & 2) | | | | | |
| | | Avg of all 8 rings | ASF | ≤ 1.0 | ≤ 1.2 | ≤ 1.0 | ≤ 1.0 |
| | | Max. for any 1st ring | ASF | ≤ 1.0 | ≤ 2.5 | ≤ 1.0 | ≤ 1.0 |
| | | Max. for any 2nd ring | ASF | 0.0 | 0.0 | 0.0 | 0.0 |
| | | EOT TBN (ISO 3771) | mgKOH/g | ≥ 4.0 | ≥ 4.0 | ≥ 6.0 | ≥ 4.0 |
| | | EOT TAN (ASTM D664) | mgKOH/g | Report | Report | Report | Report |
| Effects of biodiesel (12) | CEC-L-104 | Piston Cleanliness | Merits | - | | Report | |
| | | Ring Sticking | ASF | - | | Report | |
| | | Sludge | Merits | - | | Report | |

**Note:**

(11) Test report has to give measured values before and after the test, all measurements to be taken in the same lab. Note: TAN is considered to become performance criteria in the future. Not all parameters are yet official CEC parameters.

(12) Test is still under development at the time of publishing of this specification. 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). All test criteria is rate and report.

## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices

| Requirements | Test Method | Properties | Unit | ACEA LIMITS | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1-12 | C2-12 | C3-12 | C4-12 |
| Viscosity grades | | SAE J300 Latest active issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature. | | | |
| Shear stability (1) | CEC-L-014-93 or ASTM D6278 | 100°C Viscosity after 30 cycles | $mm^2/s$ | All grades to be Stay-in-grade | | | |
| Viscosity at High temp. & high shear rate | CEC L-036-90 (2nd edition) (Ravenfield) | Viscosity at 150°C and $10^6 s^{-1}$ shear rate | mPa.s | ≥ 2.9 | | ≥ 3.5 | |
| Evaporative loss | CEC-L-040-93 (NOACK) | Max weight loss after 1 hr at 250°C | % | ≤ 13 | | | ≤ 11 |
| Sulphur (2) (3) | ASTM D5185 | | % m/m | ≤ 0.2 | ≤ 0.3 | ≤ 0.3 | ≤ 0.2 |
| Phosporous (2) (3) | ASTM D5185 | | % m/m | ≤ 0.05 | ≤ 0.090 | ≥0.070 and ≤0.090 | ≤ 0.090 |
| Sulphated ash (2) | ASTM D874 | | % m/m | ≤ 0.5 | ≤ 0.8 | ≤ 0.8 | ≤ 0.5 |
| Chlorine | ASTM D6443 | | ppm m/m | Report | | | |
| TBN | ASTM D2896 | | mgKOH/g | - | - | ≥ 6.0 | |

| Requirements | Test Method | Properties | Unit | Elastomer type | | | | |
|---|---|---|---|---|---|---|---|---|
| Oil /Elastomer compatibility (4) | CEC-L-039-96 | Max variation of characteristics after immersion for 7 days in fresh oil without pre-ageing | | RE1 | RE2-99 | RE3-04 | RE4 | DBL-AEM |
| | | Hardness DIDC | Points | -1/+5 | -5/+8 | -22/+1 | -5/+5 | -0.5/+10 |
| | | Tensile strength | % | -40/+10 | -15/+18 | -30/+10 | -20/+10 | -35/- |
| | | Elongation at rupture | % | -50/+10 | -35/+10 | -20/+10 | -50/+10 | -50/- |
| | | Volume variation | % | -1/+5 | -7/+5 | -1/+22 | -5/+5 | -5/+15 |

**Note:**

(1) The minimum viscosity for xW-20 oils after shearing is 5,6 cSt.

(2) Maximum limits. Values take into account method and production tolerances.

(3) Internal standard method has to be used.

(4) 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 D8948/200 are VDA 675301, 7 days ± 2h, 150°C ± 2°C, closed cup test.

## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices - Cont'd

| Requirements | Test Method | Properties | Unit | ACEA LIMITS | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1-12 | C2-12 | C3-12 | C4-12 |
| Foaming tendency | ASTM D892 without option A | Tendency-Stability | ml | Sequence I (24°C) 10-nil<br>Sequence II (94°C) 50-nil<br>Sequence III (24°C) 10-nil | | | |
| High Temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency-Stability | ml | Sequence IV (150°C) 100-nil | | | |
| TBN | ASTM D2896 | | mgKOH/g | | | ≥ 6.0 | |
| Oxidation in presence of biodiesel (5) | GFC-Lu-43A-11 | Catalysed aging test until 144 hrs at 170°C & with air bubbling:<br>1. on pure oil<br>2. with B10 added (B71 1892 GO B10 LUB) | | | | | |
| | | PAI at 144 hrs | % | Report | | | |
| | | Kin. Viscosity at 100°C variation: | | | | | |
| | | - @ 72 hrs | cSt & % | Report | | | |
| | | - @ 96 hrs | cSt & % | Report | | | |
| | | - @ 120 hrs | cSt & % | Report | | | |
| | | - @ 144 hrs | cSt & % | Report and @ 144 hrs: < +200% (no solidification) | | | |
| Low Temprature Pumpability | CEC-L-105 | MRV<br>Yield stress (MRV at SAE J300 temperatures applicable for the fresh oil viscosity grade) | mPa.s<br>Pa | Acc to SAE J300 for fresh oil | | | |

**Note:**

(5) Until a CEC Test Method is developed, the oxidation behavior of engine oil formulations must be proved by GFC-Lu-43A-11. 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.

## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices - Cont'd

| Requirements | Test Method | Properties | Unit | ACEA LIMITS | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1-12 | C2-12 | C3-12 | C4-12 |
| High temperature deposits<br>Ring sticking<br>Oil thickening | CEC-L-088-A-02<br>(PSA TU5JP-L4)<br>72 hrs test | Ring sticking (each part) | merit | ≥ 9.0 | | | |
| | | Piston varnish (5 elements, average of 4 pistons) | merit | ≥ RL 216 | | | |
| | | Absolute viscosity increase @40°C between min. and max. values during test | $mm^2/s$ | ≤ 0.8 * RL 216 | | | |
| | | Oil consumption | kg/test | Report | | | |
| Low temperature sludge (6) | ASTM D6593-00<br>(sequence VG)<br>Under protocol and requirements for API | Average Engine sludge | merit | ≥ 7.8 | | | |
| | | Rocker cover sludge | merit | ≥ 8.0 | | | |
| | | Average piston skirt varnish | merit | ≥ 7.5 | | | |
| | | Average engine varnish | merit | ≥ 8.9 | | | |
| | | Comp. Ring (hot stuck) | | none | | | |
| | | Oil screen clogging | % | ≤ 20 | | | |
| Valve train scuffing wear | CEC-L-038-A-94<br>(TU3M) | Cam wear average | µm | ≤ 10 | | | |
| | | Cam wear max | µm | ≤ 15 | | | |
| | | Pad merit (avg. of 8 pads) | merit | ≥ 7.5 | | | |
| Black Sludge (7) | MB In-House Method (M 271) | Average engine sludge | merit | ≥ RL 140 + 40 | | | |
| Fuel economy (8) | CEC-L-54-T-96<br>(M 111) | Fuel economy improvement vs reference oil RL 191 (15W-40) | % | ≥ 3.0 | ≥ 2.5 | ≥ 1.0 for Xw-30 grades | |
| Medium temperature dispersivity | CEC-L-093-04<br>(DV4TD) **To be replaced by DV6** | Absolute viscosity increase @ 100°C and 6% of soot | $mm^2/s$ | ≤ 0.60 * RL223 result | | | |
| | | Piston merit | merit | ≥ (RL223 -2,5 pts) | | | |

**Note:**

(6) 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.

(7) 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. 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. Limits are based on the same reference oil as with the old M 111 sludge test..

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



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## ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices - Cont'd

| Requirements | Test Method | Properties | Unit | ACEA LIMITS | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1-12 | C2-12 | C3-12 | C4-12 |
| Oil Dispersion at Medium Temperature for Passenger Car Direct Injection Diesel Engines (9) | CEC-L-106 (DV6C) | Absolute viscosity increase at 100°C and 6% soot | $mm^2/s$ | limits to be defined | | | |
| | | Piston merit | merit | | | | |
| Wear (10) | CEC-L-099-08 (OM 646 LA) | Cam wear outlet (avg. max. wear 8 cams ) | µm | ≤ 120 | ≤ 120 | ≤ 120 | |
| | | Cam wear inlet (avg. max. wear 8 cam) | µm | ≤ 100 | report | ≤ 100 | |
| | | Cylinder wear (avg. 4 cyl) | µm | ≤ 5.0 | ≤ 5.0 | ≤ 5.0 | |
| | | Bore polishing (13 mm) max. value of 4 cylinders. | % | ≤ 3.0 | ≤ 3.0 | ≤ 3.0 | |
| | | Tappet wear inlet (avg. max. wear 8 cams) | µm | Report | Report | Report | |
| | | Tappet wear outlet (avg. max. wear 8 cams) | µm | Report | Report | Report | |
| | | Piston cleanliness (avg. 4 pistons) | merit | Report | Report | ≥ 12 | |
| | | Engine sludge avg. | merit | Report | Report | ≥ 8.8 | |

**Note:**
(10) Not all parameters are yet official CEC parameters. C2 limit for inlet cam wear under definition.

# ACEA 2012 Service-Fill Oils For Gasoline And Diesel Engines With After Treatment Devices - Cont'd

| Requirements | Test Method | Properties | Unit | ACEA LIMITS | | | |
|---|---|---|---|---|---|---|---|
| | | | | C1-12 | C2-12 | C3-12 | C4-12 |
| DI Diesel Piston cleanliness & Ring sticking (11) | CEC-L-078-99 (VW TDI) | Piston cleanliness | merit | ≥ RL 206 | ≥ RL 206 | ≥ RL 206 | |
| | | Ring sticking (Ring 1 & 2) | | | | | |
| | | Avg of all 8 rings | ASF | ≤ 1.0 | ≤ 1.2 | ≤ 1.0 | |
| | | Max. for any 1st ring | ASF | ≤ 1.0 | ≤ 2.5 | ≤ 1.0 | |
| | | Max. for any 2nd ring | ASF | 0.0 | 0.0 | 0.0 | 0.0 |
| | | EOT TBN (ISO 3771) | mgKOH/g | Report | Report | Report | Report |
| | | EOT TAN (ASTM D664) | mgKOH/g | Report | Report | Report | Report |
| Effects of biodiesel (12) | CEC-L-104 | Piston Cleanliness | Merits | Report | | | |
| | | Ring Sticking | ASF | Report | | | |
| | | Sludge | Merits | Report | | | |

**Note:**

(11) Test report has to give measured values before and after the test, all measurements to be taken in the same lab. Note: TAN is considered to become performance criteria in the future. Not all parameters are yet official CEC parameters.

(12) Test is still under development at the time of publishing of this specification. 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). All test criteria is rate and report.

## ACEA 2012 Service-Fill Oils For Heavy Duty Diesel Engines

| Laboratory test | Test Method | Properties | Unit | ACEA LIMITS | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | E4 -12 | E6 -12 | E7 -12 | E9 -12 | |
| Viscosity grades | | SAE J300 Latest active issue | | No restriction except as defined by shear stability and HT/HS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature | | | | |
| Shear stability | CEC-L-014-93 or ASTM D6278 | Viscosity after 30 cycles @ 100°C | $mm^2/s$ | Stay-in-grade | - | | | |
| | ASTM D6278 | Viscosity after 90 cycles @ 100°C | $mm^2/s$ | - | Stay-in-grade | | | |
| Viscosity at High temp. & high shear rate | CEC-L-036-90 | Viscosity at 150°C and $10^6 s^{-1}$ shear rate | mPa.s | ≥ 3.5 | | | | |
| Evaporative loss | CEC-L-040-93 (NOACK) | Max weight loss after 1h @ 250°C | % | ≤ 13 | | | | |
| Sulphated ash | ASTM D874 | | % m/m | ≤ 2.0 | ≤ 1.0 | ≤ 2.0 | ≤ 1.0 | |
| Phosporous (1) | ASTM D5185 | | % m/m | | ≤ 0.08 | | ≤ 0.12 | |
| Sulphur (1) | ASTM D5185 | | % m/m | | ≤ 0.3 | | ≤ 0.4 | |
| Oil /Elastomer compatibility (2) | CEC-L-039-96 | Max variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | Elastomer type | | | | |
| | | | | RE1 | RE2-99 | RE3-04 | RE4 | DBL-AEM |
| | | Hardness DIDC | Points | -1/+5 | -5/+8 | -25/+1 | -5/+5 | -5/+10 |
| | | Tensile Strength | % | -50/+10 | -15/+18 | -45/+10 | -20/+10 | -35/- |
| | | Elongation Rupture | % | -60/+10 | -35/+10 | -20/+10 | -50/+10 | -50/- |
| | | Volume Vairation | % | -1/+5 | -7/+5 | -1/+30 | -5/+5 | -5/+15 |
| Foaming tendency | ASTM D892 without option A | Tendency-Stability | ml | Sequence I (24°C) 10-nil | | | Sequence I (24°C) 10-nil | |
| | | | | Sequence II (94°C) 50-nil | | | Sequence II (94°C) 20-nil | |
| | | | | Sequence III (24°C) 10-nil | | | Sequence III (24°C) 10-nil | |

**Note:**

(1) Internal standard method has to be used.

(2) 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 ± 2h, 150°C ± 2°C, closed cup test.

RE1, RE2, RE3, RE4 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.

## ACEA 2012 Service-Fill Oils For Heavy Duty Diesel Engines - Cont'd

| Laboratory test | Test Method | Properties | Unit | E4 -12 | E6 -12 | E7 -12 | E9 -12 |
|---|---|---|---|---|---|---|---|
| High Temperature foaming tendency | ASTM D6082 | Tendency-Stability | ml | Sequence IV (150°C) 200-50 | | | |
| Oxidation | CEC-L-085-99 (PDSC) | Oxidation induction time | min. | R&R | | ≥ 65 | |
| Corrosion | ASTM D6594 | Copper increase | ppm | R&R | | R&R | ≤ 20 |
| | | Lead increase | ppm | R&R | | ≤ 100 | ≤ 100 |
| | | Copper strip rating | max. | R&R | | R&R | 3 |
| TBN [3] | ASTM D2896 | | mg KOH/g | ≥ 12 | ≥ 7 | ≥ 9 | ≥ 7 |
| Low Temprature Pumpability | CEC-L-105 | MRV<br>Yield stress (MRV at SAE J300 temperatures applicable for the fresh oil viscosity grade) | mPas<br>Pa | Acc to SAE J300 for fresh oil | | | |
| Bore polishing Piston Cleanliness [6] | CEC-L-101-08 (OM501LA) | Average Bore polishing | % | ≤ 1.0 | ≤ 1.0 | ≤ 2.0 | ≤ 2.0 |
| | | Average Piston cleanliness | merit | ≥ 26 | ≥ 26 | ≥ 17 | ≥ 17 |
| | | Oil consumption | kg/test | ≤ 9 | ≤ 9 | ≤ 9 | ≤ 9 |
| | | Average engine sludge | merit | R&R | R&R | R&R | R&R |
| **Engine Tests** | | | | | | | |
| Wear [4] | CEC-L-099-08 (OM646LA) | Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 140 | ≤ 140 | ≤ 155 | ≤ 155 |
| Soot in oil [5] | ASTM D5967 (Mack T-8E) | Test duration 300 hrs<br>Relative viscosity at 4.8% soot and 50% shear loss<br>1 test/2 test/3 test average | | ≤ 2.1 / 2.2 / 2.3 | ≤ 2.1 / 2.2 / 2.3 | ≤ 2.1 / 2.2 / 2.3 | |

**Note:**

(3) For E7, values < 9.00 are not accepted.

(4) OM 602 A 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.

(5) Mack T11 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.

(6) Bore polish, oil consumption and engine sludge are non-approved CEC parameters. OM 441 LA data can be used instead of OM 501 LA data providing it meets the requirements as specified in the 2007 ACEA sequences.

## ACEA 2012 Service-Fill Oils For Heavy Duty Diesel Engines - Cont'd

| Laboratory test | Test Method | Properties | Unit | E4 -12 | E6 -12 | E7 -12 | E9 -12 |
|---|---|---|---|---|---|---|---|
| Soot in oil | ASTM D7156 (Mack T-11) | 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 |
| Soot induced wear | Cummins ISM | Merit | | | | | ≥ 1000 |
| | | Rocker pad average weight loss at 3.9% soot | mg | | | ≤ 7.5/7.8/7.9 | ≤ 7.1 |
| | | 1 test/ 2 test / 3 test average Oil filter diff. pressure @ 150 hrs | kPa | - | - | ≤ 55/67/74 | ≤ 19 |
| | | 1 test/ 2 test / 3 test average Engine Sludge | merit | - | - | ≥ 8.1/8.0/8.0 | ≥ 8.7 |
| | | 1 test/ 2 test / 3 test average Adjust screw weight loss | mg | - | - | | ≤ 49 |
| Wear (liner-ring-bearings) (8) | Mack T12 | Merit | | | ≥ 1000 | ≥1000 | ≥ 1000 |
| | | Average liner wear | µm | | ≤ 26 | ≤ 26 | ≤ 24 |
| | | Average top ring weight loss | mg | | ≤ 117 | ≤ 117 | ≤ 105 |
| | | End of test lead | ppm | | ≤ 42 | ≤ 42 | ≤ 35 |
| | | Delta lead 250-300 hrs | ppm | | ≤ 18 | ≤ 18 | ≤ 15 |
| | | Oil consumption (Phase II) | g/hr | | ≤ 95 | ≤ 95 | ≤ 85 |

**Note:**

(7) For E7 results from M11HST (ASTM D6838), at API CH-4, or M11EGR (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.

(8) 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.

## US Military Specifications: Engine Test Requirements

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



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## Additional Test Requirements For MIL-L-2104E

| Test | Parameter | MIL-L-2104E |
|---|---|---|
| Detroit Diesel 6V-53T (FTM 355T) | Piston Area | |
| | Avg. total deposits, max. | 400 |
| | Hot stuck rings | None |
| | Average Ring Face Distress, demerits, %, max. | - |
| | Fire ring | Report |
| | Nos 2 and 3 compression | 13.0 |
| | Liner and Head Area | - |
| | Avg. liner scuffing, %, max. | 12.0 |
| | Valve distress | None |
| | Port plugging, % | Report |
| Allison C-3 (Seal) | Total Immersion (Buna N) | - |
| | Volume change, % | 0 to +5 |
| | Hardness change, points | -5 to +5 |
| | Dip Cycle (Polyacrylate) | - |
| | Volume change, % | 0 to 10 |
| | Hardness change, points | 10 to 0 |
| | Tip Cycle (Silicone) | - |
| | Volume change, % | 0 to +5 |
| | Hardness change, points | -10 to 0 |
| C-3 (Time/Torque) | Slip Time at 5500 cycles max. | 0.85 |
| | Torque, Nm. at 0.2s. slip time, min. | 101.7 |
| | Δ between 1500 & 5500 cycles, max. | 40.7 |
| Caterpillar TO-2 | Stopping Time Increase, %, max. | 15 (1) (2) |
| | Average Total Wear, µm. max. | 350 |

**Note:**

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

## MIL-L-2104F Engine Test Requirements

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

## MIL-L-2104F Transmission Test Requirements

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

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

## US Military Specifications: MIL-PRF-2104H

(July 2004, Superseding MIL-PRF-2104G)
Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service

| Property | Limits | | |
|---|---|---|---|
| | SAE Grade 40 | SAE Grade 15W-40 | SAE Grade 5W-40 |
| Kinematic Viscosity @ 100°C, cSt | ≥ 12.5 and < 16.3 | ≥ 12.5 and < 16.3 | ≥ 12.5 and < 16.3 |
| Low Temperature Cranking viscosity, cP, ASTM D5293 | - | 7000 @ -25°C, min | 6200 @ -35°C, min |
| | - | 7000 @ -20°C, max | 6600 @ -30°C, max |
| HTHS @ 150°C, cP, ASTM D4683 | - | ≥ 3.7 | ≥ 3.7 |
| Low Temperature Pumping Viscosity, cP, max, ASTM D4684 | - | 60 000 @ -25 | 60 000 @ -35 |
| Pour Point, °C, max. | -15 | -25 | -40 |
| Flash Point, °C, min, ASTM D92 | 225 | 215 | 210 |
| Evaporative Loss, %, max, ASTM D5800 | - | 15 | 15 |
| Sulfated Ash, %, max, ASTM D874 | 1.5 | 1.5 | 1.5 |
| Foaming, ASTM D 892 (option A not allowed) | | | |
| Sequence I, foam/settling, ml, max. | 10/0 | | |
| Sequence II, foam/settling, ml, max. | 50/0 | | |
| Sequence III, foam/settling, ml, max. | 10/0 | | |
| Aeration, ASTM D6894 | | | |
| Aeration (EOAT), Volume, %, max. | 8.0 (MTAC) (1) | | |
| Shear Stability Performance, ASTM D6278 | | | |
| Kinematic viscosity after shearing, cSt, min. | - | 12.5 | |

**Note:**
(1) Multiple Test Acceptance Criteria (MTAC) is a data-based approach for evaluation of the quality and performance of a formulation where more than one test may be run.



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## US Military Specifications: MIL-PRF-2104H

(July 2004, Superseding MIL-PRF-2104G)
Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service

| Material | Rated or Measured parameters | Primary Performance Criteria | | |
|---|---|---|---|---|
| | | One Test | Two Test | Three Test |
| Piston deposits and scuffing performance | | | | |
| Aluminium<br>CAT 1K<br>ASTM D6750 | Weighted Piston Demerits (WPD), max. | 332 | 347 | 353 |
| | Top Groove Fill (TGF), %, max. | 24 | 27 | 29 |
| | Top Land Heavy Carbon (TLHC), %, max. | 4 | 5 | 5 |
| | Average Oil Consumption, g/kW-hr, max. | 0.5 | 0.5 | 0.5 |
| | Piston, Ring and Liner scuffing | none | none | none |
| Steel<br>CAT 1P<br>ASTM D6684 | Weighted Piston Demerits (WPD), max. | 350 | 378 | 390 |
| | Top Groove Carbon (TGC), demerit, max. | 36 | 39 | 41 |
| | Top Land Carbon (TLC), demerit, max. | 40 | 46 | 49 |
| | Average Oil Consumption, (0-360 hrs.), g/h, max. | 12.4 | 12.4 | 12.4 |
| | Final Oil Consumption, (312-360 hrs.), g/h, max. | 14.6 | 14.6 | 14.6 |
| | Piston, Ring and Liner scuffing | none | none | none |
| | | | | |
| Properties of Sludge control, filterability and sliding valvetrain wear, Cummins M11 EGR, ASTM D6975 | | | | |
| Avg. Crosshead weight loss, mg, max. | | 20 | 21.8 | 22.6 |
| Avg. Top ring weight loss, mg, max. | | 175 | 186 | 191 |
| Oil filter delta pressure @ 250 hrs, kPa, max. | | 275 | 320 | 341 |
| Avg. Engine sludge, CRC merit, min. | | 7.8 | 7.6 | 7.5 |
| Soot control, MACK T-8E, ASTM D5967 | | | | |
| Relative viscosity at 4.8% soot, max. [2] | | 1.8 | 1.9 | 2 |

**Note:**

(2) Relative viscosity = (Viscosity at 4.8% soot) / (Viscosity of new oil shared in ASTM D6278).

## US Military Specifications: MIL-PRF-2104H

(July 2004, Superseding MIL-PRF-2104G))

Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service

| Rated or Measured parameters | | Primary Performance Criteria | | |
|---|---|---|---|---|
| | | One Test | Two Test | Three Test |
| Used Oil pumpability, ASTM D4684 | | | | |
| Requirement A | Viscosity after 75 hrs. of Mack T-10 test, tested @ -20°C, mPa-s, max. | - | 25 000 | |
| Requirement B | Viscosity after 75 hrs. of Mack T-10 test, tested @ -20°C, mPa-s, max. | - | 25 000 | |
| | Yield Stress, Pa | - | < 35 | |
| Properties of two-stroke cycle diesel engine | | | | |
| Average ring face distress | | | | |
| Fire Ring, avg. | | 0.33 | 0.34 | 0.36 |
| Nos 2 and 3 compression ring, avg. | | 0.28 | 0.29 | 0.3 |
| Broken rings, avg. | | none | none | none |
| Cylinder liner area | | | | |
| Liner distress, % area, avg, max. | | 60 | 63.5 | 65 |
| Port plugging, % area, avg, max. | | | | |
| Average | | 2 | 2 | 2 |
| Single Cylinder | | 5 | 5 | 5 |
| Valvetrain wear control criteria, ASTM D5966 | | | | |
| Average Pin wear, µm, max. | | 7.6 | 8.4 | 9.1 |



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## US Military Specifications: MIL-PRF-2104H

(July 2004, Superseding MIL-PRF-2104G)
Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service

| Rated or Measured Parameters | Primary Performance Criteria | | |
|---|---|---|---|
| | One Test | Two Test | Three Test |
| **The following parameters are required to ensure the right protection when the oil is used in power shift transmission, cooled friction component or hydraulic systems such as steering braking and disconnect clutches** | | | |
| Frictional characteristics and wear | | | |
| Allison Graphite and Paper Friction Test Mid Point dynamic friction coefficient (3)(4) | Measured mid-point friction shall be greater than or equal to the qualified batch sample mean mid-point friction coefficient minus 0.012 | | |
| Allison Graphite and Paper Friction Test Slip Time, seconds (3)(4) | Slip time shall be less than or equal to the maximum acceptable slip time criteria | | |
| Caterpillar TO-4 / TO-4M, Seq 1220 (5) | | | |
| Average dynamic coefficient, % | 90-140 | | |
| Average static coefficient, % | 91-127 | | |
| Disc wear, mm, max. | 0.04 | | |
| Energy limit, m/s, min. | 25 | | |
| Caterpillar TO-4 / TO-4M, SEQFRRET (5) | | | |
| Average dynamic coefficient, % | | | |
| @ 3000 cycles | 85-130 | | |
| @ 8000 cycles | 90-125 | | |
| @ 15,000 cycles | 90-125 | | |
| @ 25,000 cycles | 95-125 | | |

**Note:**

(3) Variation in frictional performance from one batch of friction plates to the next demands that minimum acceptance criteria be developed with respect to individual batches.

(4) Maximum acceptable slip time (tmax)

a. Allison Paper Friction Test : tmax = 0.1108-0.6012μ

b. Allison Graphite Friction Test : tmax = 1/[-221*(μ-0.1421)2+1.756]

c. Where μ is the minimum acceptable coefficient at mid-point

(5) TO-4M requirements are only for 5W-40 and 15W-40 viscosity grades.

## US Military Specifications: MIL-PRF-2104H

(July 2004, Superseding MIL-PRF-2104G)
Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service

| Rated or Measured Parameters | Primary Performance Criteria | | |
|---|---|---|---|
| | One Test | Two Test | Three Test |
| **The following parameters are required to ensure the right protection when the oil is used in power shift transmission, cooled friction component or hydraulic systems such as steering braking and disconnect clutches** | | | |
| Caterpillar TO-4M, EHD Film-Forming Test [5] | | | |
| % of Elastohydrodynamic (EHD) reference film thickness at 2 m/s | - | | |
| @ 70°C | - | ≥ 90 | |
| @ 100°C | - | ≥ 96 | |
| @ 130°C | - | ≥ 98 | |
| Piston ring, liner and bearing wear control, ASTM D6987 (T-10) | | | |
| Merit rating, min. | 1000 | | |
| Property of oxidation and nitration control, ASTM D6984 | | | |
| % increase kinematic viscosity @ 40°C, max. | 275 (MTAC) [1] | | |
| Interface Requirements | | | |
| Homogeneity and miscibility, ASTM D6922 | Pass | | |
| Elastomer Seal compatibility, GMN10055 DEXRON-III, H Revision Automatic Transmission Fluid Specifications | Pass | | |
| Corrosion control, HTCBT, ASTM D6594 | | | |
| Copper increase, ppm, max. | | 20 | |
| Lead increase, ppm, max. | | 120 | |
| Tin increase, ppm, max. | | 50 | |
| Copper strip coupon rating, max. [6] | | 3 | |

**Note:**

(1) Multiple Test Acceptance Criteria (MTAC) is a data-based approach for evaluation of the quality and performance of a formulation where more than one test may be run.

(5) TO-4M requirements are only for 5W-40 and 15W-40 viscosity grades.

(6) The rating system in test method ASTM D130 is used to rate the copper strip coupon.



Afton CHEMICAL

## Diesel Engine Oil Standards

| | | | | Units | Performance Criteria | | |
|---|---|---|---|---|---|---|---|
| | | | | | DH-1-05 | DH-2-05 | DL-1-05 |
| Viscosity Grade | | | | | - | - | xW-30, xW-20 |
| Jaso Hot Tube Test Hot Surface Deposit Control | @ 280˚C | | | Merit Rating | 7.0 min. | 7.0 min. | 7.0 min. |
| Anti-foaming | Sequence I | | Foaming/ Stability | ml/ml | 10/0 max. | 10/0 max. | 10/0 max. |
| | Sequence II | | | ml/ml | 50/0 max. | 50/0 max. | 50/0 max. |
| | Sequence III | | | ml/ml | 10/0 max. | 10/0 max. | 10/0 max. |
| High Temp Anti-foaming | Sequence IV | | | ml/ml | - | - | 100/0 max. |
| Volatility | Evaporative Loss | | | mass % | 18.0 max. | 18.0 max. | 15.0 max. |
| Anti-Corrosion | Copper | | | mass ppm | 20 max. | 20 max. | 20 max. |
| | Lead | | | mass ppm | 120 max. | 100 max. | 120 max. |
| | Tin | | | mass ppm | 50 max. | 50 max. | 50 max. |
| | Discolouration of Copper coupon after test @ 135˚C | | | - | 3 max. | 3 max. | 3 max. |
| Shear Stability | Kinetic viscosity of oil after test @ 100˚C | | | $mm^2/s$ | Stay-in-grade of virgin oil viscosity classification in SAE J300 | Stay-in-grade of virgin oil viscosity classification in SAE J300 | xW-30:8.6 min. xW-20: Stay-in-grade of virgin oil viscosity classification in SAE J300 |
| Sulphated Ash | | | | mass % | - | 1.0 ±0.1 | 0.6 max. |
| Base Number | | | | mgKOH/g | 10.0 min. | 5.5 min.<br>- | -<br>- |
| Phosphorus | | | | mass % | - | 0.12 max. | 0.10 max. |
| Sulphur | | | | mass % | - | 0.5 max. | 0.5 max. |
| Chlorine | | | | mass ppm | - | 50 max. | 50 max. |
| Seal Compatibility | RE1 (Fluoro) | Hardness Change | | Point | -1 to +5 | -1 to +5 | -1 to +5 |
| | | Tensile Strength Rate of Change | | % | -40 to +10 | -50 to +10 | -40 to +10 |
| | | Elongation Rate of Change | | % | -50 to +10 | -60 to +10 | -50 to +10 |
| | | Volume Rate of Change | | % | -1 to +5 | -1 to +5 | -1 to +5 |
| | RE2-99 (Acrylic) | Hardness Change | | Point | -5 to +8 | -5 to +8 | -5 to +8 |
| | | Tensile Strength Rate of Change | | % | -15 to +18 | -15 to +18 | -15 to +18 |
| | | Elongation Rate of Change | | % | -35 to +10 | -35 to +10 | -35 to +10 |
| | | Volume Rate of Change | | % | -7 to +5 | -7 to +5 | -7 to +5 |

## Diesel Engine Oil Standards

| | | | Units | Performance Criteria | | |
|---|---|---|---|---|---|---|
| | | | | DH-1-05 | DH-2-05 | DL-1-05 |
| Seal Compatibility | RE3 (Silicon) | Hardness Change | point | -25 to +1 | -25 to +1 | -25 to +1 |
| | | Tensile Strength Rate of Change | % | -45 to +10 | -45 to +10 | -45 to +10 |
| | | Elongation Rate of Change | % | -20 to +10 | -20 to +10 | -20 to +10 |
| | | Volume Rate of Change | % | -1 to +30 | -1 to +30 | -1 to +30 |
| | RE4 (Nitrile) | Hardness Change | point | -5 to +5 | -5 to +5 | -5 to +5 |
| | | Tensile Strength Rate of Change | % | -20 to +20 | -20 to +20 | -20 to +20 |
| | | Elongation Rate of Change | % | -50 to +10 | -50 to +10 | -50 to +10 |
| | | Volume Rate of Change | % | -5 to +5 | -5 to +5 | -5 to +5 |
| | AEM (Ethylene Acrylic) | Hardness Change | point | Per agreement between concerned parties | Per agreement between concerned parties | Per agreement between concerned parties |
| | | Tensile Strength Rate of Change | % | | | |
| | | Elongation Rate of Change | % | | | |
| | | Volume Rate of Change | % | | | |
| Nissan TD25 (M336) Piston Detergency | TGF (Top Groove Fill) | | vol % | 60.0 | 60.0 | 60.0 |
| | Piston Ring Stickings | | | All free | All free | All free |
| | Deposits on Ring Lands | | Merit Rating | Report | Report | Report |
| Mitsubishi 4D34T4 Valve Train Wear Protection (M354) | Average Cam Diameter Loss (Normalised at 4.5 mass % Carbon Residue Increase) | | µm, max. | 95.0 | 95.0 | 95.0 |
| | Maximum Cam Diameter Loss (Normalised at 4.5 mass % Carbon Residue Increase) | | µm, max | 210 | 210 | 210 |
| | Cam Surface Wear | | | No pitting | No pitting | No pitting |
| Mack T8A Soot Dispersancy (D5967) | Viscosity Increase (100 to 150 hr) @ 100˚C | | $mm^2/s$ h | 0.2 | 0.2 | 0.2 |
| Sequence IIIE High Temperature Oxidation Stability (D6984) | Viscosity Increase @ 40˚C, max. | | % max. | 200 | 200 | - |
| | or Viscosity Increase @ 40˚C (60 hr) | | %, max. | 295 | 295 | - |
| | Viscosity Increase @ 40˚C (80 hr) | | %, max. | - | - | 275 |
| Fuel Economy (CEC-L-54-T-96) | Fuel Economy Improvement, min. | | %, min. | - | - | 2.5 |

## JASO 2008 Diesel Engine Oil Standards

| | | Units | Performance Criteria DH-1-05 | DH-2-08 | DL-1-08 | Method |
|---|---|---|---|---|---|---|
| Viscosity grade | | | -- | -- | xW-30, xW-20 | SAE J300 |
| Piston Detergency JASO M336 | TGF (Top Groove Fill) | vol % | 60.0 max. | 60.0 Max. | 60.0 Max. | JASO M336 |
| | Piston Ring Stickings | All free | All free | All free | All free | |
| | Deposit on Ring lands | Merit Rating | Report | Report | Report | |
| Valve Train Wear Protection | Average Cam Diameter Loss (Normalized at 4.5 mass % Carbon Residue Increase) | µm | 95.0 max. | 95.0 max. | 95.0 max. | JASO M354 |
| | Maximum Cam Diameter Loss (Normalized at 4.5 mass % Carbon Residue Increase) | µm | 210 max. | 210 max. | 210 max. | |
| | Cam Surface Wear | No pitting | No pitting | No pitting | | |
| Soot Dispersancy | Viscosity increase (100 to 150 hrs.) @ 100°C | $mm^2/s$ | 0.2 max. | 0.2 max. | 0.2 max. | ASTM D5967 (Mack T8A and 8E) |
| High Temperature Oxidation Stability | Viscosity increase @ 40°C max | % max. | 200 max. | 200 max. | - | ASTM D5533 Seq IIIE |
| | Or Viscosity increase @ 40°C (60 hrs.) | % max. | 295 max. | 295 max. | - | ASTM D6984 Seq IIIF |
| | Viscosity increase @ 40°C (80 hrs.) | % max. | - | - | 275 max. | ASTM D6984 Seq IIIF |
| Fuel Economy | Fuel Economy Improvement | % min. | - | - | 2.5 | CEC-L-54-T-96 |
| Hot Surface Deposit Control | @ 280°C | Merit Rating | 7.0 min. | 7.0 min. | 7.0 min. | JPI-5S-55-99 |
| Anti-foaming | Sequence I | ml/ml | 10/0 max. | 10/0 max. | 10/0 max. | JIS-K-2518:2003 |
| | Sequence II<br>Foaming/ Stability | ml/ml | 50/0 max. | 50/0 max. | 50/0 max. | |
| | Sequence III | ml/ml | 10/0 max. | 10/0 max. | 10/0 max. | |
| High Temp Anti-Foaming | Sequence IV | ml/ml | - | - | 100/0 max. | ASTM D6082 |
| Volatility | Evaporation Loss @ 250°C | mass % | 18.0 max. | 18.0 max. | 15.0 max. | JPI-5S-41-2004 |
| Anti-Corrosion | Copper | mass ppm | 20 max. | 20 max. | 20 max. | ASTM D6594 |
| | Lead | mass ppm | 120 max. | 100 max. | 120 max. | |
| | Tin | mass ppm | 50 max. | 50 max. | 50 max. | |
| | Discolouration of Copper Coupon after test @ 135°C | - | 3 max. | 3 max. | 3 max. | ASTM D130 |
| Shear Stability | Kinetic Viscosity of Oil after Test @ 100°C | $mm^2/s$ | Stay-in-grade of virgin oil viscosity classification in SAE J300 | Stay-in-grade of virgin oil viscosity classification in SAE J300 | xW-30 : 8.6 Min. xW-20 Stay-in-grade of virgin oil viscosity classification in J300 | ASTM D6278 |

## JASO 2008 Diesel Engine Oil Standards

| | | | Units | Performance Criteria | | | Method |
|---|---|---|---|---|---|---|---|
| | | | | DH-1-05 | DH-2-08 | DL-1-08 | |
| Sulfated Ash | | | mass % | - | 1.0 +/- 0.1 | 0.6 Max | JIS-K-2272 1998-5 |
| Base Number | | | mg KOH/g | 10.0 min. | 5.5 min. | - | JIS-K-2501 20003 8 |
| | | | | | - | - | ASTM D4739 |
| Phosporous | | | mass % | - | 0.12 max. | 0.10 max. | JPI-5S-38-2003 |
| Sulphur | | | mass % | - | 0.5 max. | 0.5 max. | JIS-K-2541 2003 5 |
| Chlorine | | | mass ppm | - | 150 max. | 150 max. | JPI-5S-64-2002 |
| Seal Compatibility | RE1 (Fluoro) | Hardness Change | Point | -1 to +5 | -1 to +5 | -1 to +5 | CEC-L -39-T-96 |
| | | Tensile Strength Rate of Change | % | -40 to +10 | -50 to +10 | -40 to +10 | |
| | | Elongation Rate of Change | % | -50 to +10 | -60 to +10 | -50 to +10 | |
| | | Volume Rate of Change | % | -1 to +5 | -1 to +5 | -1 to +5 | |
| | RE2-99 (Acrylic) | Hardness Change | Point | -5 to +8 | -5 to +8 | -5 to +8 | |
| | | Tensile Strength Rate of Change | % | -15 to +18 | -15 to +18 | -15 to +18 | |
| | | Elongation Rate of Change | % | -35 to +10 | -35 to +10 | -35 to +10 | |
| | | Volume Rate of Change | % | -7 to +5 | -7 to +5 | -7 to +5 | |
| | RE3 (Silicon) | Hardness Change | Point | -25 to +1 | -25 to +1 | -25 to +1 | |
| | | Tensile Strength Rate of Change | % | -45 to +10 | -45 to +10 | -45 to +10 | |
| | | Elongation Rate of Change | % | -20 to +10 | -20 to +10 | -20 to +10 | |
| | | Volume Rate of Change | % | -1 to +30 | -1 to +30 | -1 to +30 | |
| | RE4 (Nitrile) | Hardness Change | Point | -5 to +5 | -5 to +5 | -5 to +5 | |
| | | Tensile Strength Rate of Change | % | -20 to +10 | -20 to +10 | -20 to +10 | |
| | | Elongation Rate of Change | % | -50 to +10 | -50 to +10 | -50 to +10 | |
| | | Volume Rate of Change | % | -5 to +5 | -5 to +5 | -5 to +5 | |
| | AEM (Ethylene Acrylic) | Hardness Change | Point | Per agreement between concerned parties | Per agreement between concerned parties | Per agreement between concerned parties | |
| | | Tensile Strength Rate of Change | % | | | | |
| | | Elongation Rate of Change | % | | | | |
| | | Volume Rate of Change | % | | | | |

## Global Engine Oil Service Specifications DHD-1 — Laboratory Tests

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

**Note:**

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

## Global Engine Oil Service Specifications DHD-1 — Engine Tests

| Test | Performance Criteria | Limits | | |
|---|---|---|---|---|
| Caterpillar 1R [1] | Weighted Demerits (WDR), max. | 397 | 416 | 440 |
| | Total Groove Carbon, %. max. | 40 | 42 | 44 |
| | Top Land Carbon, %. max. | 37 | 42 | 46 |
| | Oil Consumption g./hr. Initial max./Final max. | 13.1 / 1.5 X Initial | | |
| Cummins M11 HST [3] | Oil Filter Diff. Press. kPa. max. | 79 | 93 | 100 |
| | Eng. Sludge, CEC Merits, min. | 8.7 | 8.6 | 8.5 |
| | Rocker Pad Average Weight Loss, Normalized to 4.5% soot mg. max. | 6.5 | 7.5 | 8.0 |
| Mack T-9 [4] | Used Oil Lead, ppm. max. | 15 [2] | | |
| | TAN Increase at EOT, max. | 2.0 | | |
| | Average Wear Normalized to 1.75% soot Liner µm. max. | 25.4 | 26.6 | 27.1 |
| | Top Ring % wt. Loss, mg. max. | 120 | 136 | 144 |
| Mack T-8E | Relative Viscosity at 4.8% soot | 2.1 | 2.2 | 2.3 |
| 6.5L RFWT | Pin Wear, µm. max. | 7.6 | 8.4 | 9.1 |
| Seq IIIF, 60 hrs. | Kv 40°C Viscosity Increase, %. max. | 200 | | |
| HEUI | Aeration, vol. %. max. | 8.0 | | |
| Mercedes Benz OM 441 LA | Bore Polish, % Area. max. | 2.0 | | |
| | Boost Pressure Loss at 400 hrs, %. max. | 4 | | |
| | Weighted Merits, min. | 25.0 | | |
| | Oil Consumption, kg./test max. | 40 | | |
| Mitsubishi 4D34T4 160 hrs. | Avg. Cam Lobe Wear, µm. | 95.0 | | |

**Note:**

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

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

(3) Cummins ISM being considered as a replacement test.

(4) Mack T-12 is an approved alternative.

## Two-Stroke Classifications: API TC

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

**Note:**

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

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

## Two-Stroke Classifications: ISO/JASO

| ISO | | | EGB | EGC | EGD | | |
|---|---|---|---|---|---|---|---|
| JASO | | | FB | FC | FD | | |
| **Physical Chemical Properties** | | | | | | | |
| **Evaluation Item** | | | **Limit** | | | **Test Procedure** | |
| | | | | | | **JIS** | **ASTM** |
| Kinematic viscosity @ 100°C, cSt | | | 6.5 min. | | | JIS K 2283 | D445 |
| Flash Point, °C | | | 70 min. | | | JIS K 2265 | D83 |
| Sulfated Ash, % wt. | | | 0.25 | 0.25 | 0.18 | JIS K 2272 | D874 |
| **Test procedures and Standard Indices** | | | | | | | |
| **Evaluation item** | | | **Standard Index (min.)** | | | **Test Procedure** | |
| Lubricity [1] | | | | | 95 | JASO M340 | |
| Initial Torque [1] | | | | | 98 | JASO M340 | |
| Detergency [1] | Evaluation after 60 min. | Fundamental Part | 85 | 95 | - | JASO M341 60 min. Test | |
| | | Piston Skirt Part | - | - | - | | |
| | Evaluation after 180 min. | Fundamental Part | - | - | 125 | JASO M341 180 min. Test | |
| | | Piston Skirt Part | - | - | 95 | | |
| Exhaust Smoke [2] | | | 45 | 85 | 85 | JASO M342 | |
| Exhaust System blocking [2] | | | | 90 | 90 | JASO M343 | |

**Note:**

(1) Engine : HONDA DIO AF27.

(2) Engine : SUZUKI SX800R.

**Specification description:**

FA Obsolete

FB / EGB Increased lubricity, detergency, exhaust smoke and exhaust system blocking requirements over FA.

FC / EGC Lubricity and initial torque requirements same as FB, however far higher detergency, exhaust smoke and exhaust system blocking requirements over FB.

FD / EGD Same as FC with far higher detergency requirement.

## Two-Stroke Classifications: TISI 1040

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

**Note:**

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

Tests use different fuel:oil ratios to evaluate performance.

Piston Seizure and Ring Scuffing various down to 200:1

Detergency 40:1

Exhaust Smoke 10:1

## Two-Stroke Classifications: NMMA TC-W3 For Outboard Motors

NMMA - National Marine Manufacturer Association (1)

| Test | Parameter |
|---|---|
| **Analytical Test Results** | |
| Viscosity, cSt, 40°C | |
| Pour Point, °C | |
| Flash Point, ASTM D93, °C | |
| Nitrogen, %wt. | |
| TBN, ASTM D2896, mgKOH/g | |
| Cloud Point, ASTM D2500, °C | |
| **Bench Test Results** | |
| Compatibility, % Sediments | Homogeneous after mixed separately with each reference oil (*,**) and stored 48 hrs |
| Brookfield (Fluidity) @ -25°C, cP | ≤ 7500 |
| Miscibility @ -25°C, cP Inversions | No more than 10% inversions than reference |
| % Rust | Equal to or less than reference |
| Filterability, % change | Decrease in flow rate no more than 20% |
| **Engine Test Results** | |
| **OMC 40 Horsepower Test (98) hrs** | |
| Average Piston Varnish | Equal to or better than reference - 0.6* |
| Top Ring Sticking | Equal to or better than reference - 0.6* |
| **OMC 70 Horsepower Test (98) hrs** | |
| Average Piston Deposits | Equal to or better than reference - 0.5* |
| Second Ring Stick | Equal to or better than reference based on formula * : 0.537 * Reference + 4.4 |
| **Mercury 15 Horsepower Test (100) hrs.** (2 consecutive passes are required) | |
| Circumferential Scuffing | Equal to or less than 15% |
| Compression Loss | Less than 20psig |
| Average Second Ring Sticking | Equal to or better than 8.0 |
| Average Second Land Deposits | Equal to or better than 6.0 |
| Ring Wiping | Less than 5% |
| Needle Bearing Stickiness - Original | Must Pass |
| Needle Bearing Stickiness - Proposed | Must Pass |
| **Yamaha CE50S Tightening / Lubricity Test** | |
| Torque Drop, Lb-in. | Equal to or less than reference ** within 90% confidence level |
| **Yamaha CE50S Preignition Test (100) hrs** | |
| Major preignitions | Equal to or less than reference * |
| **AF-27 Lubricity Test** | |
| Torque Loss, Nm | Equal to or less than reference oil XPA 3259 within 90% confidence limit |

**Note:**

* # 93738

** XPA-3259

(1) Some specifics read-across rules applied, check the Product Approval System (Specifications).

## Four-Stroke Classifications: JASO T903: 2006, 2011

| Requirements | | Performance Criteria | Test Procedure |
|---|---|---|---|
| Sulphated Ash, mass %, max. | | 1.2 | JIS-K-2272 |
| Phosphorus Content mass %, min. | | ≥ 0.08 and ≤ 0.12 | JPI-5S-38 |
| Evaporative Loss mass %, max. | | 20 | JPI-5S-41 |
| Foaming Tendency (foaming/settling) | Sequence I ml | 10/0 | JIS K 2518 |
| | Sequence II ml | 50/0 | |
| | Sequence III ml | 10/0 | |
| Shear Stability (Kinematic Viscosity (100˚C) $mm^2$/s, min. after test) | | xW-30: 9.0<br>xW-40: 12.0<br>xW-50: 15.0<br>Other grades: Stay-in-grade | JPI-5S-29 (1) |
| High temperature high shear viscosity mPa$^2$s | | 2.9 min | JPI-5S-36 |

Above requirements apply to both 2006 and 2011. Friction requirements below differ between 2006 and 2011 Specifications.

## Four-Stroke Classifications: JASO T903, 2006

| JASO T904 | Dynamic Friction Characteristic Index (DFI) | Static Friction Characteristic Index (SFI) | Stop Time Index (STI) |
|---|---|---|---|
| JASO MA | 1.45 ≤ DFI < 2.50 | 1.15 ≤ SFI < 2.50 | 1.55 ≤ STI < 2.50 |
| JASO MA1 | 1.45 ≤ DFI < 1.80 | 1.15 ≤ SFI < 1.70 | 1.55 ≤ STI < 1.90 |
| JASO MA2 | 1.80 ≤ DFI < 2.50 | 1.70 ≤ SFI < 2.50 | 1.90 ≤ STI < 2.50 |
| JASO MB | 0.50 ≤ DFI < 1.45 | 0.50 ≤ SFI < 1.15 | 0.50 ≤ STI <1.55 |

## Four-Stroke Classifications: JASO T903, 2011

| JASO T904 | Dynamic Friction Characteristic Index (DFI) | Static Friction Characteristic Index (SFI) | Stop Time Index (STI) |
|---|---|---|---|
| JASO MA | 1.30 ≤ DFI < 2.50 | 1.25 ≤ SFI < 2.50 | 1.45 ≤ STI < 2.50 |
| JASO MA1 | 1.30 ≤ DFI < 1.80 | 1.25 ≤ SFI < 1.70 | 1.45 ≤ STI < 1.85 |
| JASO MA2 | 1.85 ≤ DFI < 2.50 | 1.70 ≤ SFI < 2.50 | 1.85 ≤ STI < 2.50 |
| JASO MB | 0.50 ≤ DFI < 1.30 | 0.50 ≤ SFI < 1.25 | 0.50 ≤ STI <1.45 |

**Note:**

(1) Test shall be conducted by diesel injector method under the standard test conditions (30 cycles).

The JASO T903 specifications were implemented to ensure oils with the correct viscosity and friction characteristics were available in the market for four-stroke motorcycles. These oils must meet a minimum requirement of API SG, SH. SJ, SL, SM*, NS** or ILSAC GF-2, GF-3 or ACEA A1/B1, A3/B3, A5/B5, C2, C3, C4 and must meet these physical/chemical requirements in addition to the JASO T904: 2006 friction test.

* SM excluding SM-EC

** SN excluding SN-RC

## Four-Stroke Classifications: NMMA FCW

| Engine Tests | Test Method | Result |
|---|---|---|
| Kinematic Viscosity @ 40˚C | D445 | Report only |
| Viscosity Index | D2270 | Report only |
| Specific Gravity | D1298 OR D4052 | Report only |
| Total Base Number | D2896 | Report only |
| Total Acid Number | D664 | Report only |
| Elements | D4951, D4927 OR D4628 | Report only |
| Sulphur Content | D5453 | Report only |
| Nitrogen Content | D5291 OR D5762 | Report only |
| IR Spectrum | E1421 | Report only |
| Kinematic Viscosity @ 100˚C | D445 | Per SAE Grades |
| Cold Crank Viscosity | D5293 | Per SAE Grades |
| MRV-TP-1 Viscosity | D4684 | Per SAE Grades |
| Foam, Seq. I, ml | D892 | 10/0 maximum |
| Foam, Seq. II, ml | D892 | 50/0 maximum |
| Foam, Seq. III, ml | D892 | 10/0 maximum |
| Foam, Seq. IV, ml | D6082 | 200/50 maximum |
| Shear Stability, 30 cycles | D6278 | Report only |
| HTHS (after 30 cycles of D6278), cP | D4683, D4741 OR D548 | 3.3 minimum |
| Rust, % | NMMA FC-W® method | ≤ Reference Oil |
| NOACK Volatility, % | ASTM D5800 | Report only |
| EOFT, % change | GM 9099P | ≤ 50 |
| 115 HP Gen. Perf. Test | NMMA FC-W® method | A Pass is determined by inspection of the following parts;<br>Cam lobes<br>Cam caps<br>Cam journals<br>Cam bearings<br>Piston rings<br>Piston<br>Con rod bearing<br>Cylinder bore<br>Main bearing<br>Crank journals<br>Fuel pump lobe, reference only |

**Note:**
NMMA developed the FCW specifications for four-stroke outboard engines, in response to the increasing need for a dedicated lubricant for this application, as opposed to the use of a traditional passenger car engine oil. Oils seeking NMMA FCW approval must meet a minimum of API SG in addition to responding to the corrosion inhibition and anti-wear requirements of an outboard engine.

## OEM Specifications: General Motors dexos1™ and dexos2™

| Requirements | Parameter | Units | Limits | |
|---|---|---|---|---|
| | | | dexos1™ (Gasoline engines) | dexos2™ (Diesel engines) |
| Viscosity Classification Service Fill | SAE J300 | SAE Grade | 0W-20, 0W-30; 5W-20, 5W-30 | 0W-30, 5W-30; 0W-40, 5W-40 |
| Viscosity Classification Factory Fill | SAE J300 | SAE Grade | 5W-30 | 5W-30 |
| HTHS Viscosity | CEC-L-36-A-90, ASTM D4741 | mPa.s | xW-20 ≥ 2.6 | ≥ 3.5 |
| | | | xW-30 ≥ 2.9 | |
| Low Temperature Cranking Viscosity | ASTM D5293 | mPa.s | SAE 0W ≤ 6.200 @ -35 °C | SAE 0W ≤ 6.200 @ -35 °C |
| | | | SAE 5W ≤ 6.600 @ -30 °C | SAE 5W ≤ 6.600 @ -30 °C |
| Low Temperature Pumping Visc. -40°C (no yield stress) | ASTM D4684 | mPa.s | SAE 0W ≤ 40.000 SAE 5W Rate & Report | SAE 0W ≤ 40.000 SAE 5W Rate & Report |
| Low Temperature Pumping Visc. -35°C (no yield stress) | ASTM D4684 | mPa.s | SAE 5W ≤ 40.000 SAE 0W Rate & Report | SAE 5W ≤ 40.000 SAE 0W Rate & Report |
| Evaporative Loss (NOACK) | CEC-L-40-A-93, ASTM D5800/A | % wt. | ≤ 13.0 | ≤ 13.0 |
| Sulphated Ash | DIN 51 575, ASTM D874 | % wt. | ≤ 1.0 | ≤ 0.8 |
| Kin. Viscosity +100°C | DIN ISO 3104, ASTM D445 | mm²/s | 9.3 - <12.5 | SAE 30: 9.3 - <12.5 SAE 40: 12.5 - 16.3 |
| Total Base Number | DIN ISO 3771, ASTM D2896 | mg KOH/g | ≥ 6.0 | ≥ 6.0 |
| Chlorine | ISO 15597 (XRF) | mg / kg | ≤ 150 | ≤ 150 |
| Phosphorus | DIN 51 363-3, ASTM D4951 (ICP) DIN 51 363-2, ASTM 6443 (XRF) | mg / kg | ≤ 850 | 700-900 |
| Sulphur | DIN 51 400-10, ASTM D4951 (ICP) EN ISO 14596, ASTM D2622 (XRF) | mg / kg | ≤ 4500 | ≤ 3500 |
| Foaming Tendency / Stability | | | | |
| Sequence I (24°C) | ASTM D892 | | 10/0 | |
| Sequence II (94°C) | | | 50/0 | |
| Sequence III (24°C) | | | 10/0 | |
| HT Foaming Tendency | | | | |
| Sequence IV (150°C) | ASTM D6082 | ml | 100/0 | |
| Ball Rust Test | ASTM D6557 | avg. grey value | ≥ 100 | |
| Corrosion Performance | LBCH02-45[ISO 6270-2 (2005) & prep. acc. ASTM D6594, 8.3] | merit | 1 | 1 |
| Shear Stability - Bosch Injector (kin. Viscosity at 100°C) | CEC-L-14-A-93, DIN ISO 3104, ASTM D664 | mm²/s | SAE 20: ≥ 5.6 | SAE 30: ≥ 9.3 |
| | | | SAE 30: ≥ 9.3 | SAE 40: ≥ 12.5 |

## OEM Specifications: General Motors dexos1™ and dexos2™

| Requirements | Parameter | Units | Limits | |
|---|---|---|---|---|
| | | | dexos1™ (Gasoline engines) | dexos2™ (Diesel engines) |
| **Elastomer Test / Materials** | | | | |
| ACEA Elastomer - RE1 (FPM) | | | | |
| Hardness DIDC | CEC-L-39-T-96 | points | -1 / +5 | -1 / +5 |
| Tensile strength | | % | -40 / +10 | -40 / +10 |
| Elongation at rupture | | % | -50 / +10 | -50 / +10 |
| Volume variation | | % | -1 / +5 | -1 / +5 |
| ACEA Elastomer - RE4 (NBR) | | | | |
| Hardness DIDC | CEC-L-39-T-96 | points | -5 / +5 | -5 / +5 |
| Tensile strength | | % | -20 / +10 | -20 / +10 |
| Elongation at rupture | | % | -50 / +10 | -50 / +10 |
| Volume variation | | % | -5 / +5 | -5 / +5 |
| ACEA Elastomer - AEM | | | | |
| Hardness DIDC | VDA 675301 | Shore A | -5 / +10 | -5 / +10 |
| Tensile strength | | % | ≥ -35 | ≥ -35 |
| Elongation at rupture | | % | ≥ -50 | ≥ -50 |
| Volume variation | | % | -5 / +15 | -5 / +15 |
| SAE Elastomer - SAE J2643 ACM-1 | | | | |
| Hardness DIDC | ASTM D2240 | points | -5 / +5 | -5 / +5 |
| Tensile strength | ASTM D412 | % | -20 / +10 | -20 / +10 |
| Elongation at rupture | ASTM D412 | % | -35 / ±0 | -35 / ±0 |
| Volume variation | ASTM D471 | % | -5 / +5 | -5 / +5 |
| Change in tensile stress at 50% elongation | ASTM D412 | % | -10 / +35 | -10 / +35 |
| SAE Elastomer - SAE J2643 VMQ-1 | | | | |
| Hardness DIDC | ASTM D2240 | points | -20 / +10 | -20 / +10 |
| Tensile strength | ASTM D412 | % | -45 / ±0 | -45 / ±0 |
| Elongation at rupture | ASTM D412 | % | -40 / ±0 | -40 / ±0 |
| Volume variation | ASTM D471 | % | -5 / +40 | -5 / +40 |
| Change in tensile stress at 50% elongation | ASTM D412 | % | -50 / +10 | -50 / +10 |
| **Engine Tests - ACEA Gasoline** | | | | |
| Peugeot TU5JP-L4 High Temperature Deposits Ring Sticking Oil Thickening CEC-L-88-T-02 | Ring Sticking (each part) | merit | ≥ 9.0 | ≥ 9.0 |
| | Average Piston Varnish (6 elements) | merit | ≥ RL216 | ≥ RL216 |
| | Avg. Piston Varnish of RL216 | merit | - | - |
| | Absolute Viscosity Increase at 40°C between min. and max. values during test | $mm^2/s$ | ≤ 0.8 x RL216 | ≤ 0.8 x RL216 |
| | Absolute Viscosity Increase with RL216 | $mm^2/s$ | - | - |
| | Oil consumption | kg/test | RR | RR |

## OEM Specifications: General Motors dexos1™ and dexos2™

| Requirements | Parameter | Units | Limits | |
|---|---|---|---|---|
| | | | dexos1™ (Gasoline engines) | dexos2™ (Diesel engines) |
| **Engine Tests - ACEA Gasoline** | | | | |
| Sequence VG, Low Temperature Sludge, ASTM D6593 | Average Engine Sludge | merit | ≥ 8.3 | ≥ 8.3 |
| | Rocker Cover Sludge | merit | ≥ 8.5 | ≥ 8.5 |
| | Average Piston Skirt Varnish | merit | ≥ 7.5 | ≥ 7.5 |
| | Average Engine Varnish | merit | ≥ 8.9 | ≥ 8.9 |
| | Compression Ring (Hot Stuck) | - | None | None |
| | Oil Screen Clogging | % | ≤ 5 | ≤ 5 |
| Peugeot TU3M Wear Test, Valve Train, Scuffing Wear, CEC-L-38-A-94 | Average Cam Wear | µm | ≤ 10 | ≤ 10 |
| | Max. Cam Wear | µm | ≤ 15 | ≤ 15 |
| | Pad Merit (avg. of 8 pads) | merit | ≥ 7.5 | ≥ 7.5 |
| MB M111 Black Sludge, CEC-L-53-T-95 | Average Engine Sludge | merit | ≥ RL140 | ≥ RL140 |
| | Average Engine Sludge of RL140 | merit | Report | Report |
| | Average Cam Wear | µm | Rate & Report | Rate & Report |
| M111 Fuel Economy, CEC-L-54-T-96 | Fuel Economy Improvement vs. RL 191(SAE 15W-40) | % | Report (If results are available) | ≥ 2.0 |
| **Engine Tests - ILSAC Gasoline** | | | | |
| Sequence IIIG, High Temperature Deposits, Ring Sticking, Oil Thickening | Viscosity Increase at 100 hrs. | % | ≤ 150 | ≤ 150 |
| | Average weighted Piston Deposits | merit | ≥ 4.5 | ≥ 4.5 |
| | Hot stuck rings | | none | none |
| | Average Cam plus Lifer wear | µm | ≤ 60 | ≤ 60 |
| | Oil Consumption | kg/test | Rate & Report | Rate & Report |
| Sequence IIIGA, ASTM D4684 | Aged oil low temperature pumping viscosity | mPa.s | Meet requirement of original grade or next higher grade depending on results of ASTM D5293 | Meet requirement of original grade or next higher grade depending on results of ASTM D5293 |
| Sequence VIB, Fuel Economy, ASTM D6837 | Fuel Economy Improvement 1 | % | "xW-20 ≥ 2.3 xW-30 ≥ 1.8" | - |
| | Fuel Economy Improvement 2 | % | "xW-20 ≥ 2.0 xW-30 ≥ 1.5" | - |
| Sequence VIII, Bearing Corrosion, ASTM D6709 | Bearing weight loss | mg | ≤ 26 | ≤ 26 |
| | 10 hr stripped viscosity | mm²/s | Stay-in-grade | Stay-in-grade |

## OEM Specifications: General Motors dexos1™ and dexos2™

| Requirements | Parameter | Units | Limits | |
|---|---|---|---|---|
| | | | dexos1™ (Gasoline engines) | dexos2™ (Diesel engines) |
| **Engine Tests - ACEA Light Duty Diesel** | | | | |
| DV4TD, Medium Temperature Dispersivity, CEC-L-093 | Absolute Viscosity Increase at +100°C and 6% soot | $mm^2/s$ | - | ≤ 0.60 x RL223 |
| | Absolute Viscosity Increase of RL223 | $mm^2/s$ | - | - |
| OM 646 LA, Wear, Viscosity Stability, Oil Consumption, Draft CEC-L-099 | Average Cam Wear | µm | - | tbd |
| | Viscosity Increase @ +40°C | % | - | tbd |
| | Bore Polishing | % | - | tbd |
| | Average Cylinder Wear | µm | - | tbd |
| | Oil Consumption | kg / test | - | tbd |
| VW DI, Diesel Piston Cleanliness, Ring Sticking, CEC-L-78-T-99 | Piston Cleanliness | merit | | ≥ RL206 |
| | Piston Cleanliness of RL206 | merit | | |
| | Ring Sticking (rings 1 & 2) | | | |
| | Average all 8 rings | ASF | | ≤ 1.2 |
| | Maximum for any 1st ring | ASF | | ≤ 2.5 |
| | Maximum for any 2nd ring | ASF | | ≤ 0.0 |
| | TBN (DIN ISO 3771) | mgKOH/g | | RR |



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## OEM Specifications: General Motors dexos1™ and dexos2™

| Requirements | Parameter | Units | Limits | |
|---|---|---|---|---|
| | | | dexos1™ (Gasoline engines) | dexos2™ (Diesel engines) |
| **Engine Tests - GM** | | | | |
| Oil Release Test Gasol. Engines (OP1), GMPTE-T DUR020 | Function Test, Oil pressure | bar | OK | OK |
| | Run in oil consumption | g/h | 15-39 | 15-39 |
| | Kin. Viscosity Increase @ +40°C, DIN ISO 3104 | ^% | ≤ 130 | ≤ 130 |
| | Total Acid Number after Test, ASTM D664 | mgKOH/g | ≤ 8.0 | ≤ 8.0 |
| | Nitration after Test, DIN 51 453 | A/cm | ≤ 30 | ≤ 30 |
| Aeration Test, GMPTE-T MEC024 | Aeration rate of Candidate Oil vs. Reference Oil | | Candidate Oil ≤ Reference Oil | Candidate Oil ≤ Reference Oil |
| | Maximum Difference in Aeration of aged Candidate Oil vs. Reference Oil | % | Aged Candidate oil - fresh Reference oil < +2 | Aged Candidate oil - fresh Reference oil < +2 |
| Valve Train Wear Test, Radionuclid - Method, GMPTE-T DUR021 | Maximum Cam Wear | nm/h | ≤ 5.0 | ≤ 5.0 |
| | Maximum Tappet Wear | nm/h | ≤ 2.0 | ≤ 2.0 |
| Oil Release Test, Diesel Engines, GMPTE-T DUR019, Duration: 400 hrs. | Piston Ring Clearance 1st ring (avg.) | mm | - | ≤ 0.05 |
| | Piston Ring Clearance 2nd ring (avg.) | mm | - | ≤ 0.15 |
| | Piston Ring Clearance 3rd ring (avg.) | mm | - | ≤ 0.08 |
| | Con Rod Bearing Wear | µm | - | ≤ 3 |
| | Main bearing Wear (avg.) | µm | - | ≤ 3 |
| | Average Camshaft Wear (avg.) | µm | - | ≤ 10 |
| | Timing Chain Elongation | mm | - | ≤ 0.8 |
| | Duplex Chain Elongation | mm | - | ≤ 0.7 |
| | Balancer Chain Elongation | mm | - | ≤ 1.5 |
| | Piston Cleanliness | merit | - | RR |
| | Oil Consumption (max.) | g/h | - | ≤ 15 |
| | Blow-by (max.) | L/min | - | ≤ 50 |
| | Viscosity Increase @ +100°C and 2,5% wt. soot (DIN 51 452), DIN ISO 3104 | $mm^2/s$ | - | ≤ 6 |

## OEM Specifications: Mercedes Benz Sheets For Passenger Car Engine Oils v.2009.1

| Sheet Number | Units | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 |
|---|---|---|---|---|---|---|
| **Viscosity Requirements** | | | | | | |
| Mono / Multigrade | | Multi | Multi | Multi | Multi | Multi |
| Viscosity Grades | SAE | acc. ACEA | 0W-, 5W-, 10W-X | 0W-, 5W-, 10W-X | 0W-, 5W-, 10W-X | 0W-, 5W-, 10W-X |
| **Read-Across Guidelines** | | | | | | |
| MB Read-Across (1) | RA | yes | yes | yes | yes | yes |
| MB Package Pass (1) | RA | no | no | no | no | no |
| ACEA Oil Sequences required | ACEA | When any ACEA Ax, Bx, Cx or Ex oil sequence is claimed, then all tests within this oil sequence are mandatory | | | | |
| API Oil Categories required, min. | API | - | - | - | - | - |
| DDC Oil Specification level | PGOS | - | - | - | - | - |
| **Laboratory Tests** | | | | | | |
| Sulphated ash (DIN 51575 or ASTM D874) | %b.w | > 0,8 & ≤ 1,5 | > 0,8 & ≤ 1,5 | ≤ 0,8 | > 0,8 & ≤ 1,5 | ≤ 0,8 |
| TBN (ISO 3771 or ASTM D2896 fresh oil) | mg KOH/g | 6.0 | 7.0 | 6.0 | 8.0 | 6.0 |
| TBN (ASTM D4739 fresh oil) | mg KOH/g | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Pour Point ( ISO 3016 or ASTM D97) | °C | -27 | -27 | -27 | -27 | -27 |
| Evaporative loss CEC-L-40-A-93, NOACK | % | 13 | 13 | 12 | 10 | 10 |
| Viscosity HTHS, CEC-L-36-A-90, i3 2nd edition | mPa.s | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Zinc, min. (DIN 51391 -2/-3 or ASTM D5185 / 6443) | % b.w | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| Sulphur (DIN EN ISO 14596 or ASTM D5185 / 2622) | % b.w | Rate & Report | 0.5 | 0.3 | 0.5 | 0.3 |
| Phosphorus (DIN 51363 -2/-3 / ASTM D5185 / 4951) | % b.w | Rate & Report | 0,05 - 0,11 | 0,05 - 0,09 | 0,05 - 0,11 | 0,05 - 0,09 |
| Chlorine (DIN ISO 15597:2006-01 or ASTM D6443) | % b.w | Rate & Report | 0,0150 | 0,0150 | 0,0150 | 0,0150 |

**Note:**

(1) Read-Across only according to MB Read-Across Guidelines for engine tests (based on latest ATC and ATIEL Code of Practice).
MB Package Pass only for Mineral Oils (SN, ATIEL Grp. I & II) and for SAE 15W-40, 20W-40, 15W-50, 20W-50.

## OEM Specifications: Mercedes Benz Sheets For Passenger Car Engine Oils v.2009.1

| Sheet Number | Units | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 |
|---|---|---|---|---|---|---|
| **Laboratory Tests (continued)** | | | | | | |
| Oxidation Test (DAI In-house Method) | | | | | | |
| Variation KV @ 100°C Relative | % | Equal or better than ref oil | Equal or better than ref oil | Equal or better than ref oil | Equal or better than ref oil | Equal or better than ref oil |
| Variation KV @ 100°C Absolute | $mm^2/s$ | Equal or better than ref oil | Equal or better than ref oil | Equal or better than ref oil | Equal or better than ref oil | Equal or better than ref oil |
| Oxidation DIN 51 453 | A/cm | Equal or better than ref oil | Equal or better than ref oil | Equal or better than ref oil | Equal or better than ref oil | Equal or better than ref oil |
| SRV (Schwing Reib Verschleiß) (DAI Method) COF* after 3 hrs | | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.3 |
| Deposit test (MTU, DIN 51535) | mg | - | - | - | - | - |
| TC Perfom. test CEC-TDG-L-100 - when ready | mg | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **Sooted Oil MRV T11/11A ASTM D6896** | | | | | | |
| 180 hr sample T-11/T11 A drain MRV | mPa.s | - | - | - | - | - |
| MRV Yield Stress | Pa | - | - | - | - | - |
| **Corrosion Tendency ASTM D6594 (135°C, HTCBT)** | | | | | | |
| Cu, ppm increase | ppm | | | | | |
| Pb, ppm increase | ppm | | | | | |
| Copper strip rating | | | | | | |
| **Shear Stability CEC-L-14-93, ASTM D6278 / 7109** | | Pass @ 30 cyl | Pass @ 30 cyl | Pass @ 30 cyl | Pass @ 90 cyl | Pass @ 90 cyl |
| Kinematic Viscosity after 30 / 90 Pass Shearing @ 100°C | $mm^2/s$ | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade |
| **Foaming Tendency** | | Pass | Pass | Pass | Pass | Pass |
| Sequence I (24°C) ASTM D892 w/o option A | ml | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 |
| Sequence II (94°C) ASTM D892 w/o option A | ml | 50 / 0 | 20 / 0 | 20 / 0 | 20 / 0 | 20 / 0 |
| Sequence III (24°C) ASTM D892 w/o option A | ml | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 |
| Sequence IV (150°C) ASTM D6082 | ml | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Related DBL | DBL | 6615 | 6615 | 6615 | 6615 | 6615 |
| Elastomer Compatibility (2) | DBL | Pass | Pass | Pass | Pass | Pass |

**Note:** (2) Elastomer compatibility tests according to VDA 675301 and DBL 6674 / 6610 / 6615 with materials NBR34, AK6, ACM E7503, VMQ RE3-04 and EAM D8948-200.1. Limits according to DBL 6610 / 6615.

## OEM Specifications: Mercedes Benz Sheets For Passenger Car Engine Oils v.2009.1

| Sheet Number | Units | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 |
|---|---|---|---|---|---|---|
| ***Engine Tests (x = number of tests for Package Pass)*** | | | | | | |
| **M 271 (MB DL, Sludge)** (3) | | | | | | |
| Engine sludge avg. (with fuel batch 1), merit, min. | | 8.5 | 8.8 | 8.8 | 9.1 | 9.1 |
| **M 271 (MB DL, Wear, 250 hrs.)** (3) | | Pass | Pass | Pass | Pass | Pass |
| Cam wear inlet / outlet valve (avg. max. wear 8 cams) | µm | 5,0 / 5,0 | 5,0 / 5,0 | 5,0 / 5,0 | 5,0 / 5,0 | 5,0 / 5,0 |
| Piston Ring wear radial @ ring 1 / ring 2 (avg.) (4) | µm | 5,0 / 12,0 | 5,0 / 12,0 | 5,0 / 12,0 | 5,0 / 12,0 | 5,0 / 12,0 |
| Piston Ring wear axial @ ring 1 / groove 1 (avg.) (4) | µm | 5,0 / 15,0 | 5,0 / 15,0 | 5,0 / 15,0 | 5,0 / 15,0 | 5,0 / 15,0 |
| Ring sticking | Yes/No | no | no | no | no | no |
| Main Bearing wear (avg.) (4) / (max.) | µm | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 |
| Conrod Bearing wear (avg.) (4) / (max.) | µm | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 |
| Timing Chain wear (elongation) | % | 0,25 | 0,25 | 0,25 | 0,25 | 0,25 |
| Timing Chain wear (single chain link) | % | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| Timing Chain wear (single chain link), %, max. | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **M 111 (CEC SG-L-54)** | | | Pass | Pass | Pass | Pass |
| Fuel economy improvement vs. RL 191 (15W-40) | % | - | 1,0 | 1,0 | 1,7 | 1,7 |

**Note:**

(3) Re-rating by Daimler at EP/MOR for all related engine parts.

(4) The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.

## OEM Specifications: Mercedes Benz Sheets For Passenger Car Engine Oils v.2009.1

| Sheet Number | Units | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 |
|---|---|---|---|---|---|---|
| **OM 646 DE22 LA (CEC SG-L-099)** (3) | | Pass | Pass | Pass | Pass | Pass |
| Cam wear inlet (avg. max. wear 8 cams) | µm | 120 | 110 | 110 | 100 | 100 |
| Cam wear outlet (avg. max. wear 8 cams) | µm | 155 | 140 | 140 | 120 | 120 |
| Cylinder wear (avg. 4 cylinder) | µm | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 |
| Bore polishing (13 mm) - max. value of 4 cyl. | % | 4,0 | 3.5 | 3.5 | 3.0 | 3.0 |
| Piston cleanliness (avg. 4 pistons) | merit | 10,0 | 12.0 | 12.0 | 14.0 | 14.0 |
| Engine sludge avg. | merit | 8,5 | 8,7 | 8,7 | 9,0 | 9,0 |
| Ring sticking | yes/no | no | no | no | no | no |
| Tappet wear inlet (avg. max. wear 8 cams) | µm | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Tappet wear outlet (avg. max. wear 8 cams) | µm | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |

**Note:**

(3) Re-rating by Daimler at EP/MOR for all related engine parts.

## OEM Specifications: Mercedes Benz Sheets For Passenger Car Engine Oils v.2009.1

| Sheet Number | Units | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 |
|---|---|---|---|---|---|---|
| **OM 646 DE22 LA (CEC SG-L-099)** (3) | | Pass | Pass | Pass | Pass | Pass |
| Bearing wear main / con rod bearing | µm | 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 (4) | µm | 10,4 | 10,4 | 10,4 | 8,7 | 8,7 |
| Piston ring wear axial @ ring 2 (4) | µm | 6,0 | 6,0 | 6,0 | 4.0 | 4.0 |
| Piston ring wear axial @ ring 3 (4) | µm | 5,0 | 5,0 | 5,0 | 3.0 | 3.0 |
| Piston ring wear radial @ ring 1 (4) | µm | 10,0 | 10,0 | 10,0 | 10,0 | 10,0 |
| Piston ring wear radial @ ring 2 (4) | µm | 12,0 | 12,0 | 12,0 | 12,0 | 12,0 |
| Piston ring wear radial @ ring 3 (4) | µm | 8,0 | 8,0 | 8,0 | 8,0 | 8,0 |
| Timing chain wear (elongation) | % | 0,4 | 0,4 | 0,4 | 0,4 | 0,4 |
| Oil consumption | g/test | 7000 | 7000 | 7000 | 7000 | 7000 |
| Soot | % | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 |
| Viscosity increase at 100°C | % | 100 | 100 | 100 | 90 | 90 |

**Note:**

(3) Re-rating by Daimler at EP/MOR for all related engine parts.

(4) The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.

## OEM Specifications: Mercedes Benz Sheets For Passenger Car Engine Oils v.2009.1

| Sheet Number | Units | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 |
|---|---|---|---|---|---|---|
| NEFZ Dyno Test - when ready | | | | | | |
| Chassis: W204 C250CDI / Engine: OM 651 | % | tbd | tbd | tbd | tbd | tbd |
| Chassis: W204 C350CDI / Engine: OM 642 | % | tbd | tbd | tbd | tbd | tbd |
| Chassis: W204 C200K / Engine: M271 ML18 | % | tbd | tbd | tbd | tbd | tbd |
| Chassis: W204 C350CGI / Engine: M272 DE35 | % | tbd | tbd | tbd | tbd | tbd |
| VW TDI (CEC-SG-L-078) | | Pass | Pass | Pass | Pass | Pass |
| Piston cleanliness (avg.) | merit | RL 206 - 4 | RL 206 | RL 206 | RL 206 | RL 206 |
| All other requirements as listed in ACEA B4 & C3-08 | Pass | B3 | B4 | C3 | B4 | C3 |
| VW PV 1449 | | - | Pass | Pass | Pass | Pass |
| VW 502.00 or PV 1449 | Pass | | Yes | Yes | Yes | Yes |

## OEM Specifications: Mercedes-Benz Sheets For Passenger Car Engine Oils v.2012.2

| Sheet Number [1] | Units | 226.5 | 226.51 | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 | 229.52 |
|---|---|---|---|---|---|---|---|---|---|
| **Viscosity Requirements** | | | | | | | | | |
| Mono / Multigrade | | multi | multi | multi | multi | multi | multi | multi | multi |
| Viscosity Grades | SAE | 0W-30, -40<br>5W-30, -40<br>10W-40 | 0W-30, -40<br>5W-30, -40 | acc. ACEA | 0W-, 5W-,<br>10W-X | 0W-, 5W-,<br>10W-X | 0W-, 5W-,<br>10W-X | 0W-, 5W-,<br>10W-X | 0W-, 5W-X |
| SAE XW-30 and 0W-40 | Possible | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Read-Across Guidelines** | | | | | | | | | |
| MB Read-Across [2] | RA | No | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Package Pass [2] | RA | No | No | No | No | No | No | No | No |
| ACEA Oil sequence required | ACEA | | | | | | | | |
| API Oil Categories required min. | API | - | - | - | - | - | - | - | - |
| DDC Oil Specification level | PGOS | - | - | - | - | - | - | - | - |
| RN Oil specification - RN approval letter mandatory | RN Spec | RN0710 | RN0720 | - | - | - | - | - | - |
| **Laboratory Tests** | | | | | | | | | |
| Sulphated ash (DIN 51575 or ASTM D874) | %b.w | ≥0,7 & <1,5 | ≤ 0,5 | > 0,8 & ≤ 1,5 | > 0,8 & ≤ 1,5 | ≤ 0,8 | > 1,0 & ≤ 1,6 | ≤ 0,8 | ≤ 0,8 |
| TBN (ISO 3771 or ASTM D2896 fresh oil) | mgKOH/g | 8,0 | 6,0 | 6,0 | 7,0 | 6,0 | 10,0 | 6,0 | 6,0 |
| TBN (ASTM D4739 fresh oil) | mgKOH/g | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Pour Point ( ISO 3016 or ASTM D97) | °C | Rate & Report | Rate & Report | -27 | -27 | -27 | -27 | -27 | -36 |
| Evaporative loss CEC L-40-A-93, ASTM D5800, NOACK | % | 12 | 11 | 13 | 13 | 12 | 10 | 10 | 10 |
| Viscosity @ HTHS (CEC L-36-90) | mPa.s | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 |
| Zinc, min (DIN 51391 -2/-3 or ASTM D5185 / 6443) | % b.w | Rate & Report | Rate & Report | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 |
| Sulfur (DIN EN ISO 14596 or ASTM D5185 / 2622) | % b.w | Rate & Report | 0,2 | Rate & Report | 0,5 | 0,3 | 0,5 | 0,3 | 0,3 |
| Phosphorus (DIN 51363 -2/-3 / ASTM D5185 / 4951) | % b.w | Rate & Report | 0,9 | Rate & Report | 0,05 - 0,11 | 0,05 - 0,09 | 0,05 - 0,11 | 0,05 - 0,09 | 0,05 - 0,09 |
| Chlorine (DIN ISO 15597:2006-01 or ASTM D6443) | % b.w | Rate & Report | Rate & Report | Rate & Report | 0,0150 | 0,0150 | 0,0150 | 0,0150 | 0,0100 |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(2) Read-Across only according to MB Read-Across Guidelines for engine tests (based on latest ATC and ATIEL Code of Practice). MB Package Pass only for Mineral Oils (SN, ATIEL Grp. I & II) and for SAE 15W-40, 20W-40, 15W-50, 20W-50.



Afton CHEMICAL

## OEM Specifications: Mercedes-Benz Sheets For Passenger Car Engine Oils v.2012.2 - Cont'd

| Sheet Number [1] | Units | 226.5 | 226.51 | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 | 229.52 |
|---|---|---|---|---|---|---|---|---|---|
| **Laboratory Tests (continued)** | | | | | | | | | |
| Daimler Oxidation Test - Fresh Oil (Daimler Oxidation Test Procedure) [3] | | | | Pass | Pass | Pass | Pass | Pass | Pass |
| Kin. Viscosity @ 100°C, EOT 168 hrs, avg. of 3 runs | mm²/s | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Oxidation DIN 51453 @ EOT 168 hrs, avg. of 3 runs | A/cm | - | - | Rate & Report | 60 | 60 | 25 | 25 | 20 |
| Delta Kin. Viscosity KV100 avg. of 3 runs - absolute | mm²/s | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Delta Kin. Viscosity KV100 avg. of 3 runs - relative | % | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | 50 |
| Daimler Oxidation Test with Fuel Dilution 5% B100 (FAME from OM 646 Biodiesel Test) [3] | | | | Pass | Pass | Pass | Pass | Pass | Pass |
| Kin. Viscosity @ 100°C, EOT 168 hrs, avg. of 3 runs | mm²/s | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Oxidation DIN 51453 @ EOT 168 hrs, avg. of 3 runs | A/cm | - | - | Rate & Report | 120 | 120 | 80 | 80 | 40 |
| Delta Kin. Viscosity KV100 avg. of 3 runs - absolute | mm²/s | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Delta Kin. Viscosity KV100 avg. of 3 runs - relative | % | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | 50 |
| TOC Oxidation Test (D55 3099) | | Pass | Pass | - | - | - | - | - | - |
| TAN | mg KOH/g | R&R @ 80 hrs | R&R @ 96 hrs | - | - | - | - | - | - |
| PAI CO | | 400 @ 80 hrs | 400 @ 96 hrs | - | - | - | - | - | - |
| Variation of viscosity at 40°C @ 96 hrs | % | 200 | 200 | - | - | - | - | - | - |
| Variation of viscosity at 100°C | % | R&R @ 80 hrs | R&R @ 96 hrs | - | - | - | - | - | - |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.



Afton CHEMICAL

## OEM Specifications: Mercedes-Benz Sheets For Passenger Car Engine Oils v.2012.2 - Cont'd

| Sheet Number [1] | Units | 226.5 | 226.51 | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 | 229.52 |
|---|---|---|---|---|---|---|---|---|---|
| **Laboratory Tests (continued)** | | | | | | | | | |
| **MCT Cokefaction Test (GFC Lu 27)** | merit cot. 1 | 7,0 | 7,0 | - | - | - | - | - | - |
| **SRV (Schwing Reib Verschleib) Test (MBN 10474)** [3] | MBN 10474 | | | Pass | Pass | Pass | Pass | Pass | Pass |
| Load carrying capacity avg. 5 runs - fresh oil | N | - | - | 100 | 100 | 100 | 100 | 100 | 100 |
| Coefficient of friction avg. 5 runs - fresh oil | µm | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Load carrying capacity avg. 5 runs - aged oil | N | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Coefficient of friction avg. 5 runs - aged oil | µm | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **CEC Low Temperature Pumping Test (CEC-TDG-L 105)** [3] | | | | Pass | Pass | Pass | Pass | Pass | Pass |
| MRV @ SAE J300 fresh oil temperature | mPa s | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| MRV @ SAE J300 fresh oil temperature +5°C | mPa s | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Yield Stress (≤35 = no yield stress) | Pa | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **Deposit test (MTU, DIN 51535)** | mg | - | - | - | - | - | - | - | - |
| **Sooted Oil MRV T11/11A ASTM D6896** | | | | | | | | | |
| 180 hr sample T-11/T11 A drain MRV | mPa s | - | - | - | - | - | - | - | - |
| MRV Yield Stress | Pa | - | - | - | - | - | - | - | - |
| **High Temperature Corrosion Bench Test HTCBT (modified ASTM D6594 @ 135°C)** [3] | | | | - | Pass | Pass | Pass | Pass | Pass |
| Cu, ppm increase - w/o & with 10% B100 RME/SME* | ppm | - | - | - | R&R/ R&R | R&R/ R&R | R&R/ R&R | R&R/ R&R | R&R/ R&R |
| Pb, ppm increase - w/o & with 10% B100 RME/SME* | ppm | - | - | - | R&R/ R&R | R&R/ R&R | R&R/ R&R | R&R/ R&R | R&R/ R&R |
| Copper strip rating - w/o & with 10% B100 RME/SME* | ppm | - | - | - | R&R/ R&R | R&R/ R&R | R&R/ R&R | R&R/ R&R | R&R/ R&R |
| * Reference Fuel B100 (80% RME +20% SME) from OM 646 TDG-L104 | | | | | | | | | |
| **Shear Stability CEC-L-14-93, ASTM D6278 / 7109** | | Pass @ 30 cycles | Pass @ 30 cycles | Pass @ 30 cycles | Pass @ 30 cycles | Pass @ 30 cycles | Pass @ 90 cycles | Pass @ 90 cycles | Pass @ 90 cycles |
| Kin.Viscosity after 30 / 90 pass Shearing @ 100°C | $mm^2/s$ | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.



Afton CHEMICAL

## OEM Specifications: Mercedes-Benz Sheets For Passenger Car Engine Oils v.2012.2 - Cont'd

| Sheet Number (1) | Units | 226.5 | 226.51 | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 | 229.52 |
|---|---|---|---|---|---|---|---|---|---|
| **Laboratory Tests (continued)** | | | | | | | | | |
| Foaming tendency | | | | Pass | Pass | Pass | Pass | Pass | Pass |
| Sequence I (24°C) ASTM D892 w/o option A | ml | 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 | 10 / 0 | 10 / 0 | 50 / 0 | 20 / 0 | 20 / 0 | 20 / 0 | 20 / 0 | 20 / 0 |
| Sequence III (24°C) ASTM D892 w/o option A | ml | 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. settle period | ml | 100 / 0 | 100 / 0 | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Elastomer Compatibility - (CEC-L-39-96) (4) | ACEA | ACEA A3/B3 | ACEA C4 | ACEA A3/B4 | ACEA A3/B4 | ACEA C3 | ACEA A3/B4 | ACEA C3 | ACEA C3 |
| Related Daimler Liefervorschrift | DBL | | | 6615 | 6615 | 6615 | 6615 | 6615 | 6615 |
| **Engine Tests (x = number of tests for Package Pass) (5)** | | | | | | | | | |
| **M 271 Sludge Test (M 271 Classic Sludge DL) Until M 271 EVO Sludge (CEC-TDG-L 107) is ready @ CEC (3)** | | | | Pass | Pass | Pass | Pass | Pass | Pass |
| Engine sludge avg. | merit | RL 140 + 4σ | RL 140 + 4σ | 8,5 | 8,8 | 8,8 | 9,1 | 9,1 | 9,1 |
| **M 271 EVO Sludge Test (CEC-TDG-L107) when ready @ CEC as alternative to M 271 Sludge Test (3)** | | | | Pass | Pass | Pass | Pass | Pass | Pass |
| Engine sludge avg. | merit | - | - | 8,5 | 8,8 | 8,8 | 9,1 | 9,1 | 9,1 |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.

(4) Elastomer compatibility tests according to ACEA 2012 or to DBL 6674 / 6610 / 6615 with materials NBR34, AK6, ACM E7503, VMQ RE3-04 and EAM D8948-200.1. Limits according to DBL 6610 / 6615.

(5) Approval conditions for engine oils for natural gas (CNG) engines: positive field test with MB CNG busses or a pass result in a 500 hrs CNG engine test by MB do Brasil or a Read-Across from MAN M 3271 approval.

## OEM Specifications: Mercedes-Benz Sheets For Passenger Car Engine Oils v.2012.2 - Cont'd

| Sheet Number [1] | Units | 226.5 | 226.51 | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 | 229.52 |
|---|---|---|---|---|---|---|---|---|---|
| **Engine Tests (x = number of tests for Package Pass)** [5] | | | | | | | | | |
| **M 271 (MB DL, Wear, 250 hrs)** [3] | | | | Pass | Pass | Pass | Pass | Pass | Pass |
| Cam wear inlet / outlet valve (avg. max. wear 8 cams) | µm | - | - | 5,0 / 5,0 | 5,0 / 5,0 | 5,0 / 5,0 | 5,0 / 5,0 | 5,0 / 5,0 | 5,0 / 5,0 |
| Piston ring wear radial @ ring 1 / ring 2 (avg.) [6] | µm | - | - | 5,0 / 12,0 | 5,0 / 12,0 | 5,0 / 12,0 | 5,0 / 12,0 | 5,0 / 12,0 | 5,0 / 12,0 |
| Piston ring wear axial @ ring 1 / groove 1 (avg.) [6] | µm | - | - | 5,0 / 15,0 | 5,0 / 15,0 | 5,0 / 15,0 | 5,0 / 15,0 | 5,0 / 15,0 | 5,0 / 15,0 |
| Ring sticking | yes/no | - | - | No | No | No | No | No | No |
| Main Bearing wear (avg.) [6] / (max.) | µm | - | - | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 |
| Conrod Bearing wear (avg.) [6] / (max.) | µm | - | - | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 | 1,5 / 3,5 |
| Timing chain wear (elongation) | % | - | - | 0,25 | 0,25 | 0,25 | 0,25 | 0,25 | 0,25 |
| Timing chain wear (single chain link) | % | - | - | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| Bore polishing (xmm) - max. value of 6 cylinders | % | - | - | t.b.d | t.b.d | t.b.d | t.b.d | t.b.d | t.b.d |
| **M 111 Fuel Economy (CEC L-54-96)** [3] | | | | | Pass | Pass | Pass | Pass | Pass |
| Fuel economy improvement vs. RL 191 (15W-40) | % | 1,0 (for xW-30 C3) | 1,0 (for xW-30) | - | 1,0 | 1,0 | 1,7 | 1,7 | 1,7 |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.

(5) Approval conditions for engine oils for natural gas (CNG) engines: positive field test with MB CNG busses or a pass result in a 500 hrs CNG engine test by MB do Brasil or a Read-Across from MAN M 3271 approval.

(6) The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.

# OEM Specifications: Mercedes-Benz Sheets For Passenger Car Engine Oils v.2012.2 - Cont'd

| Sheet Number [1] | Units | 226.5 | 226.51 | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 | 229.52 |
|---|---|---|---|---|---|---|---|---|---|
| **Engine Tests (x = number of tests for Package Pass)** [5] | | | | | | | | | |
| **MB Fuel Economy Test - FE-Benefit in NEDC (PC Chassis Dynamometer Test) 0W-30/-40 and 5W-30/-40 vs MB RL001 Otto & MB RL002 Diesel** [3] | | | | | Pass | Pass | Pass | Pass | Pass |
| FE-Benefit in W204 C250 CDI / Engine: OM651 vs MB RL002 | % | - | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | 1,0 |
| FE-Benefit in W204 C350 CDI / Engine: OM642 vs MB RL002 | % | - | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | 1,0 |
| FE-Benefit in W204 C200 K / Engine: M 271 ML 18 vs MB RL001 | % | - | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| FE-Benefit in W204 C350 CGI / Engine: M 272 DE35 vs MB RL001 | % | - | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **OM 646 DE22LA Biodiesel Test (CEC-L-104)** [3] | | | | Pass | Pass | Pass | Pass | Pass | Pass |
| Piston cleanliness (avg. 4 pistons) | merit | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Engine sludge avg. | merit | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Ring sticking | yes/no | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| TBN (ASTM D4739) @ end of test | mgKOH/g | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| TAN (ASTM D664) @ end of test | mgKOH/g | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Oil consumption | g/test | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Soot | % | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Viscosity increase at 100°C | % | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **OM 646 DE22LA (CEC-SG-L-099)** [3] | | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Cam wear inlet (avg. max. wear 8 cams) | µm | 100 | 100 | 120 | 100 | 100 | 90 | 90 | 90 |
| Cam wear outlet (avg. max. wear 8 cams) | µm | 120 | 120 | 155 | 130 | 130 | 110 | 110 | 110 |
| Cylinder wear (avg. 4 cylinder), max. | µm | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 |
| Bore polishing (13 mm) - max. value of 4 cyl. | % | 3,0 | 3,0 | 4,0 | 3,5 | 3,5 | 3,0 | 3,0 | 3,0 |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.

(5) Approval conditions for engine oils for natural gas (CNG) engines: positive field test with MB CNG busses or a pass result in a 500 hrs CNG engine test by MB do Brasil or a Read-Across from MAN M 3271 approval.

## OEM Specifications: Mercedes-Benz Sheets For Passenger Car Engine Oils v.2012.2 - Cont'd

| Sheet Number (1) | Units | 226.5 | 226.51 | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 | 229.52 |
|---|---|---|---|---|---|---|---|---|---|
| **Engine Tests (x = number of tests for Package Pass) (5)** | | | | | | | | | |
| OM 646 DE22LA (CEC-SG-L-099) (3) | | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Piston cleanliness (avg. 4 pistons), min. | merit | Rate & Report | Rate & Report | 10,0 | 12,0 | 12,0 | 14,0 | 14,0 | 14,0 |
| Engine sludge avg, min. | merit | Rate & Report | Rate & Report | 8,6 | 8,8 | 8,8 | 9,1 | 9,1 | 9,1 |
| Ring sticking | yes/no | Rate & Report | Rate & Report | no | no | no | no | no | no |
| Tappet wear inlet (avg. max. wear 8 cams) | µm | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Tappet wear outlet (avg. max. wear 8 cams) | µm | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Bearing wear main / con rod bearing (6), max. | µm | 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 |
| Piston ring wear axial @ ring 1 (6), max. | µm | Rate & Report | Rate & Report | 10,4 | 10,4 | 10,4 | 8,7 | 8,7 | 8,7 |
| Piston ring wear axial @ ring 2 (6), max. | µm | Rate & Report | Rate & Report | 6,0 | 6,0 | 6,0 | 4,0 | 4,0 | 4,0 |
| Piston ring wear axial @ ring 3 (6), max. | µm | Rate & Report | Rate & Report | 5,0 | 5,0 | 5,0 | 3,0 | 3,0 | 3,0 |
| Piston ring wear radial @ ring 1 (6), max. | µm | Rate & Report | Rate & Report | 10,0 | 10,0 | 10,0 | 10,0 | 10,0 | 10,0 |
| Piston ring wear radial @ ring 2 (6), max. | µm | Rate & Report | Rate & Report | 12,0 | 12,0 | 12,0 | 12,0 | 12,0 | 12,0 |
| Piston ring wear radial @ ring 3 (6), max. | µm | Rate & Report | Rate & Report | 8,0 | 8,0 | 8,0 | 8,0 | 8,0 | 8,0 |
| Timing chain wear (elongation), max. | % | Rate & Report | Rate & Report | 0,4 | 0,4 | 0,4 | 0,4 | 0,4 | 0,4 |
| Oil consumption, max. | g/test | Rate & Report | Rate & Report | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 |
| Soot, max. | % | Rate & Report | Rate & Report | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 |
| Viscosity increase at 100°C, max. | % | Rate & Report | Rate & Report | 100 | 100 | 100 | 90 | 90 | 90 |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.

(5) Approval conditions for engine oils for natural gas (CNG) engines: positive field test with MB CNG busses or a pass result in a 500 hrs CNG engine test by MB do Brasil or a Read-Across from MAN M 3271 approval.

(6) The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.

## OEM Specifications: Mercedes-Benz Sheets For Passenger Car Engine Oils v.2012.2 - Cont'd

| Sheet Number [1] | Units | 226.5 | 226.51 | 229.1 | 229.3 | 229.31 | 229.5 | 229.51 | 229.52 |
|---|---|---|---|---|---|---|---|---|---|
| **VW TDI (CEC-SG-L-078-99)** | | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Piston cleanliness (avg.) | merit | RL206 | RL206 | RL 206-4 | RL 206 | RL 206 | RL 206 | RL 206 | RL 206 |
| All other requirements as listed in ACEA 2010 | Pass | A5/B5-10 | C4-10 | A3/B3-10 | A3/B4-10 | C3-10 | A3/B4-10 | C3-10 | C3-10 |
| **VW TDI (CEC-SG-L-078-99)** | | - | - | - | Pass | - | Pass | - | - |
| All test parameter from VW 502.00 | Pass | - | - | - | Yes | - | Yes | - | - |
| **LLR Renault in-house Test** | Pass | - | Pass | - | - | - | - | - | - |
| PAI CO @ end of test | - | - | 200 | - | - | - | - | - | - |
| Viscosity Increase @ 40°C end of test | % | - | 100 | - | - | - | - | - | - |
| Oil Consumption | g/h | - | Report | - | - | - | - | - | - |
| Piston deposits (cotation) | merit | - | 5 | - | - | - | - | - | - |
| Ring sticking (all rings) | | - | No | - | - | - | - | - | - |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

## OEM Specifications: BMW

| Specification | BMW Longlife-01 | BMW Longlife-01 FE | BMW Longlife-04 |
|---|---|---|---|
| Viscosity grades | SAE 0W-30, 0W-40, 5W-30, 5W-40 | | |
| Based performance | ACEA A3/B4 | ACEA A5/B5 | ACEA C3 |
| Kinematic Viscosity @ 100°C, cSt | As described per SAE J300 | 10.0 min. | As described per SAE J300 |
| HTHS, mPa.s | | 3.0 min. | |
| BMW N52 [(1)] | required | required | required |
| BMW N42, wear test | required | required | required |
| BMW In-house Fuel Economy | - | required | - |

**Note:**

(1) BMW N52 will be replaced by N20 test during 2012.

## OEM Specifications: Volkswagen

| Requirements | VW 501 01 | VW 502 00 | VW 504 00 | VW 505 00 | VW 505 01 | VW 507 00 |
|---|---|---|---|---|---|---|
| Minimum ACEA performance level | A3/B3 | - | - | - | - | - |
| Viscosity grades | All grades | 0W-30, 0W-40, 5W-30, 5W-40, 10W-30, 10W-40 | 5W-30 0W-30 | 5W/10W/15W 20W-X XW-30/40/50/60 | 0W-30, 0W-40 5W-30, 5W-40 10W-30, 10W-40 | 5W-30 0W-30 |
| TBN, mg KOH/g (DIN ISO 3771) min. | 7 | 7 | - | - | 7 | - |
| Sulphated ash, % wt. (DIN 51575) max. | 1.5 | 1.5 | 1.5 | 1.5 | 0.8 | 1.5 |
| Phosphorus, % wt. (DIN 51363-3) min. | 0.08 | 0.08 In combination with VW 505 00 0.07 In combination with VW 505 01 | | 0.08 | 0.07 | - |
| NOACK, %wt. (CEC-L-40-A-93) max. | 13 | 13 | 11 | 13 | 13 | 11 |
| High Temperature High Shear viscosity, 150°C, $10^6 s^{-1}$ (CEC-L-36-A-90) min. | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Shear Stability (Bosch) | | | | | | |
| Viscosity at 100°C, cSt, min. | Stay-in-grade | Stay-in-grade | 9.3 | Stay-in-grade | Stay-in-grade | 9.3 |
| Viscosity loss, %, max. | 15.0 | 15.0 | 15 | 15.0 | 15.0 | 15 |
| Seals compatibility (PV 3344) | See last page of this section | | | | | |
| Cam and Tappet (PV 5106) | | | | | | |
| Cam pitting, μm, max. | 20 | 20 | 20 | 20 | 20 | 20 |
| Tappet pitting, μm, max. | 20 | 20 | 20 | 20 | 20 | 20 |
| Cam wear, μm, max. | 75 | 75 | 75 | 75 | 75 | 75 |
| Tappet wear, μm, max. | 100 | 100 | 100 | 100 | 100 | 100 |
| TU5 JP-L4 (CEC-L-88-T-02) | | - | - | - | - | - |
| Piston ring sticking, points, min. | 9.0 | - | - | - | - | - |
| Piston varnish, merit, min. | RL 216 | - | - | - | - | - |
| Viscosity increase @ 40°C, $mm^2/s$, max. | 0.8 X RL216 | - | - | - | - | - |



Afton CHEMICAL

## OEM Specifications: Volkswagen

| Requirements | VW 501 01 | VW 502 00 | VW 504 00 | VW 505 00 | VW 505 01 | VW 507 00 |
|---|---|---|---|---|---|---|
| **M271 Sludge MB In-house Method** | | | | | | |
| Sludge rating, avg, merit | 8.6 | 8.6 | 8.6 | - | - | - |
| Differential pressure on oil filter, bar, max. | - | 1.8 | 1.8 | - | - | - |
| **VW T4 (PV 1449)** | - | - | - | - | - | - |
| Viscosity at 40°C at end of the test, $mm^2/s$ | - | ≤ 200 - $V_{fresh\ oil}$ x X (1) | ≤ 200 - $V_{fresh\ oil}$ x X (1) | - | - | - |
| Viscosity increase at 40°C, mm /s | - | ≤ 130 - X (1) | ≤ 130 - X (1) | | | - |
| EOT TBN, mg KOH/g | - | ≥ 5 + $TBN_{new\ oil}$ x Y (2) | ≥ 5 + $TBN_{new\ oil}$ x Y (2) | | | - |
| Piston ring sticking, ASF | - | - | > 1 point | - | - | - |
| Piston cleanliness, merit | - | - | 0 ASF | - | - | - |
| **VW Fuel Economy Test (PV 1451), %, min.** | | | | | | |
| Fuel Economy, % (comparison with RL 191) | - | - | ≥ 2.0 for 5W-30 and ≥2.5 for 0W-30 | - | - | ≥ 2.0 for 5W-30 and ≥2.5 for 0W-30 |
| Fuel Economy of each phases, % | - | - | Phase 1: 3.0 ≤ FE ≤ 5.0<br>Phase 2: 1.0 ≤ FE ≤ 3.0<br>Phase 3: 0.0 ≤ FE ≤ 2.0 | -<br>- | -<br>- | Phase 1: 3.0 ≤ FE ≤ 5.0<br>Phase 2: 1.0 ≤ FE ≤ 3.0<br>Phase 3: 0.0 ≤ FE ≤ 2.0 |
| **VW FSI (Direct Injection Gasoline) (PV 1481)** | - | - | - | - | - | - |
| Engine oil for reference runs | - | - | FSI 5510 | - | - | - |
| Weight increase of the 8 intake valves, g | - | - | ≤ $MW_{Test\ bed\ (FSI\ 5510)}$ - 40% | - | - | - |
| **VW ICTD (PV 1431)** | - | - | - | - | - | - |
| Piston ring sticking, ASF | - | 0 | 0 | - | - | - |
| Piston cleanliness, merit | - | >1 | >1 | - | - | - |

**Note:**

(1) X = Δv (reference oil) - Δv (candidate oil) with Δv being the variation of viscosity @ 40°C for the specified oil during the test.

(2) Y = ΔTBN (reference oil) - ΔTBN (candidate oil) with ΔTBN being the variation of TBN for the specified oil during the test.



Afton CHEMICAL

## OEM Specifications: Volkswagen

| Requirements (1) | VW 501 01 | VW 502 00 | VW 504 00 | VW 505 00 | VW 505 01 | VW 507 00 |
|---|---|---|---|---|---|---|
| VW TDi (PV 1452) | - | - | - | - | - | - |
| Piston cleanliness, merit, min. | - | - | - | RL206+s-4 | RL 206 +s-3 | RL 206 +s |
| Piston ring sticking | - | - | - | - | - | - |
| Average of all 1st rings, ASF, max. | - | - | - | 2,5 | 1 | 1 |
| Max. for any 1st ring, ASF, max. | - | - | - | 1 | 1 | 1 |
| Max. for any 2nd ring, ASF, max. | - | - | - | 0 | 0 | 0 |
| EOT TBN mg/KOHg | - | - | - | ≥4 | - | - |
| Diesel Particle Filter Test (2) | - | - | - | - | - | required |
| Baumusterprüfung (2) | - | - | - | - | - | - |
| RNT Wear Test | - | - | (650 hrs.) | - | (250 hrs.) | (650 hrs.) |
| Gasoline Engine Tests (2) | - | - | required | - | - | - |
| Diesel Engine Tests (2) | - | - | - | - | required | required |

**Note:**

(1) Possible approval combinations are VW 501.01/505.00, VW 505.00, VW 502.00/505.00, VW 502.00/505.01, VW 504.00/507.00.

(2) Needs to be discussed with VW on a case by case basis.

## **Renault Service Fill RN0700** - Laboratory Tests (ACEA A3/B4 or A5/B5)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| 1.1 Viscosity grades | | SAE J300 Latest active issue | | 0W-30/5W-30<br>0W-40/5W-40/10W-40 |
| 1.2 Shear stability | CEC-L-014-93 or ASTM D6278 | Viscosity after 30 cycles @ 100°C | $mm^2/s$ | Stay-in-grade |
| 1.3 Viscosity at high temp. & high shear rate | CEC-L-036-90 (2nd edition) (Ravenfield) | Viscosity at 150°C and $10^6 s^{-1}$ shear rate | mPa.s | ≥ 2.9 for 5W30 and ≥ 3.5 for 5W40 |
| 1.4 Evaporative loss | CEC-L-040-93 (NOACK) | Max weight loss after 1 hr @ 250°C | % | ≤ 13.0 |
| 1.5 Sulphur (1) | ASTM D5185 | | %m/m | Report |
| 1.6 Phosporous (1) | ASTM D5185 | | %m/m | Report |
| 1.7 Sulphated ash | ASTM D874 | | %m/m | < 1.5 |
| 1.8 Chlorine | ASTM D6443 | | ppm m/m | Report |
| 1.9 TBN | ASTM D2896 | | mgKOH/g | ≥ 8.0 |
| 1.10 Oil / Elastomer compatibility | CEC-L-039-96 (3) | Max variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | As ACEA A5/B5-04 |
| | | Hardness DIDC | points | |
| | | Tensile strength | % | |
| | | Elongation at rupture | % | |
| | | Volume variation | % | |
| 1.11 Foaming tendency | ASTM D892 without option A | Tendency - Stability | ml | Sequence I (24°C) 10-nil |
| | | | | Sequence II (94°C) 50-nil |
| | | | | Sequence III (24°C) 10-nil |
| 1.12 High temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency - Stability | ml | Sequence IV (150°C) 100-nil |
| 1.13 Dynamic Viscosity CCS | ASTM D5293 | Dynamic viscosity @ -20°C | | See SAE J300 |
| | | Dynamic viscosity @ -30°C | | |
| 1.14 Pumpability limit temperature | ASTM D4684 | Pumpability temperature | °C | <-30 |
| 1.15 Density | ISO 12185 | | $kg/m^3$ | Report |
| 1.16 Open cup flash point | ISO 2592 | | °C | > 200 |
| 1.17 Pour point | ISO 3016 | | °C | Report |
| 1.18 Copper corrosion (3 hrs. @ 150°C) | ISO 2160 | | Cotation | 1a |

**Note:**

(1) The internal method standard has to be used.

(3) Use either complete Daimler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR : NBR34 DIN 53538 T3 (100°C +/- 2°C); FPM: AK6 (150°C +/- 2°C); ACM: E7503 (150°C +/- 2°C); AEM: D8948/200.1 (150°C +/- 2°C)) + RE3, or complete requirements above + Daimler requirements for AEM.

## **Renault Service Fill RN0700** - Laboratory Tests (ACEA A3/B4 or A5/B5)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| 1.19 Anti-wear properties (60min-40daN) | D551994 | Average diameter | mm | < 0.5 |
| 1.20 De-airing @ 40°C | NFT 60 149 | | min. | < 35 |
| 1.21 Water content | D50 1622 | | % | < 0.05 |
| 1.22 Type of base oil | | Percent of each type (Gp I, Gp II, Gp III, GP IV, Gp V) | % | |
| 1.23 Oxidation test TOC | D553099 | Big Tube (150g), 170°C, 360ppm of Iron, 10L/hr air | | |
| | | Samples at 0, 8, 80, 96, 104 hrs | | |
| | | (TAN, PAI CO, Viscosity) | | |
| | | TAN @ 80 hrs | mgKOH/g | Report |
| | | PAI CO @ 80 hrs. | | < 400 |
| | | Variation of viscosity at 40°C @ 80 hrs | % | < 200 |
| | | Variation of viscosity at 1000°C @ 80 hrs | % | Report |
| 1.24 MCT Cokefaction test | GFC Lu 27 | | Merit cotation 1 | > 6.0 |
| 1.25 Auto-ignition temperature | ASTM E659 | | °C | Report |
| 1.26 Storage Stability test* | See annex 1 (Official RN0700 Spec Sheet) | After a temperature cycle: | | No cloudiness, No deposit, No salting-out |
| | | Variation in viscosity @ 40°C | % | ≤ 2 |
| | | Variation in HTHS | mPa.s | ≤ 0.13 |
| | | | | |
| | | After 2 months of storage | | No cloudiness, No deposit, No salting-out |
| | | Variation in viscosity @ 40°C | % | ≤ 2 |
| | | Variation in HTHS | mPa.s | ≤ 0.13 |
| 1.27 Compatibility with current Renault First Fill oils | See annex 2 (Official RN0700 Spec Sheet) | | | No cloudiness, No deposit, No salting-out |
| 1.28 Compatibility with plastics* | See annex 3 (Official RN0700 Spec Sheet) | | | See annex 3 (RN0700 Spec Sheet) |
| 1.29 Particular contamination* | ISO 4426 | Measured with HIAC or manually with microscope on industrial batch | Code ISO | 16/13 |
| 1.30 Filterability (PALL Method)* | ME 64120 A 014/--B | Filter KN (7µ > 1000) | kPa | < 0.05 after 5 min |
| | | | | < 0.2 after 50 min |
| 1.31 Filterability (PALL Method)* | ME 64120 A 014/--B | FMA | Micron | ≥ 12 |

* Only for first fill oil

## **Renault Service Fill RN0700** - Engines Tests (ACEA A3/B4 or A5/B5)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| **2. ACEA Engine test** | | | | |
| 2.1 High temperature deposits Ring sticking Oil thickening | CEC-L-088-A-02 (PSA TU5JP-L4) 72 hrs. test | Ring sticking (each part) | merit | ≥ 9.0 |
| | | Piston varnish (6 elements, average of 4 pistons) | merit | ≥ RL 216 |
| | | Absolute viscosity increase @40°C between min. and Max. values during test | $mm^2/s$ | ≤ 0.8 * RL216 |
| | | Oil consumption | kg/test | Report |
| 2.2 Low temperature sludge | ASTM D6593-00 (sequence VG) Under protocol and requirements for API(4) | Average engine sludge | merit | ≥ 7.8 |
| | | Rocker cover sludge | merit | ≥ 8.0 |
| | | Average piston skirt varnish | merit | ≥ 7.5 |
| | | Average engine varnish | merit | ≥ 8.9 |
| | | Comp. ring (hot stuck) | | none |
| | | Oil screen clogging | % | ≤ 20 |
| 2.3 Valve train scuffing wear | CEC-L-038-A-94 (TU3M) | Cam wear average | µm | ≤ 10 |
| | | Cam wear max. | µm | ≤ 15 |
| | | Pad merit (avg. of 8 pads) | merit | ≥ 7.5 |
| 2.4 Sludge | MB In-house Method (M271) | Average engine sludge (4) | merit | 8.6 |
| 2.5 Fuel economy (5) | CEC-L-54-T-96 (M111FE) | Fuel economy improvement vs. reference oil RL 191 (15W40) | % | ≥ 2.5 for 5W30 |
| 2.6 Medium temperature dispersivity | CEC-L-093-04 (DV4TD) | Absolute viscosity increase @ 100°C and 6% of soot | $mm^2/s$ | ≤ 0.60 * RL233 |
| | | Piston merit | merit | ≥ (RL233-2.5pts) |
| 2.7 DI Diesel Piston cleanliness & Ring sticking | CEC-L-078-99 (VW TDI) | Piston cleanliness | merit | ≥ RL206 for xW30 and ≥ RL206 - 3pts for xW40 |
| | | Ring sticking (rings 1 & 2) | | |
| | | Avg. of all 8 rings | ASF | ≤ 1.2 |
| | | Max. for any 1st ring | ASF | ≤ 2.5 |
| | | Max. for any 2nd ring | ASF | 0.0 |
| | | EOT TBN (ISO 3771) | mg KOH/g | ≥ 4.0 |
| | | EOT TAN (ASTM D664) | mg KOH/g | Report |
| 2.8 Wear, Viscosity stability & Oil consumption | CEC-L-51-A-98 (OM 602 A) | Average Cam wear (new tappet) | µm | ≤ 50.0 |
| | | Viscosity increase @ 40°C | % | ≤ 90 |
| | | Bore polishing | % | ≤ 7 |
| | | Average Cylinder wear | µm | ≤ 20 |
| | | Oil consumption | kg/test | ≤ 10 |

**Note:**

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

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

## **Renault Service Fill RN0700** - Engines Tests (ACEA A3/B4 or A5/B5)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| 2.8 Wear | CEC-L-099-08 (OM 646 LA) Replacement of OM 602 A | Cam wear outlet (avg. max. wear 8 cams ) | µm | ≤ 120 |
| | | Cam wear inlet (avg. max wear 8 cam) (6) | µm | ≤ 100 |
| | | Cylinder wear (avg. 4 cyl) (6) | µm | ≤ 5.0 |
| | | Bore polishing (13 mm) max. value of 4 cylinders (6) | % | ≤ 3.0 |
| | | Tappet wear inlet (avg. max. wear 8 cams) | µm | Report |
| | | Tappet wear outlet (avg. max. wear 8 cams) | µm | Report |
| | | Piston cleanliness (avg. 4 pistons) | merit | Report |
| | | Engine sludge avg. | merit | Report |

**Note:**
(6) Not yet official CEC parameters.

## **Renault Service Fill RN0710** - Laboratory Test (ACEA A3/B4)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| 1.1 Viscosity grades | | SAE J300 Latest active issue | | 0W-40/5W-40/ 5W-30 for first fill only |
| 1.2 Shear stability | CEC-L-014-93 or ASTM D6278 | Viscosity after 30 cycles @ 100°C | mm$^2$/s | Stay-in-grade |
| 1.3 Viscosity at high temp. & high shear rate | CEC-L-036-90 (2nd edition) (Ravenfield) | Viscosity at 150°C and $10^6 s^{-1}$ shear rate | mPa.s | ≥ 2.9 for 5W30 and ≥ 3.5 for 5W40 |
| 1.4 Evaporative loss | CEC-L-040-93 (NOACK) | Max. weight loss after 1 hr @ 250°C | % | ≤ 11.0 |
| 1.5 Sulphur (1) | ASTM D5185 | | %m/m | Report |
| 1.6 Phosporous (1) | ASTM D5185 | | %m/m | Report |
| 1.7 Sulphated ash | ASTM D874 | | %m/m | < 1.5 |
| 1.8 Chlorine | ASTM D6443 | | ppm m/m | Report |
| 1.9 TBN | ASTM D2896 | | mgKOH/g | ≥ 8.0 |
| 1.10 Oil / Elastomer compatibility | CEC-L-039-96 (3) | Max. variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | As ACEA A5/B5-04 |
| | | Hardness DIDC | points | |
| | | Tensile strength | % | |
| | | Elongation at rupture | % | |
| | | Volume variation | % | |
| 1.11 Foaming tendency | ASTM D892 without option A | Tendency - Stability | ml | Sequence I (24°C) 10-nil |
| | | | | Sequence II (94°C) 50-nil |
| | | | | Sequence III (24°C) 10-nil |
| 1.12 High Temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency - Stability | ml | Sequence IV (150°C) 100-nil |
| 1.13 Dynamic Viscosity CCS | ASTN D5293 | Dynamic viscosity @ -20°C | | See SAE J300 |
| | | Dynamic viscosity @ -30°C | | |
| 1.14 Pumpability limit temperature | ASTM D4684 | Pumpability temperature | °C | <-30 |
| 1.15 Density | ISO 12185 | | kg/m$^3$ | Report |
| 1.16 Open cup Flash point | ISO 2592 | | °C | > 200 |
| 1.17 Pour point | ISO 3016 | | °C | Report |
| 1.18 Copper corrosion (3 hr @ 150°C) | ISO 2160 | | Cotation | 1a |

**Note:**

(1) The internal method standard has to be used.

(3) Use either complete Daimler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR : NBR34 DIN 53538 T3 (100°C +/- 2°C); FPM: AK6 (150°C +/- 2°C); ACM: E7503 (150°C +/- 2°C); AEM: D8948/200.1 (150°C +/- 2°C)) + RE3, or complete requirements according to 1.10 above + Daimler requirements for AEM.



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## **Renault Service Fill RN0710** - Laboratory Test (ACEA A3/B4)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| 1.19 Anti-wear properties (60min-40daN) | D551994 | Average diameter | mm | < 0.5 |
| 1.20 De-airing @ 40°C | NFT 60 149 | | min | < 35 |
| 1.21 Water content | D50 1622 | | % | < 0.05 |
| 1.22 Type of base oil | | Percent of each type (Gp I, Gp II, Gp III, GP IV, Gp V) | % | |
| 1.23 Oxidation test TOC | D553099 | Big Tube (150g), 170°C, 360ppm of Iron, 10l /hr air | | |
| | | Samples at 0, 8, 80, 96, 104 hr | | |
| | | (TAN, PAI CO, Viscosity) | | |
| | | TAN @ 80 hrs | mgKOH/g | Report |
| | | PAI CO @ 80 hrs. | | < 400 |
| | | Variation of viscosity @ 40°C @ 80 hrs | % | < 200 |
| | | Variation of viscosity at 1000°C @ 80 hrs | % | Report |
| 1.24 MCT Cokefaction test | GFC Lu 27 | | Merit cotation 1 | > 6.0 |
| 1.25 Auto-ignition temperature | ASTM E659 | | °C | Report |
| 1.26 Storage Stability test * | See annex 1 (Official RN0700 Spec Sheet) | After a temperature cycle: | | No cloudiness, No deposit, No salting-out |
| | | Variation in viscosity at 40°C | % | ≤ 2 |
| | | Variation in HTHS | mPa.s | ≤ 0.13 |
| | | | | |
| | | After 2 months of storage | | No cloudiness, No deposit, No salting-out |
| | | Variation in viscosity at 40°C | % | ≤ 2 |
| | | Variation in HTHS | mPa.s | ≤ 0.13 |
| 1.27 Compatibility with current Renault First Fill oils | See annex 2 (Official RN0700 Specs Sheet) | | | No cloudiness, No deposit, No salting-out |
| 1.28 Compatibility with plastics * | See annex 3 (Official RN0700 Specs Sheet) | | | See annex 3 (RN0700 Specs Sheet) |
| 1.29 Particular contamination * | ISO 4426 | Measured with HIAC or manually with microscope on industrial batch | Code ISO | 16/13 |
| 1.30 Filterability (PALL Method)* | ME 64120 A 014/--B | Filter KN (7μ > 1000) | kPa | < 0.05 after 5 min<br>< 0.2 after 50 min |
| 1.31 Filterability (PALL Method)* | ME 64120 A 014/--B | FMA | Micron | ≥ 12 |

* Only for first fill oil

## **Renault Service Fill RN0710** - Engines Tests (ACEA A3/B4)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| **2. ACEA Engine test** | | | | |
| 2.1 High temperature deposits Ring sticking Oil thickening | CEC-L-088-A-02 (PSA TU5JP-L4) 72 hr test | Ring sticking (each part) | merit | ≥ 9.0 |
| | | Piston varnish (6 elements, average of 4 pistons) | merit | ≥ RL 216 |
| | | Absolute viscosity increase @ 40°C between min. and max. values during test | $mm^2/s$ | ≤ 0.8 * RL216 |
| | | Oil consumption | kg/test | Report |
| 2.2 Low temperature sludge | ASTM D6593-00 (sequence VG) under protocol and requirements for API(4) | Average engine sludge | merit | ≥ 7.8 |
| | | Rocker cover sludge | merit | ≥ 8.0 |
| | | Average piston skirt varnish | merit | ≥ 7.5 |
| | | Average engine varnish | merit | ≥ 8.9 |
| | | Comp. ring (hot stuck) | | none |
| | | Oil screen clogging | % | ≤ 20 |
| 2.3 Valve train scuffing wear | CEC-L-038-A-94 (TU3M) | Cam wear average | µm | ≤ 10 |
| | | Cam wear max | µm | ≤ 15 |
| | | Pad merit (avg. of 8 pads) | merit | ≥ 7.5 |
| 2.4 Sludge | MB In-house Method (M271) | Average engine sludge (4) | merit | 8.6 |
| 2.5 Fuel economy (5) | CEC-L-54-T-96 (M111FE) | Fuel economy improvement vs. reference oil RL 191 (15W40) | % | ≥ 2.5 for 5W30 |
| 2.6 Medium temperature dispersivity | CEC-L-093-04 (DV4TD) | Absolute viscosity increase @ 100°C and 6% of soot | $mm^2/s$ | ≤ 0.60 * RL233 results |
| | | Piston merit | merit | ≥ (RL233-2.5pts) |
| 2.7 DI Diesel Piston cleanliness & Ring sticking | CEC-L-078-99 (VW TDI) | Piston cleanliness | merit | ≥ RL206 |
| | | Ring sticking (ring 1 & 2) | | |
| | | Avg. of all 8 rings | ASF | ≤ 1.2 |
| | | Max. for any 1st ring | ASF | ≤ 2.5 |
| | | Max. for any 2nd ring | ASF | 0.0 |
| | | EOT TBN (ISO 3771) | mg KOH/g | ≥ 4.0 |
| | | EOT TAN (ASTM D664) | mg KOH/g | Report |
| 2.8 Wear, Viscosity stability & Oil consumption | CEC-L-51-A-98 (OM 602 A) | Average cam wear (new tappet) | µm | ≤ 50.0 |
| | | Viscosity increase @ 40°C | % | ≤ 90 |
| | | Bore polishing | % | ≤ 7 |
| | | Average cylinder wear | µm | ≤ 20 |
| | | Oil consumption | kg/test | ≤ 10 |

**Note:**

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

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

## **Renault Service Fill RN0710** - Engines Tests (ACEA A3/B4)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| 2.8 Wear | CEC-L-099-08 (OM 646 LA) Replacement of OM 602 A | Cam wear outlet (avg. max. wear 8 cams ) | µm | ≤ 120 |
| | | Cam wear inlet (avg. max. wear 8 cam) (6) | µm | ≤ 100 |
| | | Cylinder wear (avg. 4 cyl) (6) | µm | ≤ 5.0 |
| | | Bore polishing (13 mm) max. value of 4 cylinders (6) | % | ≤ 3.0 |
| | | Tappet wear inlet (avg. max. wear 8 cams) | µm | Report |
| | | Tappet wear outlet (avg. max. wear 8 cams) | µm | Report |
| | | Piston cleanliness (avg. 4 pistons) | merit | Report |
| | | Engine sludge avg. | merit | Report |
| **3. Renault Engine Test** | | | | |
| **3.1 Turbosludge Test F4Rt** | | IN DEVELOPMENT | | TO BE DEFINED |

**Note:**
(6) Not yet official CEC parameters.

## **Renault Service Fill RN0720** - Laboratory Test (ACEA C4)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| 1.1 Viscosity grades | | SAE J300 Latest active issue | | 0W30/5W30/ 0W40/5W40 |
| 1.2 Shear stability | CEC-L-014-93 or ASTM D6278 | Viscosity after 30 cycles @ 100°C | $mm^2/s$ | Stay-in-grade |
| 1.3 Viscosity at high temp. & high shear rate | CEC-L-036-90 (2nd edition) (Ravenfield) | Viscosity at 150°C and $10^6 s^{-1}$ shear rate | mPa.s | ≥ 3.5 |
| 1.4 Evaporative loss | CEC-L-040-93 (NOACK) | Max. weight loss after 1hr @ 250°C | % | ≤ 11.0 |
| 1.5 Sulphur [1] | ASTM D5185 | | %m/m | ≤ 0.2 |
| 1.6 Phosporous [1] | ASTM D5185 | | %m/m | ≤ 0.09 |
| 1.7 Sulphated ash | ASTM D874 | | %m/m | ≤ 0.50 |
| 1.8 Chlorine | ASTM D6443 | | ppm m/m | Report |
| 1.9 TBN | ASTM D2896 | | mgKOH/g | ≥ 6.0 |
| 1.10 Oil / Elastomer compatibility | CEC-L-039-96 [3] | Max. variation of characteristics after immersion for 7 days in fresh oil without pre-aging | | AS ACEA C3-04 |
| | | Hardness DIDC | points | |
| | | Tensile strength | % | |
| | | Elongation at rupture | % | |
| | | Volume variation | % | |
| Renault Specifications | | To be defined | | |
| 1.11 Foaming tendency | ASTM D892 without option A | Tendency - Stability | ml | Sequence I (24°C) 10-nil |
| | | | | Sequence II (94°C) 50-nil |
| | | | | Sequence III (24°C) 10-nil |
| 1.12 High temperature foaming tendency | ASTM D6082 High temperature foam test | Tendency - Stability | ml | Sequence IV (150°C) 100-nil |
| 1.13 Dynamic Viscosity CCS | ASTN D5293 | Dynamic viscosity @ -20°C | | See SAE J300 |
| | | Dynamic viscosity @ -30°C | | |
| 1.14 Pumpability limit temperature | ASTM D4684 | Pumpability temperature | °C | <-30 |
| 1.15 Density | ISO 12185 | | $kg/m^3$ | Report |
| 1.16 Open cup flash point | ISO 2592 | | °C | > 200 |
| 1.17 Pour point | ISO 3016 | | °C | Report |
| 1.18 Copper corrosion (3 hrs. @ 150°C) | ISO 2160 | | Cotation | 1a |

**Note:**

(1) The internal method standard has to be used.

(3) Use either complete Daimler requirements (VDA 675301, 7 days +/- 2h, 4 materials (NBR : NBR34 DIN 53538 T3 (100°C +/- 2°C); FPM: AK6 (150°C +/- 2°C); ACM: E7503 (150°C +/- 2°C); AEM: D8948/200.1 (150°C +/- 2°C)) + RE3, or complete requirements according to 1.10 above + Daimler requirements for AEM.

## **Renault Service Fill RN0720** - Laboratory Test (ACEA C4)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| 1.19 Anti-wear properties (60min-40daN) | D551994 | Average diameter | mm | < 0.5 |
| 1.20 De-airing @ 40°C | NFT 60 149 | | min. | < 35 |
| 1.21 Water content | D50 1622 | | % | < 0.05 |
| 1.22 Type of base oil | | Percent of each type (Gp I, Gp II, Gp III, GP IV, Gp V) | % | |
| 1.23 Oxidation test TOC | D553099 | Big Tube (150g) 170°C, 360ppm of Iron, 10L/hrs. air | | |
| | | Samples at 0, 8, 80, 96, 136, 168 hrs | | |
| | | (TAN, PAI CO, Viscosity) | | |
| | | TAN @ 96 hrs | mgKOH/g | Report |
| | | PAI CO @ 96 hrs. | | < 400 |
| | | Variation of viscosity at 40°C @ 96 hrs | % | < 200 |
| | | Variation of viscosity at 1000°C @ 96 hrs. | % | Report |
| 1.24 MCT Cokefaction test | GFC Lu 27 | | Merit cotation 1 | > 6.0 |
| 1.25 Auto-ignition temperature | ASTM E659 | | °C | Report |
| 1.26 Storage Stability test* | See annex 1 (Official RN0700 Spec Sheet) | After a temperature cycle | | No cloudiness, No deposit, No salting-out |
| | | Variation in viscosity at 40°C | % | ≤ 2 |
| | | Variation in HTHS | mPa.s | ≤ 0.13 |
| | | | | |
| | | After 2 months of storage | | No cloudiness, No deposit, No salting-out |
| | | Variation in viscosity at 40°C | % | ≤ 2 |
| | | Variation in HTHS | mPa.s | ≤ 0.13 |
| 1.27 Compatibility with current Renault First Fill oils | See annex 2 (Official RN0700 Spec Sheet) | | | No cloudiness, No deposit, No salting-out |
| 1.28 Compatibility with plastics* | See annex 3 (Official RN0700 Spec Sheet) | | | See annex 3 (Official RN0700 Spec Sheet) |
| 1.29 Particular contamination* | ISO 4426 | Measured with HIAC or manually with microscope on industrial batch | Code ISO | 16/13 |
| 1.30 Filterability (PALL Method)* | ME 64120 A 014/--B | Filter KN (7µ > 1000) | kPa | < 0.05 after 5 min. |
| | | | | < 0.2 after 50 min. |
| 1.31 Filterability (PALL Method)* | ME 64120 A 014/--B | FMA | Micron | ≥ 12 |

* Only for first fill oil.

## Renault Service Fill RN0720 - Engines Tests (ACEA C4)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| **2. ACEA Engine test** | | | | |
| 2.1 High temperature deposits Ring sticking Oil thickening | CEC-L-088-A-02 (PSA TU5JP-L4) 72 hrs. test | Ring sticking (each part) | merit | ≥ 9.0 |
| | | Piston varnish (6 elements, avg. of 4 pistons) | merit | ≥ RL 216 |
| | | Absolute viscosity increase @40°C between min. and max. values during test | $mm^2/s$ | ≤ 0.8 * RL216 |
| | | Oil consumption | kg/test | Report |
| 2.2 Low temperature sludge | ASTM D6593-00 (sequence VG) Under protocol and requirements for API(4) | Average engine sludge | merit | ≥ 7.8 |
| | | Rocker cover sludge | merit | ≥ 8.0 |
| | | Average piston skirt varnish | merit | ≥ 7.5 |
| | | Average engine varnish | merit | ≥ 8.9 |
| | | Comp. ring (hot stuck) | | none |
| | | Oil screen clogging | % | ≤ 20 |
| 2.3 Valve train scuffing wear | CEC-L-038-A-94 (TU3M) | Cam wear average | µm | ≤ 10 |
| | | Cam wear max. | µm | ≤ 15 |
| | | Pad merit (avg. of 8 pads) | merit | ≥ 7.5 |
| 2.4 Sludge | MB In-house Method (M271) | Average engine sludge (4) | merit | 8.6 |
| 2.5 Fuel economy (5) | CEC-L-54-T-96 (M111FE) | Fuel economy improvement vs. reference oil RL 191 (15W40) | % | ≥ 1.0 for xW30 grades |
| 2.6 Medium temperature dispersivity | CEC-L-093-04 (DV4TD) | Absolute viscosity increase @ 100°C and 6% of soot | $mm^2/s$ | ≤ 0.60 * RL233 |
| | | Piston merit | merit | ≥ (RL233-2.5pts) |
| 2.7 DI Diesel Piston cleanliness & Ring sticking | CEC-L-078-99 (VW TDI) | Piston cleanliness | merit | ≥ RL206 |
| | | Ring sticking (rings 1 & 2) | | |
| | | Avg. of all 8 rings | ASF | ≤ 1.0 |
| | | Max. for any 1st ring | ASF | ≤ 1.0 |
| | | Max. for any 2nd ring | ASF | 0.0 |
| | | EOT TBN (ISO 3771) | mg KOH/g | Report |
| | | EOT TAN (ASTM D664) | mg KOH/g | Report |
| 2.8 Wear, Viscosity stability & Oil consumption | CEC-L-51-A-98 (OM 602 A) | Average cam wear (new tappet) | µm | ≤ 45.0 |
| | | Viscosity increase @ 40°C | % | ≤ 70 |
| | | Bore polishing | % | ≤ 4.5 |
| | | Average cylinder wear | µm | ≤ 15 |
| | | Oil consumption | kg/test | ≤ 10 |

**Note:**

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

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

## **Renault Service Fill RN0720** - Engines Tests (ACEA C4)

| Requirements | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| 2.8 Wear | CEC-L-099-08 (OM 646 LA) Replacement of OM 602 A | Cam wear outlet (avg. max. wear 8 cams ) | µm | ≤ 120 |
| | | Cam wear inlet (avg. max. wear 8 cam) (6) | µm | ≤ 100 |
| | | Cylinder wear (avg. 4 cyl) (6) | µm | ≤ 5.0 |
| | | Bore polishing (13 mm) max. value of 4 cylinders (6) | % | ≤ 3.0 |
| | | Tappet wear inlet (avg. max. wear 8 cams) | µm | Report |
| | | Tappet wear outlet (avg. max. wear 8 cams) | µm | Report |
| | | Piston cleanliness (avg. 4 pistons) | merit | Report |
| | | Average engine sludge | merit | Report |
| **3. Renault Engine Test** | | | | |
| **3.1 LLR Renault In-house Test** | | Oil oxidation at the end of the test: | | |
| | | PAI CO | | 250 |
| | | Viscosity increase at 40°C | % | ≤ 100 |
| | | Oil Consumption | g/h | Report |
| | | Piston deposits: | | |
| | | Cotation | merit | |
| | | Ring sticking | | No sticking (for all rings) |

**Note:**

(6) Not yet official CEC parameters.

## PSA First-fill Specifications

| Requirements | Limits | | | |
|---|---|---|---|---|
| | B71 2295 | B71 2294 | B71 2296 | B71 2290 |
| ACEA | A3/B3 | A3/B3 or A3/B4 | A3/B4 or A5/B5 | C2 |
| SAE J300 | depending on geographical area and engine type | | | |
| Bosch shear stability<br>CEC-L-14-A-88 30 cycl. | xW-30: 9 min.<br>xW-40: 12 min.<br>xW-50: 15 min. | Stay-in-grade | Stay-in-grade | 10 cSt min. |
| HTHS | > 3,5 | > 3,5 | A5/B5: > 2.9<br>others: >3.5 | 2.9 min. |
| NOACK | 5W: 13% max.<br>> 5W: 15% max. | < 13 | <13 | <13 |
| Sulphated ash | < 1.5% | A3/B3: < 1.5%<br>A3/B4: <1.6% | < 1.6% | <0.8% |
| Seal compatibility | RE1 - RE5 according to ACEA 2008 | | | |
| TBN ASTM D4739 | EC: 8 min. | EC: 8 min. | EC: 8 min. | 3 min. |
| TBN D2896 | Outside EC: 10 min. | Outside EC: 10 min. | Outside EC: 10 min. | 6 min. |
| Cokefaction PCT (24 hrs. @ 288°C) | 8 min. | 8 min. | 8 min. | 8 min. |
| Four Ball, wear | 0,5 mm, 100kg min. | | | |
| Oxidation test | see separate sheet | | | |
| Engine performance level | | | | |
| ACEA 2008 | A3/B3 | A3/B3 or A3.B4 | A3/B4 or A5/B5 | C2 |
| DW 10TD PSA 845.04<br>Endurance test | | | | |
| Viscosity increase | + 3 cSt | + 3 cSt | + 3 cSt | + 3 cSt |
| Piston deposits | 10/10 | 10/10 | 10/10 | 10/10 |

## PSA Service Oils - NIV.2 ACEA A3/B4 Specification 2010 71 2300

| Bench Testing | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| Viscosity Grades | SAE J300 Latest active issue | | | |
| Shear Stability | CEC-L-014-93 or ASTM D6278 | Viscosity after 30 cycles @ 100°C | mm2/s | Stay-in-grade |
| Viscosity at high temperature and high shear rate | CEC-L-036-90 | Viscosity at 150°C and $10^6 s^{-1}$ shear rate | mPa.s | ≤ 3.5 |
| Evaporative loss (NOACK) | CEC-L-040-93 (NOACK) | Max weight loss after 1hr @ 250°C | % | < 13 |
| Sulphated ash | As ACEA 2008 | | %m/m | < 1.6 for A3/B4 oils |
| Aeration | Time for desertion + curve | | | |
| Oil/Elastomer compatibility | CEC-L-039-96 | RE1, RE2, RE3, RE4 & RE5 | | As per ACEA 08 |
| | | Hardness DIDC | points | |
| | | Tensile Strength | % | |
| | | Elongation at rupture | % | |
| | | Volume variation | % | |
| TBN. | ASTM 4739 | Zone Europe | mgKOH/g | ≥ 8 |
| TBN. | ASTM 2896A | Outside Europe | mgKOH/g | ≥ 10 |
| Cokefaction PCT | 24 hrs. @ 288°C | Pictures to be shown | merit | ≥ 8 |
| Cokefaction PCT | 16 hrs. @ 305°C | Pictures to be shown | merit | Report |
| Four-Ball Test (limits to be targeted indication) | Wear (60 min, 1500rpm 40kg) | Wear scare | mm | ≤ 0.50 |
| | EP (1 min, 1500rpm) | Load before welding | kg | ≥ 100 |

## PSA Service Oils - NIV.2 ACEA A3/B4 Specification 2010 71 2300

| Bench Testing | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| Oxidation stability (170°C) + 100ppm Iron | According to PSA CPBM_ CMPM07_1564 | % KV variation @ 48 hrs | % cSt | Report |
| | | % KV variation @ 72 hrs | % cSt | Report |
| | | % KV variation @ 96 hrs | % cSt | -20% or +20% max. or max. of grade tested. |
| | | % KV variation @ 120 hrs | % cSt | +250% max. |
| | | PAI or TAN @ 72 hrs, 96 hrs. and 120 hrs | | Report |
| | | Insoluble content. Visual aspect and/or evaluation if deposits present | % (Deposits) | < 0.05 |
| Oxidation stability (170°C) + 100ppm Iron + FAME in GOPSA10 LUB | According to PSA CPBM_ CMPM07_0961 (available at TOTAL ACS) | % KV variation @ 48 hrs | % cSt | Report |
| | | % KV variation @ 72 hrs | % cSt | Report |
| | | % KV variation @ 96 hrs | % cSt | -20% or +20% max. or max. of grade tested |
| | | % KV variation @ 120 hrs | % cSt | Report |
| | | PAI or TAN @ 72 hrs, 96 hrs. and 120 hrs | | Report |
| | | Insoluble content. Visual aspect and/or evaluation if deposits present | % (Deposits) | < 0.05 |
| Nitro-oxidation stability (EHN 1%) | Performed by PSA. Accepted by PSA | | | |
| Durability and compatibility with E10 Fuel | Performed by PSA. Accepted by PSA | | | |



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## PSA Service Oils - NIV.2 ACEA A3/B4 Specification 2010 71 2300

| Engine Testing | Test Method | Limits |
|---|---|---|
| ACEA Engine Test | | |
| All ACEA Engine Tests | See ACEA 08 | ACEA C2 - 2008 level<br>Following reports have to be sent to PSA:<br>CEC-L-088-T-02 (TU5JP-L4)<br>CEC-L-038-94 (TU3M)<br>CEC-L-093-04 (DV4TD)<br>Other reports have to be available on demand |
| Specific PSA Tests | | |
| Endurance Test DW10 Engines | Method PSA 845.04 or PSA 01523_09_00234 if available | Complete report has to be sent to PSA:<br>- Specific Criteria<br>- Acceptability by PSA |
| If Read-Across rules are used, a document with oil references (oil reference and batch number used) and its components (oil bases: type and percentage, additive packages: name and percentage) have to be sent with the engine test reports. | | |

## PSA Service Oils - Low SAPs ACEA C3 Specification 2010 B71 2297

| Bench Testing | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| Viscosity Grades | SAE J300 Latest active issue | | | |
| Shear Stability | CEC-L-014-93 or ASTM D6278 | Viscosity after 30 cycles @ 100°C | $mm^2/s$ | ≥ 10 |
| Viscosity at high temperature and high shear rate | CEC-L-036-90 | Viscosity at 150°C and $10^6 s^{-1}$ sheer rate | mPa.s | ≤ 3.5 |
| Evaporative loss (NOACK) | CEC-L-040-93 (NOACK) | Max weight loss after 1 hr @ 250°C | % | < 13 |
| Sulphated ash | As ACEA 2008 | | %m/m | < 0.8 |
| Aeration | Time for desertion + curve | | | |
| Oil / Elastomer compatibility | CEC-L-039-96 | RE1, RE2, RE3, RE4 & RE5 | | As per ACEA 08 |
| | | Hardness DIDC | points | |
| | | Tensile Strength | % | |
| | | Elongation at rupture | % | |
| | | Volume variation | % | |
| TBN. | ASTM 4739 | | mgKOH/g | ≥ 3 |
| TBN. | ASTM 2896A | | mgKOH/g | ≥ 6 |
| Cokefaction PCT | 24 hrs. at 288°C | Pictures to be shown | merit | ≥ 8 |
| Cokefaction PCT | 16 hrs. at 305°C | Pictures to be shown | merit | Report |
| Four-Ball Test (limits to be targeted indication) | Wear (60 min, 1500rpm, 40kg) | Wear scare | mm | ≤ 0.50 |
| | EP (1 min, 1500rpm) | Load before welding | kg | ≥ 100 |

## PSA Service Oils - Low SAPs ACEA C3 Specification 2010 B71 2297

| Bench Testing | Test Method | Properties | Unit | Limits |
|---|---|---|---|---|
| Oxidation stability (170°C) + 100ppm Iron | According to PSA CPBM_ CMPM07_1564 | % KV variation @ 120 hrs | % cSt | Grade 30: -20% max. Grade 40: 9,3 cSt min. |
| | | % KV variation @ 120 hrs | % cSt | +20% max. or max. of grade tested |
| | | % KV variation @ 144 hrs | % cSt | +200% max. |
| | | PAI or TAN @ 72 hrs, 96 hrs. and 120 hrs | | Report |
| | | Insoluble content. Visual aspect and/or evaluation if deposits present | % (Deposits) | < 0.05 |
| Oxidation stability (170°C) + 100ppm Iron + FAME in GOPSA10 LUB | According to PSA CPBM_ CMPM07_0961 (available at TOTAL ACS) | % KV variation @ 48 hrs | % cSt | Report |
| | | % KV variation @ 72 hrs | % cSt | Report |
| | | % KV variation @ 96 hrs | % cSt | -20% or + 20% max. or max. of grade tested |
| | | % KV variation @ 120 hrs | % cSt | Report |
| | | PAI or TAN @ 72 hrs, 96 hrs. and 120 hrs | | Report |
| | | Insoluble content. Visual aspect and/or evaluation if deposits present | % (Deposits) | < 0.05 |
| Nitro-oxidation stability (EHN 1%) | Performed by PSA. Accepted by PSA | | | |
| Durability and compatibility with E10 Fuel | Performed by PSA. Accepted by PSA | | | |

## PSA Service Oils - Low SAPs ACEA C3 Specification 2010 B71 2297

| Engine Testing | Test Method | Limits |
|---|---|---|
| ACEA Engine Test | | |
| All ACEA Engine Tests | See ACEA 08 | ACEA C2 - 2008 level<br>Following reports have to be sent to PSA:<br>CEC-L-088-T-02 (TU5JP-L4)<br>CEC-L-038-94 (TU3M)<br>CEC-L-093-04 (DV4TD)<br>Other reports have to be available on demand |
| Specific PSA Tests | | |
| Endurance Test DW10 Engines | Method PSA 845.04 or PSA 01523_09_00234 if available | Complete report has to be sent to PSA:<br>- Specific Criteria<br>- Acceptability by PSA |
| If Read-Across rules are used, a document with oil references (oil reference and batch number used) and its components (oil bases: type and percentage, additive packages: name and percentage) have to be sent with the engine test reports. | | |

## OEM Specifications: Mercedes-Benz Sheets For Heavy Duty Diesel Engine Oils v.2012.2

| Sheet Number [1] | Units | 226.9 | 228.0/.1 | 228.2/.3 | 228.31 | 228.5 | 228.51 |
|---|---|---|---|---|---|---|---|
| **Viscosity Requirements** | | | | | | | |
| Mono / Multigrade | | multi | mono/multi | mono/multi | multi | multi | multi |
| Viscosity Grades | SAE | acc. ACEA | acc. ACEA | acc. ACEA | acc. ACEA | acc. ACEA | acc. ACEA |
| SAE XW-30 and 0W-40 | Possible | No | Yes [7] | Yes [7] | Yes [7] | Yes [7] | Yes [7] |
| **Read-Across Guidelines** | | | | | | | |
| MB Read-Across [2] | RA | No | Yes | Yes | Yes | Yes | Yes |
| Package Pass [2] | RA | Yes | Yes | Yes | Yes | No | No |
| ACEA Oil sequence required | ACEA | When any ACEA Ax, Bx, Cx or Ex oil sequence is claimed, then all tests within this oil sequence are mandatory | | | | | |
| API Oil Categories required min. | API | - | - | - | API CJ-4 | - | - |
| DDC Oil Specification level | PGOS | - | - | - | (93K218) | - | - |
| RN Oil specification - RN approval letter mandatory | RN Spec | - | - | - | - | - | - |
| **Laboratory Tests** | | | | | | | |
| Sulphated ash (DIN 51575 or ASTM D874) | %b.w | ≤ 1,0 | ≤ 2,0 | > 1,0 & ≤ 2,0 | ≤ 1,0 | > 1,0 & ≤ 2,0 | ≤ 1,0 |
| TBN (ISO 3771 or ASTM D2896 fresh oil) | mgKOH/g | - | 6,0 | 8,0 | 7,0 | 12,0 | 7,0 |
| TBN (ASTM D4739 fresh oil) | mgKOH/g | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Pour Point (ISO 3016 or ASTM D97) | °C | -27 | R&R/-27 | R&R/-27 | -27 | -27 | -27 |
| Evaporative loss CEC-L-40-A-93, ASTM D5800, NOACK | % | 13 | 13 | 13 | 13 | 13 | 12 |
| Viscosity @ HTHS (CEC-L-36-90) | mPa.s | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 | 3,5 |
| Zinc, min (DIN 51391 -2/-3 or ASTM D5185 / 6443) | % b.w | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Sulfur (DIN EN ISO 14596 or ASTM D5185 / 2622) | % b.w | Rate & Report | Rate & Report | Rate & Report | 0,4 | Rate & Report | 0,3 |
| Phosphorus (DIN 51363 -2/-3 / ASTM D5185 / 4951) | % b.w | Rate & Report | Rate & Report | Rate & Report | 0,12 | Rate & Report | 0,08 |
| Chlorine (DIN ISO 15597:2006-01 or ASTM D6443) | % b.w | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | 0,0150 |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(2) Read-Across only according to MB Read-Across Guidelines for engine tests (based on latest ATC and ATIEL Code of Practice).
MB Package Pass only for Mineral Oils (SN, ATIEL Grp. I & II) and for SAE 15W-40, 20W-40, 15W-50, 20W-50.

| OEM Specifications: Mercedes-Benz Sheets For Heavy Duty Diesel Engine Oils v.2012.2 - Cont'd | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sheet Number [1]** | **Units** | **226.9** | **228.0/.1** | **228.2/.3** | **228.31** | **228.5** | **228.51** |
| **Daimler Oxidation Test - Fresh Oil (Daimler Oxidation Test Procedure) [3]** | | | | Pass | Pass | Pass | Pass |
| Kin. Viscosity @ 100°C, EOT 168 hrs, avg. of 3 runs | $mm^2/s$ | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Oxidation DIN 51453 @ EOT 168 hrs, avg. of 3 runs | A/cm | - | - | 60 | 60 | 25 | 25 |
| Delta Kin. Viscosity KV100 avg. of 3 runs - absolute | $mm^2/s$ | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Delta Kin. Viscosity KV100 avg. of 3 runs - relative | % | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **Daimler Oxidation Test with Fuel Dilution 5% B100 (FAME from OM 646 Biodiesel Test) [3]** | | | | Pass | Pass | Pass | Pass |
| Kin. Viscosity @ 100°C, EOT 168 hrs, avg. of 3 runs | $mm^2/s$ | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Oxidation DIN 51453 @ EOT 168 hrs, avg. of 3 runs | A/cm | - | - | 120 | 120 | 90 | 90 |
| Delta Kin. Viscosity KV100 avg. of 3 runs - absolute | $mm^2/s$ | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Delta Kin. Viscosity KV100 avg. of 3 runs - relative | % | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **CEC Low Temperature Pumping Test (CEC-TDG-L 105) [3]** | | Pass | Pass | Pass | Pass | Pass | Pass |
| MRV @ SAE J300 fresh oil temperature | mPa.s | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| MRV @ SAE J300 fresh oil temperature +5°C | mPa.s | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Yield Stress (≤35 = no yield stress) | Pa | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **Deposit test (MTU, DIN 51535)** | mg | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.



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## OEM Specifications: Mercedes-Benz Sheets For Heavy Duty Diesel Engine Oils v.2012.2 - Cont'd

| Sheet Number [1] | Units | 226.9 | 228.0/.1 | 228.2/.3 | 228.31 | 228.5 | 228.51 |
|---|---|---|---|---|---|---|---|
| **Sooted Oil MRV T11/11A ASTM D6896** | | | | | Pass | | |
| 180 hrs sample T-11/T11 A drain MRV | mPa.s | - | - | - | 18.000 | - | - |
| MRV Yield Stress | Pa | - | - | - | 35 | - | - |
| **High Temperature Corrosion Bench Test HTCBT (modified ASTM D6594 @ 135°C)** [3] | | - | - | Pass | Pass | Pass | Pass |
| Cu, ppm increase - w/o & with 10% B100 RME/SME* | ppm | - | - | R&R / R&R | 20 / R&R | R&R / R&R | R&R / R&R |
| Pb, ppm increase - w/o & with 10% B100 RME/SME* | ppm | - | - | 100 / R&R | 120 / R&R | R&R / R&R | R&R / R&R |
| Copper strip rating - w/o & with 10% B100 RME/SME* | ppm | - | - | R&R / R&R | 3 / R&R | R&R / R&R | R&R / R&R |
| * Reference Fuel B100 (80% RME +20% SME) from OM 646 TDG-L104 | | | | | | | |
| **Shear Stability CEC-L-14-93, ASTM D6278 / 7109** | | Pass @ 30 cycles | Pass @ 30 cycles | Pass @ 30 cycles | Pass @ 90 cycles | Pass @ 90 cycles | Pass @ 90 cycles |
| Kin.Viscosity after 30 / 90 pass Shearing @ 100°C | mm²/s | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade | Stay-in-grade |
| **Foaming tendency** | | Pass | Pass | Pass | Pass | Pass | Pass |
| Sequence I (24° C) ASTM D892 w/o option A | ml | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 |
| Sequence II (94°C) ASTM D892 w/o option A | ml | 50 / 0 | 50 / 0 | 20 / 0 | 20 / 0 | 20 / 0 | 20 / 0 |
| Sequence III (24°C) ASTM D892 w/o option A | ml | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 | 10 / 0 |
| Sequence IV (150°C) ASTM D6082 After 1 min. settle period | ml | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **Elastomer Compatibility - (CEC-L-39-96)** [4] | ACEA | ACEA E9 | ACEA E7 | ACEA E7 | ACEA E9 | ACEA E4 | ACEA E6 |
| Related Daimler Liefervorschrift | DBL | 6610 | 6610 | 6610 | 6610 | 6610 | 6610 |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.

(4) Elastomer compatibility tests according to ACEA 2012 or to DBL 6674 / 6610 / 6615 with materials NBR34, AK6, ACM E7503, VMQ RE3-04 and EAM D8948-200.1. Limits according to DBL 6610 / 6615.



Afton CHEMICAL

## OEM Specifications: Mercedes-Benz Sheets For Heavy Duty Diesel Engine Oils v.2012.2 - Cont'd

| Sheet Number [1] | Units | 226.9 | 228.0/.1 | 228.2/.3 | 228.31 | 228.5 | 228.51 |
|---|---|---|---|---|---|---|---|
| **Engine Tests (x = number of tests for Package Pass )** [5] | | | | | | | |
| **OM 646 DE22LA Biodiesel Test (CEC-L-104)** [3] | | | Pass | Pass | Pass | Pass | Pass |
| Piston cleanliness (avg. 4 pistons) | merit | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Engine sludge avg. | merit | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Ring sticking | yes/no | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| TBN (ASTM D4739) @ end of test | mgKOH/g | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| TAN (ASTM D664) @ end of test | mgKOH/g | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Oil consumption | g/test | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Soot | % | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Viscosity increase at 100°C | % | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **OM 646 DE22LA (CEC-SG-L-099)** [3] | | - | Pass | Pass | Pass | Pass | Pass |
| Cam wear inlet (avg. max. wear 8 cams) | µm | - | 120 | 100 | 100 | 90 | 90 |
| Cam wear outlet (avg. max. wear 8 cams) | µm | - | 155 | 130 | 130 | 110 | 110 |
| Cylinder wear (avg. 4 cylinder), max. | µm | - | 5,0 | 5,0 | 5,0 | 5,0 | 5,0 |
| Bore polishing (13 mm) - max. value of 4 cyl. | % | - | 4,0 | 3,5 | 3,5 | 3,0 | 3,0 |
| Piston cleanliness (avg. 4 pistons), min. | merit | - | 10,0 | 12,0 | 12,0 | 14,0 | 14,0 |
| Engine sludge avg, min. | merit | - | 8,6 | 8,8 | 8,8 | 9,1 | 9,1 |
| Ring sticking | yes/no | - | no | no | no | no | no |
| Tappet wear inlet (avg. max. wear 8 cams) | µm | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Tappet wear outlet (avg. max. wear 8 cams) | µm | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Bearing wear main / con rod bearing [6], max. | µm | - | 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 [6], max. | µm | - | 10,4 | 10,4 | 10,4 | 8,7 | 8,7 |
| Piston ring wear axial @ ring 2 [6], max. | µm | - | 6,0 | 6,0 | 6,0 | 4,0 | 4,0 |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.

(5) Approval conditions for engine oils for natural gas (CNG) engines: positive field test with MB CNG busses or a pass result in a 500 hrs CNG engine test by MB do Brasil or a Read-Across from MAN M 3271 approval.

(6) The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.



Afton CHEMICAL

## OEM Specifications: Mercedes-Benz Sheets For Heavy Duty Diesel Engine Oils v.2012.2 - Cont'd

| Sheet Number (1) | Units | 226.9 | 228.0/.1 | 228.2/.3 | 228.31 | 228.5 | 228.51 |
|---|---|---|---|---|---|---|---|
| **Engine Tests (x = number of tests for Package Pass ) (5)** | | | | | | | |
| OM 646 DE22LA Biodiesel Test (CEC-L-104) (3) | | | Pass | Pass | Pass | Pass | Pass |
| Piston ring wear axial @ ring 3 (6), max. | µm | - | 5,0 | 5,0 | 5,0 | 3,0 | 3,0 |
| Piston ring wear radial @ ring 1 (6), max. | µm | - | 10,0 | 10,0 | 10,0 | 10,0 | 10,0 |
| Piston ring wear radial @ ring 2 (6), max. | µm | - | 12,0 | 12,0 | 12,0 | 12,0 | 12,0 |
| Piston ring wear radial @ ring 3 (6), max. | µm | - | 8,0 | 8,0 | 8,0 | 8,0 | 8,0 |
| Timing chain wear (elongation), max. | % | - | 0,4 | 0,4 | 0,4 | 0,4 | 0,4 |
| Oil consumption, max. | g/test | - | 7000 | 7000 | 7000 | 7000 | 7000 |
| Soot, max. | % | - | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 | 4,0 - 7,0 |
| Viscosity increase at 100°C, max. | % | - | 100 | 100 | 100 | 90 | 90 |
| OM 501 LA Euro 5 (CEC SG-L-101) (3) (7) | | - | Pass | Pass | Pass | Pass | Pass |
| Piston cleanliness avg., min. | merit | - | 16,0 | 19,0 | 19,0 | 28,0 | 28,0 |
| Ring sticking 2. piston rings, max. | ASF | - | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| Engine sludge avg, min. | merit | - | 9,0 | 9,0 | 9,0 | 9,4 | 9,4 |
| General engine deposits avg, max. | demerit | - | 3,0 | 2,0 | 2,0 | 2,0 | 2,0 |
| Wear rating (visual) avg, max. | demerit | - | 3,0 | 2,0 | 2,0 | 2,0 | 2,0 |
| Bore polishing avg, max. | % | - | 3,0 | 2,0 | 2,0 | 1,0 | 1,0 |
| Cylinder wear avg, max. | mm | - | 0,008 | 0,008 | 0,008 | 0,008 | 0,008 |
| Turbocharger deposits, max. | demerit | - | 3,0 | 2,0 | 2,0 | 2,0 | 2,0 |
| TBN (ASTM D4739) @ end of test. | mgKOH/g | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| TAN (ASTM D664) @ end of test | mgKOH/g | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| Specific oil consumption, max. | g/h | - | 50,0 | 30,0 | 30,0 | 30,0 | 30,0 |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.

(5) Approval conditions for engine oils for natural gas (CNG) engines: positive field test with MB CNG busses or a pass result in a 500h CNG engine test by MB do Brasil or a Read-Across from MAN M 3271 approval.

(6) The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.

(7) 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/PHC.



Afton CHEMICAL

## OEM Specifications: Mercedes-Benz Sheets For Heavy Duty Diesel Engine Oils v.2012.2 - Cont'd

| Sheet Number (1) | Units | 226.9 | 228.0/.1 | 228.2/.3 | 228.31 | 228.5 | 228.51 |
|---|---|---|---|---|---|---|---|
| **OM 501 LA Euro 5 Fuel Economy-Test (Daimler Inhouse Test, based on WHTC, FE-Benefit bs MB RL003, 10W-40) (3)** | | - | - | Pass | Pass | Pass | Pass |
| FE-Benefit vs MB RL003 - only required for xW-30) | % | - | - | Rate & Report | Rate & Report | Rate & Report | Rate & Report |
| **Mack T-12 EGR (8)** | | - | - | - | Pass | - | - |
| Mack Merit Rating, min. | merit | - | - | - | 1000 | - | - |
| **Mack T-11 (ASTM D7156)** | | - | - | - | Pass | - | - |
| Minimum TGA % Soot @ 4.0 cSt increase @ 100° C | % | - | - | - | 3,5 / 3,4 / 3,3 | - | - |
| Minimum TGA % Soot @ 12.0 cSt increase @ 100° C | % | - | - | - | 6,0 / 5,9 / 5,9 | - | - |
| Minimum TGA % Soot @ 15.0 cSt increase @ 100° C | % | - | - | - | 6,7 / 6,6 / 6,6 | - | - |
| **Cummins ISM EGR (8)** | | - | - | - | Pass | - | - |
| Cummins Merit Rating, min. | merit | - | - | - | 1000 | - | - |
| Top Ring Weight Loss, max. | mg | - | - | - | 100 / 100 / 100 | - | - |
| **Cummins ISB EGR** | | - | - | - | Pass | - | - |
| Average Slider Tappet Weight Loss | mg | - | - | - | 100 / 108 / 112 | - | - |
| Average Cam Lobe Wear, µm, max. 55 | µm | - | - | - | 55 / 59 / 61 | - | - |
| Average Crosshead Weight Loss, max. R&R | mg | - | - | - | Rate & Report | - | - |
| **Caterpillar C13 (8)** | | - | - | - | Pass | - | - |
| CAT Merit Rating, min. | merit | - | - | - | 1000 | - | - |
| Hot-stuck piston ring | | - | - | - | none | - | - |

**Note:**

(1) All required data have to be measured, calculated values are not accepted.

(3) Complete Test Report is required. Additional for MB Engine Tests: Rerating at RD/PDI for all related engine parts.

(8) Detailed rating for Mack T-12, Cummins ISM and Cat C-13 according to API CJ-4 Merit Systems.



Afton CHEMICAL

## OEM Specifications: Mercedes-Benz Sheets For Heavy Duty Diesel Engine Oils v.2012.2 - Cont'd

| Sheet Number [1] | Units | 226.9 | 228.0/.1 | 228.2/.3 | 228.31 | 228.5 | 228.51 |
|---|---|---|---|---|---|---|---|
| **Caterpillar 1N (ASTM D6750)** | | - | - | - | Pass | - | - |
| Weighted Demerits, max. | demerit | - | - | - | 286,2 / 311,7 / 323,0 | - | - |
| Top Groove Fill, max. | % | - | - | - | 20 / 23 / 25 | - | - |
| Top Land Heavy Carbon, max. | % | - | - | - | 3 / 4 / 5 | - | - |
| Oil Consumption (0-252 hrs), max. | g/ kW h | - | - | - | 0,5 | - | - |
| Piston/ring/liner scuffing | | - | - | - | none | - | - |
| Piston ring stick | | - | - | - | none | - | - |
| **Sequence IIIF (ASTM D6984)** | | - | - | - | Pass | - | - |
| EOT Kinematic Viscosity / %Incr. @ 40° C, max. | | - | - | - | 275%(MTAC) | - | - |
| Sequence IIIG (alternative to IIIF) | | - | - | - | Pass | - | - |
| EOT Kinematic Viscosity / %Incr. @ 40° C, max. | | - | - | - | 150%(MTAC) | - | - |
| **Roller Follower Wear Test (ASTM D5596)** | | - | - | - | Pass | - | - |
| Average pin wear, mils, max. | mils | - | - | - | 0,30 /0,33 /0,36 | - | - |
| or Average pin wear, µm, max | µm | - | - | - | 7,6 / 8,4 / 9,1 | - | - |
| **Engine Oil Aeration Test (ASTM D6894)** | | - | - | - | Pass | - | - |
| Oil aeration volume %, max. (MTAC) | % | - | - | - | 8,0 | - | - |

**Note:**
(1) All required data have to be measured, calculated values are not accepted.



Afton CHEMICAL

**Additional Notes**

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

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

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

**3.** Base oil blends to meet requirements of MAN N699. Unconventional base oils may require additional testing.

## OEM Specifications: MAN 270, MAN 271

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

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

# OEM Specifications: MAN M 3275-1 (Multi-Grade Oils)

| Requirements | Method/Units | MAN M 3275 | | |
|---|---|---|---|---|
| SAE J300 Viscosity Grades | | 5W-X | 10W-X | 15W-X |
| Density @ 15°C, g/ml | DIN 51757 | To be reported | | |
| Apparent viscosity, mPa.s | DIN 51377 | according DIN 51511 | | |
| Viscosity @ 40°C, mm2/s | DIN 51562-1 | To be reported | | |
| Viscosity @ 100°C, mm2/s | DIN 51562-2 | according DIN 51511 | | |
| HTHS Viscosity, mPa.s | CEC-L-36-A-90 | ≥ 3.5 | | |
| Viscosity after shear, mm2/s | DIN EN ISO 20844 | xW-30: ≥ 9 and xW-40: ≥ 12 | | |
| NOACK Evaporation Loss, % mass | DIN 51581-1 | ≤ 13 | | |
| Flash Point (COC), °C | DIN EN ISO 2592 | ≥ 215 | | |
| Pour Point, °C, max | DIN ISO 3016 | -40 | -30 | -27 |
| TBN, mg KOH/g | DIN ISO 3771 | To be reported | | |
| TAN mg KOH/g | ASTM D664 | To be reported | | |
| Metals, Calcium, Magnesium and others % wt. | DIN 51399-1 | To be reported | | |
| Zinc, % wt. | DIN 51399-1 | ≥ 0.08 | | |
| Phosphorous, % wt. | DIN 51399-1 | To be reported | | |
| Nitrogen (additive) | Calculated | To be reported | | |
| Sulphated Ash, % wt. | DIN 51575 | ≤ 2.0 | | |
| Ethylene Glycol, % wt. | DIN 51375-2 | ≤ 0.05 | | |
| Turbocharger deposits (MTU), mg | DIN 51535 | To be reported | | |
| Foaming (without option A) | ASTM D892 | | | |
| Tendency I,II,III ml | | ≤ 10/50/10 | | |
| Stability I,II,III ml | | 0 | | |
| Seals test NBR 28, AK6 | | Pass | | |



Afton CHEMICAL

## OEM Specifications: MAN M 3275-1 (Multi-Grade Oils)

| Requirements | Method/Units | MAN M 3275 | | |
|---|---|---|---|---|
| SAE J300 Viscosity Grades | | 5W-X | 10W-X | 15W-X |
| **Engine Tests** | | | | |
| **OM 501 LA** (1) | CEC-L-101-08 | | | |
| Piston cleanliness avg. | merit | ≥ 17.0 | | |
| Wear rating (visual) avg. | demerit | ≤ 3.0 | | |
| Bore polishing avg. | % | ≤ 2.0 | | |
| General engine deposits avg. | demerit | ≤ 2.0 | | |
| Engine sludge avg. | merit | ≥ 9.0 | | |
| Turbocharger deposits | demerit | ≤ 2.0 | | |
| Cylinder wear avg. | mm | ≤ 0.008 | | |
| Ring sticking 2. piston rings | ASF | ≤ 1.0 | | |
| Specific oil consumption | g/h | ≤ 9 | | |
| TBN (ASTM D4739) @ end of test | mgKOH/g | Rate & Report | | |
| TAN (ASTM D664) @ end of test | mgKOH/g | Rate & Report | | |
| **OM 646 LA** (2) (3) | CEC-L-099-08 | | | |
| Cam wear inlet (avg. max. wear 8 cams) | µm | ≤ 110 | | |
| Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 140 | | |
| Cylinder wear (avg. 4 cylinder) | µm | ≤ 5.0 | | |
| Bore polishing (13 mm) - max. value of 4 cyl. | % | ≤ 3.5 | | |
| Tappet wear inlet (avg. max. wear 8 cams) | µm | Rate & Report | | |
| Tappet wear outlet (avg. max. wear 8 cams) | µm | Rate & Report | | |
| Viscosity increase at 100°C | % | ≤ 100 | | |
| Oil consumption | g/test | ≤ 7 | | |

**Note:**

(1) MAN In-house Reference oil

(2) Deposits on intercooler or turbocharger with individual rating of 5 will not be accepted.

(3) Test run to be aborted if oil consumption exceeds 9.5 kg oil during the first 100 hrs.

## OEM Specifications: MAN M 3275-2 (Mono-Grade Oils)

| Requirements | Method/Units | MAN M 3275 | | |
|---|---|---|---|---|
| SAE J300 Viscosity Grades | | 30 | 40 | 50 |
| Density @ 15°C, g/ml | DIN 51757 | To be reported | | |
| Apparent viscosity, mPa.s | DIN 51377 | according DIN 51511 | | |
| Viscosity @ 40°C, $mm^2/s$ | DIN 51562-1 | To be reported | | |
| Viscosity @ 100°C, $mm^2/s$ | DIN 51562-2 | according DIN 51511 | | |
| HTHS Viscosity, mPa.s | CEC-L-36-A-90 | ≥ 3.5 | | |
| Viscosity after shear, $mm^2/s$ | DIN EN ISO 20844 | xW-30: ≥ 9 and xW-40: ≥ 12 | | |
| NOACK Evaporation Loss, % mass | DIN 51581-1 | ≤ 10 | | |
| Flash Point (COC), °C | DIN EN ISO 2592 | ≥ 215 | | |
| Pour Point, °C, max. | DIN ISO 3016 | To be reported | | |
| TBN, mg KOH/g | DIN ISO 3771 | To be reported | | |
| TAN mg KOH/g | ASTM D664 | To be reported | | |
| Metals, Calcium, Magnesium and others % wt. | DIN 51399-1 | To be reported | | |
| Zinc, % wt. | DIN 51399-1 | ≥ 0.08 | | |
| Phosphorous, % wt. | DIN 51399-1 | To be reported | | |
| Nitrogen (additve) | Calculated | To be reported | | |
| Sulphated Ash, % wt. | DIN 51575 | ≤ 2.0 | | |
| Ethylene Glycol, % wt. | DIN 51375-2 | ≤ 0.05 | | |
| Turbocharger deposits (MTU), mg | DIN 51535 | To be reported | | |
| Foaming (without option A) | ASTM D892 | | | |
| Tendency I,II,III ml | | ≤ 10/50/10 | | |
| Stability I,II,III ml | | 0 | | |
| Seals test NBR 28, AK6 | | Pass | | |

## OEM Specifications: MAN M 3275-2 (Mono-Grade Oils)

| Requirements | Method/Units | MAN M 3275 | | |
|---|---|---|---|---|
| SAE J300 Viscosity Grades | | 5W-X | 10W-X | 15W-X |
| **Engine Tests** | | | | |
| **OM 501 LA** (1) | CEC-L-101-08 | | | |
| Piston cleanliness avg. | merit | ≥ 17.0 | | |
| Wear rating (visual) avg. | demerit | ≤ 3.0 | | |
| Bore polishing avg. | % | ≤ 2.0 | | |
| General engine deposits avg. | demerit | ≤ 3.0 | | |
| Engine sludge avg. | merit | ≥ 9.0 | | |
| Turbocharger deposits | demerit | ≤ 2.0 | | |
| Cylinder wear avg. | mm | ≤ 0.008 | | |
| Ring sticking 2. piston rings | ASF | ≤ 1.0 | | |
| Specific oil consumption | g/h | ≤ 9 | | |
| TBN (ASTM D4739) @ end of test | mgKOH/g | Rate & Report | | |
| TAN (ASTM D664) @ end of test | mgKOH/g | Rate & Report | | |
| **OM 646 LA** (2) (3) | CEC-L-099-08 | | | |
| Cam wear inlet (avg. max. wear 8 cams) | µm | ≤ 110 | | |
| Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 140 | | |
| Cylinder wear (avg. 4 cylinder) | µm | ≤ 5.0 | | |
| Bore polishing (13 mm) - max. value of 4 cyl. | % | ≤ 3.5 | | |
| Tappet wear inlet (avg. max. wear 8 cams) | µm | Rate & Report | | |
| Tappet wear outlet (avg. max. wear 8 cams) | µm | Rate & Report | | |
| Viscosity increase at 100°C | % | ≤ 100 | | |
| Oil consumption | g/test | ≤ 7 | | |

**Note:**

(1) MAN In-house Reference oil.

(2) Deposits on intercooler or turbocharger with individual rating of 5 will not be accepted.

(3) Test run to be aborted if oil consumption exceeds 9.5 kg oil during the first 100 hrs.

## OEM Specifications: MAN M 3277

| Requirements | Method/Units | MAN M 3277 | |
|---|---|---|---|
| **SAE Viscosity Grades (J300)** | | **5W-X** | **10W-X** |
| Density @ 15°C, g/ml | DIN 51757 | To be reported | |
| Apparent viscosity, mPa.s | DIN 51377 | According DIN 51511 | |
| Viscosity @ 40°C, mm2/s | DIN 51562-1 | To be reported | |
| Viscosity @ 100°C, mm2/s | DIN 51562-2 | According to DIN 51 511 | |
| HTHS Viscosity, mPa.s | CEC-L-36-A-90 | ≥ 3.5 | |
| Viscosity after shear, mm2/s | DIN EN ISO 20844 | xW-30: ≥ 9 and xW-40: ≥ 12 | |
| NOACK Evaporation Loss, % mass | DIN 51581-1 | ≤ 12 | |
| Flash Point (COC), °C | DIN EN ISO 2592 | ≥ 215 | |
| Pour Point, °C, max. | DIN ISO 3016 | -40 | -30 |
| TBN, mg KOH/g | DIN ISO 3771 | To be reported | |
| TAN mg KOH/g | ASTM D664 | To be reported | |
| Metals, Calcium, Magnesium and others % wt. | DIN 51399-1 | To be reported | |
| Zinc, % wt. | DIN 51399-1 | To be reported | |
| Phosphorous, % wt. | DIN 51399-1 | To be reported | |
| Nitrogen (additive), % wt. | Calculated | To be reported | |
| Sulphated Ash, % wt. | DIN 51575 | ≤ 2.0 | |
| Ethylene Glycol, % wt. | DIN 51375-2 | ≤ 0.05 | |
| Foaming (without option A) | ASTM D892 | | |
| Tendency I,II,III ml | | ≤ 10/50/10 | |
| Stability I,II,III ml | | 0 | |
| Turbocharger Deposit (MTU), mg | DIN 51535 | ≤ 120 | |
| Seals test NBR 28, AK6 | | Pass | |
| **Engine tests** | | | |
| **OM 501 LA** (1) | **CEC-L-101-08** | | |
| Piston cleanliness avg. | merit | ≥ 26.0 | |
| Wear rating (visual) avg. | demerit | ≤ 2.0 | |
| Bore polishing avg. | % | ≤ 1.0 | |
| General engine deposits avg. | demerit | ≤ 2.0 | |
| Engine sludge avg. | merit | ≥ 9.4 | |
| Turbocharger deposits | demerit | ≤ 2.0 | |
| Cylinder wear avg. | mm | ≤ 0.008 | |
| Ring sticking 2. piston rings | ASF | ≤ 1.0 | |
| Specific oil consumption | g/h | ≤ 9 | |
| TBN (ASTM D4739) @ end of test | mgKOH/g | Rate & Report | |
| TAN (ASTM D664) @ end of test | mgKOH/g | Rate & Report | |
| **OM 646 LA** (2)(3) | CEC-L-099-08 | | |
| Cam wear inlet (avg. max. wear 8 cams) | µm | ≤ 100 | |
| Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 120 | |
| Cylinder wear (avg. 4 cylinder) | µm | ≤ 5.0 | |
| Bore polishing (13 mm) - max. value of 4 cyl. | % | ≤ 3.0 | |
| Tappet wear inlet (avg. max. wear 8 cams) | µm | Rate & Report | |
| Tappet wear outlet (avg. max. wear 8 cams) | µm | Rate & Report | |
| Viscosity increase at 100°C | % | ≤ 90 | |
| Oil consumption | g/test | ≤ 7 | |

**Notes:**

(1) MAN In-house Reference oil.

(2) Deposits on intercooler or turbocharger with individual rating of 5 will not be accepted.

(3) Test run to be aborted if oil consumption exceeds 9.5 kg oil during the first 100 hrs.

## OEM Specifications: MAN M 3277

| Requirements | Method/Units | MAN M 3277 | |
|---|---|---|---|
| **SAE Viscosity Grades (J300)** | | **5W-X** | **10W-X** |
| **MAN In-house Test** | **D2876 LF04** | **M 3477** (1) | |
| Engine cleanliness | | | |
| Sludge | points | ≥ 9.0 | |
| Piston | | | |
| Piston cleanliness | points | ≥ 51.6 | |
| Piston Rings | | | |
| Piston Ring wear | | Rate & Report | |
| Ring sticking | merit | ≥ 9.7 | |
| Cylinder Liners | | | |
| Bore polishing | | Rate & Report | |
| Cylinder Wear | µm | ≤ 2.1 | |
| Engine Controls | | | |
| Rocker Arm wear | | Rate & Report | |
| Tappets | | Rate & Report | |
| Camshaft | | Rate & Report | |
| Wear - Rocker Arm Axis Outlet | µm | ≤ 2.2 | |
| Wear - Valve Bridges Inlet | µm | ≤ 7.3 | |
| Wear - Valve Bridges Outlet | µm | ≤ 6.4 | |
| Bearing and Oil Pump | | | |
| Bearing and Oil Pump | | Rate & Report | |
| Deposits | | | |
| Total Engine Deposits (2) | rating | ≤ 3.0 | |
| Used Oil Analysis (target values) | | | |
| Viscosity Increase at 4% Soot | % | max. 45 | |
| Iron Content at 4% Soot | mg/kg | max. 180 | |
| Oil Consumption (target value) | | | |
| Oil Consumption, total, 400 hrs | kg | max. 34.5 (3) | |

**Notes:**

(1) MAN In-house Reference oil.

(2) Deposits on intercooler or turbocharger with individual rating of 5 will not be accepted.

(3) Test run to be aborted if oil consumption exceeds 9.5 kg oil during the first 100 hrs.

## OEM Specifications: MAN M 3477

| Requirements | | MAN M 3477 | |
|---|---|---|---|
| **SAE J300 Viscosity Grades** | | **0W-X / 5W-X** | **10W-X** |
| Density @ 15°C, g/ml | DIN 51757 | To be reported | |
| Apparent viscosity, mPa.s | DIN 51377 | According DIN 51511 | |
| Viscosity @ 40°C, mm2/s | DIN 51562-1 | To be reported | |
| Viscosity @ 100°C, mm2/s | DIN 51562-2 | According to DIN 51 511 | |
| HTHS Viscosity, mPa.s | CEC-L-36-A-90 | ≥ 3.5 | |
| Viscosity after shear, mm2/s | DIN EN ISO 20844 | xW-30: ≥ 9 and xW-40: ≥ 12 | |
| NOACK Evaporation Loss, % mass | DIN 51581-1 | ≤ 12 | |
| Flash Point (COC), °C | DIN EN ISO 2592 | ≥ 215 | |
| Pour Point, °C, max. | DIN ISO 3016 | -40 | -30 |
| TBN, mg KOH/g | DIN ISO 3771 | To be reported | |
| TAN mg KOH/g | ASTM D664 | To be reported | |
| Metals, Calcium, Magnesium and others % wt. | DIN 51399-1 | To be reported | |
| Zinc, %wt. | DIN 51399-1 | To be reported | |
| Phosphorous, % wt. | DIN 51399-1 | ≤ 0.08 | |
| Bore, % wt. | DIN 51399-1 | To be reported | |
| Nitrogen (additive) | Calculated | To be reported | |
| Sulphated Ash, % wt. | DIN 51575 | ≤ 1.0 | |
| Sulphur Total (only additive) | DIN EN ISO 14596 | ≤ 0.3 | |
| Ethylene Glycol, % wt. | DIN 51375-2 | To be reported | |
| Turbocharger Deposit (MTU), mg | DIN 51535 | ≤ 120 | |
| Oxidation stability, PDSC, min | CEC-L-85-T-99 | ≥ 100 | |
| Foaming (without option A) | ASTM D892 | | |
| Tendency I,II,III ml | | ≤ 10/50/10 | |
| Stability I,II,III ml | | 0 | |
| Seals test NBR 28, AK6 | | Pass | |



Afton CHEMICAL

## OEM Specifications: MAN M 3477

| Requirements | Method/Units | MAN M 3477 | |
|---|---|---|---|
| **SAE Viscosity Grades (J300)** | | **5W-X** | **10W-X** |
| **MAN In-house Test** | **D2876 LF04** | **M 3477 (1)** | |
| Engine cleanliness | | | |
| Sludge | points | ≥ 9.0 | |
| Piston | | | |
| Piston cleanliness | points | ≥ 51.6 | |
| Piston Rings | | | |
| Piston Ring wear | | Rate & Report | |
| Ring sticking | merit | ≥ 9.7 | |
| Cylinder Liners | | | |
| Bore polishing | | Rate & Report | |
| Cylinder wear | µm | ≤ 2.1 | |
| Engine Controls | | | |
| Rocker Arm wear | | Rate & Report | |
| Tappets | | Rate & Report | |
| Camshaft | | Rate & Report | |
| Wear - Rocker Arm Axis Outlet | µm | ≤ 2.2 | |
| Wear - Valve Bridges Inlet | µm | ≤ 7.3 | |
| Wear - Valve Bridges Outlet | µm | ≤ 6.4 | |
| Bearing and Oil Pump | | | |
| Bearing and Oil Pump | | Rate & Report | |
| Deposits | | | |
| Total Engine Deposits (2) | rating | ≤ 3.0 | |
| Used Oil Analysis (target values) | | | |
| Viscosity Increase at 4% Soot | % | max. 45 | |
| Iron Content at 4% Soot | mg/kg | max. 180 | |
| Oil Consumption (target value) | | | |
| Oil Consumption, total, 400 hrs | kg | max. 34.5 (3) | |

**Note:**

(1) MAN In-house Reference oil.

(2) Deposits on intercooler or turbocharger with individual rating of 5 will not be accepted.

(3) Test run to be aborted if oil consumption exceeds 9.5 kg oil during the first 100 hrs.

# OEM Specifications: MAN M 3575

| Requirements | Method/Units | MAN M 3575 | |
|---|---|---|---|
| **SAE J300 Viscosity Grades** | | **XW-40** | **XW-30** |
| Density @ 15°C, g/ml | DIN 51757 | To be reported | |
| Apparent viscosity, mPa.s | DIN 51377 | According DIN 51511 | |
| Viscosity @ 40°C, mm2/s | DIN 51562-1 | To be reported | |
| Viscosity @ 100°C, mm2/s | DIN 51562-2 | According to DIN 51 511 | |
| HTHS Viscosity, mPa.s | CEC-L-36-A-90 | ≥ 3.5 | |
| Viscosity @ 100 after shear, mm2/s | DIN EN ISO 20844 | ≥ 12.0 | ≥ 9.0 |
| NOACK Evaporation Loss, % mass | DIN 51581-1 | ≤ 13 | |
| Flash Point (COC), °C | DIN EN ISO 2592 | ≥ 215 | |
| Pour Point, °C, max | DIN ISO 3016 | -30 | -27 |
| TBN, mg KOH/g | DIN ISO 3771 | To be reported | |
| TAN mg KOH/g | ASTM D664 | To be reported | |
| Metals, Calcium, Magnesium and others % wt. | DIN 51399-1 | To be reported | |
| Zinc, % wt. | DIN 51399-1 | To be reported | |
| Phosphorous, % wt. | DIN 51399-1 | ≤ 0.12 | |
| Bore, % wt. | DIN 51399-1 | To be reported | |
| Nitrogen (additive) | Calculated | To be reported | |
| Sulphated Ash, % wt. | DIN 51575 | ≤ 1.0 | |
| Sulphur Total (only additive) | DIN EN ISO 14596 | ≤ 0.4 | |
| Ethylene Glycol, % wt. | DIN 51375-2 | ≤ 0.05 | |
| Turbocharger Deposit (MTU), mg | DIN 51535 | ≤ 120 | |
| Oxidation stability, PDSC, min. | CEC-L-85-T-99 | ≥ 100 | |
| Foaming (without option A) | ASTM D892 | | |
| Tendency I,II,III ml | | ≤ 10/50/10 | |
| Stability I,II,III ml | | 0 | |
| Seals test NBR, FPM | | Pass | |



Afton CHEMICAL

## OEM Specifications: MAN M 3575

| Requirements | Method/Units | MAN M 3575 | |
|---|---|---|---|
| **SAE J300 Viscosity Grades** | | **XW-40** | **XW-30** |
| **Engine Tests** | | | |
| **OM 501 LA** (1) | **CEC-L-101-08** | | |
| Piston cleanliness avg. | merit | ≥ 17.0 | |
| Wear rating (visual) avg. | demerit | ≤ 3.0 | |
| Bore polishing avg. | % | ≤ 2.0 | |
| General engine deposits avg. | demerit | ≤ 3.0 | |
| Engine sludge avg. | merit | ≥ 9.0 | |
| Turbocharger deposits | demerit | ≤ 2.0 | |
| Cylinder wear avg. | mm | ≤ 0.008 | |
| Ring sticking 2. piston rings | ASF | ≤ 1.0 | |
| Specific oil consumption | g/h | ≤ 9 | |
| TBN (ASTM D4739) @ end of test | mgKOH/g | Rate & Report | |
| TAN (ASTM D664) @ end of test | mgKOH/g | Rate & Report | |
| **OM 646 LA** (2)(3) | CEC-L-099-08 | | |
| Cam wear inlet (avg. max. wear 8 cams) | µm | ≤ 110 | |
| Cam wear outlet (avg. max. wear 8 cams) | µm | ≤ 130 | |
| Cylinder wear (avg. 4 cylinder) | µm | ≤ 5.0 | |
| Bore polishing (13 mm) - max. value of 4 cyl. | % | ≤ 3.5 | |
| Tappet wear inlet (avg. max. wear 8 cams) | µm | Rate & Report | |
| Tappet wear outlet (avg. max. wear 8 cams) | µm | Rate & Report | |
| Viscosity increase at 100°C | % | ≤ 100 | |
| Oil consumption | g/test | ≤ 7 | |

**Note:**

(1) MAN In-house Reference oil.

(2) Deposits on intercooler or turbocharger with individual rating of 5 will not be accepted.

(3) Test run to be aborted if oil consumption exceeds 9.5 kg oil during the first 100 hrs.

# OEM Specifications: Volvo Drain Specifications (VDS)

**Performance Requirements:**

API CD/CE

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

**Field Trial Requirements:**

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

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

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

**Other:**

From January 1st 2012, no new VDS approvals will be issued by Volvo.

Approvals issued before January 1st 2012 will remain valid as long as the finished oil remains unchanged from the time of original approval.

# OEM Specifications: Volvo Drain Specifications - 2 (VDS-2)

VDS-2 is the oil quality intended for Volvo Truck engines meeting the 1996 European (Euro 2) emission requirements.

**Test Conditions:**

Field test to involve a minimum of three trucks.
Test oil shall be minimum ACEA E3 or API CG-4 of viscosity 5W30, 5W40, 10W30, 10W40 or 15W40. Other viscosity grades can be accepted after agreement with Volvo.
Trucks used for the test to be equipped with Volvo TD 123 Series, 12 litre intercooled engine.

**Field Test:**

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

Oil samples are taken after 15,000, 30,000, 45,000 and 60,000 km. of the drain interval and checked with respect to:

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

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

**Inspection and Evaluation:**

Upon completion of the field test, the following engine components are inspected: Pistons, Piston rings, Cylinder liners, Tappets, Camshaft, Rocker arms, Valves, Bearings. Cleanliness of covers and oil sump also inspected.

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

**Other:**

Read-across to other viscosity grades, base oils or viscosity modifiers are subject to discussion with Volvo.

From January 1st 2012, no new VDS-2 approvals will be issued by Volvo.

Approvals issued before January 1st 2012 will remain valid as long as the finished oil remains unchanged from the time of original approval.



Afton CHEMICAL

# OEM Specifications: Volvo Drain Specifications - 3 (VDS-3)

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

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

**Field Test:** European Long Haul Service only, two trucks minimum.

**Test Length and Drain Intervals:**
GVW up to 44t: 3 x 100,000 km oil drains with oil samples taken at 0, 25,000, 50,000, 75,000 and 100,000 km.
GVW over 44t: 4 x 75,000 km oil drains with oil samples taken at 0, 25,000, 50,000 and 75,000 km.

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

**Limits:** On completion of the field test, engine parts will be inspected for piston cleanliness, bore polish and ring wear.

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

**Other Requirements:** For VDS-3 oils sold in Europe, ACEA E7 or DHD-1 performance to be demonstrated.

For VDS-3 oils sold outside Europe, DHD-1 performance to be demonstrated for global markets or API CI-4 for US market.

T8E limits as per Mack EO-M+ Mack T12 CI-4 limits + Seq. IIIF limits as per API CI-4 specification.

**Engine Test Alternative:** The Volvo D12D engine test can now be run, in place of field trials to qualify an oil against the VDS-2 and VDS-3 specifications. The limits are similar, but VDS-3 requires a merit rating of 1250 in the Mack T12 engine test.

**Criteria**

| | | **VDS-2** | **VDS-3** |
|---|---|---|---|
| Piston cleanliness | points | ≥ 40 | ≥ 40 |
| Ring riding | % | Max. 50 | Max. 50 |
| Oil Consumption (total and final 100h) | g/h | Max. 35 | Max. 35 |
| Bore Polish (based on OM 501 LA Procedure) | $cm^2$ | Max. 150 | Max. 150 |
| Other needed criteria | - | ACEA E7 | ACEA E7 Merit of 1250 in Mack T12 |

## OEM Specifications: Volvo Drain Specifications - 4 (VDS-4)

| Requirements | Limits | |
|---|---|---|
| Viscosity grade | SAE 15W-30 | SAE 15W-40 |
| | 97486-13 | 97486-15 |
| Viscosity at 100 ˚C, $mm^2/s$, (cSt), min.<br>max. | 9.3<br>12.5 | 12.5<br>16.3 |
| Viscosity at 40 ˚C, $mm^2/s$, (cSt) | Report | Report |
| Viscosity at 110 ˚C after shearing (90 cycles), $mm^2/s$ (cSt), min. | 9.3 | 12.5 |
| HTHS after shearing by ASTM D7109 (90 cycles), mPas (cP), min. | 3.4 | 3.9 |
| Base oil viscosity at 100 ˚C, $mm^2/s$ (cSt), min. | 6.2 | 6.5 |
| Density, $kg/m^3$ | Report | Report |
| Flash point COC, ˚C | Report | Report |
| Pour point, ˚C | Report | Report |
| Evaporative loss (NOACK), %, max. | 13 | 13 |
| Sulphated ash, % w/w, max. | 1.0 | 1.0 |
| Phosphorus, % w/w, max. | 0.12 | 0.12 |
| Sulphur, % w/w, max. | 0.4 | 0.4 |
| Foaming tendency/stability | | |
| Sequence I, ml/ml, max. | 10/0 | 10/0 |
| Sequence II, ml/ml, max. | 20/0 | 20/0 |
| Sequence III, ml/ml, max. | 10/0 | 10/0 |
| Corrosion | | |
| Cu, ppm, max. | 20 | 20 |
| Pb, ppm, max. | 120 | 120 |
| Cu strip, max. | 3 | 3 |

**Note:**

Grade SAE 10W-30 now allowed for VDS-4 but specifications have not been updated yet.

## OEM Specifications: Volvo Drain Specifications - 4 (VDS-4)

| Requirements | | Limits | |
|---|---|---|---|
| Viscosity grade | | SAE 15W-30 | SAE 15W-40 |
| Specifications number | | 97486-13 | 97486-15 |
| Seal compatibility | | | |
| Nitrile | | | |
| | Volume, % | +5/-3 | +5/-3 |
| | Hardness, points | +7/-5 | +7/-5 |
| | Tensile strength, % | +10/-TMC 1006 | +10/-TMC 1006 |
| | Elongation at break, % | +10/-TMC 1006 | +10/-TMC 1006 |
| Silicone | | | |
| | Volume, % | +TMC 1006/-3 | +TMC 1006/-3 |
| | Hardness, points | +5/-TMC 1006 | +5/-TMC 1006 |
| | Tensile strength, % | +10/-45 | +10/-45 |
| | Elongation at break, % | +20/-30 | +20/-30 |
| Polyacrylate | | | |
| | Volume, % | +5/-3 | +5/-3 |
| | Hardness, Points | +8/-5 | +8/-5 |
| | Tensile strength, % | +18/-15 | +18/-15 |
| | Elongation at break, % | +10/-35 | +10/-35 |
| FKM | | | |
| | Volume, % | +5/-2 | +5/-2 |
| | Hardness, Points | +7/-5 | +7/-5 |
| | Tensile strength, % | +10/-TMC 1006 | +10/-TMC 1006 |
| | Elongation at break, % | +10/-TMC 1006 | +10/-TMC 1006 |
| Vamac G | | | |
| | Volume, % | +TMC 1006/-3 | +TMC 1006/-3 |
| | Hardness, Points | +5/-TMC 1006 | +5/-TMC 1006 |
| | Tensile strength, % | +10/-TMC 1006 | +10/-TMC 1006 |
| | Elongation at break, % | +10/-TMC 1006 | +10/-TMC 1006 |

**Note:**

Grade SAE 10W-30 now allowed for VDS-4 but specifications have not been updated yet.

## OEM Specifications: Volvo Drain Specifications - 4 (VDS-4)

| Requirements | Limits | |
|---|---|---|
| Viscosity grade | SAE 15W-30 | SAE 15W-40 |
| Specifications number | 97486-13 | 97486-15 |
| **Cummins ISM** | | |
| Merit, rating, min | 1000 | 1000 |
| Cross head % wt. loss at 3.9% soot, mg, max. | 7.1 | 7.1 |
| OFDP at 150 hrs, kPa, max | 19 | 19 |
| Avg. engine sludge, merit, min. | 8.7 | 8.7 |
| Avg. VAS % wt. loss at 3.9% soot, mg, max. | 45 | 45 |
| **Cummins ISB** | | |
| Avg. Slider Tappet % wt. loss, mg, max | 100 / 108 / 112 | 100 / 108 / 112 |
| Avg. Cam Lobe Wear, µm, max. | 50 / 53 / 55 | 50 / 53 / 55 |
| Avg. Crosshead % wt. loss, mg, max. | Rate & Report | Rate & Report |
| **Mack T11 (D7516)** | | |
| TGA soot at 4 cSt increase @ 100˚C %, min. | 3.5 / 3.4 / 3.3 | 3.5 / 3.4 / 3.3 |
| TGA soot at 12 cSt increase @ 100˚C %, min. | 6.0 / 5.9 / 5.9 | 6.0 / 5.9 / 5.9 |
| TGA soot at 15 cSt increase @ 100˚C %, min. | 6.7 / 6.6 / 6.5 | 6.7 / 6.6 / 6.5 |
| **Mack T11A used MRV TP-1** | | |
| 180 hr drain MRV, mPas, max. | 18,000 | 18,000 |
| MRV yield stress, Pa, max. | 35 | 35 |
| **Mack T12** | | |
| Mack Merit rating, min. | 1300 | 1300 |
| Cylinder liner wear, µm, max. | 21 | 21 |
| Top ring weight. loss, mg, max. | 105 | 105 |
| Lead 0-300 hrs, ppm, max. | 30 | 30 |
| Delta Lead 250-300 hrs, ppm, max. | 12 | 12 |
| Oil consumption, g/h, max. | 80 | 80 |
| **Caterpillar C13** | | |
| Merit rating, min | 1000 | 1000 |
| Delta Oil consumption, g/h, max. | 31 | 31 |
| Avg. Top Land Carbon, demerit, max. | 35 | 35 |
| Avg. Top Groove Carbon, demerit, max. | 53 | 53 |
| 2nd Ring Top Face Carbon, demerit, max. | 33 | 33 |
| **Sequence IIIG** | | |
| EOT KV increase (adjusted), %, max. | 150 | 150 |
| KV40 Increase Parameters | | |
| 100 hr (unadjusted) [B], %, max. | Report | Report |
| 80 hr " [C], % | Report | Report |
| 60 hr " [D], % | Report | Report |
| EOT Ratio [(B-C)/(C-D)], max. | 2.5 | 2.5 |

**Note:**

Grade SAE 10W-30 now allowed for VDS-4 but specifications have not been updated yet.



Afton CHEMICAL

## OEM Specifications: Volvo Drain Specifications - 4 (VDS-4)

| Requirements | Limits | |
|---|---|---|
| Viscosity grade | SAE 15W-30 | SAE 15W-40 |
| Specifications number | 97486-13 | 97486-15 |
| **Roller Follower Wear Test (D5596)** | | |
| Avg. pin wear, µm, max. | 7.6 / 8.4 / 9.1 | 7.6 / 8.4 / 9.1 |
| **Engine Oil Aeration Test** | | |
| Aeration, % volume, max. | 8.0 | 8.0 |
| **Turbocharger Deposits** | | |
| Boost pressure loss and/or, %, max. | to be determined | to be determined |
| Deposit weight, mg, max. | to be determined | to be determined |
| **D12D460** | | |
| Piston deposits, merit, min. | 40 | 40 |
| Ring riding, %, max. | 50 | 50 |
| Bore polish, $cm^2$, max | 150 | 150 |
| Oil consumption (400 h), g/h, max. | 35 | 35 |
| Oil consumption (final 100 h), g/h, max. | 35 | 35 |
| Fuel economy, D12D460, g/kW-h | ≥ ref oil | - |

**Note:**

Grade SAE 10W-30 now allowed for VDS-4 but specifications have not been updated yet.

## OEM Category: MTU MTL 5044

Laboratory Tests

| | Method | Monograde | | Multigrade | | |
|---|---|---|---|---|---|---|
| | | | | 1 to 3 | | 3.1 |
| Viscosity grade | SAE J300 | SAE 30 | SAE 40 | 5W-30 10W-30 | 5W-40 10W-40 15W-40 | 10W40 |
| Appearance | Visual | Clear & free from insoluble material | | | | |
| Kinematic viscosity@ 100°C, mm2/s | DIN 51562-1 or ASTM D445 | 9.3-12.5 | 12.5-16.3 | 9.3-12.5 | 12.5-16.3 | 12.5-16.3 |
| Kinematic viscosity@ 40°C, mm2/s | DIN 51562-1 or ASTM D445 | To be submitted | | | | |
| Dynamic Viscosity, mPa.s | DIN 51377 or SAE J300 | To be submitted | | | | |
| High Temperature High Shear at 150°C, $10^6 s^{-1}$ | CEC-L-36-A-90 | - | - | ≥ 3.5 | | |
| Viscosity Index, VI | ISO 2909 or ASTM D1298 | To be submitted | | | | |
| Specific gravity at 15°C, g/ml | DIN 51757 or ASTM D1298 | To be submitted | | | | |
| Shear Stability, Viscosity on shearing at 100°C, mm2/s | CEC-L-14-A-88, ASTM D6278, ASTM D7109, DIN 51382 30 cycles | - | | Oil category 1 and 2 Stay-in-grade | | |
| | ASTM D6278, ASTM D7109, 90 cycles | | | Oil category 2.1, 3, 3.1 Stay-in-grade | | |
| Pour point, °C | ISO 3016 or ASTM D97 | To be submitted | | | | |
| Flash Point | | | | | | |
| COC, °C | ISO 2592 or ASTM D92 | ≥ 225 | | | | |
| PM, °C | ISO 2719 | To be submitted | | | | |
| Distillation Loss at 250°C, NOACK Method | CEC-L-40-A-93 or DIN 51581 | ≤ 10 | | ≤ 12 | | ≤ 13 |
| Sulfated Ash, % wt. | DIN 51575 or ASTM D874 | 1.0 to 2.0 | | 1.0 to 2.0 Oil category 2.1 ≤ 1.0 | | ≤ 1.0 |
| TBN, mg KOH/g | ISO 3771 or ASTM D2896 | ≥ 8.0 | | Oil Category 1 and 2 ≥ 8.0 Oil category 2.1 ≥ 7.0 Oil category 3 ≥ 12.0 | | ≥ 7.0 |
| TAN, mg KOH/g | ASTM D664 | To be submitted | | | | |
| Chlorine, ppm | DIN ISO 15597 | Less than 150 | | | | |
| Magnesium, % wt. | DIN 51391-3 | To be submitted | | | | |
| Phosphorous, % wt. | DIN 51363-2 DIN 51363-3 | To be submitted | | To be submitted Oil category 2.1 ≤ 0.12 | | ≤ 0.08 |
| Sulphur, % wt. | DIN 51400-1 DIN EN ISO 14596 | To be submitted | | To be submitted Oil category 2.1 ≤ 0.4 | | ≤ 0.3 |

## OEM Category: MTU MTL 5044

Laboratory Tests

| | | Method | Monograde | Multigrade 1 to 3 | Multigrade 3.1 |
|---|---|---|---|---|---|
| Calcium, % wt. | | DIN 51391-3 | To be submitted | | |
| Zinc, % wt. | | DIN 51391-3 | ≥ 0.035 | | |
| Nitrogen, % wt. | | ASTM D3228<br>ASTM D5762 | To be submitted | | |
| Boron, % wt. | | DIN 51443-2 | To be submitted | | |
| Molybdenum, % wt. | | DIN 51379-2<br>DIN 51396-1 | To be submitted | | |
| Further additive elements, >0,01 %wt. | | - | To be submitted | | |
| Elastomer compatibility | | | | | |
| - Standard strip S 2 to Din 53504 -Test material SRE-NBR 28 to DIN 53538-3 | Volume Change, % | DIN 53521 (168 +/- 2)h at (100 +/- 1) °C. Test agent volume : 80 * test body volume sealed container | 0 to +10 | | |
| | Shore A hardness change | | 0 to -10 | | |
| | Tensile strength change, % | | max. -20 | | |
| | Elongation Rupture Change % | | max. -35 | | |
| - Standard strip S 2 to Din 53504 -Test material FKM-AK6 (Note1) | Volume Change, % | DIN 53521 (168 +/- 2)h at (150 +/- 2) °C. Test agent volume : 80 * test body volume sealed container | 0 to +5 | | |
| | Shore A hardness change | | -5 to +5 | | |
| | Tensile strength change, % | | max. -50 | | |
| | Elongation Rupture Change % | | max. -55 | | |
| Mechanical test in the FZG gear rig | Test load stage | DIN 51354-2 or CEC-L-07-A-95 | min. 11 | | |
| Foaming test at 150°C, ml | | ASTM D6082 | max. 250-50 | | |
| Deposits only for multigrade oils, mg | | DIN 51535 | - - | *max. 120 | |

**Note:**

* Test limit should be the average of two tests, run in two different labs.

## OEM Specifications: MTU MTL 5044

Engine Tests

| Oil Category | 1 | 2 / 2.1 | 3 / 3.1 |
|---|---|---|---|
| **OM 364 LA** (1) | | | |
| Bore polishing, % | max. 3,5 | | |
| Piston cleanliness, merit | min. 40 | | |
| Cylinder wear, µm | max. 3,5 | | |
| Engine sludge, merit | min. 9,4 | | |
| Oil consumption, kg/test | max. 16 | | |
| **OM 441 LA** (1) | | | |
| Bore polishing, % | max. 3,0 | max. 2,0 | max. 2,0 |
| Piston Cleanliness, merit | min. 20 | min. 25 | min. 40 |
| Cylinder wear, µm | max. 8,0 | max. 8,0 | max. 8,0 |
| Engine Sludge, merit | min. 9,0 | min. 9,0 | min. 9,0 |
| Oil consumption, kg/test | max. 100g/h | max. 100g/h | max. 100g/h |
| Viscosity increase at 40°C, % | - | - | To be submitted |
| Wear rating, merit | max. 2,5 | max. 2,5 | max. 2,5 |
| General engine deposit, merit | max. 3,0 | max. 3,0 | max. 3,0 |
| Oil drain interval, hrs. | 200 | 400 | 400 |
| **OM 501 LA** (2) | | | |
| Piston cleanliness avg. merit | min. 14,0 | min. 17,0 | min. 26,0 |
| Ring sticking 2. piston rings, ASF | max. 1,0 | max. 1,0 | max. 1,0 |
| Engine sludge avg., merit | min. 9,0 | min. 9,0 | min. 9,4 |
| General engine deposits avg., demerit | max. 3,0 | max 2,0 | max 2,0 |
| Wear rating (visual) avg., demerit | max. 3,0 | max. 3,0 | max. 2,0 |
| Bore polishing avg., % | max. 3,0 | max. 2,0 | max. 1,0 |
| Cylinder wear avg., mm | max. 0,008 | max. 0,008 | max. 0,008 |
| Turbocharger deposits, demerit | max. 3,0 | max. 2,0 | max. 2,0 |
| TBN (ASTM D4739) @ end of test, mg KOH/g | Rate & Report | Rate & Report | Rate & Report |
| TAN (ASTM D664) @ end of test, mg KOH/g | Rate & Report | Rate & Report | Rate & Report |
| Specific oil consumption, g/hr | max 50,0 | max 30,0 | max 30,0 |
| **OM 611 (300 hrs.)** | | | |
| Bore polishing, % | max. 4,0 | max. 3,5 | max. 3,0 |
| Piston cleanliness, merit | min. 23 | min. 25 | min. 27 |
| Cylinder wear (avg), µm | max. 7,0 | max. 7,0 | max. 5,2 |
| Cam wear, µm | max. 140 (3)<br>max. 155 (4) | max. 140 3)<br>max. 155 (4) | max. 120 (3)<br>max. 140 (4) |
| Engine sludge avg., merit | min. 8,0 | min. 8,5 | min. 9,0 |
| Oil consumption, kg/test | max. 6 | max. 6 | max. 6 |
| Viscosity increase at 40°C, % | max. 100 | max. 100 | max. 90 |

**Note:**
(1) OM 441 LA test as alternative to the OM 364 LA.
(2) OM 501 LA test as alternative to the OM 441 LA.
(3) Inlet valve.
(4) Outlet valve.



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## OEM Specifications: MTU MTL 5044 — Engine Tests

| Oil Category | 1 | 2 / 2.1 | 3 / 3.1 |
|---|---|---|---|
| **OM 646 DE22LA (CEC-SG-L-099)** (5) | | | |
| Cam wear inlet (avg. max. wear 8 cams), µm | max. 120 | max. 110 | max. 100 |
| Cam wear outlet (avg. max. wear 8 cams), µm | max. 155 | max. 140 | max. 120 |
| Cylinder wear (avg. 4 cylinder), µm | max. 5 | max. 5 | max. 5 |
| Bore polishing (13 mm) - max. value of 4 cyl., % | max. 4,0 | max. 3,5 | max. 3,0 |
| Piston cleanliness (avg. 4 pistons), merit | min. 10,0 | min. 12,0 | min. 14,0 |
| Engine sludge avg., merit | min. 8,5 | min. 8,7 | min. 9,0 |
| Ring sticking, yes/no | no | no | no |
| Tappet wear inlet (avg. max. wear 8 cams),µm | Rate & Report | Rate & Report | Rate & Report |
| Tappet wear outlet (avg. max. wear 8 cams), µm | Rate & Report | Rate & Report | Rate & Report |
| Bearing wear main / con rod bearing, µm | max. 2,1 / 2,1 | max. 2,1 / 2,1 | max. 2,1 / 2,1 |
| Piston ring wear axial @ ring 1*, µm | max. 10,4 | max. 10,4 | max. 8,7 |
| Piston ring wear axial @ ring 2*, µm | max. 6,0 | max. 6,0 | max. 4,0 |
| Piston ring wear axial @ ring 3*, µm | max. 5,0 | max. 5,0 | max. 3,0 |
| Piston ring wear radial @ ring 1*, µm | max. 10,0 | max. 10,0 | max. 10,0 |
| Piston ring wear radial @ ring 2*, µm | max. 12,0 | max. 12,0 | max. 12,0 |
| Piston ring wear radial @ ring 3*, µm | max. 8,0 | max. 8,0 | max. 8,0 |
| Timing chain wear (elongation), % | max. 0,4 | max. 0,4 | max. 0,4 |
| Oil consumption, g/test | max. 7000 | max. 7000 | max. 7000 |
| Soot, % | max. 4,0-7,0 | max. 4,0-7,0 | max. 4,0-7,0 |
| Viscosity increase at 100°C, % | max. 100 | max. 100 | max. 90 |

**Note:**
(5) OM 646 DE 22 LA test as alternative to the OM 611.
* The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.



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# OEM Specifications: Scania LDF 1&2 (DM 2004_181 2008-10-07, Issue 6)

**Oil Specifications:** Quality level must pass one or more of the following specifications ACEA E4, E6, E7, E9, API CJ-4

**Number of vehicles:** Minimum 3 vehicles with candidate oil to complete the test.

**Test Engine Type:** Approvals issued based on field testing with Euro III, IV and Euro V engine types

DT12 12, 420 HP and DT12 17, 480 HP both Euro IV engine types

DC13 10, 440 HP Euro V engine type

Scania recommends that engine mileage is not more than 60,000 km before start of test and that the existing oil is analysed to screen for proper operation before switching to the candidate oil.

**Test Distance:** 2 x 120,000 kms (Total 240,000kms) or 3 x 90,000 kms (Total 270,000 kms) depending on vehicle operation (medium or severe).

Alternatively for Low Ash Oil, 4 x 60,000 kms in severe operation is permitted. In this case, no approvals for LDF, LDF-2 or LDF-3 will be given.

**Test Drain Periods:** 120,000 ± 5,000 kms, 90,000 ± 5,000 kms or 60,000 ± 2,000 kms

**Oil samples:** Samples have to be taken at least at 0, 10.000, 30.000, 60.000, 90.000 and 120,000 kms for each drain intervals. For 4 x 60.000 kms samples have to be taken at 0, 10,000, 30,000, 45,000 and 60,000 kms

| Component/System | Scania Specification | EURO III | EURO IV | EURO V |
|---|---|---|---|---|
| | | Minimum Piston Rating average | | |
| Piston | LDF-3 | 38 | 38 | 44 |
| | LDF-2 | 35 | 35 | 38 |
| | LDF | 32 | 32 | 35 |
| | Scania Low Ash | 32* | 32* | 35* |
| | | EOT TBN mg KOH/g ASTM D 4739 | | |
| Lubricant | LDF-3 | 7 | 7 | 8 |
| | LDF-2 | 4 | 3.5 | 4 |
| | LDF | 3.5 | 2.5 | 3.5 |
| | Scania Low Ash | -** | -** | -** |
| **Component/System** | **Parameter** | **Method** | **Criteria** | **Remarks** |
| Valves | Valve head deposit | CRC Manual No 20, p115 | Average ≥ 8.0 | - |
| Turbocharger | Deposits on compressor backplate | Scania Turbocharger deposit gauge, see appendix 5 | ≤ 0.15 mm thickness | - |
| | Diffuser | Scania Turbocharger deposit gauge, see appendix 5 | ≤ 0.15 mm thickness | - |
| Full required parameters and comments are mentioned in the Scania Specifications DM 2004_181, 2008-10-07, Issue 6 | | | | |

## OEM Specifications: Caterpillar

| Bench Tests | Cat ECF-1a | Cat ECF-2 | Cat ECF-3 |
|---|---|---|---|
| | API CH-4 Only | API CI-4, CI-4 + CJ-4 Acceptable | CJ-4 |
| SAE Grade | SAE J300, latest active issue | | |
| Sulfated Ash, % wt. max. | 1.5; 2x1P's if > 1.3 | 1.50 | 1.0 |
| NOACK, % max (ASTM D5800) | 18 (15W-40); 20 (10W-30) | 15 | 13 |
| HTHS Viscosity, mPa.s, min. | Stay-in-grade | 3.5 | 3.5 |
| Sulphur, % wt. max. | - | - | 0.4 |
| Phosphorus, % wt. max. | - | - | 0.12 |
| Mack T-11A 180 hrs.<br>Used Oil MRV, mPa.s, max. | - | Use if CJ-4 | 25,000 |
| Mack T-11A 180 hrs.<br>Used Oil Yield Stress, max. | - | - | 35 |
| Mack T-10A 75 hrs.<br>Used Oil MRV, mPa.s, max. | - | 25,000 | - |
| Mack T-10A 75 hrs.<br>Used Oil Yield Stress, max. | - | 35 | - |
| Corrosion (D6594) | | | |
| Cu, ppm increase max. | 20 | 20 | 20 |
| Pb, ppm increase max. | 120 | 120 | 120 |
| Sn, ppm increase max. | 50 | 50 | - |
| Cu, Strip Rating, max. | 3 | 3 | 3 |
| Shear Stability (ASTM D7109) | by ASTM D6278 | ASTM D6278<br>or D7109 | |
| 100˚C viscosity after 90 cycles, cSt | Stay-in-grade | Stay-in-grade | 9.3 (xw30)<br>12.5 (xw40) |
| Foaming tendency / stability | | | |
| Sequence I (w/o Option A), ml, max. | 10 / 0 | 10 / 0 | 10 / 0 |
| Sequence II (w/o Option A), ml, max. | 20 / 0 | 20 / 0 | 20 / 0 |
| Sequence III (w/o Option A), ml, max. | 10 / 0 | 10 / 0 | 10 / 0 |
| Elastomer Compatibility | | | |
| API CJ-4 (D7216) Seal Compatibility | - | Use if CJ-4 | Pass |
| API CJ-4 Seal Compatibility | - | Pass | - |

## OEM Specifications: Caterpillar

| Engine Tests | Cat ECF-1a | Cat ECF-2 | Cat ECF-3 |
|---|---|---|---|
| | API CH-4 Only | API CI-4, CI-4 + CJ-4 Acceptable | CJ-4 |
| **Mack T-12 EGR** (1) | - | Use if CJ-4 | |
| Mack Merit Rating, min. | - | 1000 | 1000 |
| Cylinder liner wear, um max. | 30.0 / 30.8 / 31.1 | - | - |
| Top Ring % wt. Loss, mg. max. | 120 / 132 / 137 | - | - |
| Delta Pb, 250 - 300 hrs, ppm max. | 65 / 75 / 79 | - | - |
| **Mack T-11 (D7156)** (1) | | Use if CJ-4 or CI-4+ | |
| Min. TGA % Soot @ 4 cSt Increase, @ 100˚C, min. | - | - | 3.5 / 3.4 / 3.3 |
| Min. TGA % Soot @ 12 cSt Increase, @ 100˚C, min. | - | - | 6.0 / 5.9 / 5.9 |
| Min. TGA % Soot @ 15 cSt Increase, @ 100˚C, min. | - | - | 6.7 / 6.6 / 6.5 |
| **Mack T-10 EGR** (1) | | | |
| Merit Rating, min. | - | 1000 | - |
| Avg. Liner Wear, micron, max. | 32 / 34 / 35 | - | - |
| Avg. TRWL, mg, max. | 150 / 159 / 163 | - | - |
| EOT Used Oil/New Oil Pb Content, ppm max. | - | - | - |
| Pb Increased 250 - 300 hrs, ppm, max. | 50 / 56 / 59 | - | - |
| Avg. Oil Consumption, g/h, max. | - | - | - |
| **Mack T-9 (ASTM D6483)** | | | |
| Avg. liner wear, microns, max. | 25.4 / 26.6 / 27.1 | - | - |
| Avg. Top Ring Weight Loss, mg, max. | 120 / 136 / 144 | - | - |
| Pb Increase, ppm, max. | 25 / 32 / 36 | - | - |
| **Mack T-8E (D5967-96 EXT)** | | | |
| Relative Viscosity @ 4.8% Soot, cSt, max. | 2.1 / 2.2 / 2.3 | 1.8 / 1.9 / 2.0 | - |
| Viscosity Increase @ 3.8% Soot, cSt, max. | 11.5 / 12.5 / 13.0 | - | - |

**Note:**

(1) For Cat ECF-1-a run either Mack T9, Mack T10, or Mack 12.
For Cat ECF-2 run either Mack T11 or Mack T12.

## OEM Specifications: Caterpillar

| Engine Tests | Cat ECF-1a | Cat ECF-2 | Cat ECF-3 |
|---|---|---|---|
| | API CH-4 Only | API CI-4, CI-4 + CJ-4 Acceptable | CJ-4 |
| **Cummins ISM EGR** | | Use if CJ-4 | |
| Cummins Merit Rating, min. | - | - | 1000 |
| Top Ring % wt. Loss, mg max. | - | - | 100 |
| Crosshead Wear. Loss, mg max. | - | 7.5 / 7.8 / 7.9 | - |
| OFDP @ 150 hrs, kPa max. | - | 55 / 67 / 74 | - |
| Avg. Engine Sludge, merit min. | - | 8.1 / 8.0 / 8.0 | - |
| **Cummins M-11 (D6838)** | | | |
| Crosshead % wt. Loss, mg, max. | 6.5 / 7.5 / 8.0 | - | - |
| OFDP, kPa, max. | 79 / 93 / 100 | - | - |
| Sludge rating, merits, min. | 8.7 / 8.6 / 8.5 | - | - |
| **Cummins M-11 EGR** (2) | | | |
| Avg Crosshead % wt. Loss, mg, max. | - | 20.0 / 21.8 / 22.6 | - |
| Avg Top Ring % wt. Loss, mg, max. | - | Report | - |
| OFDP at 250 hr, kPa, max. | - | 275 / 320 / 341 | - |
| Avg Engine Sludge rating, merits at EOT, min. | - | 7.8 / 7.6 / 7.5 | - |
| **Cummins ISB** | | | |
| Avg. Slider Tappet % wt. Loss, mg, max. | - | - | 100 / 108 / 112 |
| Avg. Cam Lobe Wear, um. max. | - | - | 55 / 59 / 112 |
| Avg. Crosshead % wt. Loss, mg max. | - | - | Report |
| **Caterpillar C13** | | | |
| Caterpillar Merit Rating, min. | - | 1000 | 1000 |
| Hot stuck piston ring | - | None | None |
| **Caterpillar 1R** (3) | | | |
| Weighted Total Demerits, max. | - | 382 / 396 / 402 | - |
| Top Grove Carbon, Demerits, max. | - | 52 / 57 / 59 | - |
| Top Land Carbon, Demerits, max. | - | 31 / 35 / 36 | - |
| Initial Oil Consumption, g/hr, max. | - | 13.1 / 13.1 / 13.1 | - |
| Final Oil Consumption, g/hr, max. | - | I.O.C. + 1.8 | - |
| Piston ring & liner scuffing, ring sticking | - | None | - |
| **Caterpillar 1P (D6681)** | - | | |
| Weighted Total Demerits, max. | 350 / 378 / 390 | - | - |
| Top Groove Carbon, %, max. | 36 / 39 / 41 | - | - |
| Top Land Carbon, %, max. | 40 / 46 / 49 | - | - |
| Avg. Oil Consumption, g/hr, max. | 12.4 / 12.4 / 12.4 | - | - |
| Final Oil Consumption, g/hr, max. | 14.6 / 14.6 / 14.6 | - | - |
| Piston ring and liner scuffing | None | - | - |

**Note:**

(2) For ECF-2 run Cummins ISM or M11 EGR.

(3) For ECF-2, run Caterpillar 1R or 1P.

## OEM Specifications: Caterpillar

| | Cat ECF-1a | Cat ECF-2 | Cat ECF-3 |
|---|---|---|---|
| | API CH-4 Only | API CI-4, CI-4 + CJ-4 Acceptable | CJ-4 |
| **Caterpillar 1N** (5) | | | |
| Weighted Demerits, max. | - | 286.2 / 311.7 / 323.0 | 286.2 / 311.7 / 323.0 |
| Top Grove Fill, % max. | - | 20 / 23 / 25 | 20 / 23 / 25 |
| Top Land Heavy Carbon, % max. | - | 3 / 4 / 5 | 3 / 4 / 5 |
| Oil Consumption, g/Kw-h max.) | - | 0.5 / 0.5 / 0.5 | 0.5 / 0.5 / 0.5 |
| Piston/ring/liner scuffing | - | None | None |
| Piston ring sticking | - | None | None |
| **Caterpillar 1K** (5) | | | |
| Weighted total demerits, max. | 332 / 347 / 353 | 332 / 347 / 353 | - |
| Top Groove Fill, %, max. | 24 / 27 / 29 | 24 / 27 / 29 | - |
| Top Land Heavy Carbon, % max. | 4 / 5 / 5 | 4 / 5 / 5 | - |
| Avg Oil Consumption, g/bhp-hr, max. | 0.5 / 0.5 / 0.5 | 0.5 / 0.5 / 0.5 | - |
| Piston ring and liner | None | None | - |
| **Sequence IIIF (ASTM D6984)** | | | |
| EOT KV % Increase @ 40°C, max. | - | 275 (MTAC) | 275 (MTAC) |
| Viscosity Increase @ 60 hrs, % max. | 295 (MTAC) | - | - |
| **Sequence IIIG (D7320)**(4) | | | |
| EOT KV % Increased @ 40°C, max. | 150 (MTAC) | 150 (MTAC) | 150 (MTAC) |
| **RFWT (D5596)** | | | |
| Avg. pin wear, mils max. | - | 0.3 / 0.33 / 0.36 | 0.3 / 0.33 / 0.36 |
| **EOAT (D6894)** | | | |
| Oil aeration volume, % max. | 8.0 (MTAC) | 8.0 (MTAC) | 8.0 (MTAC) |

**Note:**

(4) For Cat ECF-1-a, ECF-2 & ECF-3 run Sequence IIIF or Sequence IIIG.

(5) For Cat ECF-2 run Cat IN or Cat 1K.

## OEM Specifications: Cummins

| Bench Tests | Cummins 20078 | Cummins 20081 |
|---|---|---|
| | CI-4 / CI-4 + | CJ-4 |
| SAE Grade | SAE J300, latest active issue | SAE J300, latest active issue |
| Sulfated Ash, (D874) % wt. max. | 1.85 | 1.00 / 1.02 / 1.03 |
| TBN, mg KOH/g, m | 10 | Report |
| NOACK, (D5800) %, max. | 15 | 13:xW40, 15:xW30 |
| HTHS Viscosity, (D4683) mPa.s, min. | 3.5 | 3.5 |
| Sulphur, % wt. max. | - | 0.4 |
| Phosphorus, % wt. max. | - | 0.12 |
| Gelation Index (D5133), max. | 12 | 12 |
| Aeration Volume, % max. | 8.0 | 8.0 |
| Mack T-11A 180 hrs. Used Oil MRV, mPa.s, max. | - | 18,000 |
| Mack T-11A 180 hrs. Used Oil Yield Stress, max. | - | 35 |
| Mack T-10A 75 hrs. Used Oil MRV, mPa.s, max. | 25,000 | - |
| Mack T-10A 75 hrs. Used Oil Yield Stress, max. | 35 | - |
| Corrosion (D6594) | | |
| Cu, ppm increase, max. | 20 | 20 |
| Pb, ppm increase, max. | 120 | 120 |
| Sn, ppm increase, max. | 50 | 50 |
| Cu strip rating, max. | 3 | 3 |
| Shear Stability (D7109) | by ASTM D6278 | |
| 100°C viscosity after 90 cycles, cSt | Stay-in-grade | Stay-in-grade |
| Foaming (ASTM D892) | | |
| Sequence I (w/o Option A) | 10 / 0 | 10 / 0 |
| Sequence II (w/o Option A) | 20 / 0 | 20 / 0 |
| Sequence III (w/o Option A) | 10 / 0 | 10 / 0 |
| Elastomer Compatibility | | |
| API CJ-4 (D7216) Seal Compatibility | - | Pass |
| API CI-4 Seal Compatibility | Pass | - |
| **Engine Tests** | | |
| **Mack T-12 EGR (1)** | | |
| Mack Merit rating, min. | - | 1300 |
| Avg Liner Wear, um, max. | - | 20 |
| Avg Top Ring % wt. Loss, mg, max. | - | 105 |
| Delta Pb, 0 - 300 hrs, ppm, max. | - | 30 |
| Delta Pb, 250 - 300 hrs, ppm, max. | - | 12 |
| Oil Consumption, g/hr, max. | - | 80 |

**Note:**
(1) For Cummins 20078, run Mack T12 or T10.

## OEM Specifications: Cummins

| Bench Tests | Cummins 20078 | Cummins 20081 |
|---|---|---|
| | CI-4 / CI-4 + | CJ-4 |
| **Mack T-11 (ASTM D7156)** | | |
| TGA % Soot @ 4 cSt Increase, at 100°C, min. | - | 3.5 |
| TGA % Soot @ 12 cSt Increase, at 100°C, min. | - | 6.0 |
| TGA % Soot @ 15 cSt Increase, at 100°C, min. | - | 6.7 |
| **Mack T-10 EGR** (1) | | |
| Merit Rating, min. | 1000 | - |
| Avg. Liner Wear, µm, max. | 32 | - |
| Avg. TRWL, mg, max. | 158 | - |
| EOT Used Oil/New Oil Pb Content, ppm max. | 35 | - |
| Pb Increase 250 - 300 hrs, ppm, max. | 14 | - |
| Average oil consumption, g/h, max. | 65 | |
| **Mack T-8E (D5967-96 EXT)** | | |
| Relative Viscosity @ 4.8% Soot, cSt, max. | 1.8 max | - |
| Viscosity increase @ 3.8% Soot, cSt, max. | Report | - |
| **Cummins ISM** | | |
| Cummins Merit Rating, min. | - | 1000 |
| Crosshead % wt. Loss, mg max. | 7.5 | 7.1 |
| OFDP @ 150 hrs, kPa max. | 55 | 19 |
| Avg. Engine Sludge, merit min. | 8.1 | 8.7 |
| Avg. Adj. Screw % wt. Loss, mg max. | - | 45 |
| **Cummins M-11 EGR** | | |
| Avg. crosshead % wt. Loss, mg, max. | 20 | - |
| Top Ring % wt. Loss, mg max. | 175 | - |
| OFDP @ 150 hrs, kPa max. | 275 | - |
| EOT Sludge Rating, merits, min. | 7.8 | - |
| **JASO M354-2000** | | |
| Cam Lobe Wear, µm, max. | 95 | - |
| **Cummins ISB EGR** | | |
| Avg. Slider Tappet % wt. Loss, mg max. | - | 100 / 108 / 112 |
| Avg. Cam Lobe Wear, mm, max. | - | 50 / 53 / 55 |
| Avg. Crosshead % wt. Loss, mg max. | - | Report |
| **Caterpillar C13** | | |
| Caterpillar Merit Rating, min. | - | Report |
| Hot stuck piston ring | - | Report |
| Delta Oil Consumption, g/hr max. | - | Report |
| Avg. Top Land Carbon, Demerit max. | - | Report |
| Avg. Top Groove Carbon, Demerit max. | - | Report |
| 2nd Ring Top Carbon, Demerit max. | - | Report |

**Note:**
(1) For Cummins 20078, run Mack T12 or T10.

## OEM Specifications: Cummins

| Engine Tests | Cummins 20078 | Cummins 20081 |
|---|---|---|
| | CI-4 / CI-4 + | CJ-4 |
| **Caterpillar 1R** | | |
| Weighted Demerits, max. | 382 | - |
| Top Groove Carbon, Demerits, max. | 52 | - |
| Top Land Carbon, Demerits, max. | 31 | - |
| Initial Oil Consumption, g/h, max. | 13.1 | - |
| Final Oil Consumption, g/h, max. | IOC + 1.8 | - |
| Piston ring and liner scuffing, ring sticking | None | - |
| **Caterpillar 1N** | | |
| % wt. Demerits, max. | 286 | 286.2 |
| Top Groove Fill, % max. | 20 | 20 |
| Top Land Heavy Carbon, % max. | 3 | 3 |
| Oil Consumption, g/kW-h max. | 0.5 | 0.5 |
| Piston/ring/liner scuffing | None | None |
| Piston ring sticking | None | None |
| **Caterpillar 1K** | | |
| Weighted Total Demerits, max. | 332 | - |
| Top Groove Fill, %, max. | 24 | - |
| Top Land Heavy Carbon, % max. | 4 | - |
| Avg Oil Consumption, g/bhp-hr, max. | 0.5 | - |
| Piston ring and liner scuffing | None | - |
| **Sequence IIIF (2) (ASTM D6984)** | | |
| EOT KV % Increase @ 40˚C, max. | 275 | 275 |
| Cam + Tappet Wear, µm, max. | 20 | |
| Oil Consumption, Litres, max. | 5.2 | |
| **Sequence IIIG (2)** | | |
| EOT KV % Increase @ 40˚C, max. | - | 150 |
| **RFWT (D5596)** | | |
| Avg. pin wear, mils max. | 0.3 | 0.3 |
| **EOAT (D6894)** | | |
| Oil aeration volume, % max. | 8.0 | 8.0 |

**Note:**
(2) For Cummins 20081, run sequence IIIF or sequence IIIG.

## OEM Specifications: DDC

| Bench Tests | DDC 93K214 | DDC 93K215 | DDC 93K218 |
|---|---|---|---|
| SAE Grade | SAE J300, latest active issue | SAE J300, latest active issue | |
| Sulfated Ash, % wt. max. | 2.0 | 2.0 | 1.0 |
| Pour Point, ˚C max. | -25 | -25 | -25 |
| NOACK, (D5800) % max. | 13 | 18 | 13 |
| HTHS Viscosity, mPa.s min. | 4.2 | 3.5 | Stay-in-grade |
| Sulphur, % wt. max. | - | - | 0.4 |
| Phosphorus, % wt. max. | - | - | 0.12 |
| Mack T-11A 180 hr Used Oil MRV, mPa.s, max. | - | - | 18,000 |
| Mack T-11A 180 hr Used Oil Yield Stress, max. | - | - | 35 |
| Mack T-10A 75 hr Used Oil MRV, mPa.s, max. | 25,000 | - | - |
| Mack T-10A 75 hr Used Oil Yield Stress, max. | 35 | - | - |
| Corrosion (ASTM D6594) | | | |
| Cu, ppm increase max. | 20 | 20 | 20 |
| Pb, ppm increase max. | 120 | 120 | 120 |
| Sn, ppm increase max. | 50 | 50 | |
| Cu, strip rating, max. | 3 | 3 | 3 |
| Shear Stability (ASTM D7109) | | | |
| 100˚C Viscosity after 90 cycles, cSt | Stay-in-grade | Stay-in-grade | Stay-in-grade |
| HTHS after 90 cycle shear stability, mPa.s. | 3.9 | - | 3.9 |
| Foaming (ASTM D892) | | | |
| Sequence I (w/o Option A) | 10 / 0 | 10 / 0 | 10 / 0 |
| Sequence II (w/o Option A) | 20 / 0 | 20 / 0 | 20 / 0 |
| Sequence III (w/o Option A) | 10 / 0 | 10 / 0 | 10 / 0 |
| Elastomer Compatibility | | | |
| Related DBL Elastomer Compatibility | Pass CI-4 Test | - | - |
| CEC-L-39-T-96 | - | Pass | - |
| API CJ-4 (D7216) Seal Compatibility | Report | - | Pass |
| API CI-4 Seal Compatibility | Compression Set | Pass | - |
| **Engine Tests** | | | |
| **OM 441 LA Euro 2 (CEC-L-52-T-97)** | | | |
| Avg Piston Cleanliness, merit min | 25.0 | 25.0 | 25.0 |
| Bore polishing, % max. | 2.0 | 2.0 | 2.0 |
| Specific Oil Consumption, kg/test max. | 40 | 40 | 40 |
| Boost pressure loss at 400 hrs, % max. | 4 | 4 | 4 |

# OEM Specifications: DDC

| Engine Tests | DDC 93K214 | DDC 93K215 | | | DDC 93K218 | | |
|---|---|---|---|---|---|---|---|
| **OM 501 LA Euro 5** | - | - | | | **Pass** | | |
| Piston cleanliness avg., min., merit | | | | | 17.0 | | |
| Ring sticking 2. piston rings, max., ASF | | | | | 1.0 | | |
| Engine sludge avg., min., merit | | | | | 9.0 | | |
| General engine deposits avg., max., demerit | | | | | 2.0 | | |
| Wear rating (visual) avg., max., demerit | | | | | 2.0 | | |
| Bore polishing avg., % max. | | | | | 2.0 | | |
| Cylinder wear avg., mm max. | | | | | 0,008 | | |
| Turbocharger deposits, max., demerit | | | | | 2,0 | | |
| TBN (ASTM D4739) @ end of test, mgKOH/g | | | | | Rate & Report | | |
| TAN (ASTM D664) @ end of test, mgKOH/g | | | | | Rate & Report | | |
| Specific oil consumption, max., g/hr | | | | | 30,0 | | |
| **Mack T-12 EGR**(1) | | | | | | | |
| Mack Merit Rating, min. | 1000 | 1000 | | | 1000 | | |
| **Mack T-11 (ASTM D7156)** | | | | | | | |
| TGA % Soot @ 4 cSt Increase, at 100˚C, min. | - | - | | | 3.5 | 3.4 | 3.3 |
| TGA % Soot @ 12 cSt Increase, at 100˚C, min. | 6.00 | - | | | 6.0 | 5.9 | 5.9 |
| TGA % Soot @ 15 cSt Increase, at 100˚C, min. | - | - | | | 6.7 | 6.6 | 6.6 |
| **Mack T-10 EGR**(1) | | | | | | | |
| Merit Rating, min. | 1000 | 1000 | | | - | | |
| Avg. Liner Wear, µm, max. | 32 | 32 | 34 | 35 | - | | |
| Avg. Top Ring % wt. loss, mg, max. | 158 | 150 | 159 | 163 | - | | |
| EOT Used Oil/New Oil Pb Content, ppm, max. | 35 | 50 | 56 | 59 | - | | |
| Pb Increase 250 - 300 hrs, ppm, max. | 14 | - | | | - | | |
| Avg. Oil Consumption, g/hr, max. | 65 | 65 | | | - | | |
| **Mack T-8E (D5967-96 EXT)** | | | | | | | |
| Relative Viscosity @ 4.8% Soot, cSt, max. | - | 2.1 | 2.2 | 2.3 | - | | |
| Viscosity Increase @ 3.8% Soot, cSt, max. | - | 11.5 | 12.5 | 13.0 | - | | |
| **Cummins ISM** | | | | | | | |
| Cummins Merit Rating, min. | 1000 | 1000 | | | 1000 | | |
| Crosshead % wt. loss, mg, max. | 7.5 | 7.5 | | | 100 | | |
| **Cummins M-11** | | | | | | | |
| Crosshead % wt. loss, mg, max. | - | 6.5 | 7.5 | 8.0 | - | | |
| OFDP, kPa, max. | - | 79 | 93 | 100 | - | | |
| Sludge rating, merits, min. | - | 8.7 | 8.6 | 8.5 | - | | |

**Note:**

(1) For DDC 93K214 & 93K215, run either Mack T12 or T10.

(2) TBD = Limit to be determined.

N.R. = Not Required.

T.B.D. = To Be Determined.

## OEM Specifications: DDC

| Bench Tests | DDC 93K214 | DDC 93K215 | DDC 93K218 | | |
|---|---|---|---|---|---|
| **Cummins M-11 EGR** | | | | | |
| Crosshead % wt. Loss, mg, max. | 20.0 | - | - | | |
| Top Ring % wt. Loss, mg, max. | 175 | - | - | | |
| OFDP @ 250 hrs, kPa, max. | 275 | - | - | | |
| Avg. Engine Sludge Rating, merits, min. | 7.8 | - | - | | |
| **JASO M354-2000** | | | | | |
| Avg. Cam Lobe Wear, µm | - | 95 | - | | |
| **Cummins ISB** | | | | | |
| Avg. Slider Tappet % wt. Loss, mg, max. | - | - | 100 | 108 | 112 |
| Avg. Cam Lobe Wear, µm, max. | - | - | 55 | 59 | 61 |
| Avg. Crosshead % wt. Loss, mg, max. | - | - | Report | | |

## OEM Specifications: DDC

| Bench Tests | DDC 93K214 | DDC 93K215 | | | DDC 93K218 | | |
|---|---|---|---|---|---|---|---|
| **Caterpillar C13** | | | | | | | |
| Caterpillar Merit Rating, min. | - | - | | | 1000 | | |
| Hot stuck piston ring | - | - | | | None | | |
| **Caterpillar 1R** | | | | | | | |
| Weighted Demerits, max. | 382 | - | | | - | | |
| Top Groove Carbon, Demerits, max. | 52 | - | | | - | | |
| Top Land Carbon, Demerits, max. | 31 | - | | | - | | |
| Initial Oil Consumption, g/h, max. | 13.1 | - | | | - | | |
| Final Oil Consumption, g/h, max. | IOC + 1.8 | - | | | - | | |
| Piston ring and liner scuffing, ring sticking | None | - | | | - | | |
| **Caterpillar 1P (D6681)** | | | | | | | |
| Weighted Demerits, max. | - | 350 | 378 | 390 | - | | |
| Top Groove Carbon, %, max. | - | 36 | 39 | 41 | - | | |
| Top Land Carbon, %, max. | - | 40 | 46 | 49 | - | | |
| Avg. Oil Consumption, g/hr, max. | - | 12.4 | 12.4 | 12.4 | - | | |
| Final Oil Consumption, g/hr, max. | - | 14.6 | 14.6 | 14.6 | - | | |
| Piston ring and liner scuffing | - | None | | | - | | |
| **Caterpillar 1N (D6750)** | | | | | | | |
| Weighted Demerits, max. | 286.2 | - | | | 286.2 | 311.7 | 323.0 |
| Top Groove Fill, %, max. | 20 | - | | | 20 | 23 | 25 |
| Top Land Heavy Carbon, %, max. | 3 | - | | | 3 | 4 | 5 |
| Oil Consumption, g/kW-hr, max. | 0.5 | - | | | 0.5 | | |
| Piston/ring/liner scuffing | None | - | | | None | | |
| Piston ring sticking | None | - | | | None | | |
| **Caterpillar 1K** | | | | | | | |
| Weighted Demerits, max. | 332 | 332 | 347 | 353 | - | | |
| Top Groove Fill, %, max. | 24 | 24 | 27 | 29 | - | | |
| Top Land Heavy Carbon, %, max. | 4 | 4 | 5 | 5 | - | | |
| Avg. Oil Consumption, g/kW-hr, max. | 0.5 | 0.5 | 0.5 | 0.5 | - | | |
| Piston ring and liner scuffing | None | None | | | - | | |
| **Sequence IIIF[2] (ASTM D6984)** | | | | | | | |
| EOT KV % Increase @ 40˚C, max. | 275 | - | | | 275 | | |
| Viscosity Increase @ 60 hrs, %, max. | - | 295 | | | - | | |
| Oil Consumption, litres, max | 5.2 | - | | | - | | |
| **Sequence IIIG [2]** | | | | | | | |
| EOT KV % Increase @ 40˚C, max. | - | - | | | 150 | | |
| **RFWT (D5596)** | | | | | | | |
| Avg. pin wear, mils, max. | 0.3 | 0.3 | 0.33 | 0.36 | 0.3 | 0.33 | 0.36 |
| **EOAT (D6894)** | | | | | | | |
| Oil aeration volume, %, max. | 8.0 | 8.0 | | | 8.0 | | |

**Note:**

(2) For DDC 93K218, run either Sequence IIIF or IIIG.

## OEM Specifications: Mack

| Bench Tests | Mack EO-N PP 03 | Mack EO-O/VDS-4 | | |
|---|---|---|---|---|
| SAE Grade | xW-40 | 15W-40 | | |
| Sulfated ash, % wt. max. | - | 1.0 | | |
| TBN (D4739) min. | 10 | - | | |
| NOACK, %, max. | 13 | 13 | | |
| HTHS Viscosity @ 100˚C, cSt, min. | 4.2 | 3.5 | | |
| Base Oil Viscosity, mPa.s | 6.8 | 6.5 | | |
| Sulphur, % wt. max. | - | 0.4 | | |
| Phosphorus, % wt. max. | - | 0.12 | | |
| Pending CEC Turbo Deposit Test | - | T.B.D(1) | | |
| Mack T-11A 180 hrs. Used Oil MRV, mPa.s | 18,000 | 18,000 | | |
| Mack T-11A 180 hrs. Used Oil Yield Stress, max. | 35 | 35 | | |
| Corrosion (D6594) | | | | |
| Cu, ppm increase, max. | 20 | 20 | | |
| Pb, ppm increase, max. | 120 | 120 | | |
| Sn, ppm increase, max. | 50 | - | | |
| Cu Strip Rating, max. | 3 | 3 | | |
| Shear Stability (ASTM D7109) | | | | |
| 100˚C viscosity after 90 cycles, cSt | Stay-in-grade | Stay-in-grade | | |
| HTHS after 90 cycle shear stability, min. mPa.s | 3.9 | 3.9 | | |
| Foaming Tendency Stability | | | | |
| Sequence I (w/o Option A), ml, max. | 10/0 | 10/0 | | |
| Sequence II (w/o option A), ml, max. | 20/0 | 20/0 | | |
| Sequence III (w/o Option A), ml, max. | 10/0 | 10/0 | | |
| Elastomer Compatibility | | - | | |
| Related DBL Elastomer Compatibility | - | Pass | | |
| Vamac API CJ-4 (D7216) Seal Compatibility | Pass | - | | |
| Vamac API CI-4 Seal Compatibility | Pass | - | | |
| HFRR Boundary Trace | Required | - | | |
| **Engine Tests** | | | | |
| **Mack T-12 EGR** | | | | |
| Mack Merit Rating, min. | - | 1300 | | |
| Cylinder liner wear, um, max. | - | 21 | | |
| Top Ring % wt. loss, mg, max. | - | 105 | | |
| Delta Pb, 0-300 hrs, ppm, max. | - | 30 | | |
| Delta Pb, 250-300 hrs, ppm, max. | - | 12 | | |
| Oil Consumption, g/hr, max. | - | 80 | | |
| **Mack T-11 (D7156)** | | | | |
| TGA Soot @ 4 cSt Increase, at 100˚C, %, min. | - | 3.5 | 3.4 | 3.3 |
| TGA Soot @ 12 cSt Increase, at 100˚C, %, min. | 6.0 | 6.0 | 5.9 | 5.9 |
| TGA Soot @ cSt Increase, at 100˚C, %, min. | - | 6.7 | 6.6 | 6.5 |

**Note:**

(1) Limit to be determined.

Grade SAE 10W-30 now allowed for MACK EO-O / VDS-4 but specifications for it have not been updated yet.

## OEM Specifications: Mack

<table>
<tr><th>Engine Tests</th><th>Mack EO-N PP 03</th><th colspan="3">Mack EO-O/VDS-4</th></tr>
<tr><td>Mack T-10 EGR</td><td></td><td colspan="3"></td></tr>
<tr><td>Merit Rating, min.</td><td>1500</td><td colspan="3">-</td></tr>
<tr><td>Avg. Liner wear, mm, max.</td><td>26</td><td colspan="3">-</td></tr>
<tr><td>Avg. Top Ring Weight Loss, mg, max.</td><td>120</td><td colspan="3">-</td></tr>
<tr><td>EOT Used Oil/New Oil Pb Content, ppm, max.</td><td>20</td><td colspan="3">-</td></tr>
<tr><td>Pb Increase 200-300 hrs, ppm, max.</td><td>10</td><td colspan="3">-</td></tr>
<tr><td>Pb Increase 250-300 hrs, ppm, max.</td><td>5</td><td colspan="3">-</td></tr>
<tr><td>Avg. Oil Consumption, g/h, max.</td><td>45</td><td colspan="3">-</td></tr>
<tr><td>EOT Oxidation - FTIR. max.</td><td>250</td><td colspan="3">-</td></tr>
<tr><td>Cummins ISM</td><td></td><td colspan="3"></td></tr>
<tr><td>Cummins Merit Rating, min.</td><td>-</td><td colspan="3">1000</td></tr>
<tr><td>Top Ring % wt. loss, mg, max.</td><td>-</td><td colspan="3">100</td></tr>
<tr><td>Crosshead % wt. loss, @ 3.9% soot mg, max.</td><td>-</td><td colspan="3">7.1</td></tr>
<tr><td>OFDP @ 150 hrs, kPa, max.</td><td>-</td><td colspan="3">19</td></tr>
<tr><td>Avg Engine Sludge, merit, min.</td><td>-</td><td colspan="3">8.7</td></tr>
<tr><td>Avg. Adj. Screw % wt. Loss, mg, max.</td><td>-</td><td colspan="3">45</td></tr>
<tr><td>Cummins M-11 EGR</td><td></td><td colspan="3"></td></tr>
<tr><td>Crosshead % wt. loss, mg, max.</td><td>12</td><td colspan="3">-</td></tr>
<tr><td>Top Ring % wt. loss, mg, max.</td><td>175</td><td colspan="3">-</td></tr>
<tr><td>OFDP at 250 hrs, kPa, max.</td><td>275</td><td colspan="3">-</td></tr>
<tr><td>Sludge rating, merits, min.</td><td>7.8</td><td colspan="3">-</td></tr>
<tr><td>Cummins ISB EGR</td><td></td><td colspan="3"></td></tr>
<tr><td>Avg. Slider Tappet % wt. loss, mg, max.</td><td>-</td><td>100</td><td>108</td><td>112</td></tr>
<tr><td>Avg. Cam Lobe Wear, um, max.</td><td>-</td><td>50</td><td>53</td><td>55</td></tr>
<tr><td>Avg. Crosshead % wt. loss, mg, max.</td><td>-</td><td colspan="3">Report</td></tr>
<tr><td>Caterpillar C13</td><td></td><td colspan="3"></td></tr>
<tr><td>Caterpillar Merit rating, min.</td><td>-</td><td colspan="3">1000</td></tr>
<tr><td>Hot stuck piston ring</td><td>-</td><td colspan="3">None</td></tr>
<tr><td>Delta Oil Consumption, g/hr, max.</td><td>-</td><td colspan="3">31</td></tr>
<tr><td>Avg. Top. Land Carbon, Demerit, max.</td><td>-</td><td colspan="3">35</td></tr>
<tr><td>Avg. Top. Groove Carbon, Demerit, max.</td><td>-</td><td colspan="3">53</td></tr>
<tr><td>2nd Ring Top Carbon, Demerit, max.</td><td>-</td><td colspan="3">33</td></tr>
<tr><td>Caterpillar 1R</td><td></td><td colspan="3"></td></tr>
<tr><td>Weighted Demerits, max.</td><td>382</td><td colspan="3">-</td></tr>
<tr><td>Top Groove carbon, Demerits, max.</td><td>52</td><td colspan="3">-</td></tr>
<tr><td>Top Land Carbon, Demerits, max.</td><td>31</td><td colspan="3">-</td></tr>
<tr><td>Initial Oil Consumption, g/hr, max.</td><td>13.1</td><td colspan="3">-</td></tr>
<tr><td>Final Oil Consumption, g/hr, max.</td><td>IOC + 1.8</td><td colspan="3">-</td></tr>
<tr><td>Piston ring and liner scuffing, ring sticking</td><td>None</td><td colspan="3">-</td></tr>
<tr><td>Sequence IIIF (ASTM D6984)</td><td></td><td colspan="3"></td></tr>
<tr><td>EOT KV % Increase @ 40°C, max.</td><td>80</td><td colspan="3">-</td></tr>
<tr><td>70 - 80 hr Viscosity Increase, %</td><td>25</td><td colspan="3">-</td></tr>
</table>

**Note:**
Grade SAE 10W-30 now allowed for MACK EO-O / VDS-4 but specifications for it have not been updated yet.

## OEM Specifications: Mack

| Engine Tests | Mack EO-N PP 03 | Mack EO-O/VDS-4 | | |
|---|---|---|---|---|
| **Sequence IIIG** | | | | |
| EOT KV % Increase @ 40˚C, max. | - | 150 | | |
| KV 40˚C Increase parameters | | | | |
| 100 hrs. unadjusted (B), % | - | Report | | |
| 80 hrs. unadjusted (C), % | - | Report | | |
| 60 hrs. unadjusted (D), % | - | Report | | |
| EOT ratio [(B-C)/(C-D)] max. | - | 2.5 | | |
| **RFWT (D5596)** | | | | |
| Avg. pin wear, mils, max. | 0.3 | 0.3 | 0.33 | 0.36 |
| **EOAT (D6894)** | | | | |
| Oil aeration volume, %, max. | 8.0 | 8.0 | | |
| **Volvo D12D460** | | | | |
| Piston Deposits, merit, min. | - | 40 | | |
| Ring Riding, %, max. | - | 50 | | |
| Bore Polish. $cm^2$, max. | - | 150 | | |
| Oil Consumption (400 hrs.), g/hrs, max. | - | 35 | | |
| Oil Consumption (final 100 hrs.), g/hrs, max. | - | 35 | | |
| **VD3 Approval** | Required | - | | |

**Note:**
Grade SAE 10W-30 now allowed for MACK EO-O / VDS-4 but specifications for it have not been updated yet.

# European OEM Seal Test Requirements For Automotive Engine Oils

| | | | | Test Conditions | | Test Limits | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OEM** | **Specifications** | **Test Method** | **Elastomer** | **Temp (°C)** | **Time (Hrs.)** | **Change in Hardness (Shore A)** | **Tensile Strength at Break (N/mm$^2$)** | **Change in Tensile Strength at yield (%)** | **Elongation at break (%)** | **Change in elongation at break (%)** | **Volume Change (%)** | **Weight Change (%)** | **Cracking** |
| Mercedes Benz | 229.1, 229.3, 229.31, 229.5, 229.52, 228.0/1, 228.2/3, 228.31, 228.5, 228.51 | VDA 675301 | NBR 34 | 100 | 168 | -8+2 | - | -20 max. | - | -35 max. | 0/+10 | - | - |
| | | | AK6 | 150 | 168 | -5/+5 | - | -50 max. | - | -55 max. | 0/+5 | - | - |
| | | | ACM E7503 | 150 | 168 | -2/+6 | - | -30 max. | - | -50 max. | -3/+10 | - | - |
| | | | EAM D8948-200 | 150 | 168 | -5/+10 | - | -35 max. | - | -50 max. | -5/+15 | - | - |
| Volkswagen | 505.00 | PV 3344 | AK6 | 150 | 3 X 94 | - | 8 min. | -50 max. | 160 min. | -50 max. | - | - | No Cracks |
| | 501.01 502 505.01 | PV 3344 | AK6 | 150 | 3 X 94 | - | 8 min. | -50 max. | 160 min. | -50 max. | - | - | No Cracks |
| | | | ACM | 150 | 168 | -5/+6 | - | -30 max. | - | -30 max. | - | -2/+4 | - |
| | | | VAMAC | 150 | 168 | -8/+8 | - | -30 max. | - | -30 max. | - | -3/+15 | - |
| | 504.00 507.00 | PV 3344 | AK6 | 150 | 168 | - | 7 min. | -60 max. | 160 min. | -50 max. | - | - | No Cracks |
| | | | ACM | 150 | 500 | -4/+10 | - | -40 max. | - | -40 max. | - | -2/+6 | - |
| | | | VAMAC | 150 | 500 | -4/+10 | - | -40 max. | - | -40 max. | - | -3/+10 | - |
| MAN | 270, 271 M3275 M3277 | DIN 53521 | NBR 28 | 100 | 168 | -10 max. | - | -20 max. | - | -30 max. | 0/+10 | - | - |
| | | | AK6 | 150 | 168 | -5/+5 | - | -30 max. | - | -40 max. | -2/+5 | - | - |

Specification Handbook

# Driveline

# Contents Driveline

**Automotive Gear:**


API Lubricant Service Designation for:

Automotive Manual Transmissions & Axles....2

API Lubricant Service Designation....3

SAE J306 Automotive Gear Viscosity Classifications....4

DEF STAN 91-59/2 Lubricating Oil, Extreme Pressure....5

MACK GO-H Requirements....6

MACK GO-J and GO-J Plus Requirements....7

MACK TO-A Plus Requirements....8

MAN 341.1 and 341.2 Specifications....9

MAN 342 Specifications....13

MAN 3343 Specifications....14

Performance Requirements For MIL-L-2105D (GL-5) Lubricants....15

Performance Requirements For SAE J2360

(formerly MIL-PRF-2105E)....16

MT-1 Category Tests and Acceptance Criteria....17

Scania STO 1:0 ....18

Volvo Transmission Oil Specifications 1273.07 and 1273.12....19

ZF Specifications: Master List....21


**Automatic Transmission Fluids:**


Ford Specifications....25

Ford MERCON® V Specifications....26

General Motors Allison C-4 Specifications ....27

Allison TES-439 Specifications ....29

Allison TES 389 (Rev. B) Specifications ....31

General Motors Specifications....32

General Motors H Revision ....37

General Motors DEXRON® VI....39

# API Lubricant Service Designation for Automotive Manual Transmission([1]) & Axles

This material was prepared by the Lubricants Service Classification Task Force of the Fuels and Lubricants Committee, Marketing Department, American Petroleum Institute, to assist manufacturers and users of automotive equipment in the selection of transmission and axle lubricants for the operating conditions as described.

In transmissions, and particularly in rear axles, gears of different designs are available for a variety of different service conditions. Selection of a lubricant for specific applications involves careful consideration of the operating conditions and the chemical and physical characteristics of the lubricant to meet these service conditions. Until recently, transmission and differential lubricants were described in qualitative terms and by a variety of designations, each one attempting to describe both the lubricant and the service conditions under which the lubricant must perform. Consideration of these lubricant designations to a minimum number was deemed highly desirable in the light of present day technology. The American Petroleum Institute, therefore, prepared six lubricant service designations for automotive manual transmissions and axles, each designation referring to the performance required of a gear lubricant for a specific type of automotive service. These designations also recognise the possibility that lubricant may be developed for more than one service classification and as a result may be so designated.

In developing the language for the service classifications, a need was recognised to supplement the descriptions for certain gear lubricants, particularly those for hypoid gears, by referring to a series of tests which would serve as a "test language" to provide more detailed information on the performance requirements of such lubricant. This "test language" was developed by Section III of Technical Division B on Automotive Lubricants of ASTM Committee D-2, and reference is made to these test procedures in the API service designations described below.

This system of designations replaced all previous API gear lubricant designations and became effective May 1, 1969. These designations are as follows:-

**API GL-1**

Designates the type of service characteristic of automotive spiral-bevel and worm-gear axles and some manually operated transmissions operating under such mild conditions of low unit pressures and sliding velocities, that straight mineral oil can be used satisfactorily. Oxidation and rust inhibitors, defoamers, and pour depressants may be utilised to improve the characteristics of lubricants for this service. Frictional modifiers and extreme pressure agents shall not be utilised.

**API GL-2**

Designates the type of service characteristic of automotive type worm-gear axles operating under such conditions of load temperature and sliding velocities, that lubricants satisfactory for API GL-1 service will not suffice.

**API GL-3**

Designates the type of service characteristic of manual transmissions and spiral-bevel axles operating under moderately severe conditions of speed and load. These service conditions require a lubricant having load carrying capacities greater than those which will satisfy API GL-1 service, but below the requirements of lubricants satisfying API GL-4 service.

# API Lubricant Service Designation

**API GL-4**

This classification is still used commercially to describe lubricants, but the equipment required for the anti-scoring test procedures to verify lubricant performance is no longer available.

Designates the type of service characteristic of gears, particularly hypoid[(2)] in passenger cars and other automotive type of equipment operated under high-speed, low-torque, and low-speed, high-torque conditions.

Lubricants suitable for this service are those which provide anti-score protection equal to or better than that defined by CRC Reference Gear Oil RGO-105 and have been subjected to the test procedures and provide the performance levels described in ASTM STP-512A, dated March 1987[(3)].

**API GL-5**

Designates the type of service characteristic of gears, particularly hypoid in passenger cars and other automotive equipment operated under high-speed, shock-load; high-speed, low-torque; and low-speed, high-torque conditions.

Lubricants suitable for this service are those which provide anti-score protection equal to or better than that defined by CRC Reference Gear Oil RGO-110 and have been subjected to the test procedures and provide the performance levels described in ASTM D7450[(2)].

**API GL-6**

This category is obsolete and is listed for historical reference only.
The equipment used to measure performance is no longer available.

**Footnotes:**

(1) Automatic or semi-automatic transmissions, fluid couplings, torque converters, and tractor hydraulic systems usually require special lubricants. For the proper lubricant to be used, consult the manufacturer or lubricant supplier.

(2) Limited slip differentials generally have special lubricant requirements. The lubricant supplier shall be consulted regarding the suitability of their lubricant for such differentials. Information helpful in evaluating lubricants for this type of service may be found in ASTM D7450.

(3) The complete publication is titled “Laboratory Performance Tests for Automotive Gear Lubricants intended for API GL-5 Service.”

**Note:**

API GL-4 oils are not suitable for highly-loaded hypoid axles. API GL-4 oils are used in synchronised manual transmissions and transaxles as well as in mild hypoid and spiral bevel axles.



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## **SAE J306 Automotive Gear Viscosity Classifications** Axle and Manual Transmission Lubricant Viscosity Classification

| | | 70W | 75W | 80W | 85W | 80 | 85 | 90 | 110 | 140 | 190 | 250 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Viscosity at 100°C, $mm^2/s$ | | | | | | | | | | | | |
| | min. | 4.1 | 4.1 | 7.0 | 11.0 | 7.0 | 11.0 | 13.5 | 18.5 | 24.0 | 32.5 | 41.0 |
| | max. | No requirement | | | | < 11.0 | < 13.5 | < 18.5 | < 24.0 | < 32.5 | < 41.0 | No req |
| Max. Viscosity of 150,000 mPa.s, at temp °C | | -55 | -40 | -26 | -12 | No requirement | | | | | | |
| 20 hr. KRL Shear (CEC L-45-A-99), KV100 after Shear, $mm^2/s$, min. | | 4.1 | 4.1 | 7.0 | 11.0 | 7.0 | 11.0 | 13.5 | 18.5 | 24.0 | 32.5 | 41.0 |



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## DEF STAN 91-59/2 Lubricating Oil, Extreme Pressure

**Grades 75W and 80W90: Joint Service Designation OEP-38 and OEP-220 Respectively**

| Property | Limits | | Test Method |
|---|---|---|---|
| | OEP-38 | OEP-220 | |
| Appearance | Clear homogenous and free from visual impurities | | Visual Examination |
| Kinematic Viscosity mm²/s at 100°C | | | BS EN ISO 3104 (1) |
| min. | 4.1 | 13.5 | |
| max. | - | 24.0 | |
| Viscosity Index, min. | 85 | - | ASTM D2270, IP 226 |
| Low Temperature Viscosity: mPa.s | | | ASTM D2983 |
| at -26°C max. | - | 150 000 | |
| at -40°C max. | 150 000 | - | |
| Detection of Copper Corrosion | | | BS 2000 Part 154 or ASTM D130: IP 154 3 hrs at ±120°C |
| Copper Strip Classification, max. | 3 | | |
| Condition of Copper Strip | No pitting or etching | | |
| Flash point, °C, min. | 150 | 165 | IP36 |
| Detection of Steel Corrosion Appearance of test piece | No rusting or pitting | | BS 2000 Part 135 ASTM D665: IP 135 Procedure A (60±1)°C |
| Foaming tendency and stability characteristics: | | | BS 2000 Part 146 ASTM D892/IP 146 |
| Sequence I, ml, max. | 20/0 | 20/0 | |
| Sequence II, ml, max. | 50/0 | 50/0 | |
| Sequence III, ml, max. | 20/0 | 20/0 | |
| Additive Elements | See clause 6.1 | | See clause 6.1 |
| Thermal oxidation stability (TOST) | | | ASTM D5704 (L-60-1) |
| Kinematic Viscosity at 100°C increase percent, max. | 100 | | |
| Change in total acid number mg KOH/g, max. | 3.0 | | |
| Pentane Insolubles, % m/m, max. | 3.0 | | |
| Toluene Insolubles, % m/m, max. | 2.0 | | |
| Carbon Varnish rating, min. | 7.5 | | |
| Sludge rating, min. | 9.4 | | |
| High Torque test Condition of Gear Teeth Condition of Half-Shaft and Axle Housing | The performance of the oil shall be superior to that of the CRC reference oil RGO 104 | | ASTM D6121 (L-37) |
| High speed/shock load test | The performance of the oil shall be superior to that of the CRC reference oil RGO 114 | | L-42 |
| Storage Stability | | | Annex A |
| Solid, % m/m, max. | 0.25 | | |
| Liquid % volume, max. | 0.50 | | |

**Note:**

(1) Test facilities for these tests are available at DQA/TS Woolwich.

The above requirements are absolute and not subject to correction for tolerance of test method.
This specification is currently (March 2000) under review.



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## MACK GO-H Requirements

Covering SAE 90, SAE 140, SAE 80W-90 and SAE 85W-140 oils

| Test | Parameters | | Limits |
|---|---|---|---|
| Power Divider Snap Test 5GT11 | Condition of cams and divider wedges: | | |
| | | Breakage | none |
| | | Chipping | none |
| | | Scoring | none |
| | | Hard snaps during test | none |
| MIL-L-2105D | Full approval required | | |
| Test for Transmission and Carrier Radial Lip Seal 5 GT 75 | Immersion at 93°C for 100 hrs: | | |
| | | Appearance | as original |
| | | Blistering | none |
| | | Gum | none |
| | | Tackiness | none |
| | | Brittleness | none |
| | | Swelling | none |
| Timken Bearing Corrosion 09196 | Sample heated for 6 hrs at 150°C. Bearing dipped in sample and drained for 1 hr Bearing placed in humidity cabinet for 3 hrs at 60°C in 100% humidity | | |
| | | Rust at end of test, max. | none |
| Thermal Oxidation Stability | 200g/sample in uncovered 400 ml. beaker for 100 hrs. at 150°C in a gravity convection oven | | |
| | | Evaporation Loss, max. % | 10 |
| | | Viscosity Increase at 99°C, max. % | 15 |
| | | Precipitation Number, max. | 0.65 |
| Gear Oil Spalling Test 5 GT 71A | Minimum B 10 life of 50% above the GO-G reference | | 160 hrs minimum |
| Transmission Test for Evaluation of Thermally Stable Gear Oils 5 GT 73 | No missed shifts and no measurable shifter fork wear at the centre of the pads | | Minimum 65,000 cycles |

**Note:**

The lubricant must be a blend from well-refined virgin base stocks (high viscosity index - 95 min.) compounded with load-carrying and lubricity ingredients.
The oil shall be stable and contain no abrasive or corrosive ingredients.

## MACK GO-J and GO-J Plus Requirements



| | Extended Drain (GO-J Plus) | Standard Drain (GO-J) |
|---|---|---|
| Highway (Class A, B)[1] | 500,000 Miles or 3 Years | 250,000 Miles or 2 Years |
| Vocational (Class AA, BB, C, CC)[1] | 80,000 Miles or 1 Year or 1,200 hrs | 40,000 Miles or 1 Year or 1,200 hrs |
| Off Road (Class D)[1] | 6 Months | 6 Months |

| Test | Procedure | Extended Drain Limits | Standard Drain Limits | Comment |
|---|---|---|---|---|
| Rust Protection | ASTM D7038 (L-33) | (2) | (2) | - |
| Copper Corrosion | ASTM D130 | (2) | (2) | - |
| Foaming Tendencies | ASTM D892 | (2) | (2) | - |
| Oil Seal Compatibility | ASTM D5662 | (2) | (2) | - |
| PG2 Oil Seal Compatibility | ASTM D5662 | (2) | (2) | Section 3.3 |
| Thermal Capability | ASTM D5704 (L-60-1) | 100 hr. test | (2) | Section 3.4 |
| SS+C | Fed. Test No. 791C | - | - | - |
| Storage Stability | Method 3440.1 | (2) | (2) | - |
| Compatibility | Method 3430.2 | (2) | (2) | - |
| Surface Protection | ASTM STP512A (L-42) | (2) | (2) | - |
| Surface Protection | ASTM D6121 (L-37) | (2) | (2) | - |
| Cyclic Durability Test | ASTM D5579 | 1.5 times[2] | (2) | Section 3.5 |
| Power Divider Snap Test | MAT 700 WI | - | - | Section 3.6 |
| Tapered Bearing Shear | DIN 51 350 Part 6, Test C | Stay-in-grade<br>17% Max. Change | Stay-in-grade<br>17% Max. Change | Section 3.7 |
| Spalling Test | MAT 701 WI | - | - | Section 3.8 |
| Wet Axle Gear Durability | MAT 706 WI (L-37 Modified) | (2) | Not Required | Section 3.9 |
| Field Testing | - | 500,000 miles | (2) | Section 3.10 |
| Monitoring Program | - | Required | Required | Section 3.11 |

**Note:**

(1) Vehicle classifications as determined for Mack Trucks' vehicle warranty.

(2) SAE J2360 Limits.



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## MACK TO - A Plus Requirements

| | Extended Drain (TO-A Plus) |
|---|---|
| Highway (Class A,B)(1) | 500,000 Miles or 3 Years |
| Vocational (Class AA, BB, C, CC)(1) | 80,000 Miles or 1 Year or 1,200 hrs |
| Off Road (Class D) | Not Available |

| Test | Procedure | Extended Drain Limits | Comment |
|---|---|---|---|
| Copper Corrosion | ASTM D130 | ASTM D5760 Limits | - |
| Foaming Tendencies | ASTM D892 | ASTM D5760 Limits | - |
| Oil Seal Compatibility | ASTM D5662 | ASTM D5760 Limits | - |
| Thermal Capability | ASTM D5704 | - | Section 3.2 |
| Cyclic Durability | ASTN D5579 | 1.5 X ASTM D5760 Limits | - |
| Compatibility | Fed. Test No. 791C Method 3430.2 | SAE J2360 Limits | - |
| Tapered Bearing Shear | DIN 51 350 Part 6, Test C | Stay-in-grade, 17% Max. Change | Section 3.3 |
| Scuffing Resistance (FZG) | ASTM D5182 | ASTM D5760 Limit | - |
| Field Test | - | 500,000 miles | Section 3.4 |
| Monitoring Program | - | Required | Section 3.5 |
| Pour Point | ASTM D97 | -40°C minimum | - |

**Note:**
(1) Vehicle classifications as determined for Mack Trucks' vehicle warranty.

## MAN 341-1 Specifications

| Test | Requirement | | | | | Test Method |
|---|---|---|---|---|---|---|
| Type | Z1 | Z2 | Z3 | Z4 | Z5 | |
| SAE J306 classifications | 80W<br>80W-85<br>80W-90 | 75W-80<br>75W-85<br>75W-90<br>80W<br>80W-85<br>80W-90 | 75W-80 | 75W-80<br>75W-85 | 75W-80 | |
| ZF Approval Required | Obsolete | 02B | Obsolete | 02L | 02E | |
| Density at 15°C, g/ml | Report | | | | | DIN 51757 |
| Brookfield temperature, °C | -26/-40 | | -40 | | | DIN 51398 |
| Brookfield viscosity, mPa.s | Report | | | | | DIN 51398 |
| Kinematic Viscosity | | | | | | |
| at 40°C, cSt | Report | | max. 65 | | | DIN 51562-1 |
| at 100°C, cSt | min. 8.5 | | min. 9.0 | | | |
| Loss of viscosity at 100°C after 20 hrs shearing | within viscosity grade limits and 10% max. loss | | | | | DIN 51350-6 KRL |
| Flash Point (COC), °C | Report | | | | | DIN EN ISO 2592 |
| Pour Point, °C | Report | | | | | DIN ISO 3016 |
| TBN, mgKOH/g | Report | | | | | DIN ISO 3771 |
| TAN, mgKOH/g | Report | | | | | ASTM D664 |
| Neutralisation Number, mgKOH/g | Report | | | | | DIN 51558-1 |
| Elementals | | | | | | |
| Calcium, % | Report | | | | | DIN 51391-3 |
| Zinc, % | Report | | | | | DIN 51391-3 |
| Magnesium, % | Report | | | | | DIN 51391-3 |
| Phosphorus, % | Report | | | | | DIN 51363-3 |
| Sulphur, % | Report | | | | | E DIN 51400-10 |
| Boron, % | Report | | | | | DIN 51443-2 |
| Chlorine, mg/kg | Report | | | | | DIN 51577-4 |

## MAN 341-1 Specifications - Cont'd

| Test | | Requirement | Test Method |
|---|---|---|---|
| Steel Corrosion (2) | | Procedure A (distilled water), No rust | DIN ISO 7120 |
| Copper Corrosion (2) | | 2 or better (3 hrs / 120°C) | DIN EN ISO 2160<br>ASTM D130 |
| Foam | | | ASTM D892 |
| | Sequence I, ml, max. | 20/0 | |
| | Sequence II, ml, max. | 50/0 | |
| | Sequence III, ml, max. | 20/0 | |

**Note:**

(2) Report metal content in oil at end of test.

## MAN 341-2 Specifications

| Test | Requirement | | Test Method |
|---|---|---|---|
| Type | ZE, VR | MB | |
| SAE J306 classifications | 75W-80 | 75W-90 | |
| Density at 15°C, g/ml | Report | | DIN 51757 |
| Brookfield temperature, °C | -40 | | DIN 51398 |
| Brookfield Viscosity, mPa.s | max. 150000 | max. 60,000 | DIN 51398 |
| Kinematic Viscosity | | | DIN 51562-1 |
| at 40°C, cSt | Report | Report | |
| at 100°C, cSt | 11 | 13.5 | |
| Loss of viscosity at 100°C after 20 hrs shearing | within viscosity grade limits and 10% max. loss | | DIN 51350-6 KRL |
| Flash point (COC), °C | Report | ≥ 200 | DIN EN ISO 2592 |
| Pour point, °C | Report | ≤ -40 | DIN ISO 3016 |
| TBN, mgKOH/g | Report | | DIN ISO 3771 |
| TAN, mgKOH/g | Report | | ASTM D664 |
| Neutralisation number, mg KOH/g | Report | | DIN 51558-1 |
| Elementals | | | |
| Calcium, % | Report | | DIN 51391-3 |
| Zinc, % | Report | | DIN 51391-3 |
| Magnesium, % | Report | | DIN 51391-3 |
| Phosphorus, % | Report | | DIN 51363-3 |
| Sulphur, % | Report | | E DIN 51400-10 |
| Boron, % | Report | | DIN 51443-2 |
| Chlorine, mg/kg | max. 100 | | DIN 51577-4 |
| Oxidation test, 192 hrs (1), 160°C | | | CEC-L-48-A-00-B |
| Kv 100 increase, % | max. 25 | | DIN 51562-1 |
| Change in TAN, mgKOH/g | max. 2 | | ASTM D664 |
| Sludge | none | | |
| Steel corrosion (2) | Procedure A (distilled water), No rust | | DIN ISO 7120 |
| Copper corrosion (2) | 2 or better (3h/120°C) | | DIN EN ISO 2160<br>ASTM D130 |

**Note:**

(1) Testing for 384 hrs could also be considered.

(2) Report metal content in oil at end of test.

## MAN 341-2 Specifications - Cont'd

| Test | | Requirement | Test Method |
|---|---|---|---|
| Foam | | | ASTM D892 |
| | Sequence I, ml, max. | 20/0 | |
| | Sequence II, ml, max. | 50/0 | |
| | Sequence III, ml, max. | 20/0 | |
| SRE-NBR 28 | | | VDA 675 301 |
| | Hardness change, shore A | -10 to +10 | |
| | Tensile strength change, % | -30 | |
| | Elongation rupture change, % | -40 | |
| | Volume change, % | 0 to +10 | |
| AK-6 | | | VDA 675 301 |
| | Hardness change, shore A | -5 to +10 | |
| | Tensile strength change, % | -40 | |
| | Elongation rupture change, % | -50 | |
| | Volume change, % | 0 to +5 | |
| 70 ACM 121 433 | | | VDA 675 301 |
| | Hardness change, shore A | -10 to +5 | |
| | Tensile strength change, % | -20 | |
| | Elongation rupture change, % | -30 | |
| | Volume change, % | 0 to +5 | |

## MAN 342 Specifications

| Type | M1, M2 and M3 | | | | S1, S2 |
|---|---|---|---|---|---|
| SAE Viscosity Class | 80W | 80W-90 | 85W-90 | 90 | 75W-90 |
| Density at 15°C, g/ml | Report | Report | Report | Report | Report |
| Max. Temperature at which the Brookfield Viscosity is 150,000 mPa.s,°C | -26 | -26 | -12 | - | -40 |
| Kinematic Viscosity at 40°C, mm²/s | Report | Report | Report | Report | Report |
| Kinematic Viscosity at 100°C, mm²/s | 7.0 min. | 13.5 min. | 13.5 min. | 13.5 min. | 13.5 min. |
| Viscosity at 100°C after Shear (20 hr KRL), mm²/s | Stay-in-grade (max. 10% loss) | | | | |
| Flash Point, °C | 190 min. | 190 min. | 200 min. | 200 min. | 200 min. |
| Pour Point, °C | -27 max. | -27 max. | -21 max. | - | -40 max. |
| Total Acid No., mg KOH/g | Report | Report | Report | Report | Report |
| Calcium, Magnesium, Zinc mg/kg | Report | Report | Report | Report | Report |
| Boron Content, mg/kg | Report | Report | Report | Report | Report |
| Phosphorus, % mass | Report | Report | Report | Report | Report |
| Sulphur, % mass | Report | Report | Report | Report | Report |
| Chlorine, mg/kg | 100 max. | 100 max. | 100 max. | 100 max. | 100 max. |
| Oxidation Stability CEC-L-48-A-00 (B) | 192 hrs at 150°C | | | | 192 hrs at 160°C |
| Viscosity Increase at 100°C, % | 130 max. | 130 max. | 130 max. | 130 max. | 130 max. |
| Change in TAN, mg KOH/g | 10 max. | 10 max. | 10 max. | 10 max. | 10 max. |
| Sludge Formation | Report | Report | Report | Report | None |
| Steel Corrosion (DIN ISO 7120 Method A) - Metallic elements in oil after test to be reported | no rust | no rust | no rust | no rust | no rust |
| Copper Corrosion (3 hrs at 120°C) ASTM D130 - Copper in oil after test to be reported | 2 max | 2 max | 2 max | 2 max | 2 max |
| Foaming Tendency/Stability, ml, max. | | | | | |
| Sequence I | 20/0 | 20/0 | 20/0 | 20/0 | 20/0 |
| Sequence II | 50/0 | 50/0 | 50/0 | 50/0 | 50/0 |
| Sequence III | 20/0 | 20/0 | 20/0 | 20/0 | 20/0 |
| MAN Seal Tests (168 hrs: 100°C NBR-28, 150°C AK6 & ACM 121433) | Pass | Pass | Pass | Pass | Pass |

| Testing Required for new Additive Technologies | |
|---|---|
| API GL-5 and MIL-L-2105D Performance | Meet |
| FZG Pitting (C/8.3/90), 3 Runs, Hrs | M1, M2, M3: 90 min. - S1, S2: 250 min. |
| FZG Sprung S-A 10/16, 6R/90, Pass Load Stage | 10 min. |
| FZG A/8, 3/90 on used oil after DKA oxidation, Pass Load Stage | 10 min. (1) |
| FZG wear C/0.05/90/10 and C/0.05/90/12, wear, mg | Max 400mg in 120 hrs |
| Dynamic Seals Test: 240 hrs at 120°C (10 cycles): 75 FPM 595 and FKM 585 | Pass (1) |
| Bearing wear test - DIN 51819-3 | Report results |
| Field Test for M3 and S1, S2 Grades - must include trucks with Intarders / Retarders | 500,000km |

**Note:** (1) Only required for S1, S2. (2) Only required for M3 and SI, S2.



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## Performance Requirements For MIL-L-2105D (GL-5) Lubricants

| SAE Viscosity Grade | | 75W | 80W-90 | 85W-140 |
|---|---|---|---|---|
| ASTM D5704 (formerly CRC L-60-1 or L-60) | | | | |
| Thermal Oxidation Stability | 100°C Viscosity Increase at 50 hrs, max. % | 100 | 100 | 100 |
| | Pentane Insolubles, max. % | 3 | 3 | 3 |
| | Toluene Insolubles, max. % | 2 | 2 | 2 |
| ASTM D7038 (formerly CRC L-33-1) | | | | |
| Moisture Corrosion | Final rust merit rating, min | 9 | 9 | 9 |
| ASTM D6121 (formerly CRC L-37) | | | | |
| Low Speed - High Torque | "Green" Gears | Pass | Pass | NR |
| ASTM D7452 (formerly CRC L-42) | | | | |
| High Speed-Shock Loading Axle Test | Ring & Pinion Tooth Scoring, max. % | Equal to or better than Passing reference oil | | NR |
| ASTM D130 (3 hrs @ 121°C) | | | | |
| Copper Strip Corrosion | Strip Rating, max. | 3 | 3 | 3 |
| ASTM D892 | | | | |
| Foam Tendency/Stability, ml, max | Sequence I | 20/0 | 20 | 20 |
| | Sequence II | 50/0 | 50 | 50 |
| | Sequence III | 50/0 | 50 | 50 |

**Note:**
NR: Not Required, if 80W90 passes in the same base stock. Lower L-37 and L-42 test temperatures are required for 75W oils often referred to as Canadian versions.

## Performance Requirements For SAE J2360 (formerly MIL-PRF-2105E) November 1998

| SAE Viscosity Grade | | 75W | 80W-90 | 85W-140 |
|---|---|---|---|---|
| Viscosity at 100°C, $mm^2/s$ | | | | |
| min. | | 4.1 | 13.5 | 24.0 |
| max. | | - | 18.5 | 32.5 |
| Viscosity at 150,000 mPa.s, max temp °C | | -40 | -26 | -12 |
| Flash Point, min, °C | | 150 | 165 | 180 |
| ASTM D5704 (formerly CRCL-60-1) | | | | |
| Thermal Oxidation Stability | 100°C Viscosity Increase at 50 hrs, max. % | 100 | 100 | 100 |
| | Pentane Insolubles, max. % | 3 | 3 | 3 |
| | Toluene Insolubles, max. % | 2 | 2 | 2 |
| | Carbon Varnish, min, Rating | 7.5 | 7.5 | 7.5 |
| | Sludge, max. Rating | 9.4 | 9.4 | 9.4 |
| ASTM D7038 (formerly CRC L-33-1) | | | | |
| Moisture Corrosion | Rust on Gear Teeth Bearings and Cover plate, Rating, min | 9.0 | 9.0 | 9.0 |
| ASTM D6121 (formerly CRC L-37) | | | | |
| High Speed - Low Torque | “Green Gears” | Pass | Pass | NR |
| High Torque - Low Speed | “Lubrited” Gears | Pass | Pass | NR |
| ASTM D7542 (formerly CRC L-42) | | | | |
| High Speed-Shock Loading Axle Test | Ring and Pinion Tooth Scoring, max., % | Equal to or better than passing reference oil | | NR |
| ASTM D130 | | | | |
| Copper Corrosion/3 hrs at 121°C | Strip Rating, max. | 3 | 3 | 3 |
| Elastomer Compatibility (ASTM D5662) | | Polyacrylate | Fluoroelastomer | Nitrile |
| Polyacrylate + Fluoroelastomer | Elongation Change, min, % | -60 | -75 | -60 |
| at-150°C for 240 hrs | Hardness Change, Points | -35 to + 5 | -5 to + 10 | -10 to + 5 |
| Nitrile at 100°C for 240 hrs | Volume Change, % | -5 to + 30 | -5 to + 15 | -5 to + 20 |
| ASTM D892 | | | | |
| Foam Tendency/Stability, ml, max. | Sequence I | 20/0 | 20/0 | 20/0 |
| | Sequence II | 50/0 | 50/0 | 50/0 |
| | Sequence III | 20/0 | 20/0 | 20/0 |
| SS&C FTM 791 | | | | |
| Storage Stability & Compatibility | Method 3340 | Pass | Pass | Pass |
| Field Trial [1] | | Pass | Pass | Pass |

**Note:**
NR: Not required, if 80W-90 passes in the same base stock. Lower L-37 and L-42 Test Temperatures are required for 75W oils.

[1] Must pass once in a single SAE grade per additive, 100,000 miles light duty and 200,000 miles heavy duty axles only.



Afton CHEMICAL

## MT-1 Category Tests and Acceptance Criteria

| Test | | Minimum | Maximum |
|---|---|---|---|
| Test method for Evaluation of the Thermal and Oxidative Stability of Lubricants used for Manual Transmissions and Final Drive Axles L-60-1(ASTM D5704) | | | |
| | Viscosity Increase, % | - | 100 |
| | Pentane Insolubles, % | - | 3.0 |
| | Toluene Insolubles, % | - | 2.0 |
| | Carbon/Varnish Rating | 7.5 | - |
| | Sludge Rating | 9.4 | - |
| Test method for determining Automotive Gear Oil compatibility with Typical Oil Seal Elastomers (ASTM D5662) | | | |
| Polyacrylate at 150°C, 240 hrs | | | |
| | Elongation change, % | No limits | -60 |
| | Hardness change, points | -35 | +5 |
| | Volume change, % | -5 | +30 |
| Fluoroelastomer at 150°C, 240 hrs | | | |
| | Elongation change, % | No limits | -75 |
| | Hardness change, points | -5 | +10 |
| | Volume change, % | -5 | +15 |
| Test method for evaluating the thermal stability of manual transmission lubricants in a Cyclic Durability Test Cycles to fail (ASTM D5579) | | Better than passing reference oil | - |
| Test method D130 for detection of copper corrosion from petroleum products by the Copper Strip Tarnish Test, 121°C, 3 hrs | | - | 2a |
| Test Method D5182 for evaluating the scuffing (scoring) load capacity of oils Failing load stage | | 11 | - |
| Test Method D892 for foaming characteristics of lubricating oils (tendency only) | | | |
| | Sequence I, ml | - | 20 |
| | Sequence II, ml | - | 50 |
| | Sequence III, ml | - | 20 |
| Federal Test Method 791C, Method 3430.2, for compatability characteristics of Universal Gear Lubricant | | Compatible with J2360 oils(1) | - |
| Federal Test Method 791C, Method 3440.1, for storage solubility characteristics of Universal Gear Lubricant | | Pass(2) | - |

**Note:**

(1) Shall be compatible with specific reference oils when tested in accordance with Federal Test Method 3430.2. Reference oils may be obtained from SAE, 400 Commonwealth Drive, Warrendale, Pennsylvania, 15096.

(2) Shall pass the performance requirements as specified in the SAE J2360 specifications when tested in accordance with Federal Test Method 3440.1.



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## Scania STO 1:0

| Type | Requirement | Limits |
|---|---|---|
| Gear Oil | API | GL-5 |
| STO [1] 1:0 | API | GL-5 |
| | Shear Stability | |
| | 20 hr KRL Shear (CEC-L-45-A-99) | Viscosity change (%) less than or equal to RL181 |
| | Filterability | Minimum 90% in stage 2 of ISO 13357-2 using 5µm filter and 1.0 bar pressure |
| | Thermal and Oxidation Stability, ASTM D5704 (L-60-1) [2] | Carbon varnish = 7.5 min. (on large gear only)<br>Sludge = 9.4 min. (on both gears) |

**Note:**

(1) Scania Gear Oil.

(2) MIL-PRF-2105E (SAE J2360) Limits.

## Volvo Transmission Oil Specifications 1273.07

| Test | Limits | Test Method |
|---|---|---|
| Density, kg/m$^3$ | To be stated | ASTM D1298 |
| Flash Point, COC, min, °C | 200 | ASTM D92 |
| Pour Point, max. °C | -48 | ASTM D97 |
| Viscosity at 100°C, mm$^2$/s | | ASTM D445 |
| min. | 9 | |
| max. | 12 | |
| Viscosity Loss after Shearing, 20 hrs, max. % | 5 | ASTM D445<br>CEC L-45-A-99 |
| Viscosity at -40°C, mPa.s, max. | 150,000 | ASTM D2983 |
| Oxidation Stability after 160°C/192 hrs | | CEC L-48-A-95B |
| Viscosity Increase, 100°C, max. % | 10 | |
| Tan Increase, mg KOH/mg, max. | 1.0 | |
| Copper Corrosion, 3 hrs, max. 150°C | 1B | ASTM D130 |
| Rust Protection 24 hrs | No rust | ASTM D665 A |
| Rust Protection after Oxidation | No rust | ASTM D665 A<br>CEC L-48-A-95 |
| Foaming Tendency, ml/ml | | ASTM D892 |
| Sequence I/II/III, max. | 50/0 | |
| Water Content, ppm, max. | 200 | ASTM D1744 |
| Solid Particles, code, max. | 18/13 | ISO 4406 |
| Synchronization Properties | (1) | |
| Seal Compatibility | Pass | VTM-02-95(2) |
| Load Carrying Capacity, load stage, min. | 12 + | CEC L-07-A-95 |
| Surface Fatigue, gears | 50% better than reference oil | VTM-01-96(2) |
| Field Tests | 400,000 km | VTM-03-95(2) |

**Note:**

(1) The oil shall be tested in the Volvo test rig with approved results after 300,000 engagements.

(2) Volvo Test Method.



Afton CHEMICAL

## Volvo Transmission Oil Specifications 1273.12

| Test | Limits | Test Method |
|---|---|---|
| Density, kg/m$^3$ | To be stated | ASTM D1298 |
| Flash Point, COC, min, °C | 200 | ASTM D92 |
| Pour Point, max. °C | -48 | ASTM D97 |
| Viscosity at 100°C, mm$^2$/s | | ASTM D445 |
| min. | 13.5 | |
| max. | 18 | |
| Viscosity Loss after Shearing, 20 hrs, max. % | 5 | ASTM D445<br>CEC L-45-A-99 |
| Viscosity at -40°C, mPa.s max. | 150,000 | ASTM D2983 |
| Oxidation Stability after 120°C/192 hrs | | CEC L-48-A-95B |
| Viscosity Increase, 100°C, max. % | 10 | |
| Tan Increase, mg KOH/mg, max. | 1.0 | |
| Copper Corrosion, 3 hrs, max. 120°C | 1B | ASTM D130 |
| Rust Protection 24 hrs | No rust | ASTM D665 A |
| Rust Protection after Oxidation | No rust | ASTM D665 A<br>CEC L-48-A-95 |
| Foaming Tendency, ml/ml | | ASTM D892 |
| Sequence I/II/III, max. | 50/0 | |
| Water Content, ppm, max. | 200 | ASTM D1744 |
| Solid Particles, code, max. | 18/13 | ISO 4406 |
| API | GL-5 | |
| Seal Compatibility | Pass | VTM-02-95(1) |
| Surface Fatigue, gears | 30% better than reference oil | VTM-01-96(1) |
| Field Tests | 400,000 km | VTM-03-95(1) |

**Note:**
(1) Volvo Test Method.



Afton CHEMICAL

## ZF Specifications: Master List

| Description | ZF List | Notes | Viscosity Grades |
|---|---|---|---|
| TE-ML 01<br>Manual synchronised transmissions for commercial vehicles | Class 01E<br>Class 01L | Requires ZF TE-ML 02E | SAE 75W-80 |
| | | Requires ZF TE-ML 02L | SAE 75W-80 |
| TE-ML 02<br>Manual and automatic transmissions for trucks and buses | Class 02A (1) | Gear oils of API GL-4, MIL-L-2105 quality - not applicable for intarder | SAE 80W / SAE 75W-80 / 80W-85W / 80W-90 |
| | Class 02B | Gear oils - not applicable for intarder | SAE 80W / 80W-85 / 80W-90 / SAE 90 /75W-80 / 75W-85 / 75W-90 |
| | Class 02C (1) | Monograde engine oils - mineral oil based - applicable for intarder | SAE 30 |
| | Class 02D (1) | Semi-synthetic gear oils - applicable for intarder | SAE 75W-80 |
| | Class 02E | Gear oil - Synthetic gear oil applicable for intarder | SAE 75W-80 |
| | Class 02F | ATF (Automatic Transmission Fluid) | |
| | Class 02G (1) | Gear oil - mineral based, not applicable for intarder | SAE 75W |
| | Class 02H | Monograde engine oils (mineral based) - applicable for in tarder | SAE 30, SAE 40<br>80W / 80W-85W / 80W90 / 85W-90 / 90 |
| | Class 02K | Hydraulic oil | |
| | Class 02L | Semi-synthetic gear oil - applicable for intarder | SAE 75W-80 |
| TE-ML 03<br>Torque convertor transmissions for off-road vehicles and machinery (construction plant, special vehicles, lift trucks) | Class 03A | Mineral based engine oil in accordance with Group Standard | SAE 10W-30 / 10W-40<br>SAE 15W-30 / 5W-40<br>SAE 20W-20 & 30 grade / 20W-40 |
| | Class 03B | Mineral based engine oil in accordance with Group Standard | SAE 10W / 5W-30 / 5W-40 |
| | Class 03C | Off highway lubricants | SAE 5W-30 / 5W-40 / 10W / 10W-30 / 10W-40 / 15W-30 / 15W-40 / 20W-20 / 20W-40 / SAE 30 |
| | Class 3D | ATF | |
| | Class 03E | Universal Tractor transmission oils (UTTO) for converter transmissions for off-road equipment | |
| | Class 03F | Universal Tractor transmission oils (UTTO) for use at outside temperatures below -10ºC | |
| | Class 03G | Universal construction machinery oil | |
| TE-ML 04<br>Marine | Class 04A | Monograde engine oils - API CD / CE / CF-4 / CF / SF / SG / SH / SJ<br>or ACEA categories A / B / E | SAE 30<br>(SAE 40 in hot countries) |
| | Class 04B | Monograde engine oils | |
| | Class 04C | Multigrade engine oils | SAE 5W-40,<br>10W-40, 15W-40 |
| | Class 04D | ATF | |
| | Class 04E | Monograde engine oils (API CD / CE /CF-4 / CG-4 / CH-4 / CI-4 / SF / SG / SH / SJ / SL or ACEA categories A / B / C | SAE 50 |
| | Class 04F | Oil CLP 220 in accordance with DIN 51517 -3 | ISO VG 220 |

**Note:**
(1) Now obsolete: Class 02A, 02C, 02D, 02G.

## ZF Specifications: Master List

| Description | ZF List | Required Performance | Viscosity Grades |
|---|---|---|---|
| TE-ML 05<br>Axles for off-road vehicles | Class 05A | Mineral oil based & semi-synthetic gear oils | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| | Class 05B | Synthetic gear oils | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| | Class 05C | Mineral oil based gear oils with limited slip additives | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| | Class 05D | Synthetic gear oils with limited slip additives | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| No longer active | Class 05E | Universal Tractor Transmission Oils (UTTO) | SAE 20W-40 |
| | Class 05F | Universal Tractor Transmission Oils (UTTO) as service oil for ZF axles in off-road vehicles with and without wet breaks and/or differential | |
| | Class 05G | Universal construction machinery oil | |
| | Class 05H | Bio-degradeable lubricant | SAE 75W-80 |
| | Class 05K | Engine oil in accordance with API CD / CE / CF-4 / CG-4 / CH-4 / CI-4 or SF / SG / SH / SJ / SL or ACEA Catagories A / B / C | SAE 10-W, 10W-30, 10W-40 |
| | Class 05L | Mineral ATF in accordance with General Motors | |
| TE-ML 06<br>Tractor transmissions and hydraulic lifts | Class 06A | Engine oils - API CD / CE / CF-4 / CF / SF / SG / SH / SJ or ACEA categories A / B / E | SAE 20W-20 |
| | Class 06B | STOU (Super Tractor Oil Universal) braking test | SAE 10W-30 / 10W-40 / 15W-30 / 15W-40 / 20W-40 |
| | Class 06C | STOU (Super Tractor Oil Universal) | SAE 10W-30 / 10W-40 / 15W-30 / 15W-40 / 20W-40 |
| | Class 06D | STOU (Super Tractor Oil Universal) | SAE 10W-30 |
| | Class 06E | Universal Tractor Transmission Oil (UTTO) | |
| | Class 06F | Super Tractor Oil Universal (STOU) and Universal Tractor Transmission Oil (UTTO) | SAE 10W-30 / 10W-40 / 15W-30 / 15W-40 |
| | Class 06G | Biodegradeable lubricant with environmental labels RAL-UZ 79 (Blue Angel), Vamil-regeling | SAE 75W-80 |
| | Class 06H | Tractor oils | SAE 10W-30 / 10W-40 |
| | Class 06K | Universal Tractor Transmission Oil (UTTO) | |
| | Class 06L | Gear oils GL-4 and Mil 2105 | SAE 75W-80 / 75W-85 / 80W / 80W-85 |
| | Class 06M | Tractor oils | SAE 10W-30 / 10W-40 / 15W-30 / 15W-40 |
| | Class 06Q | Tractor oils | SAE 15W-40 |
| TE-ML 07<br>Hydrostatic & mechanical drives and electric drive systems | Class 07A | Gear oils | SAE 75W-90 / 75W-110 / 75W-140 / 80W-85 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-140 / 85W-110 / 90 |
| | Class 07B | STOU (Super Tractor Oil Universal) | SAE 10W-30 / 10W-40 / 15W-30 / 15W-40 / 20W-40 |
| | Class 07C | Engine oil | SAE 5W-40 / 10W-40 / 15W-40 |
| | Class 07D | Engine oils - API CD / CE / CF-4 / CF / CG-4 / CH-4 / CI-4 / SF / SG / SH / SJ / SL or ACEA categories A / B / E | SAE 20W-20 / 30 / 5W-30 / 5W-40 / 10W-30 / 10W-40 / 15W-30 / 15W-40 for powershift transmissions SAE 10W-40 / 15W-40 for Mobile mixer drives |
| | Class 07E | Biodegradeable lubricant Environmental labels RAL-UZ 79 (Blue Angel) Vamil-regeling | SAE 75W-80 |
| | Class 07F | Off highway lubricants | SAE 30 |
| | Class 07G | Biodegradeable lubricant with environmental labels RAL-UZ 79 (Blue Angel), Vamil-regeling and Swedish standard 15 54 34 | ISO VG 46 / 68 |
| | Class 07H | Mineral based hydraulic oil HLP or HVLP in accordance with DIN 51524-2 | ISO VG 46 / 68 |



Afton CHEMICAL

## ZF Specifications: Master List

| Description | ZF List | Required Performance | Viscosity Grades |
|---|---|---|---|
| TE-ML 08<br>Steering systems (non-power assisted) for cars, commercial vehicles and off road vehicles | | Gear oils (API GL-4, MIL-L-2105) | SAE 75W-80 / 75W-85 / 75W-90 / 80W / 80W-85 / 80W-90 |
| | | Gear oils (API GL-5, MIL-L-2105D, MIL-PRF-2105E, SAE J2360) | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-140 / 90 |
| TE-ML 09<br>Steering systems and oil pumps for cars, commercial vehicles and off road vehicles | Class 09X | Special approvals | |
| TE-ML 11<br>Manual transmissions, double clutch transmissions and automatic transmissions for cars | Class 11A | Automatic transmission fluid (ATF) | |
| | Class 11B | Automatic transmission fluid (ATF) | |
| TE-ML 12<br>Axles for cars, commercial vehicles and buses<br>Axles, differentials, wheel heads and wheel hubs - 12B,12C,12D,12E<br>Axles and differentials with multi disc self locking differentials - 12C & 12D | Class 12B | Synthetic gear oils - subject to intensified wear protection requirements | SAE 75W-90 / 75W-110 / 75W-140 |
| | Class 12C | Mineral oil based gear oils with limited slip additives | SAE 80W-90 / 80W-140 / 80W-110 / 85W-90 / 85W-110 / 85W-140 / 90 |
| | Class 12D | Synthetic gear oils with limited slip additives | SAE 75W-90 / 75W-110 / 75W-140 |
| | Class 12E | Mineral oil & semi-synthetic gear oil - subject to intensified wear protection requirements | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| TE-ML 13<br>ZF assemblies in special purpose vehicles | | | |
| TE-ML 14<br>Powershift transmissions, type Ecomat, for buses, trucks and special vehicles | Class 14A | Mineral oil based ATFs | |
| | Class 14B | Semi-synthetic ATFs | |
| | Class 14C | Synthetic ATF | |
| | Class 14E | Fully synthetic ATF | |
| TE-ML 15<br>Brake systems for special vehicles | | | |

## ZF Specifications: Master List

| Description | ZF List | Required Performance | Viscosity Grades |
|---|---|---|---|
| TE-ML 16 Transmissions for rail vehicles | Class 16A | Gear oil - Mineral oil based & semi-synthetic | SAE 80W-90 / 85W-90 / 90 |
| | Class 16B | Gear oil - Mineral oil based & semi-synthetic | SAE 75W-90 / 80W-90 / 85W-90 / 90 |
| | Class 16C | Gear oil - Mineral oil based & semi-synthetic | SAE 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| | Class 16D | Gear oil - Mineral oil based & semi-synthetic | SAE 80W-140 / 85W-140 / 140 |
| | Class 16E | Gear oil with limited slip additives - Mineral oil based | SAE 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| | Class 16F | Gear oil - Synthetic | SAE 75W-90 / 75W-110 / 75W-140 / 80W-110 / 85W-110 |
| | Class 16G | Gear oil with limited slip additives - Synthetic | SAE 75W-90 / 75W-110 / 75W-140 |
| | Class 16K | Gear oil of viscosity grade 75W85 (synthetic, suitable for intarder) | SAE 75W-80 |
| | Class 16L | Semi-synthetics ATFs | |
| | Class 16M | Synthetic ATFs | |
| | Class 16N | Synthetic ATFs | |
| | Class 16P | Synthetic gear oil suitable for intarder | SAE 75W-80 |
| TE-ML 17 Transmissions and axles for lift-trucks | Class 17A | Gear oil in accordance with API GL-4, MIL-2105 | SAE 75W-80 / 75W-85 / 75W-90 / 80W / 80W-85 / 80W-90 / 85W-90 / 90 |
| | Class 17B | Gear oil | SAE 75W-80 / 75W-85 / 75W-90 / 80W / 80W-85 / 80W-90 / 85W-90 / 90 |
| | Class 17C | ATF and special requirements | |
| | Class 17D special approvals | | |
| | Class 17E | | |
| | Class 17F | | |
| TE-ML 18 Axles for cars | | | |
| TE-ML 19 Transfer and offset transmissions for commercial vehicles | Class 19A | Gear oil | SAE 80W-90 / 85W-90 / 90 |
| | Class 19B | Mineral oil-based and semi-synthetic gear oil | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 85W-90 / 90 |
| | Class 19C | Synthetic gear oil | SAE 75W-90 / 75W-110 / 75W-140 |
| TE-ML 20 Powershift transmissions type Ecolife, for buses | Class 20A | | |
| | Class 20B | | |
| | Class 20C | | |
| | Class 20D | | |
| | Class 20E | | |
| | Class 20E | | |
| TE-ML 21 Tractor front axles, transmissions for harvesters and final drives | Class 21A | Gear oil | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| | Class 21B | Gear oil | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| | Class 21C | Gear oil with limited slip additives | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |
| | Class 21D | Gear oil with limited slip additives | SAE 75W-90 / 75W-110 / 75W-140 / 80W-90 / 80W-110 / 80W-140 / 85W-90 / 85W-110 / 85W-140 / 90 |

## Ford Specifications

| Test | Method | MERCON® V | FORD |
|---|---|---|---|
| Miscibility | FORD Appendix 1 | No separation | No separation |
| Viscosity | | | |
| at 100°C | ASTM D445 | 6.8 mm²/s, min. | 6.8 mm²/s, min. |
| at -20°C | ASTM D2983 | 1,500 mPa.s, max. | 1,500 mPa.s, max. |
| at -40°C | ASTM D2983 | 13,000 mPa.s, max. | 20,000 mPa.s, max. |
| Shear Stability | | | |
| Degraded 100°C | ASTM D445/KRL 20 hrs | 6.0 mm²/s, min. | |
| Apparent Vis at 150°C | ASTM D4683 | | |
| ULSV | 40 passes FISST | Read & Report | |
| UHSV | (D5275) | Read & Report | |
| DLSV | | Read & Report | |
| DHSV | | 2.6 mPa.s, min. | |
| Apparent Vis at 100°C | ASTM D4683 | | |
| DHSV | | 5.4 mPa.s, min. | |
| Vis after mod. NOACK at -40°C<br>Evaporation Loss | ASTM D2983<br>Modified NOACK (150°C, 2 hrs) | ASTM D2983<br>10% maximum change | 2,000 mPa.s maximum change<br>10% maximum change |
| Flash Point | ASTM D92 | 180°C, min. | 177°C, min. |
| Copper Strip | ASTM D130 | 1b, max. | 1b, max |
| Non-Corrosion and Non-Rusting Properties | ASTM D665 A | No visible rust | No visible rust |
| Colour | ASTM D1500 Red | 6.0 - 8.0 | 6.0 - 8.0 |
| Vane Pump Wear Test | ASTM D2882 | 10mg, max. | 10mg, max. |
| FZG Wear Test | ASTM D5182, 1450 rpm,<br>15 min. at 150°C | 11 Load Stage Pass | |
| Four Ball Wear | ASTM D4172<br>600rpm, 100°C<br>600rpm, 150°C | Average scar diameter of two runs<br>0.61 mm max.<br>0.61 mm max. | |
| Falex EP Test<br>Method B | ASTM D3233<br>No seizure at 100°C<br>No seizure at 150°C | <br>Average of 750 lbs. min.<br>Average of 750 lbs. min. | |
| FORD Timken | ASTM D2782<br>9lb. Load, 150°C, 10 min. | No scoring<br>Average 0.60 mm max. | |



Afton CHEMICAL

## Ford Specifications - Cont'd

| Test | Method | MERCON® V | FORD |
|---|---|---|---|
| Anti-shudder Evaluation | MERCON® V Appendix 4 | Candidate Fluid Equivalent to Reference | |
| Clutch Friction Evaluation and Durability | MERCON® V Appendix 5<br>20K Friction Durability | SD 1777 | |
| | | Midpoint Coeff. , 0.140 - 0.170 | Midpoint Coeff. , 0.13 - 0.16 |
| | | Low Speed Dynamic, 0.135 - 0.160 | Low Speed Dynamic, 0.12 - 0.16 |
| | | Stop Time, s 0.70 - 0.90 | Engagement time, s 0.75 - 1.0 |
| | | E/M (S1/D) Ratio, 0.85 - 1.07 | E/M (S1/D) Ratio, 0.90 - 1.0 |
| | | Static Breakaway, 0.100 - 0.155 | Static Breakaway, 0.10 - 0.15 |
| | | | S2/D Ratio, Rate & Report |
| Anti-foaming Properties | ASTM D892 | Tendency/Stability | Tendency/Stability |
| | | Sequence 1: 50/0 max. | Sequence 1: 100/0 max. |
| | | Sequence 2: 50/0 max. | Sequence 2: 100/0 max. |
| | | Sequence 3: 50/0 max. | Sequence 3: 100/0 max. |
| | | Sequence 4: 100/0 max. | Sequence 4: 100/0 max. |
| Elastomer Compatibility<br>(Volume Change/Hardness Change) | MERCON® V Appendix 7<br>Volume/Hardness | ATRR 101, -3 to +4% / 0 to +10 | ATRR 101, -1 to +6% / ±7 |
| | | ATRR 201, 0 to +6% / ±5 | ATRR 201, 0 to +6% / ±5 |
| | | ATRR 300, +20 to +48% / -15 to -40 | ATRR 300, +20 to +48% / -15 to -40 |
| | | ATRR 400, 0 to +4% / ±8 | ATRR 400, 0 to +4% / ±5 |
| | | ATRR 500, +5 to +15% / ±5 | ATRR 500, -10 to +20% / -10 to 0 |
| | | ATRR 600, +5 to +35% / -30 to 0 | ATRR 600, +20 to +50% / -40 to -10 |
| | | ATRR 700, -2 to +4% / 0 to +5 | ATRR 700, -2 to +4% / ±5 |
| Aluminum Beaker Oxidation Test | MERCON® V Appendix 8 | Pentane Insolubles <0.35% | Pentane Insolubles <1% |
| | | Delta TAN, 3.5 max. | Delta TAN, 4.0 max. |
| | | Delta IR, 30 max. | Delta IR, 40 max. |
| | | Visc. Inc. at 40°C, 25% max. | Visc. Inc. at 40°C, 40% max. |
| | | Cu Strip Rating, 3b max. | Cu Strip Rating, 3b max |
| | | Al Strip Rating, No Varnish | Al Strip Rating, No Varnish |
| | | Sludge, No Sludge | Sludge, No Sludge |
| | | Viscosity at -40°C, Rate & Report | Viscosity at -40°C, Rate & Report |
| | | Calculated % wt. loss, Rate & Report | Calculated % wt. loss, Rate & Report |
| Cycling Test | GM-6297-M plus post test viscosity limits | Pass GM cycling test | Pass GM cycling test |
| | 20K cycle used oil vis at 100°C | 6.0 $mm^2/s$, min. | |
| | 20K cycle used oil vis at 40°C | Rate & Report | |
| | 20K cycle used oil vis at -40°C | Rate & Report | |
| Shift Feel | MERCON® V | Candidate Fluid Equivalent to Reference | Candidate Fluid Equivalent to Reference |

| Test | Requirements | Test Method |
|---|---|---|
| Chemical Analysis | | |
| Metals Content | | |
| Barium | Report | Emission spectroscopy: ICP |
| Boron | Report | Emission spectroscopy: ICP |
| Calcium | Report | Emission spectroscopy: ICP |
| Magnesium | Report | Emission spectroscopy: ICP |
| Phosphorus | Report | Emission spectroscopy: ICP |
| Silicon | Report | Emission spectroscopy: ICP |
| Sodium | Report | Emission spectroscopy: ICP |
| Zinc | Report | Emission spectroscopy: ICP |
| Non Metals Content | | |
| Chlorine | Report | ASTM D808 |
| Nitrogen | Report | ASTM D3228 |
| Sulphur | Report | ASTM D4951 or ASTM D129 |
| Total Acid Number | Report | ASTM D664 |
| Total Base Number | Report | ASTM D4739 or D2896 |
| Infrared Spectrum | Report | ASTM E168 |
| Physical Properties | | |
| Flash Point, °C min. | 170 | ASTM D92 |
| Fire Point, °C min. | 185 | ASTM D92 |
| Viscosity Characteristics | | |
| Kinematic Viscosity at 40°C | Report (1) | ASTM D445 |
| Kinematic Viscosity at 100°C | Report (1) | ASTM D445 |
| Apparent Viscosity | Report (1) | ASTM D2602 |
| Brookfield Viscosity | Report Temperature at 3500 mPa.s | ASTM D2983 |
| Stable Pour Point | Report (1) | ASTM D97 |

**Note:**
(1) Fluids shall meet SAE J300 Viscosity grades and in addition ATFs must meet General Motors and Ford requirements.

## **Allison Transmission - Cont'd**

C-4 Heavy Duty Transmission Fluid Specifications

| Test | | Requirements | Test Method |
|---|---|---|---|
| Bench Tests | | | GM 6297-M,Test M (Appendix A) |
| Foaming Tendency | | | |
| | Foam at 95°C, max. | Nil | |
| | Foam at 135°C, mm max. | 10 | |
| | Break time at 135°C, secs. max. | 23 | |
| Copper Corrosion | | No blackening or flaking | ASTM D130, 3 hrs at 150°C |
| Corrosion/Rust Protection | | No visible rust on test pins | ASTM D665, procedure "A" for 24 hrs |
| Rust Protection | | No rust or corrosion on any test surface | ASTM D1748, 98% humidity, 50 hrs at 40°C |
| Elastomer Compatibility | | Limits are adjusted for each new elastomer batch | GM 6137-M (Appendix B) |
| V1 | Volume difference, % | 0 to 20 | |
| | Hardness difference, points | -15 to 0 | |
| V2 | Volume difference, % | 0 to 12 | |
| | Hardness difference, points | -7 to +3 | |
| V3 | Volume difference, % | 0 to 22 | |
| | Hardness difference, points | - 14 to 0 | |
| P1 | Volume difference, % | 0 to 8 | |
| | Hardness difference, points | -10 to 0 | |
| P2 | Volume difference % | 0 to 8 | |
| | Hardness change, points | -11 to +3 | |
| P3 | Volume difference % | 0 to 4 | |
| | Hardness change, points | -8 to +4 | |
| F1 | Volume difference % | 0 to 3 | |
| | Hardness change, points | -5 to +4 | |
| F2 | Volume difference % | 0 to 4 | |
| | Hardness change, points | -2 to +5 | |
| N1 | Volume difference % | 0 to 5 | |
| | Hardness change, points | -12 to +12 | |
| N2 | Volume difference % | 0 to 6 | |

| Test | Requirements | Test Method |
|---|---|---|
| Oxidation Stability, C-4 Oxidation Test (THOT) | Satisfactory operation for 300 hrs | GM 6297-M (Appendix E) |
| Viscosity Increase, 40°C, %, max. | 100 | |
| Viscosity Increase, 100°C, %, max. | 60 | |
| TAN Increase, max. | 4.0 | |
| Carbonyl Absorbance, max. | 0.75 | |
| Wear protection | | |
| C-4 Vane Pump Wear Test,<br>Total Weight Loss, mg, max. | 30 | ASTM D2882 mod.<br>(a) 80 ± 3°C (b) 6.9 Mpa |
| Clutch Frictional Characteristics | | |
| C-4 Graphite Clutch Test | Mid-point dynamic coefficient and slip time must surpass limits set with minimum performance reference oil | Allison C-4 graphite clutch friction test |
| C-4 Paper Clutch Friction Test | | Allison C-4 paper clutch friction test |

## Allison TES 439

| Test | Requirements | Test Method |
|---|---|---|
| SAE Grades | 0W-30, 0W-40, 30, 5W-40, 10W-40, 15W-40, 40 | SAE J300 |
| Chemical Analysis | Report (ppm): Al, Ba, B, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Si, Ag, Na, S, Sn, Ti, V and Zn | ASTM D5185 |
| Total Acid Number | Report | ASTM D664 |
| Physical Properties | | |
| Flash Point, °C min. | 170 | ASTM D92 |
| Viscosity Characteristics | | |
| Kinematic Viscosity at 100°C | Report (1) | ASTM D445 |
| Low Temperature Cranking Viscosity, cP | Report (1) | ASTM D5293 |
| Low Temperature Pumping Viscosity, cP | Report (1) | ASTM D4684 |
| High Temperature Shear Rate (HTHS), 150°C, cSt | Report (1) | ASTM D4683, CEC-L-36-A-90 or ASTM D5481 |
| Glycol Response | Report (negative, trace or positive) | ASTM D2982 |
| Bench Tests | | |
| Foaming Tendency | | ASTM D892 |
| Seq I | 10/0 | |
| Seq II | 20/0 | |
| Seq III | 10/0 | |
| Copper Corrosion | 1b | ASTM D130, 3 hrs at 150°C |
| Corrosion / Rust Protection | Pass | ASTM D665, procedure "A" |
| Rust Protection, Elongation rupture change, % | No rust or corrosion permissible on 3 of 4 surfaces | ASTM D1748, (sandblasted surface, 50°C, 50hrs) |

**Note:**
(1) Fluids shall meet SAE J300 Viscosity grades.

## Allison TES 439 – Cont'd

| Test | | Requirements | Test Method |
|---|---|---|---|
| FZG Wear Test (not required if API CI-4 or API CJ-4 approved) | | Failure load stage >12 EOT total weight loss <0.12g | ASTM D5182 |
| Seals Compatibility Test | | Not required if API CI-4 or CJ-4 approved | ASTM D7216 |
| Nitrile | Volume change, % | +5 to -3 | |
| | Hardness change, shore A | +7 to -5 | |
| | Tensile strength change, % | +10 to - TMC 1006 | |
| | Elongation rupture change, % | +10 to -TMC 1006 | |
| Polyacrylate | Volume change, % | +5 to -3 | |
| | Hardness change, shore A | +8 to -5 | |
| | Tensile strength change, % | +18 to -15 | |
| | Elongation rupture change, % | +10 to -35 | |
| FKM | Volume change, % | +5 to -2 | |
| | Hardness change, shore A | +7 to -5 | |
| | Tensile strength change, % | +10 to -TMC 1006 | |
| | Elongation rupture change, % | +10 to -TMC 1006 | |
| Vamac G | Volume change, % | +TMC 1006 to -3 | |
| | Hardness change, shore A | +5 to -TMC 1006 | |
| | Tensile strength change, % | +10 to -TMC 1006 | |
| | Elongation rupture change, % | +10 to -TMC 1006 | |
| Seal Compatibility Test (TMS-22630 Material) | | Elongation to first crack after first heat soak shall be ≥ 65% | TES-439 (Appendix A) |
| Oxidation Stability [1] | | Satisfactory operation for 300 hrs | TES-439 (Appendix B) |
| Viscosity Increase, 40°C, %, max. | | 25 | |
| Viscosity Increase, 100°C, %, max. | | 25 | |
| TAN Increase, max. | | 2.5 | |
| Copper Smp Corrosion, max. | | 4a | |
| Clutch Frictional Characteristics | | | |
| Graphite Clutch Test | | Mid-point dynamic coefficient and slip time must surpass limits set with minimum performance reference oil | TES-439 (Appendix C) |

**Note:**
(1) Oxidation test similar to Ford Aluminium Beaker Oxidation test (ABOT).

# Allison TES-389 (Rev. B)

| Test | Requirements | Test Method |
|---|---|---|
| Colour | ASTM D1500 | Red (6.0 - 8.0) |
| Elemental Analysis | ASTM D5185 | Report (ppm): Al, Ba, B, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Si, Ag, Na, S, Sn, Ti, V and Zn |
| | ASTM D4927 | Report S (ppm) |
| | ASTM D6443 | Report Cl (ppm) |
| | ASTM D4629 | Report N (ppm) |
| Flash Point | ASTM D92 | 170 C (min) |
| Cleanliness Level | ISO 4406 | 24/20/15 |
| Miscibility | ASTM D6922 | 10% Candidate : 90% Reference<br>90% Candidate : 10% Reference<br>No separation or colour change |
| Water Content | ASTM D6304 | 0.1% (1000 ppm) max. |
| Brookfield Viscosity | ASTM D2983 | • 20,000 cP max. at 40°C<br>• Report, cP at -10°C, -20°C, and -30°C |
| Kinematic Viscosity | ASTM D445 | • 6.5 cSt (min.) at 100°C<br>• 8.0 cSt (max.) at 100°C<br>• Report at 40°C, 100°C and 150°C |
| Shear Stability | CEC L45-T-99<br>*40 hours* | • EOT KV 100 = 4.5 Cst (min.)<br>• Submit plot of KV 100 (cSt) at 0, 20 and 40 hrs |
| Copper Corrosion Protection | ASTM D130 (modified) *3 hours at 150°C* | 1b |
| Corrosion Protection | ASTM D665 Procedure A *4 hours* | Pass |
| Rust Protection | ASTM D1748<br>*Sandblasted surface, 40°C, 50 hours* | No rust or corrosion on any test surface |
| Water Resistance<br>Vane Pump | ASTM D7043 (modified)<br>80°C, 6.9 MPa with three gallon canister | 10 mg total weight loss (max.) |
| Foam Resistance | ASTM D892 | • Sequence I; 50/0<br>• Sequence II; 50/0<br>• Sequence III; 50/0 |
| Materials Compatibility | TES-389 Appendix A | Pass |
| Seal Compatibility Test | TES-389 Appendix B | Elongation to first crack shall be equal to or greater than 80% |
| Oxidation Resistance | TES-389 Appendix C | • EOT KV 40 change = 25% (max.)<br>• EOT KV 100 change = 25% (max.)<br>• EOT Δ = 25 (max.)<br>• Report Copper strip corrosion rating<br>• Report Aluminium strip rating<br>• Report Lead weight loss |
| Frictional Properties | TES-389 *Appendix D* | Stop Time and Midpoint Torque of both friction materials shall be within the limits established using batch controlled plates and the reference fluid |



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## A Comparison of GM Specifications Requirements

| General Motors ATF Specifications GM 6137-M | | GM II | GM II E | GM III (GM 6417-M) |
|---|---|---|---|---|
| **Test** | **Method** | **Requirement** | **Requirement** | **Requirement** |
| Colour | ASTM D1500 | Not required | 6.0 - 8.0 | 6.0 - 8.0 |
| Elemental Analysis | ASTM D4951 | Not required | Report ppm: Ba, B, Ca, Mg, P Si, Na, Zn, Cu, Al, Fe, Pb | Report ppm: Ba, B, Ca, Mg, P, Si, Na, Zn, Cu, Al, Fe, Pb |
| | ASTM D808 | Not required | Report, ppm: Cl | Report, ppm: Cl |
| | ASTM D3228 | Not required | Report, ppm: N | Report, ppm: N |
| | ASTM D129 OR D 4951 | Not required | Report, ppm: S | Report, ppm: S |
| Infrared Spectrum | ASTM E168 | Not required | Report | Report |
| Miscibility | FTM 791C Method 3470.1 | No separation or colour change at end of test | No separation or colour change at end of test using reference fluid | No separation or colour change at end of test using reference fluid |
| Kinematic Viscosity | | | | |
| at 40°C | ASTM D445 | Not Required | Report | Report |
| at 100°C | | 5.5 cSt min during and at end of oxidation and cycling tests | | |
| Flash Point | ASTM D92 | 160°C min. | 160°C min. | 170°C min. |
| Fire Point | ASTM D92 | 175°C min. | 175°C min. | 195°C min. |
| Brookfield Viscosity | ASTM D2983 | 4000 mPa.s (4.0 Pa.s) max. at -23.3°C | Report Viscosity, mPa.s at -10°C 1,500 mPa.s max. at -20°C | Report, mPa.s at -10°C 1,500 mPa.s max. at -20°C |
| | | 50,000 mPa.s (50.0 Pa.s) max. at -40°C | 5,000 mPa.s max. at -30°C 20,000 mPa.s max. at -40°C | 5,000 mPa.s max. at -30°C 20,000 mPa.s max. at -40°C |

## A Comparison of GM Specifications Requirements - Cont'd

| General Motors ATF Specifications GM 6137-M | | GM II | GM II E | | | GM III (GM 6417-M) | | |
|---|---|---|---|---|---|---|---|---|
| **Test** | **Method** | **Requirement** | **Requirement** | | | **Requirement** | | |
| Copper Strip Test | ASTM D130 Mod<br>3 hrs at 150°C | No blackening with flaking | No blackening with flaking | | | 1b | | |
| Corrosion Test | ASTM D665 Procedure A | No rust on test pins | Pass | | | Pass | | |
| Rust Protection | ASTM D1748 Mod<br>Sandblasted Surface<br>Temp. at 40°C<br>Test time of 50 hrs | No rust or corrosion on test panels | No rust or corrosion on any test surface | | | No rust or corrosion on any test surface | | |
| Foam Test | GM | No foam at 95°C | No foam at 95°C | | | No foam at 95°C | | |
| | | 10mm max. at 135°C | 6mm at 135°C | | | 5mm max. height at 135°C | | |
| | | 23 s max. break-time at 135°C | 15 s max. break-time at 135°C | | | 15 s max. collapse time at 135°C | | |
| Fluid Effect on Seals | GM Method | Elastomers: | Procedure 1 - Total Immersion | | | Procedure 1 - Total Immersion[1] | | |
| | | Nitrile | Change in: | | | Change in: | | |
| | | Polyacrylate | Elastomer | Vol, % | Hardness pts. | Elastomer | Vol,% | Hardness pts. |
| | | Silicone | A (Polyacrylate) | +5 to +12 | -8 to +1 | A (Polyacrylate) | +5 to +12 | -8 to +1 |
| | | | B (Nitrile) | +0.5 to +5 | -3 to +6 | B (Nitrile) | +1 to +6 | -3 to +6 |
| | | The limits are assigned by GM for each batch of elastomer | C (Polyacrylate) | +2 to +7 | -4 to +4 | C (Polyacrylate) | +2 to +7 | -4 to +4 |
| | | | H (Fluorinated) | +0.5 to +5 | -5 to +6 | H (Fluorinated) | +0.5 to +5 | -5 to +6 |
| | | | J (Silicone) | +23 to +45 | -30 to -13 | J (Silicone) | +23 to +45 | -30 to -13 |
| | | | R (Ethylene/ Acrylic) | +13 to +27 | -17 to -7 | R (Ethylene/ Acrylic) | +13 to +27 | -17 to - 7 |

**Note:**
(1) Tensile strength and elongation are now required to be reported but no limits have been set yet.

## A Comparison of GM Specifications Requirements - Cont'd

| General Motors ATF Specifications GM 6137-M | | GM II | GM II E | GM III (GM 6417-M) |
|---|---|---|---|---|
| Test | Method | Requirement | Requirement | Requirement |
| Saginaw Power Steering Pump Test | GM Method | Parts condition to be equal to or better than that obtained with reference fluid | | |
| Vane Pump Wear Test | ASTM D2882 Mod<br>80+/-3°C<br>6.9 MPa | | weight loss < 15mg | weight loss < 15mg |
| HEFCAD - Plate Clutch Test | GM Method | Satisfactory operation for 100 hrs | Satisfactory operation for 100 hrs | Satisfactory operation for 100 hrs |
| | GM uses SD-715 Clutch Plates | No unusual clutch plate wear or flaking | No unusual wear or flaking on test parts | No unusual wear or flaking on test parts |
| | GM uses D-1777 Clutch Plates<br><br>GM uses SD-1777 Clutch Plates | Between 24 and 100 hrs of operation:-<br>Midpoint of Dynamic Torque 115 - 175Nm<br><br>Delta Torque < 14Nm<br><br>Clutch Engagement time 0.45s - 0.75s | Between 20 and 100 hrs of operation:-<br>Midpoint of Dynamic Torque 150 - 180Nm<br><br>Maximum Torque > 150Nm<br><br>Delta Torque < 30Nm<br><br>Stop time between 0.4s - 0.6s<br><br>Report End Torque Nm | Between 10 and 100 hrs of operation:-<br>Midpoint of Dynamic Torque 150 - 180Nm<br><br>Maximum Torque > 150Nm<br><br>DeltaTorque < 30Nm<br><br>Stop time between 0.5s - 0.6s<br><br>Report End Torque Nm |

## A Comparison of GM Specifications Requirements - Cont’d

| General Motors ATF Specifications GM 6137-M | | GM II | GM II E | GM III (GM 6417-M) |
|---|---|---|---|---|
| **Test** | **Method** | **Requirement** | **Requirement** | **Requirement** |
| Band Clutch Test | GM Method Uses 3T40 Band & Drum | Not Required | Satisfactory operation for 100 hrs | Satisfactory operation for 100 hrs |
| | | | No unusual wear or flaking on test parts | No unusual wear or flaking on test parts |
| | | | Between 20 and 100 hrs of operation:-<br>145Nm < Midpoint Dynamic<br>Torque < 220Nm<br>End Torque > 170Nm<br>Delta Torque < 80Nm<br>Stop time between 0.4s - 0.6s<br>Report Maximum Torque, Nm | Between 10 and 100 hrs of operation:-<br>180Nm < Midpoint Dynamic<br>Torque < 225Nm<br>End Torque > 170Nm<br>Delta Torque < 80Nm<br>Stop time between 0.35 and 0.55 s<br>Report Maximum Torque, Nm |
| THOT - Oxidation Test | GM Method<br>THM-350<br>GM uses<br>Transmission<br><br>GM uses<br>Hydra-matic 4L60<br>Transmission | Satisfactory operation for 300 hrs | Satisfactory operation for 300 hrs. | Satisfactory operation for 300 hrs |
| | | Transmission parts cleanliness and physical condition must be equal to or better than that obtained with Reference Fluid | Transmission parts cleanliness and physical condition must be equal to or better than that obtained with Reference Fluid | Transmission parts condition must be equal to or better than that obtained with Reference Fluid |
| | | Total Acid Number Increase, 7.0 max. | Total Acid Number Increase < 4.5 | Total Acid Number Increase < 3.25 |
| | | Carbonyl Absorbance Increase, 0.8 max. | Carbonyl Absorbance Increase < 0.55 | Carbonyl Absorbance Increase < 0.45 |
| | | Min. $O_2$ content of transmission effluent gas 2% | Min. $O_2$ content of transmission effluent gas 4% | Report effluent gas $O_2$ content |
| | | Used Fluid Viscosity at - 23.3°C 6000mPa.s max;- 40°C Report | Used Fluid Viscosity at -20°C < 3,000 mPa.s | Used Fluid Viscosity at -20°C < 2000 mPa.s |
| | | Used Fluid Viscosity at 100°C, 5.5 $mm^2/s$ min. | Used Fluid Viscosity at 100°C > 5.5 $mm^2/s$ | Used Fluid Viscosity at 100°C > 5.5 $mm^2/s$ |
| | | Cooler braze alloy condition shall be acceptable | No cooler braze alloy corrosion | No cooler braze alloy corrosion |
| | | | | No expulsion of ATF from Vent |

# A Comparison of GM Specifications Requirements - Cont'd

| General Motors ATF Specifications GM 6137-M | | GM II | GM II E | GM III (GM 6417-M) |
|---|---|---|---|---|
| **Test** | **Method** | **Requirement** | **Requirement** | **Requirement** |
| Band Clutch Test | GM Method Uses 3T40 Band & Drum | Not Required | Satisfactory operation for 100 hrs | Satisfactory operation for 100 hrs |
| | | | No unusual wear or flaking on test parts | No unusual wear or flaking on test parts |
| | | | Between 20 and 100 hrs of operation:-<br>145Nm < Midpoint Dynamic<br>Torque < 220Nm<br>End Torque > 170Nm<br>Delta Torque < 80Nm<br>Stop time between 0.4s - 0.6s<br>Report Maximum Torque, Nm | Between 10 and 100 hrs of operation:-<br>180Nm < Midpoint Dynamic<br>Torque < 225Nm<br>End Torque > 170Nm<br>Delta Torque < 80Nm<br>Stop time between 0.35 and 0.55 s<br>Report Maximum Torque, Nm |
| THOT - Oxidation Test | GM Method<br>THM-350<br>GM uses<br>Transmission<br><br>GM uses<br>Hydra-matic 4L60<br>Transmission | Satisfactory operation for 300 hrs | Satisfactory operation for 300 hrs. | Satisfactory operation for 300 hrs |
| | | Transmission parts cleanliness and physical condition must be equal to or better than that obtained with Reference Fluid | Transmission parts cleanliness and physical condition must be equal to or better than that obtained with Reference Fluid | Transmission parts condition must be equal to or better than that obtained with Reference Fluid |
| | | Total Acid Number Increase, 7.0 max. | Total Acid Number Increase < 4.5 | Total Acid Number Increase < 3.25 |
| | | Carbonyl Absorbance Increase, 0.8 max. | Carbonyl Absorbance Increase < 0.55 | Carbonyl Absorbance Increase < 0.45 |
| | | Min. $O_2$ content of transmission effluent gas 2% | Min. $O_2$ content of transmission effluent gas 4% | Report effluent gas $O_2$ content |
| | | Used Fluid Viscosity at - 23.3°C 6000mPa.s max;- 40°C Report | Used Fluid Viscosity at -20°C < 3,000 mPa.s | Used Fluid Viscosity at -20°C < 2000 mPa.s |
| | | Used Fluid Viscosity at 100°C, 5.5 mm$^2$/s min. | Used Fluid Viscosity at 100°C > 5.5 mm$^2$/s | Used Fluid Viscosity at 100°C > 5.5 mm$^2$/s |
| | | Cooler braze alloy condition shall be acceptable | No cooler braze alloy corrosion | No cooler braze alloy corrosion |
| | | | | No expulsion of ATF from Vent |



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## A Comparison of GM Specifications Requirements - Cont'd

| General Motors ATF Specifications GM 6137-M | | GM II | GM II E | GM III (GM 6417-M) |
|---|---|---|---|---|
| **Test** | **Method** | **Requirement** | **Requirement** | **Requirement** |
| THCT<br>- Cycling Test | GM Method | Satisfactory operation for 20,000 cycles | Satisfactory operation for 20,000 cycles | Satisfactory operation for 20,000 cycles |
| | GM uses<br>THM 350 transmission | Transmission parts cleanliness & physical condition must be equal to or better than that obtained with the Reference Fluid | Condition of transmission parts must be equal to or better than that obtained with the Reference Fluid | Condition of transmission parts must be equal to or better than that obtained with the Reference Fluid |
| | GM uses | 0.35s < 1-2 Shift Time < 0.70s | Total Acid Number Increase < 2.50 | Total Acid Number Increase < 2.0 |
| | Hydra-matic 4L60 | 0.20s < 2-3 Shift Time < 0.55s | Carbonyl Absorbance Increase < 0.35 | Carbonyl Absorbance Increase < 0.30 |
| | transmission | Total Acid Number Increase, 6.0 max. | 1-2 Shift Time between 0.35 and 0.75s | 1-2 Shift Time between 0.30 and 0.75s |
| | | Carbonyl Absorbance Increase, 0.7 max. | 2-3 Shift Time between 0.30 and 0.75s | 2-3 Shift Time between 0.30 and 0.75s |
| | | Used Fluid Viscosity at 100°C 5.5 $mm^2/s$ min. during and at end of test | Report 3-4 Shift Time, s | Report 3-4 Shift Time, s |
| | | | Used Fluid Viscosity at 100°C, > 5.0 $mm^2/s$ | Used Fluid Viscosity at 100°C, > 5.0 $mm^2/s$ |
| | | | Used Fluid Viscosity at -20°C < 2000 mPa.s | Used Fluid Viscosity at -20°C < 2000 mPa.s |
| | | | | No expulsion of ATF from Vent |
| Vehicle Performance Test | GM Method | Shift performance essentially equal to that obtained with the Reference Fluid | Shift performance essentially equal to that obtained with the Reference Fluid | Shift performance essentially equal to that obtained with the Reference Fluid |
| ECCC Vehicle Performance Test | GM Method | Not Required | Not Required | Equal to or better than Reference Fluid |
| Sprag Wear Test | GM Method | Not Required | Not Required | 60mg maximum weight loss |

## GM, H Revision [GMN 10055]

| Test | Method | Requirement | | |
|---|---|---|---|---|
| Colour | ASTM D1500 | 6.0-8.0 | | |
| Elemental Analysis | ASTM D5185 | Report, ppm: Al, Ba, B, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Si, Ag, Na, S, Sn, Ti, V, Zn | | |
| | UOP 975 | Report, ppm: F | | |
| | ASTM D6443 | Report, ppm: Cl | | |
| | ASTM D4629 | Report, ppm: N | | |
| Fluid Profile | Proprietary GM Test | Report | | |
| Miscibility | FTM 791C: Method 3470.1 | No separation or colour change at end of test using Reference Fluid | | |
| Kinematic Viscosity | | | | |
| at 40°C | ASTM D445 | Report | | |
| at 100°C | | | | |
| at 150°C | | | | |
| Flash Point | ASTM D92 | > 170°C | | |
| Fire Point | ASTM D92 | > 195°C | | |
| Brookfield Viscosity | ASTM D2983 | Report, cP at -10°C | | |
| | | < 1500 cP at -20°C | | |
| | | < 5000 cP at -30°C | | |
| | | < 20000 cP at -40°C | | |
| Cu Corrosion Test | ASTM D130 Modified: 3 hrs at 150°C | 1B | | |
| Corrosion Test | ASTM D665: Procedure A | Pass | | |
| Rust Protection Test | ASTM D1748 Sandblasted surface, 40°C, 50hrs | No rust or corrosion on any test surface | | |
| Wear Test | ASTM D2882-00 Modified: 80 ±3°C, 6.9 MPa, 3 gal canister, Conestoga pump parts | < 10mg weight loss | | |
| Foam Test | Appendix A | No Foam at 95°C | | |
| | | < 5mm height at 135°C | | |
| | | < 15s collapse height at 135°C | | |
| Elastomer Test | Appendix B | Elast | %Vol. | Hard |
| | | V1 | +7 to +20 | -15 to -2 |
| | | V2 | +2 to +12 | -7 to +3 |
| | | V3 | +7 to +22 | -14 to -2 |
| | | P1 | 0.00 to +8 | -10 to 0 |
| | | P2 | 0.00 to +8 | -11 to +3 |
| | | P3 | 0.00 to +4 | -8 to +4 |
| | | F1 | 0.00 to +4 | -5 to +4 |
| | | F2 | 0.00 to +4 | -2 to +5 |
| | | N1 | 0.00 to +5 | -12 to +12 |
| | | N2 | 0.00 to +6 | -9 to +5 |

## GM, H Revision [GMN 10055] - Cont'd

| Test | Method | Requirement |
|---|---|---|
| Plate Friction Test | Appendix C | Satisfactory operation for 150 h with 3T40 clutch plates |
| | | No unusual wear or flaking on test parts |
| | | From 10-150 hrs of operation: |
| | | Midpoint dynamic torque, 150-180 Nm |
| | | Max. Torque > 150 Nm |
| | | Delta Torque < 30 Nm |
| | | Stop Time, 0.5-0.6s |
| | | Report End Torque, Nm |
| Band Friction Test | Appendix D | Satisfactory operation for 100 hrs on 3T40 GM Racing drums with 1473-2, Batch 00-12, Friction Material band |
| | | No unusual wear or flaking on test parts |
| | | From 10-100 hrs of operation: |
| | | Midpoint Torque, 180-225 Nm |
| | | End Torque > 170 Nm |
| | | Delta Torque < 80 Nm |
| | | Stop Time, 0.35-0.55 s |
| | | Report Max Torque, Nm |
| Oxidation Test | Appendix E | Satisfactory operation for 450 hrs |
| | | Condition of transmission parts must be equal to or better than that obtained with the Reference Fluid |
| | | TAN increase < 3.25 |
| | | Carbonyl Absorbance increase < 0.45 |
| | | Used fluid viscosity at 100°C > 5.5 cSt |
| | | Used fluid viscosity at -20°C < 2000 cP |
| | | No cooler braze alloy corrosion |
| | | No expulsion of ATF from vent |
| | | pDSC (Report) |
| Cycling Test | Appendix F | Satisfactory operation for 32,000 cycles |
| | | Condition of transmission parts must be equal to or better than that obtained with the Reference Fluid |
| | | TAN Increase < 2.0 |
| | | Carbonyl Absorbance increase < 0.30 |
| | | Used fluid viscosity at 100°C > 5.0 cSt |
| | | Used fluid viscosity at -20°C < 2000 cP |
| | | 1-2 shift time, 0.30-0.75s |
| | | 2-3 shift time, 0.30-0.75s |
| | | 3-4 shift time, s (Report) |
| | | No expulsion of ATF from vent |
| | | Used fluid viscosity at -40°C (Report, cP) |
| Vehicle Perf. Test | Appendix G | Shift performance essentially equal to that obtained with the Reference Fluid |
| ECCC Vehicle Performance Test | Appendix H | Equal to or better than Reference Fluid |
| Sprag Wear Test | Appendix I | < 60 mg weight loss |
| Low-Speed Carbon Fiber Friction Test | Appendix J | New and used fluid from Cycling Test (Report) |
| Aeration Test | Appendix K | New and used fluid from Cycling Test (Report) |



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## DEXRON® VI [GMW 16444]

| Test | Method | Requirement | | |
|---|---|---|---|---|
| Colour | ASTM D1500 | 6.0 - 8.0 | | |
| Elemental Analysis | ASTM D5185 | Report, ppm: Al, Ba, B, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Si, Ag, Na, S, Sn, Ti, V, Zn | | |
| | ASTM D4927 | Report, ppm: S | | |
| | ASTM D6443 | Report, ppm: Cl | | |
| | ASTM D4629 | Report, ppm: N | | |
| Fluid Profile | Proprietary GM Test | Report | | |
| Miscibility | FED-ST D791: Method 3470.1 | No separation or color change during or at completion of test using reference fluid | | |
| Density | ASTM D4052 : at 15°C | Report | | |
| Kinematic Viscosity | ASTM D445 | 32 cSt at 40°C max.<br>6.4 cSt at 100°C max.<br>150°C (Report)<br>4.5 cSt at 100°C min. (base oil mix) | | |
| Viscosity Index | ASTM D2270 | 145 min. | | |
| Flash Point | ASTM D92 | 180°C min. | | |
| Fire Point | ASTM D92 | 195°C min. | | |
| Brookfield Viscosity | ASTM D2983 | Report, cP at -10°C | | |
| | | < 1,500 cP at -20°C | | |
| | | < 5,000 cP at -30°C | | |
| | | < 15,000 cP at -40°C | | |
| Copper Corrosion Test | ASTM D130<br>Modified: 3 hrs at 150°C | 1b | | |
| Corrosion Test | ASTM D665:<br>Procedure A | Pass | | |
| Rust Protection Test | ASTM D1748<br>a) Sandblasted surface<br>b) 40°C<br>c) 50 hrs | No rust or corrosion on any test surface | | |
| Wear Test | ASTM D2882-00<br>Modified:<br>a) 80 ± 3°C<br>b) 6.9 MPa<br>c) 3 gal canister<br>d) Conestoga pump parts | < 10 mg weight loss | | |
| Cold Crank Simulation | ASTM D5293 -30°C | 3,200 cP max. | | |
| High Temperature High Shear | ASTM D4683 150°C | 2.00 cP min. | | |
| Noack Evaporation | ASTM D5800 | 10% evaporation max., 1 hr at 200°C | | |
| Film Thickness | EHDPROC_11<br>at Imperial College | Equal to or better than reference fluid | | |
| Taper Bearing Roller Shear | CEC L-45-A-99<br>Modified 40 hrs | 1) KV100, 5.5 cSt min.<br>2) 10% KV100 decrease max.<br>3) (BOV+EOTV)/2 > 5.0 cSt at 100°C | | |
| Foam Test | Appendix A<br>ASTM D892 Modified | | New | Used |
| | | Seq I | 50/0 | 50/0 |
| | | Seq II | 50/0 | 50/0 |
| | | Seq III | 50/0 | 50/0 |
| | | Seq I (150°C) | 50/0 | 150/0 |



Afton CHEMICAL

## DEXRON® VI [GMW 16444] - Cont'd

<table>
<tr><th>Test</th><th>Method</th><th colspan="3">Requirement</th></tr>
<tr><td rowspan="10">Elastomer Test</td><td rowspan="10">Appendix B</td><td>Elastomer</td><td>% Vol</td><td>Hardness</td></tr>
<tr><td>V1</td><td>+7 to +20</td><td>-15 to -2</td></tr>
<tr><td>V2</td><td>+2 to +12</td><td>-7 to + 3</td></tr>
<tr><td>V3</td><td>+7 to +22</td><td>-14 to -2</td></tr>
<tr><td>P1</td><td>0 to +8</td><td>-10 to 0</td></tr>
<tr><td>P2</td><td>0 to +8</td><td>-11 to +3</td></tr>
<tr><td>P3</td><td>0 to +4</td><td>-8 to +4</td></tr>
<tr><td>F1</td><td>0 to +4</td><td>-5 to +4</td></tr>
<tr><td>F2</td><td>0 to +4</td><td>-2 to +5</td></tr>
<tr><td>N1</td><td>Report</td><td>+2</td></tr>
<tr><td>Plate Friction Test</td><td>Appendix C</td><td colspan="3">1) Satisfactory operation for 200 hrs<br>2) No unusual wear or flaking on test parts<br>3) Between 10 and 200 hrs of operation:<br>a) Midpoint dynamic torque between 80 and 105 N·m<br>b) Max. Torque > 90 N·m<br>c) Delta Torque < 30 N·m<br>d) Stop Time between 0.85 and 1.05 s<br>e) Report End Torque, N·m<br>f) Report Shift Energy, kJ</td></tr>
<tr><td>Band Friction Test</td><td>Appendix D</td><td colspan="3">1) Satisfactory operation for 150 hrs on 4L60-E drums with modified Friction Material band<br>2) No unusual wear or flaking on test parts<br>3) Between 10 and 150 hrs of operation:<br>a) Midpoint dynamic torque between 180 and 290 N·m<br>b) End Torque > 200 N·m<br>c) Delta Torque < 120 N·m<br>d) Stop Time between 0.30 and 0.45 s<br>e) Report Max. Torque, N·m<br>f) Report Shift Energy, kJ (15.7 to 16.3 typical)</td></tr>
<tr><td>Oxidation Test</td><td>Appendix E</td><td colspan="3">1) Satisfactory operation for 450 hrs<br>2) Condition of transmission parts must be equal to or better than that obtained with the Reference Fluid<br>3) TAN Increase < 2.00<br>4) Carbonyl Absorbance Increase < 0.45<br>5) Used Fluid viscosity at 100°C > 5.0 cSt<br>6) Used fluid viscosity at -20°C < 2,000 cP<br>7) Used fluid viscosity at -40°C < 15,000 cP<br>8) No expulsion of ATF from vent</td></tr>
<tr><td>Cycling Test</td><td>Appendix F</td><td colspan="3">1) Satisfactory operation for 42,000 cycles<br>2) Condition of transmission parts must be equal to or better than that obtained with the Reference Fluid<br>3) TAN Increase < 2.0<br>4) Carbonyl Absorbance Increase < 0.30<br>5) Used Fluid viscosity at 100°C > 5.0 cSt<br>6) Used fluid viscosity at -20°C < 2,000 cP<br>7) Used fluid viscosity at -40°C < 15,000 cP<br>8) 1-2 shift time between 0.30 and 0.75 s<br>9) 2-3 shift time between 0.30 and 0.75 s<br>10) Report 3-4 shift time, s<br>11) No expulsion of ATF from vent</td></tr>
</table>

## DEXRON® VI [GMW 16444] - Cont'd

| Test | Method | Requirement |
|---|---|---|
| Vehicle Performance Test | Appendix G | Shift performance essentially equal to that obtained with the Reference Fluid |
| ECCC Vehicle Performance Test | Appendix H | Equal to or better than Reference Fluid |
| Sprag Wear Test | Appendix I | 50 mg weight loss (max) |
| Low-speed Carbon Fibre Friction Test | Appendix J | New and used fluid from Cycling Test must be equal to or better than Reference Fluid |
| Aeration Test | Appendix K | New and used fluid from Cycling Test must be equal to or better than Reference Fluid |

## DEXRON® VI Approved Chemistry Combinations

| Company | Chemistry Name | Treat Rate (% wt.) |
|---|---|---|
| Afton Chemical Corp | HiTEC® 3491K | 7.18 |
| | HiTEC® 5738 | 1 to 5 |
| Infineum | Infineum T 4760 | 7.25 |
| | Infineum T 4163 | 0 to 6 |

## DEXRON® VI Additional Test Methods and Requirements for New Additive Chemistries

| Test | Method | Requirement |
|---|---|---|
| Hunting Behaviour | LR4 4.8L 4L60-E | No Hunting |
| Pitting | CEC L-07-A-85 C/8.3/90 (x3) | Equal to or better than Reference Fluid |
| Carbon Fibre Durability | FORD SP Proc. 3.14 Modified: Low Speed Carbon Fibre plates | Equal to or better than Reference Fluid |
| Fleet Test | GM ATF Committee | 150,000 km |
| Additional Tests | GM ATF Committee | At the discretion of the committee |

**Note:**
New DEXRON® VI additive chemistry combinations are required to:-

1. Successfully complete a DEXRON® VI qualification program.
2. Successfully complete a DEXRON® VI qualification program using a 75% candidate, 25% reference fluid mix.
3. Successfully complete a DEXRON® VI qualification program using a 50% candidate, 50% reference fluid mix.
4. Successfully complete a DEXRON® VI qualification program using a 25% candidate, 75% reference fluid mix.
5. Successfully complete the tests listed in the above table.

Specification Handbook

# Industrial

Industrial

**Hydraulic:**

**Industry Standard:**

AIST Hydraulic Standards 126 & 127 ....3

ASTM D6158 Requirements For Type HM Mineral Oil ....4

Chinese National Hydraulics Specifications GB11118.1-2001 ....6

DIN 51524 Part 1 ....16

DIN 51524 Part 2 ....18

DIN 51524 Part 3 ....20

German Steel Industry Specifications SEB 181222 ....22

ISO 11158 Hydraulic Fluids ....24

**OEM Specifications:**

MAG Cincinnati Machine Anti-wear Hydraulic Specifications ....26

MAG Cincinnati Machine Hydraulic Specifications ....27

Parker Denison Hydraulic Requirements - TP30560 ....28

General Motors Hydraulic Lubricant Standards ....30

JCMAS HK (JCHASP 041:2004) Hydraulic Fluid For Construction Machinery ....32

SAE MS1004 Type H Hydraulic Oil Specifications ....34

**Industrial Gear:**

AGMA 9005-E02 - Anti-wear E.P. Oils ....36

AIST Requirements No. 224 Lead Free E.P. Gear Oil ....37

Chinese National Specification GB 5903-2011 ....38

DIN 51517 Part 3 - Lubricating Oils CLP ....43

Siemens Specification For Flender Gear Oils ....44

ISO 12925-1 Enclosed Gears of Category CKC ....46

SEB 181226 Industrial Gear Specifications ....47

GM Lubricant Standards ....48

MAG Cincinnati Machine Gear Lubricant Specifications ....51



Afton CHEMICAL

# Contents

**Compressor:**

Air Compressor Lubricant Standard DIN 51506 ....52

General Motors Compressor Lubricant Standards....55

SAE MS1003-2 Compressor Oils ....57

**Turbine:**

DIN 51515 Part 1 and 2 ....59

AIST Turbine Standard Requirements....60

British Standard Specifications BS 489: 1999 R & O Turbine Oils....61

SEB Turbine Specifications....62

GEK Turbine Specifications ....63

OEM Turbine Specifications 1....65

OEM Turbine Specifications 2....67

MAN TED 10000494596 001 02 ....68

Chinese National Turbine Specifications ....70

ASTM D4304 – 06A Turbine Specifications ....73

ISO 8068 Turbine Specifications....74

Russian National Turbine Specifications TP-225....77

**Slideway:**

European Slideway Specifications....78

US Slideway Specifications ....80

Chinese National Slideway Specifications....83

| AIST Hydraulic Standards 126 & 127 | February 1997 | | | | September 1997 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Specifications** | **126** | | | | **127** | | | | **ASTM Test Method** |
| Viscosity | 32, 46, 68 | | | | 32, 46, 68 | | | | D88 & D445 |
| Viscosity Index | 80 min. | | | | | | | | D567 |
| Hydraulic Pump Test (100 hrs at 2000psi), 150°F | 0.05% Total wear (by weight) | | | | 50 mg max. | | | | D2882 |
| Four-Ball Wear Test (40 Kg, 1800 rpm, 130°F, 1 hr) | 0.80 mm scar diameter max. | | | | 0.50 mm scar diameter max. | | | | D4172 (MOD) |
| RPVOT | 120 mins., min. | | | | 120 mins., min. | | | | D2272 |
| Alternate Oxidation Test, D943 | - | | | | Max. TAN 1.0 after 1000h | | | | D943 |
| Low Temp Cycling Test (U.S. Steel method) | Pass OK at 15°F | | | | Pass OK at 15°F | | | | N/A |
| Water Emulsion Test, D1401 at 130°F | ml oil | ml water | ml emulsion | minutes | ml oil | ml water | ml emulsion | minutes | |
| | 40 | 37 | 3 | ≤ 30 | 40 | 37 | 3 | ≤ 30 | D1401 |
| Rust Prevention Test, D665A | Pass | | | | Pass | | | | D665A |

## ASTM D6158 Standard Requirements for Mineral Hydraulic Oils 2010

| Test | | | | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity grade | 10 | 15 | 22 | 32 | 46 | 68 | 100 | 150 | D2422 |
| Kinematic Viscosity at 40°C, cSt | 9.0-11.0 | 13.5-16.5 | 19.8-24.2 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90.0-110 | 135-165 | D445 |
| Viscosity ≤ 750 cP °C, max. | -33 | -23 | -15 | (-8) | -2 | 4 | 10 | 16 | D2983 (3) |
| Viscosity index, min. | 90 | | | | | | | | D2270 (2) |
| Gravity (specific) | Report | | | | | | | | D1298 |
| Appearance, visual, at 20°C | Clear & Bright | | | | | | | | |
| Flash point °C, min. | 125 | 145 | 165 | 175 | 185 | 195 | 205 | 215 | D92 |
| Pour Point °C, max. | -33 | -24 | -21 | -18 | -15 | -12 | -12 | -12 | D97 |
| Acid Number mg KOH/g, max. | Report | | | | | | | | D974 / D664 |
| Rust prevention, 24 hrs | Pass | | | | | | | | D665A and D665B |
| Copper corrosion, 3 hrs at 100°C, max. | 2 | | | | | | | | D130 |
| Water separability | | | | | | | | | D1401 |
| time (mins) to 3ml emulsion max. at 54°C | 30 | 30 | 30 | 30 | 30 | 30 | - | - | |
| time (mins) to 3ml emulsion max. at 82°C | - | - | - | - | - | - | 60 | 60 | |
| Elastomer compatibility 100 ± 1°C/288 ± 2h, SRE-NBR 1 Elastomer (DIN53 538, Part 2 or AAMA 524, Part 2) | | | | | | | | | D471 |
| Relative volume change, % (1) | Report | Report | 0 to 15 | 0 to 12 | 0 to 12 | 0 to 10 | 0 to 10 | 0 to 10 | |
| Change in Shore A hardness, rating (1) | Report | Report | 0 to -8 | 0 to -7 | 0 to -7 | 0 to -6 | 0 to -6 | 0 to -6 | |
| Foam | | | | | | | | | D892 |
| Seq I, ml, max. | 150/0 | | | | | | | | |
| Seq II, ml, max. | 75/0 | | | | | | | | |
| Seq III, ml, max. | 150/0 | | | | | | | | |

**Note:**
Specifications also exist for HL, HV and HH type oils.

(1) These numbers are provisional; ASTM is trying to establish a technical consensus for possible revision.
(2) Test method D4052 can also be used.
(3) Provision of the test method for hydraulic oils at low temperatures is being improved by subcommittee D 02.07.CO, but the test method is applicable.



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## ASTM D6158 Standard Requirements for Mineral Hydraulic Oils – Cont'd 2010

| Test | | | | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|
| Air release | | | | | | | | | D3427 |
| time (mins) at 50°C, max. | 5 | 5 | 5 | 5 | 10 | 13 | - | - | |
| time (mins) at 75°C, max. | - | - | - | - | - | - | Report | Report | |
| Oxidation stability time for acid number of 2mg KOH/g, h, min. | 1000 | | | | | | | | D943 |
| Sludge tendancy | | | | | | | | | D4310 |
| Total insoluble sludge, mg, max. | 200 | | | | | | | | |
| Copper oil/water/sludge, mg | Report | | | | | | | | |
| Thermal stability | | | | | | | | | D2070 |
| Copper appearance, visual | Report | Report | Report | 5 | 5 | 5 | Report | Report | |
| Steel appearance, visual | Report | Report | Report | 1 | 1 | 1 | Report | Report | |
| Sludge, mg/100ml | Report | Report | Report | 25 | 25 | 25 | Report | Report | |
| Wear protection | | | | | | | | | D7043 |
| Weight loss vanes + ring, mg, max. at 65 6°C/100 hrs | - | - | Report | Report | Report | - | - | - | |
| Weight loss vanes + ring, mg, max. at 79 4°C/100 hrs | - | - | - | - | - | Report | Report | Report | |

**Note:**
Also specifications for HL, HV and HH type oils.

# Chinese National Hydraulic Specifications GB111118.1-2011

December 2011

| Technical Requirements and Test Methods of L-HL R&O Hydraulic Oils | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Test | Chinese Method | ASTM/ISO/IP (equivalent) | Performance Specs | | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 15 | 22 | 32 | 46 | 68 | 100 | 150 |
| Density @ 20°C [(1)], kg/m$^3$ | GB/T 1884<br>GB/T 1885 | ASTM D1298 | Report | | | | | | |
| Colour, Rating | GB/T 6540 | ASTM D1500 | Report | | | | | | |
| Appearance | Visual | - | Clear and Bright | | | | | | |
| Flash Point (COC), °C | GB/T 3536 | ASTM D92 | 140 min. | 165 min. | 175 min. | 185 min. | 195 min. | 205 min. | 215 min. |
| Viscosity, mm$^2$/s 40°C | GB/T 265 | ASTM D445 | 13.5-16.5 | 19.8-24.2 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90-110 | 135-165 |
| Viscosity, mm$^2$/s 0°C | | | 140 max. | 300 max. | 420 max. | 780 max. | 1400 max. | 2560 max. | - |
| Viscosity Index [(2)] | GB/T 1995 | ASTM D2270 | 80 min. | | | | | | |
| Pour Point [(3)], °C | GB/T 3535 | ASTM D97 | -12 max. | -9 max. | -6 max. | -6 max. | -6 max. | -6 max. | -6 max. |
| Acid Number [(4)], mg KOH/g | GB/T 4945 | ASTM D974 | Report | | | | | | |
| Water Content, % wt | GB/T 260 | ASTM D95 | Trace max. | | | | | | |
| Mechanical Impurity, % wt | GB/T 511 | Russian<br>ГОСТ6370 | None | | | | | | |
| Cleanliness | DL/T432<br>GB/T 14039 | NAS 1638<br>ISO 4406 | [(5)] | | | | | | |
| Copper Corrosion @ 100°C, 3 hrs | GB/T 5096 | ASTM D130 | 1 max. | | | | | | |
| Rust Test @ Distilled Water | GB/T 11143 | ASTM 665A | No rust | | | | | | |

**Note:**

(1) Test method can also use SH/T 0604.
(2) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.
(3) It can be negotiable with the supplier in case the user has special requirements.
(4) Test method can also use GB/T 264.
(5) It is determined by the agreement of the supplier and user. The classifications of NAS 1638 can also be used.



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# Chinese National Hydraulic Specifications GB111118.1-2011 – Cont'd

December 2011

| Technical Requirements and Test Methods of L-HL R&O Hydraulic Oils – Cont'd | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Chinese Method** | **ASTM/ISO/IP (equivalent)** | **Performance Specs** | | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 15 | 22 | 32 | 46 | 68 | 100 | 150 |
| Foam (Tendency/Stability), ml/ml | GB/T 12579 | ASTM D892 | | | | | | | |
| Sequence I 24°C | | | 150/0 max. | | | | | | |
| Sequence II 93.5°C | | | 75/0 max. | | | | | | |
| Sequence III 24°C (after) | | | 150/0 max. | | | | | | |
| Air Release @ 50°C, minute | SH/T 0308 | ASTM D3427 | 5 max. | 7 max. | 7 max. | 10 max. | 12 max. | 15 max. | 25 max. |
| Seal Compatibility Index | SH/T 0305 | IP278/72(88) | 14 max. | 12 max. | 10 max. | 9 max. | 7 max. | 6 max. | Report |
| Demulsibility (Time for emulsion to 3ml) | GB/T 7305 | ASTM D1401 | | | | | | | |
| 54°C, minute | | | 30 max. | 30 max. | 30 max. | 30 max. | 30 max. | - | - |
| 82°C, minute | | | - | - | - | - | - | 30 max. | 30 max. |
| Oxidation Stability | | | | | | | | | |
| TAN after 1000 hrs (6), mg KOH/g | GB/T 12581 | ASTM D943 | - | 2.0 max. | | | | | |
| Sludge after 1000 hrs, mg | SH/T 0565 | ASTM D4310 | - | Report | | | | | |
| RPVOT @ 150°C, minutes | SH/T 0193 | ASTM D2272 | Report | Report | | | | | |
| 4 Ball Wear Scar (392N, 60min, 75°C, 1200rpm), mm | SH/T 0189 | ASTM D4172 | Report | | | | | | |

**Note:**

(6) ISO 15 oil shall not be measured, but its antioxidant types and dosage shall be same with the test sample of the commercialized ISO 22 oil.



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# Chinese National Hydraulic Specifications GB111118.1-2011 – Cont'd

December 2011

## Technical Requirements and Test Methods of L-HM Snti-wear Hydraulic Oil (High Pressure and Conventional Types)

| Test | Chinese Method | ASTM/ISO/IP (equivalent) | Performance Specs | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L-HM (High Pressure Type) | | | | L-HM (Conventional Type) | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 32 | 46 | 68 | 100 | 22 | 32 | 46 | 68 | 100 | 150 |
| Density @ 20°C (1), $kg/m^3$ | GB/T 1884<br>GB/T 1885 | ASTM D1298 | Report | | | | Report | | | | | |
| Colour, rating | GB/T 6540 | ASTM D1500 | Report | | | | Report | | | | | |
| Appearance | Visual | - | Clear and Bright | | | | Clear and Bright | | | | | |
| Flash Point (COC), °C | GB/T 3536 | ASTM D92 | 175 min. | 185 min. | 195 min. | 205 min. | 165 min. | 175 min. | 185 min. | 195 min. | 205 min. | 215 min. |
| Viscosity, $mm^2/s$ 40°C | GB/T 265 | ASTM D445 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90-110 | 19.8-24.2 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90-110 | 135-165 |
| 0°C | | | - | - | - | - | 300 max. | 420 max. | 780 max. | 1400 max. | 2560 max. | - |
| Viscosity Index (2) | GB/T 1995 | ASTM D2270 | 95 min. | | | | 85 min. | | | | | |
| Pour Point (3), °C | GB/T 3535 | ASTM D97 | -15 max. | -9 max. | -9 max. | -9 max. | -15 max. | -15 max. | -9 max. | -9 max. | -9 max. | -9 max. |
| Acid Number (4), mg KOH/g | GB/T 4945 | ASTM D974 | Report | | | | Report | | | | | |
| Water content, %wt | GB/T 260 | ASTM D95 | Trace max. | | | | Trace max. | | | | | |
| Mechanical Impurity, %wt | GB/T 511 | Russian ГОСТ6370 | None | | | | None | | | | | |
| Cleanliness | DL/T 432<br>GB/T 14039 | NAS 1638<br>ISO 4406 | (5) | | | | (5) | | | | | |
| Copper Corrosion @ 100°C, 3 hrs | GB/T 5096 | ASTM D130 | 1 max. | | | | 1 max. | | | | | |
| Sulphated ash, % | GB/T 2433 | ISO 3987 | Report | | | | Report | | | | | |

**Note:**
(1) Test method can also use SH/T 0604.
(2) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.
(3) It can be negotiable with the supplier in case the user has special requirements.
(4) Test method can also use GB/T 264.
(5) It is determined by the agreement of supplier and user. The classifications of NAS 1638 can also be used.



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## Chinese National Hydraulic Specifications GB111118.1-2011 – Con'd

December 2011

### Technical Requirements and Test Methods of L-HM Snti-wear Hydraulic Oil (High Pressure and Conventional Types) – Cont'd

| Test | Chinese Method | ASTM/ISO/IP (equivalent) | Performance Specs | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L-HM (High Pressure Type) | | | | L-HM (Conventional Type) | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 32 | 46 | 68 | 100 | 22 | 32 | 46 | 68 | 100 | 150 |
| Rust Test (24hrs) | | | | | | | | | | | | |
| Distilled Water | GB/T 11143 | ASTM D665A | - | | | | No rust | | | | | |
| Synthetic Sea Water | GB/T 11143 | ASTM D665B | No rust | | | | - | | | | | |
| Foam (Tendency/Stability), ml/ml | GB/T 12579 | ASTM D892 | | | | | | | | | | |
| Sequence I 24°C | | | 150/0 max. | | | | 150/0 max. | | | | | |
| Sequence II 93.5°C | | | 75/0 max. | | | | 75/0 max. | | | | | |
| Sequence III 24°C (after) | | | 150/0 max. | | | | 150/0 max. | | | | | |
| Air Release @ 50°C, minute | SH/T 0308 | ASTM D3427 | 6 max. | 10 max. | 13 max. | Report | 5 max. | 6 max. | 10 max. | 13 max. | Report | Report |
| Seal Compatibility Index | SH/T 0305 | IP278/72(88) | 12 max. | 10 max. | 8 max. | Report | 13 max. | 12 max. | 10max. | 8 max. | Report | Report |
| Demulse (Time for emulsion to 3ml) | GB/T 7305 | ASTM D1401 | | | | | | | | | | |
| 54°C, minute | | | 30 max. | 30 max. | 30 max. | - | 30 max. | 30 max. | 30 max. | 30 max. | - | - |
| 82°C, minute | | | - | - | - | 30 max. | - | - | - | - | 30 max. | 30 max. |
| Oxidation Stability | | | | | | | | | | | | |
| TAN after 1500hrs, mg KOH/g | GB/T 12581 | ASTM D943 | 2.0 max. | | | | - | | | | | |
| TAN after 1000hrs, mg KOH/g | GB/T 12581 | ASTM D943 | - | | | | 2.0 max. | | | | | |
| Sludge after 1000hrs, mg | SH/T 0565 | ASTM D4310 | Report | | | | Report | | | | | |
| RPVOT @ 150°C, minutes | SH/T 0193 | ASTM D2272 | Report | | | | Report | | | | | |
| FZG (A/8 3/90) Gear Test [6], FLS | SH/T 0306 | IP 334-80 | 10 min. | 10 min. | 10 min. | 10 min. | - | 10 min. | 10 min. | 10 min. | 10 min. | 10 min. |
| Vane Pump (100hrs Wt loss)[6], mg | SH/T 0307 | ASTM D2882 | - | - | - | - | 100 max. | 100 max. | 100 max. | 100 max. | 100 max. | 100 max. |
| 4 Ball Wear Scar, mm (32N, 60min, 75°C, 1200rpm) | SH/T 0189 | ASTM D4172 | Report | | | | Report | | | | | |

**Note:**

(6) For L-MH oil (conventional type) it is required to run vane pump test with L-HM22 (conventional type) only when commercialized. The antioxidant types and dosage of the rest each ISO grade shall be the same with the test sample of the commercialized L-HM22 oil (conventional type). For L-HM oil (high-pressure type), it is required to run FZG and hybrid pump test with L-HM32 (high pressure type) only when commercialized. The antioxidant types and dosage of the rest each ISO grade shall be same with the test sample of the commercialized L-HM32 (high pressure type).



Afton CHEMICAL

## Chinese National Hydraulic Specifications GB111118.1-2011 – Con'd

December 2011

| Technical Requirements and Test Methods of L-HM Snti-wear Hydraulic Oil (High Pressure and Conventional Types) – Cont'd | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Chinese Method** | **ASTM/ISO/IP (equivalent)** | **Performance Specs** | | | | | | | | | |
| | | | L-HM (High Pressure Type) | | | | L-HM (Conventional Type) | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 32 | 46 | 68 | 100 | 22 | 32 | 46 | 68 | 100 | 150 |
| Hybrid Pump (T6H20C) Test [6] | | | | | | | | | | | | |
| Total Weight loss (Vane+Pins), mg | Appendix A | Denison A-TP-30533 | 15 max. | | | | - | | | | | |
| Total Weight loss (Pistons), mg | | | 300 max. | | | | - | | | | | |
| Hydrolytic Stability | | | | | | | | | | | | |
| Cu Strip Weight Loss, mg/cm² | SH/T 0301 | ASTM D2619 | 0.2 max. | | | | - | | | | | |
| Acidity of Water Layer, mg/KOH | | | 4.0 max. | | | | - | | | | | |
| Cu Rating | | | No grey or black discolouration | | | | - | | | | | |
| Thermal Stability (135°C, 168hrs) | | | | | | | | | | | | |
| Copper Rod Weight Loss, mg/200ml | SH/T 0209 | ASTM D2070 | 10 max. | | | | - | | | | | |
| Steel Rod Weight Loss, mg/200ml | | | Report | | | | - | | | | | |
| Total Sludge, mg/100ml | | | 100 max. | | | | - | | | | | |
| Change of Viscosity @ 40°C, % | | | Report | | | | - | | | | | |
| Change of Acid Number, % | | | Report | | | | - | | | | | |
| Copper Rod Visual | | | Report | | | | - | | | | | |
| Steel Rod Visual | | | No discolouration | | | | - | | | | | |
| Filterability | | | | | | | | | | | | |
| Dry (without water), s | SH/T 0210 | Denison TP-02100 | 600 max. | | | | - | | | | | |
| Wet (with 2% water) [7], s | | | 600 max. | | | | - | | | | | |
| Shear Stability (after 250 cycles) Drop rate of Viscosity @ 40°C % | SH/T 0103 | ASTM D6278 | 1 max. | | | | - | | | | | |

**Note:**

(7) The filtration time for wet test shall be no less than two times of that for the dry test.

## Chinese National Hydraulic Specifications GB111118.1-2011 – Cont'd

December 2011

| Technical Requirements and Test Methods of L-HV Low-temperature Hydraulic Oil | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Chinese Method** | **ASTM/ISO/IP (equivalent)** | **Performance Specs** | | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 10 | 15 | 22 | 32 | 46 | 68 | 100 |
| Density @ 20°C [(1)], kg/m$^3$ | GB/T 1884<br>GB/T 1885 | ASTM D1298 | Report | | | | | | |
| Colour, Rating | GB/T 6540 | ASTM D1500 | Report | | | | | | |
| Appearance | Visual | - | Clear and Bright | | | | | | |
| Viscosity @ 40°C, mm$^2$/s | GB/T 265 | ASTM D445 | 9.0-10.0 | 13.5-16.5 | 19.8-24.2 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90-110 |
| Flash Point, °C | GB/T 3536 | ASTM D92 | | | | | | | |
| COC | | | - | 125 min. | 175 min. | 175 min. | 180 min. | 180 min. | 190 min. |
| PMCC | | | 100 min. | - | - | - | - | - | - |
| Temperature (Viscosity=1500mm$^2$/s), °C | GB/T 265 | ASTM D445 | -33 max. | -30 max. | -24 max. | -18 max. | -12 max. | -6 max. | 0 max. |
| Viscosity Index [(2)] | GB/T 1995 | ASTM D2270 | 130 min. | 130 min. | 140 min. | 140 min. | 140 min. | 140 min. | 140 min. |
| Pour Point [(3)], °C | GB/T 3535 | ASTM D97 | -39 max. | -36 max. | -36 max. | -33 max. | -33 max. | -30 max. | -21 max. |
| Acid Number [(4)], mg KOH/g | GB/T 4945 | ASTM D974 | Report | | | | | | |
| Water Content, % wt | GB/T 260 | ASTM D95 | Trace max. | | | | | | |
| Mechanical Impurity, % wt | GB/T 511 | Russian<br>ГОСТ6370 | None | | | | | | |
| Cleanliness | DL/T432<br>GB/T 14039 | NAS 1638<br>ISO 4406 | [(5)] | | | | | | |
| Copper Corrosion @ 100°C, 3 hrs | GB/T 5096 | ASTM D130 | 1 max. | | | | | | |
| Sulphate Ash, % | GB/T 2433 | ASTM 665A | Report | | | | | | |

**Note:**

(1) Test method can also use SH/T 0604.

(2) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.

(3) It can be negotiable with the supplier in case the user has special requirements.

(4) Test method can also use GB/T 264.

(5) It is determined by the agreement of the supplier and user. The classifications of NAS 1638 can also be used.

## Chinese National Hydraulic Specifications GB111118.1-2011 – Cont'd

December 2011

| Technical Requirements and Test Methods of L-HL R&O Hydraulic Oils – Cont'd | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Chinese Method** | **ASTM/ISO/IP (equivalent)** | **Performance Specs** | | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 10 | 15 | 22 | 32 | 46 | 68 | 100 |
| Rust Test, Synthetic Sea Water | GB/T 11143 | ASTM 665B | No rust | | | | | | |
| Foam (Tendency/Stability), ml/ml | GB/T 12579 | ASTM D892 | | | | | | | |
| Sequence I 24°C | | | 150/0 max. | | | | | | |
| Sequence II 93.5°C | | | 75/0 max. | | | | | | |
| Sequence III 24°C (after) | | | 150/0 max. | | | | | | |
| Air Release @ 50°C, minute | SH/T 0308 | ASTM D3427 | 5 max. | 5 max. | 6 max. | 8 max. | 10 max. | 12 max. | 15 max. |
| Demulsibility (Time for emulsion to 3ml) | GB/T 7305 | ASTM D1401 | | | | | | | |
| 54°C, minute | | | 30 max. | 30 max. | 30 max. | 30 max. | 30 max. | 30 max. | - |
| 82°C, minute | | | - | - | - | - | - | - | 30 max. |
| Shear Stability (after 250 cycles) Drop rate of Viscosity @ 40°C, % | SH/T 0103 | ASTM D6278 | 10 max. | | | | | | |
| Seal Compatibility Index | SH/T 0305 | IP278/72(88) | Report | 16 max. | 14 max. | 13 max. | 11 max. | 10 max. | 10 max. |
| Oxidation Stability | | | | | | | | | |
| TAN after 1500 hrs [(6)], mg KOH/g | GB/T 12581 | ASTM D943 | - | - | 2.0 max. | | | | |
| Sludge after 1000 hrs, mg | SH/T 0565 | ASTM D4310 | - | - | Report | | | | |
| RPVOT @ 150°C, minutes | SH/T 0193 | ASTM D2272 | Report | Report | Report | | | | |
| FZG (A/8.3/90) Gear Test[(7)], FLS | SH/T 0306 | IP 334-80 | - | - | - | 10 min. | 10 min. | 10 min. | 10 min. |
| 4 Ball Wear Scar (392N, 60min, 75°C, 1200rpm), mm | SH/T 0189 | ASTM D4172 | Report | | | | | | |

**Note:**

(6) ISO 10 & 15 oil shall not be measured, but their antioxidant types and dosage shall be same with the test sample of the commercialized ISO 22 oil.

(7) It is required to run FZG and Hybrid pump test with L-HV32 only when commercialized. The antioxidant types and dosage of the rest each ISO grade shall be the same with the test sample of the commercialized L-H32.



Afton CHEMICAL

## Chinese National Hydraulic Specifications GB111118.1-2011 – Cont'd

December 2011

| Technical Requirements and Test Methods of L-HL R&O Hydraulic Oils – Cont'd | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Chinese Method** | **ASTM/ISO/IP (equivalent)** | **Performance Specs** | | | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 10 | 15 | 22 | 32 | 46 | 68 | 100 |
| Hybrid Pump (T6H20C) Test (8), FLS | Appendix A | Denison A-TP-30533 | | | | | | | |
| Total Weight Loss (Vane + Pin), mg | | | - | - | - | 15 max. | | | |
| Total Weight Loss (Pistons) mg | | | - | - | - | 300 max | | | |
| Hydrolytic Stability | SH/T 0301 | ASTM D2619 | | | | | | | |
| Cu Strip Weight Loss, mg/cm² | | | 0.2 max. | | | | | | |
| Acidity of Water Layer, mg/KOH | | | 4.0 max. | | | | | | |
| Cu Rating | | | No grey or black discolouration | | | | | | |
| Thermal Stability (135°C, 168hrs) | SH/T 0209 | ASTM D2070 | | | | | | | |
| Copper Rod Weight Loss, mg/200ml | | | 10 max. | | | | | | |
| Steel Rod Weight Loss, mg/200ml | | | Report | | | | | | |
| Total Sludge, mg/100ml | | | 100 max. | | | | | | |
| Change of Viscosity @ 40°C, % | | | Report | | | | | | |
| Change of Acid Number, % | | | Report | | | | | | |
| Copper Rod Visual | | | Report | | | | | | |
| Steel Rod Visual | | | No discolouration | | | | | | |
| Filterability | SH/T 0210 | Denison TP-02100 | | | | | | | |
| Dry (without water), s | | | 600 max. | | | | | | |
| Wet (with 2% water) (8), s | | | 600 max. | | | | | | |

**Note:**

(6) The filtration time for wet test shall be no less than two times of that for dry test.

## Chinese National Hydraulic Specifications GB111118.1-2011 – Cont'd

December 2011

### Technical Requirements and Test Methods of L-HS Ultra-Low Temperature Hydraulic Oil

| Test | | Chinese Method | ASTM/ISO/IP (equivalent) | Performance Specs | | | | |
|---|---|---|---|---|---|---|---|---|
| ISO Viscosity Grade | | GB/T 3141 | ISO 3448 | 10 | 15 | 22 | 32 | 46 |
| Density @ 20°C (1), $kg/m^3$ | | GB/T 1884<br>GB/T 1885 | ASTM D1298 | Report | | | | |
| Colour, Rating | | GB/T 6540 | ASTM D1500 | Report | | | | |
| Appearance | | Visual | - | Clear and Bright | | | | |
| Viscosity @ 40°C, $mm^2/s$ | | GB/T 265 | ASTM D445 | 9.0-10.0 | 13.5-16.5 | 19.8-24.2 | 28.8-35.2 | 41.4-50.6 |
| Flash Point, °C | COC | GB/T 3536 | ASTM D92 | - | 125 min. | 175 min. | 175 min. | 180 min. |
| | PMCC | | | 100 min. | - | - | - | - |
| Temperature (Viscosity=1500$mm^2/s$), °C | | GB/T 265 | ASTM D445 | -39 max. | -36 max. | -30 max. | -24 max. | -18 max. |
| Viscosity Index (2) | | GB/T 1995 | ASTM D2270 | 130 min. | 130 min. | 150 min. | 150 min. | 150 min. |
| Pour Point (3), °C | | GB/T 3535 | ASTM D97 | -45 max. | -45 max. | -45 max. | -45 max. | -39 max. |
| Acid Number (4), mg KOH/g | | GB/T 4945 | ASTM D974 | Report | | | | |
| Water Content, % wt | | GB/T 260 | ASTM D95 | Trace max. | | | | |
| Mechanical Impurity, % wt | | GB/T 511 | Russian<br>ГОСТ6370 | None | | | | |
| Cleanliness | | DL/T 432<br>GB/T 14039 | NAS 1638<br>ISO 4406 | (5) | | | | |
| Copper Corrosion @ 100°C, 3 hrs | | GB/T 5096 | ASTM D130 | 1 max. | | | | |
| Sulphate Ash, % | | GB/T 2433 | ISO 3987 | Report | | | | |

**Note:**
(1) Test method can also use SH/T 0604.
(2) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.
(3) It can be negotiable with the supplier in case the user has special requirements.
(4) Test method can also use GB/T 264.
(5) It is determined by the agreement of the supplier and user. The classifications of NAS 1638 can also be used.

## Chinese National Hydraulic Specifications GB111118.1-2011 – Cont'd

December 2011

| Technical Requirements and Test Methods of L-HS Ultra-Low Temperature Hydraulic Oil – Cont'd | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Test** | **Chinese Method** | **ASTM/ISO/IP (equivalent)** | **Performance Specs** | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 10 | 15 | 22 | 32 | 46 |
| Rust Test, Synthetic Sea Water | GB/T 11143 | ASTM 665B | No rust | | | | |
| Foam (Tendency/Stability), ml/ml | GB/T 12579 | ASTM D892 | | | | | |
| Sequence I 24°C | | | 150/0 max. | | | | |
| Sequence II 93.5°C | | | 75/0 max. | | | | |
| Sequence III 24°C (after) | | | 150/0 max. | | | | |
| Air Release @ 50°C, minute | SH/T 0308 | ASTM D3427 | 5 max. | 5 max. | 6 max. | 8 max. | 10 max. |
| Demulsibility (Time for emulsion to 3ml) | GB/T 7305 | ASTM D1401 | | | | | |
| 54°C, minute | | | 30 max. | | | | |
| Shear Stability (after 250 cycles) Drop rate of Viscosity @ 40°C, % | SH/T 0103 | ASTM D6278 | 10 max. | | | | |
| Seal Compatibility Index | SH/T 0305 | IP278/72(88) | Report | 16 max. | 14 max. | 13 max. | 11 max. |
| Oxidation Stability | GB/T 12581 | ASTM D943 | | | | | |
| TAN after 1500 hrs [(6)], mg KOH/g | | | - | - | 2.0 max. | | |
| Sludge after 1000 hrs, mg | SH/T 0565 | ASTM D4310 | - | - | Report | | |
| RPVOT @ 150°C, minutes | SH/T 0193 | ASTM D2272 | Report | Report | Report | | |

**Note:**

(6) ISO 10 & 15 oil shall not be measured, but their antioxidant types and dosage shall be same with the test sample of the commercialized ISO 22 oil.

## DIN 51524 Part 1 (April 2006)

Rust and Oxidation Protected Hydraulic Oils

| Grade (according to DIN 51502) | HL10 | HL15 | HL22 | HL32 | HL46 | HL68 | HL100 | HL150 | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity Class (DIN 51519) | VG10 | VG15 | VG22 | VG32 | VG46 | VG68 | VG100 | VG150 | DIN 51519 |
| Kinematic Viscosity at 0°C/(-20°C), mm²/s, max. | 90 (600) | 150 | 300 | 420 | 780 | 1400 | 2560 | 4500 | DIN 51562-1 |
| Kinematic Viscosity at 40°C, mm²/s, max. | 11 | 16.5 | 24.2 | 35.2 | 50.6 | 74.8 | 110 | 165 | DIN 51562-1 |
| Kinematic Viscosity at 40°C, mm²/s, min. | 9.0 | 13.5 | 19.8 | 28.8 | 41.4 | 61.2 | 90.0 | 135 | DIN 51562-1 |
| Kinematic Viscosity at 100°C, mm²/s, min. | 2.5 | 3.2 | 4.1 | 5.0 | 6.1 | 7.8 | 9.9 | 14.0 | DIN 51562-1 |
| Pour Point, °C, max. | -30 | -27 | -21 | -18 | -15 | -12 | -12 | -12 | DIN ISO 3016 |
| Flash Point (COC), °C, min. | 125 | 140 | 165 | 175 | 185 | 195 | 205 | 215 | DIN EN ISO 2592 |
| Contents of undissolved matter, mg/kg, max. | 50 | | | | | | | | DIN ISO 5884 or ISO 4405:1991 |
| Water content, expressed as a proportion by mass, in %, max. | 0.05 | | | | | | | | DIN EN ISO 12937 |
| Steel Corrosion, max. | Method A – Pass | | | | | | | | DIN ISO 7120 |
| Copper Corrosion, 3 hrs at 100°C, max. | 2 | | | | | | | | DIN EN ISO 2160 |
| Air Release, 50°C, mins., max. | 5 | | | | 10 | | 17 | 25 | DIN ISO 9120 |
| Demulsibility, mins., max. | 20 (54°C) | | | 30 (54°C) | | | 30 (82°C) | | DIN ISO 6614 |
| Oxidation Stability, Acidity max. mg KOH/g at 1000 hrs | 2.0 | | | | | | | | DIN ISO 51587 / DIN EN ISO 4263-1 |
| Behaviour towards the Relative SRE-NBR 1 sealant specified in DIN 53538 Part 1, after 7 days ±2h at 100 ±1°C | | | | | | | | | |
| Change % in volume | 0 to 18 | 0 to 15 | | 0 to 12 | | 0 to 10 | | | DIN 53538-1 and DIN ISO 1817 |
| Change in Shore A hardness | 0 to -10 | 0 to -8 | | 0 to -7 | | 0 to -6 | | | DIN ISO 1817 in conjunction with DIN 53505 |
| Foam Volume, ml, max. | | | | | | | | | ISO 6247 : 1998 inc Cor. 1 : 1999 |
| Sequence I | 150/0 | | | | | | | | |
| Sequence II | 75/0 | | | | | | | | |
| Sequence III | 150/0 | | | | | | | | |

## DIN 51524 Part 1 (April 2006) – Cont'd

Rust and Oxidation Protected Hydraulic Oils

| Grade (according to DIN 51502) | HL10 | HL15 | HL22 | HL32 | HL46 | HL68 | HL100 | HL150 | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|
| Density at 15°C , in Kg/m³ | To be specified by supplier | | | | | | | | DIN 51757 |
| Ash (oxide ash), expressed as a proportion by mass, in % | To be specified by supplier | | | | | | | | DIN 51575 or DIN EN ISO 6245 |
| Neutralization number (acid or alkaline), in mg KOH/g | To be specified by supplier | | | | | | | | DIN 51558-1 or DIN 51558-2 |
| Cleanliness Class | 21 / 19 / 16 | | | | | | | | ISO 4406 : 1999 |
| Wet Filtration | | | | | | | | | E DIN ISO 13357-1 |
| F1, min % | 70 | | | | | | | | |
| F2, min % | 50 | | | | | | | | |
| Dry Filtration | | | | | | | | | E DIN ISO 13357-2 |
| F1, min % | 80 | | | | | | | | |
| F2, min % | 60 | | | | | | | | |

# DIN 51524 Part 2 (April 2006)

Anti-wear Hydraulic Oils

<table>
<tr><th>Grade (according to DIN 51502)</th><th>HLP10</th><th>HLP15</th><th>HLP22</th><th>HLP32</th><th>HLP46</th><th>HLP68</th><th>HLP100</th><th>HLP150</th><th>ASTM Test Method</th></tr>
<tr><td>ISO Viscosity Class</td><td>VG10</td><td>VE15</td><td>VG22</td><td>VG32</td><td>VG46</td><td>VG68</td><td>VG100</td><td>VG150</td><td>DIN 51519</td></tr>
<tr><td>Kinematic Viscosity at 0°C/(-20°C), $mm^2/s$, max.</td><td>90 (600)</td><td>150</td><td>300</td><td>420</td><td>780</td><td>1400</td><td>2560</td><td>4500</td><td>DIN 51562-1</td></tr>
<tr><td>Kinematic Viscosity at 40°C, $mm^2/s$, max.</td><td>11.0</td><td>16.5</td><td>24.2</td><td>35.2</td><td>50.6</td><td>74.8</td><td>110</td><td>165</td><td>DIN 51562-1</td></tr>
<tr><td>min.</td><td>9.0</td><td>13.5</td><td>19.8</td><td>28.8</td><td>41.4</td><td>61.2</td><td>90.0</td><td>135</td><td>DIN 51562-1</td></tr>
<tr><td>Kinematic Viscosity at 100°C, $mm^2/s$, min.</td><td>2.5</td><td>3.2</td><td>4.1</td><td>5.0</td><td>6.1</td><td>7.8</td><td>9.9</td><td>14.0</td><td>DIN 51562-1</td></tr>
<tr><td>Pour Point, °C, max.</td><td>-30</td><td>-27</td><td>-21</td><td>-18</td><td>-15</td><td>-12</td><td>-12</td><td>-12</td><td>DIN ISO 3016</td></tr>
<tr><td>Flash Point (COC), °C, min.</td><td>125</td><td>140</td><td>165</td><td>175</td><td>185</td><td>195</td><td>205</td><td>215</td><td>DIN ISO EN 2592</td></tr>
<tr><td>Cleanliness Class</td><td colspan="8">21 / 19 / 16</td><td>ISO 4406 : 1999</td></tr>
<tr><td>Contents of undissolved matter expressed as a proportion by mass, mg/kg, max.</td><td colspan="8">50</td><td>DIN ISO 5884<br>ISO 4405 : 1991</td></tr>
<tr><td>Water content, expressed as a proportion by mass, in % m/m, max.</td><td colspan="8">0.05</td><td>DIN EN ISO 12937</td></tr>
<tr><td>Steel Corrosion</td><td colspan="8">Method A – Pass</td><td>DIN ISO 7120</td></tr>
<tr><td>Copper Corrosion, 3 hrs at 100°C, max.</td><td colspan="8">2</td><td>DIN ISO EN 2160</td></tr>
<tr><td>Air Release, 50°C, mins., max.</td><td colspan="4">5</td><td>10</td><td>13</td><td>21</td><td>32</td><td>DIN ISO 9120</td></tr>
<tr><td>Demulsibility, mins., max.</td><td colspan="3">20 (54°C)</td><td colspan="3">30 (54°C)</td><td colspan="2">30 (82°C)</td><td>DIN ISO 6614</td></tr>
<tr><td>FZG A/8.3/90: Load Stage Fail, min.</td><td colspan="3">-</td><td colspan="5">10</td><td>DIN 51354-2</td></tr>
<tr><td>Vane Pump Wear, mg, max.</td><td colspan="8"></td><td rowspan="3">DIN ISO EN 20703</td></tr>
<tr><td>Ring</td><td colspan="3">-</td><td colspan="3">120</td><td colspan="2">-</td></tr>
<tr><td>Vanes</td><td colspan="3">-</td><td colspan="3">30</td><td colspan="2">-</td></tr>
<tr><td>Oxidation Stability, Acidity max. mg KOH/g at 1000 hrs</td><td colspan="8">2.0</td><td>DIN 51587 or DIN EN ISO 4263-1</td></tr>
<tr><td>Behaviour towards the Relative SRE-NBR 1 sealant specified in DIN 53538 Part 1, after 7 days ±2h at 100 ±1°C</td><td colspan="8"></td><td></td></tr>
<tr><td>Change % in volume</td><td>0 to 18</td><td colspan="2">0 to 15</td><td colspan="2">0 to 12</td><td colspan="3">0 to 10</td><td>DIN 53538-1 and DIN ISO 1817</td></tr>
<tr><td>Change in Shore A hardness</td><td>0 to -10</td><td colspan="2">0 to -8</td><td colspan="2">0 to -7</td><td colspan="3">0 to -6</td><td>DIN ISO 1817 in conjunction with DIN 53505</td></tr>
</table>

## DIN 51524 Part 2 (April 2006) – Cont'd

Anti-wear Hydraulic Oils

| Grade (according to DIN 51502) | | HLP10 | HLP15 | HLP22 | HLP32 | HLP46 | HLP68 | HLP100 | HLP150 | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|
| Foam Volume, ml, max. | | | | | | | | | | ISO 6247 : 1998 inc. cor. 1: 1999 |
| | Sequence I | 150/0 | | | | | | | | |
| | Sequence II | 75/0 | | | | | | | | |
| | Sequence III | 150/0 | | | | | | | | |
| Density at 15°C Kg/m³ | | To be specified by supplier | | | | | | | | DIN 51757 |
| Ash (oxide ash), expressed as a proportion by mass, in % | | To be specified by supplier | | | | | | | | DIN 51575 or DIN EN ISO 6245 |
| Neutralization number (acid or alkaline), in mg KOH/g | | To be specified by supplier | | | | | | | | DIN 515581 or DIN EN ISO 51558-2 |
| Dry Filtration | | | | | | | | | | E DIN ISO 13357-2 |
| | F1, min. % | 80 | | | | | | | | |
| | F2, min.% | 60 | | | | | | | | |
| Wet Filtration | | | | | | | | | | E DIN ISO 13357-1 |
| | F1, min. % | 70 | | | | | | | | |
| | F2, min.% | 50 | | | | | | | | |

## DIN 51524 Part 3 (April 2006)

HVLP Hydraulic Oils

| Grade (according to DIN 51502) | | HVLP10 | HVLP15 | HVLP22 | HVLP32 | HVLP46 | HVLP68 | HVLP100 | HVLP150 | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity Class | | ISO VG 10 | ISO VG 15 | ISO VG 22 | ISO VG 32 | ISO VG 46 | ISO VG 68 | ISO VG 100 | ISO VG 150 | DIN 51519 |
| Kinematic Viscosity at -20°C, mm²/s | | To be specified by supplier | | | | | | | | DIN 51562-1 |
| Kinematic Viscosity at 0°C, mm²/s | | To be specified by supplier | | | | | | | | DIN 51562-1 |
| Kinematic Viscosity at 40°C, mm²/s | max. | 11.0 | 16.5 | 24.2 | 35.2 | 50.6 | 74.8 | 110 | 165 | DIN 51562-1 |
| | min. | 9.0 | 13.5 | 19.8 | 28.8 | 41.4 | 61.2 | 90.0 | 135 | |
| Kinematic Viscosity at 100°C, mm²/s | | To be specified by supplier | | | | | | | | DIN 51562-1 |
| Viscosity Index, min. | | 140 | | | | | | | 120 | DIN ISO 2909 |
| Pour Point, °C, max. | | -39 | -39 | -39 | -30 | -27 | -24 | -21 | -18 | DIN ISO 3016 |
| Flash Point, °C, min. | | 125 | 125 | 175 | 175 | 180 | 180 | 190 | 200 | DIN EN ISO 2592 |
| Cleanliness Class | | 21 / 19 / 16 | | | | | | | | ISO 4406 : 1999 |
| Contents of undissolved matter, expressed as a proportion by mass, mg/kg, max. | | 50 | | | | | | | | DIN ISO 5884 or ISO 4405 : 1991 |
| Water content, expressed as a proportion by mass, in % (m/m), max. | | 0.05 | | | | | | | | DIN EN ISO 12937 |
| Steel Corrosion, max. | | Pass Method A | | | | | | | | DIN ISO 7120 |
| Copper Corrosion, 3 hrs at 100°C max. | | Maximum corrosion rating: 2 | | | | | | | | DIN EN ISO 2160 |
| Air Release, 50°C, mins., max. | | 5 | | | | 13 | | 21 | 32 | DIN ISO 9120 |
| Demulsibility, 54°C, mins., max. | | 20 (54°C) | | | | 30 (54°C) | | 30 (82°C) | | DIN ISO 6614 |
| Oxidation Stability, Acidity max. mg KOH/g at 1000 hrs | | 2.0 | | | | | | | | DIN 51587 or DIN EN ISO 4263-1 |
| Behaviour towards the SRE-NBR 1 sealant specified in DIN 53538 Part 1, after 7 days ±2h at 100 ±1°C | | | | | | | | | | ISO 6247: 1998 inc. Cor. I : 1999 |
| | Change % in volume | 0 to 18 | 0 to 15 | | 0 to 12 | | 0 to 10 | | | |
| | Change in Shore A hardness | 0 to -10 | 0 to -8 | | 0 to -7 | | 0 to -6 | | | |
| Foam Volume, ml, max. | | | | | | | | | | ISO 6247 : 1998 |
| | Sequence I | 150/0 | | | | | | | | |
| | Sequence II | 75/0 | | | | | | | | |
| | Sequence III | 150/0 | | | | | | | | |



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## DIN 51524 Part 3 (April 2006) – Cont'd

HVLP Hydraulic Oils

| Grade | | HVLP10 | HVLP15 | HVLP22 | HVLP32 | HVLP46 | HVLP68 | HVLP100 | HVLP150 | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|
| Behaviour in FZG gear rig test | | | - | | | | ≥ 10 | | | DIN 51354-2 or DIN ISO 14635-1 |
| Loss of mass, in mg after mechanical test by vane-pump | Ring | | - | | ≤ 120 | | | - | | DIN 51389-2 |
| | Vane | | - | | ≤ 30 | | | - | | |
| Relative Viscosity loss at 40°C and 100°C after 20 hrs, % | | | | | To be specified by supplier | | | | | DIN 51350-6 |
| Density at 15°C, in g/ml | | | | | To be specified by supplier | | | | | DIN 51757 |
| Ash content (oxide ash) or sulphate ash, as a percentage by mass | | | | | To be specified by supplier | | | | | DIN 51575 or DIN EN ISO 6245 |
| Neutralization number (acid or alkaline), in mg KOH/g | | | | | To be specified by supplier | | | | | DIN 51558-1 or DIN 51558-2 |
| Dry Filtration | | | | | | | | | | E DIN ISO 13357-2 |
| | F1, min. % | | | | 80 | | | | | |
| | F2, min.% | | | | 60 | | | | | |
| Wet Filtration | | | | | | | | | | E DIN ISO 13357-1 |
| | F1, min. % | | | | 70 | | | | | |
| | F2, min.% | | | | 50 | | | | | |

## German Steel Industry Specifications SEB 181222

January 2007

| Hydraulic Oil Type | | HLP 22 | HLP 32 | HLP 46 | HLP 68 | HLP 100 | ASTM Test Method |
|---|---|---|---|---|---|---|---|
| Kinematic Viscosity, mm²/s. | at 0°C, max. | To be specified | | | | | DIN 51562-1 |
| | at 40°C ± 10% | 22 | 32 | 46 | 68 | 100 | |
| | at 100°C, min. | 4.1 | 5.0 | 6.2 | 8.0 | 10.2 | |
| Viscosity Index | | Report | | | | | DIN ISO 2909 |
| Pour Point, °C, max. | | -24 | -21 | | -18 | | DIN ISO 3016 |
| Flash Point, °C, min. | | 180 | 200 | | 220 | | DIN EN ISO 2592 |
| Oil Cleanliness [3] | | 21 / 18 / 15 | | | | | ISO 4406-99 |
| Water Content, Vol, -%, max. | | 0.03 | | | | | EN ISO 12937 |
| Rust Prevention, max. | | Method B No Corrosion | | | | | DIN ISO 7120 |
| Copper Corrosion (3 hrs at 125°C), max. | | Rating 1 | | | | | DIN EN ISO 2160 |
| Oxidation Stability, Acidity max. mg KOH/g at 1000 hrs | | 2.0 | | | | | DIN 51587 in connection with DIN 51 558-1 |
| Behaviour towards the SRE-NBR 1 sealant specified in DIN 53538 part 1, after 7 days at 100°C | | | | | | | |
| Relative change in volume, % max. | | 0 to +8 | | | | | DIN 53538-1 / ISO 1817 |
| Shore A hardness, max. | | 0 to -6 | | | | | DIN 53505 |
| Contents of undisolved matter, ≤ mg/kg | | 50 | | | | | SEB 181322 |
| Air Release, mins., max. | | 5 (50°C) | 10 (50°C) | | | 15 (75°C) [4] | DIN ISO 9120 |
| Foam volume, ml, max. | Sequence I | 100/0 | | | | | ISO 6247 |
| | Sequence II | 50/0 | | | | | |
| | Sequence III | 100/0 | | | | | |

## German Steel Industry Specifications SEB 181222 – Cont'd

January 2007

| Hydraulic Oil Type | | HLP 22 | HLP 32 | HLP 46 | HLP 68 | HLP 100 | ASTM Test Method |
|---|---|---|---|---|---|---|---|
| Demulsibility at 54°C, time to 38ml oil, mins., max. | | 20 | | | 30 | | DIN ISO 6614 |
| Final state, max.-min.-max., ml | | 42-38-0 | | | | | |
| Demusability at 40°C, time to 38ml oil, mins. | | To be specified | | | | | DIN ISO 6614 |
| Final state, ml | | To be specified | | | | | |
| FZG Gear Testing (A/8.3/90) | | | | | | | DIN ISO 14635-1 |
| Load Stage Fail, min. | | 10 | 12 | | | | |
| Work Related Weight Change, mg/ KWh | | To be specified by supplier | | | | | |
| Vane Pump Wear, mg, max. | Ring | 60 | | | | | DIN EN ISO 20763 |
| | Vanes | 15 | | | | | |
| Density at 15°C, kg/m³ | | To be specified | | | | | DIN 51757 |
| Ash % mass | | To be specified | | | | | DIN EN ISO 6245 |
| Neutralisation No., mg KOH/g | | To be specified | | | | | DIN 51558-1 |
| Filterability | Without water, ≥ % | 60 | | | | | ISO 13357-2 |
| | With 0.2% water, ≥ % | 60 | | | | | ISO 13357-1 |
| PCB Content, mg/kg, max. | | Current detection limit | | | | | DIN EN 12766 |
| Halogen Content, %, max. | | 0.01 | | | | | DIN ISO 15597 or DIN 51 408-1 |
| PAK (PAH) Content, max. | | 10 | | | | | GC-MS analysis |

# ISO 11158 Hydraulic Fluids

2009

| Test | HL | | | | | | | | HM | | | | | | | | HV | | | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Viscosity grade (ISO 3448)** | 10 | 15 | 22 | 32 | 46 | 68 | 100 | 150 | 10 | 15 | 22 | 32 | 46 | 68 | 100 | 150 | 10 | 15 | 22 | 32 | 46 | 68 | 100 | 150 | |
| Kinematic Viscosity | | | | | | | | | | | | | | | | | | | | | | | | | |
| at -20°C, mm²/s, max. (1) | 600 | - | - | - | - | - | - | - | 600 | - | - | - | - | - | - | - | Report | | | | | | | | ISO 3104 / 3105 |
| at 0°C, mm²/s, max. (1) | 90 | 150 | 300 | 420 | 780 | 1400 | 2560 | 4500 | 90 | 150 | 300 | 420 | 780 | 1400 | 2560 | 4500 | Report | | | | | | | | |
| at 40°C, mm²/s, min/max. (1) | 9.00<br>11.0 | 13.5<br>16.5 | 19.8<br>24.2 | 28.8<br>35.2 | 41.4<br>50.6 | 61.2<br>74.8 | 90.0<br>110 | 135<br>165 | 9.00<br>11.0 | 13.5<br>16.5 | 19.8<br>24.2 | 28.8<br>35.2 | 41.4<br>50.6 | 61.2<br>74.8 | 90.0<br>110 | 135<br>165 | 9.00<br>11.0 | 13.5<br>16.5 | 19.8<br>24.2 | 28.8<br>35.2 | 41.4<br>50.6 | 61.2<br>74.8 | 90.0<br>110 | 135<br>165 | |
| at 100°C, mm²/s, min. (1) | 2.50 | 3.20 | 4.10 | 5.00 | 6.10 | 7.80 | 9.90 | 14.0 | 2.50 | 3.20 | 4.10 | 5.00 | 6.10 | 7.80 | 9.90 | 14.0 | Report | | | | | | | | |
| Viscosity Index | Report | | | | | | | | Report | | | | | | | | 140 | | | | | | | 120 | ISO 2909 |
| Density at 15°C, kg/m³ | Report | | | | | | | | Report | | | | | | | | Report | | | | | | | | ISO 3675 |
| Colour | Report | | | | | | | | Report | | | | | | | | Report | | | | | | | | ISO 2049 |
| Appearance at 25°C | Clear & Bright | | | | | | | | Clear & Bright | | | | | | | | Clear & Bright | | | | | | | | Visual |
| Cleanliness | (1) | | | | | | | | (1) | | | | | | | | (1) | | | | | | | | – |
| Flash Point (COC), °C, min. | 125 | 140 | 165 | 175 | 185 | 195 | 205 | 215 | 125 | 140 | 165 | 175 | 185 | 195 | 205 | 215 | 125 | 125 | 175 | 175 | 180 | 180 | 180 | 200 | ISO 2592 |
| Pour Point, °C, max | -30 | -27 | -21 | -18 | -15 | -12 | -12 | -12 | -30 | -27 | -21 | -18 | -15 | -12 | -12 | -12 | -39 | -39 | -39 | -30 | -27 | -24 | -21 | -18 | ISO 3016 |
| Total Acid Number, mg KOH/g, max. | Report | | | | | | | | Report | | | | | | | | Report | | | | | | | | ISO 6618 or ISO 6619 |
| Water content, %m/m, max. | 0.025 | | | | | | | | 0.025 | | | | | | | | 0.025 | | | | | | | | ISO 6296 / 12937 / 20764 |
| Water separation (2) | | | | | | | | | | | | | | | | | | | | | | | | | ISO 6614 |
| time to 3ml emulsion at 54°C, mins., max. | 30 | | | | | | - | | 30 | | | | | | - | | 30 | | | | | | - | | |
| time to 3ml emulsion at 82°C, mins., max. | - | | | | | | 30 | | - | | | | | | 30 | | - | | | | | | 30 | | |
| Copper corrosion, 100°C, 3 hrs, class, max. | 2 | | | | | | | | 2 | | | | | | | | 2 | | | | | | | | ISO 2160 |
| Rust prevention, 24 hrs. | | | | | | | | | | | | | | | | | | | | | | | | | ISO 7120 |
| Procedure A | Pass | | | | | | | | Pass | | | | | | | | Pass | | | | | | | | |
| Procedure B | Report | | | Pass | | | | | Report | | | Pass | | | | | Report | | | Pass | | | | | |

**Note:**

(1) The requirements of the cleanliness of the hydraulic fluid is system-dependent. Cleanliness level expressed according to ISO 4406 may be established by agreement between the supplier and the end-user. It should be noted that the fluid is exposed to various influences during transport and storage; the cleanliness level required for the system should be guaranteed by careful filtering of the hydraulic fluid when filling.

(2) This method is not required for fluids with detergent properties.



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## ISO 11158 Hydraulic Fluids – Cont'd 2009

<table>
<tr><th>Test</th><th colspan="8">HL</th><th colspan="8">HM</th><th colspan="8">HV</th><th rowspan="2">ASTM Test Method</th></tr>
<tr><th>Viscosity grade (ISO 3448)</th><th>10</th><th>15</th><th>22</th><th>32</th><th>46</th><th>68</th><th>100</th><th>150</th><th>10</th><th>15</th><th>22</th><th>32</th><th>46</th><th>68</th><th>100</th><th>150</th><th>10</th><th>15</th><th>22</th><th>32</th><th>46</th><th>68</th><th>100</th><th>150</th></tr>
<tr><td>Foam Test</td><td colspan="8"></td><td colspan="8"></td><td colspan="8"></td><td rowspan="4">ISO 6247</td></tr>
<tr><td>Sequence I, ml, max.</td><td colspan="8">150/0</td><td colspan="8">150/0</td><td colspan="8">150/0</td></tr>
<tr><td>Sequence II, ml, max.</td><td colspan="8">80/0</td><td colspan="8">80/0</td><td colspan="8">80/0</td></tr>
<tr><td>Sequence III, ml, max.</td><td colspan="8">150/0</td><td colspan="8">150/0</td><td colspan="8">150/0</td></tr>
<tr><td>Air Release</td><td colspan="24"></td><td rowspan="3">ISO 9120</td></tr>
<tr><td>at 50°C, mins., max.</td><td colspan="4">5</td><td>10</td><td>10</td><td colspan="2">-</td><td colspan="4">5</td><td>10</td><td>13</td><td colspan="2">-</td><td colspan="4">5</td><td>13</td><td>13</td><td colspan="2">-</td></tr>
<tr><td>at 75°C, mins., max.</td><td colspan="6">-</td><td colspan="2">Report</td><td colspan="6">-</td><td colspan="2">Report</td><td colspan="6">-</td><td colspan="2">Report</td></tr>
<tr><td>Elastomer compatibility, NBR 1, 100°C, 168 hrs. (3)</td><td colspan="24"></td><td rowspan="3">ISO 6072</td></tr>
<tr><td>relative increase in volume</td><td>0 to 18</td><td colspan="2">0 to 15</td><td colspan="2">0 to 12</td><td colspan="3">0 to 10</td><td>0 to 18</td><td colspan="2">0 to 15</td><td colspan="2">0 to 12</td><td colspan="3">0 to 10</td><td>0 to 18</td><td colspan="2">0 to 15</td><td colspan="2">0 to 12</td><td colspan="3">0 to 10</td></tr>
<tr><td>change in shore A hardness</td><td>0 to -10</td><td colspan="2">0 to -8</td><td colspan="2">0 to -7</td><td colspan="3">0 to -6</td><td>0 to -10</td><td colspan="2">0 to -8</td><td colspan="2">0 to -7</td><td colspan="3">0 to -6</td><td>0 to -10</td><td colspan="2">0 to -8</td><td colspan="2">0 to -7</td><td colspan="3">0 to -6</td></tr>
<tr><td>Oxidation Stability, 1000 hrs.</td><td colspan="24"></td><td rowspan="3">ISO 4263-1</td></tr>
<tr><td>increase acid number, mg KOH/g, max.</td><td colspan="8">2.0</td><td colspan="8">2.0</td><td colspan="8">2.0</td></tr>
<tr><td>Insoluble sludge, mg</td><td colspan="8">Report</td><td colspan="8">Report</td><td colspan="8">Report</td></tr>
<tr><td>Wear Protection, FZG A/8.3/90, fail stage</td><td colspan="3">-</td><td colspan="5">-</td><td colspan="3">-</td><td colspan="5">10</td><td colspan="3">-</td><td colspan="5">10</td><td>ISO 14635-1</td></tr>
<tr><td>Vane pump,</td><td colspan="24"></td><td rowspan="3">ISO 20763, procedure A</td></tr>
<tr><td>weight loss cam ring, mg, max.</td><td colspan="3">-</td><td colspan="3">-</td><td colspan="2">-</td><td colspan="3">-</td><td colspan="3">120</td><td colspan="2">-</td><td colspan="3">-</td><td colspan="3">120</td><td colspan="2">-</td></tr>
<tr><td>weight loss vanes, mg, max.</td><td colspan="3">-</td><td colspan="3">-</td><td colspan="2">-</td><td colspan="3">-</td><td colspan="3">30</td><td colspan="2">-</td><td colspan="3">-</td><td colspan="3">30</td><td colspan="2">-</td></tr>
<tr><td>Filterability, dry</td><td colspan="24"></td><td rowspan="3">ISO 13357-2</td></tr>
<tr><td>Stage I, %, min.</td><td colspan="8">-</td><td colspan="8">80</td><td colspan="8">80</td></tr>
<tr><td>Stage II, %, min.</td><td colspan="8">-</td><td colspan="8">60</td><td colspan="8">60</td></tr>
<tr><td>Filterability, wet</td><td colspan="24"></td><td rowspan="3">ISO 13357-1</td></tr>
<tr><td>Stage I, %, min.</td><td colspan="8">-</td><td colspan="8">50</td><td colspan="8">50</td></tr>
<tr><td>Stage II, %, min.</td><td colspan="8">-</td><td colspan="8">50</td><td colspan="8">50</td></tr>
<tr><td>Shear Stability, tapered roller bearing, 20 hrs, 60°C</td><td colspan="24"></td><td rowspan="3">CEC L-45-A-99</td></tr>
<tr><td>loss in kinematic viscosity at 40°C, %</td><td colspan="8">-</td><td colspan="8">-</td><td colspan="8">Report</td></tr>
<tr><td>loss in kinematic viscosity at 100°C, %</td><td colspan="8">-</td><td colspan="8">-</td><td colspan="8">Report</td></tr>
</table>

**Note:**

(3) The definition of compatibility for types of elastomers other than NBR1 (e.g. FPM, EPDM, AU) may be agreed between the supplier and the end user.

(4) Test method will become ISO 26422.

## MAG Cincinnati Machine Anti-wear Hydraulic Specifications 2000

| Specifications | P-68 (HM-32) | P-69 (HM-68) | P-70 (HM-46) | ASTM Test Method |
|---|---|---|---|---|
| Viscosity Classification | ISO VG 32 | ISO VG 68 | ISO VG 46 | ASTM D2422 |
| A.P.I. Gravity at 60°F | 30 to 33 | 29 to 31 | 28 to 31.5 | ASTM D287 |
| Kinematic Viscosity at 40°C, $mm^2/s$ | 28.8 to 35.2 | 61.2 to 74.8 | 41.4 to 50.6 | ASTM D445 |
| Viscosity Index, min. | 90 | 90 | 90 | ASTM D2270 |
| Colour, max. | 2.0 | 3.0 | 3.0 | ASTM D1500 |
| Flash Point (COC), °F, min. | 370 | 385 | 385 | ASTM D92 |
| Fire Point (COC), °F, min. | 420 | 425 | 425 | ASTM D92 |
| Acid Number, mg KOH/g, max. | 1.5 | 1.5 | 1.5 | ASTM D974 |
| Steel Corrosion, rating | Pass | Pass | Pass | ASTM D665A |
| Vickers pump wear test | | | | ASTM D2882 |
| Total Ring and Vane Wt. Loss, mg, max. | 50 | 50 | 50 | |
| CM Thermal Stability | | | | CCM'A' |
| Change in Kinematic Viscosity, %, max. | 5 | 5 | 5 | |
| Acid Number change, %, max. | ±50 | ±50 | ±50 | |
| Sludge, mg/100ml, max. | 25 | 25 | 25 | |
| Steel Rod Visual, max. | 1.5 | 1.5 | 1.5 | |
| Steel Rod Deposits per 200ml, mg, max. | 3.5 | 3.5 | 3.5 | |
| Steel Rod weight loss per 200ml, mg, max. | 1.0 | 1.0 | 1.0 | |
| Copper Rod Visual, CM rating, max. | 5 | 5 | 5 | |
| Copper Rod deposits per 200ml, mg, max. | 10.0 | 10.0 | 10.0 | |
| Copper Rod weight loss per 200ml, mg, max. | 10.0 | 10.0 | 10.0 | |

## MAG Cincinnati Machine Hydraulic Specifications 2000

| Specifications | P-38 (HL-32) | P-54 (HL-68) | P-55 (HL-46) | P-57 (HL-150) | ASTM Test Method |
|---|---|---|---|---|---|
| Viscosity Classification | ISO VG 32 | ISO VG 68 | ISO VG 46 | ISO VG 150 | ASTM D2422 |
| A.P.I. Gravity at 60°F | 30 to 33 | 29 to 31 | 28 to 31.5 | 27 to 30 | ASTM D287 |
| Kinematic Viscosity at 40°C, $mm^2/s$ | 28.8 to 35.2 | 61.2 to 74.8 | 41.4 to 50.6 | 135 to 165 | ASTM D445 |
| Viscosity Index, min. | 90 | 90 | 90 | 90 | ASTM D2270 |
| Colour, max. | 2.0 | 3.0 | 3.0 | 5.0 | ASTM D1500 |
| Flash Point (COC), °F, min. | 370 | 385 | 385 | 430 | ASTM D92 |
| Fire Point (COC), °F, min. | 420 | 425 | 425 | 475 | ASTM D92 |
| Acid Number, mg KOH/g, max. | 0.20 | 0.20 | 0.20 | 0.20 | ASTM D974 |
| Steel Corrosion, rating | Pass | Pass | Pass | Pass | ASTM D665A |
| CM Thermal Stability Test | | | | | CCM'A' |
| Change in Kinematic Viscosity, %, max. | 5 | 5 | 5 | 5 | |
| Acid Number increase, mgKOH/g, max. | 0.15 | 0.15 | 0.15 | 0.15 | |
| Sludge, mg/100ml, max. | 25 | 25 | 25 | 25 | |
| Steel Rod Visual, max | 1.5 | 1.5 | 1.5 | 1.5 | |
| Steel Rod Deposits per 200ml, mg, max. | 3.5 | 3.5 | 3.5 | 3.5 | |
| Steel Rod weight loss per 200ml, mg, max. | 1.0 | 1.0 | 1.0 | 1.0 | |
| Copper Rod Visual, CM rating, max. | 5 | 5 | 5 | 5 | |
| Copper Rod Deposits per 200ml, max. | 10.0 | 10.0 | 10.0 | 10.0 | |
| Copper Rod weight loss per 200ml, mg, max. | 10.0 | 10.0 | 10.0 | 10.0 | |

## Parker Denison Hydraulic Requirements - TP30560

19 April 2012

| Test | HF-0 | HF-1 | HF-2 | HF-3 | HF-4 | HF-5 | HF-6 | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|
| Viscosity cSt at 40°C | Report | Report | Report | 65 to 140 | Report | Report | Report | D445 |
| Viscosity cSt at 100°C | Report | Report | Report | Report | Report | Report | Report | D445 |
| Viscosity index, min | 90 | 90 | 90 | 90 | 90 | 90 | 90 | D2270 |
| Gravity (specific) | 840 to 900 | 840 to 900 | 840 to 900 | 900 to 970 | 1050 to 1090 | 950 to 1300 | 840 to 900 | |
| Zinc, % wt. | Report | Report | Report | | | | Report | |
| Pour Point, °C | ≤ -20°C | ≤ -20°C | ≤ -20°C | | | | ≤ -20°C | D97 |
| PH at 25°C | | | | | 8.5 to 10.5 | | | |
| Aniline Point | > 100°C (2) | > 100°C (2) | > 100°C (2) | | | | > 100°C (2) | D611 |
| Flash Point, °C | Report | Report | Report | | | | Report | D92 |
| Water % | | | | 37 to 45 | 40 to 45 | | | |
| Acid Number | Report | Report | Report | | | | Report | D664 |
| Rust Test | | | | | | | | |
| Distilled Water | No rust | No rust | No rust | No rust | No rust | No rust | No rust | D665A |
| Synthetic Sea Water | No rust | No rust | No rust | No rust | No rust | No rust | No rust | D665B |
| Foam | | | | | | | | D892 |
| Allowable Foam after 10mn | None | None | None | | | None | None | |
| Filterability | | | | | | | | (1) |
| Filtration Time without water | (3) | (3) | (3) | | | | (3) (4) | TP-02100 |
| Filtration Time with 2% water | (3) | (3) | (3) | | | | (3) (4) | (Denison) |
| Filterability | | | | | | | | |
| Stage 2 - Dry oils % | > 60 | > 60 | > 60 | | | | | ISO 13357 Part 2 |
| Stage 2 - Wet oils % | > 50 | > 50 | > 50 | | | | | ISO 13357 Part 1 |

**Note:**

(1) Denison Instructions: Consult Standard TP-02100.
(2) If < 100°C to do seal test DIN 51524.
(3) 600 seconds maximum. Do not exceed twice the filtration time without water.
(4) Increasing in Dry Phase: 100mbar, in Wet Phase: 600mbar.



Afton CHEMICAL

## Parker Denison Hydraulic Requirements - TP30560 – Cont'd

04 April 2012

| Test | HF-0 | HF-1 | HF-2 | HF-3 | HF-4 | HF-5 | HF-6 | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|
| Demulsibility at 54°C | 40/37/3 (30 minutes) | 40/37/3 (30 minutes) | 40/37/3 (30 minutes) | | | | 40/37/3 (30 minutes) | D1401 |
| Sludge and Corrosion | | | | | | | | D4310 [5] |
| Neutralisation Number after 1000 hrs max. | 1 mg KOH | 1 mg KOH | 1 mg KOH | | | | 1 mg KOH | |
| Insoluble Sludge max. | 100 mg | 100 mg | 100 mg | | | | 100 mg | |
| Total Copper max. | 200 mg | 200 mg | 200 mg | | | | 200 mg | |
| Thermal Stability | | | | | | | | CINCINNATI P70 (ISO 46) |
| After 168 hrs at 135°C | | | | | | | | |
| Sludge max. | 100mg/100ml | 100mg/100ml | 100mg/100ml | | | | 100mg/100ml | |
| Copper Wt. loss | 10 mg | 10 mg | 10 mg | | | | 10 mg | |
| Copper rod rating | Report | Report | Report | | | | Report | |
| Hydrolytic Stability | | | | | | | | D2619 |
| Copper specimen wt. loss max. | 0.2 mg/cm$^2$ | 0.2 mg/cm$^2$ | 0.2 mg/cm$^2$ | | | | 0.2 mg/cm$^2$ | |
| Acidity of Water Layer max. | 4.0 mg KOH | 4.0 mg KOH | 4.0 mg KOH | | | | 4.0 mg KOH | |
| FZG, Load stage before damage, m/m | 9 Pass | 9 Pass | 9 Pass | | | | 9 Pass | DIN 51524 Part 2 |
| Deaeration | | | | | | | | ASTM 3427 or NFT 60-149 @ 30 cSt constant |
| ISO 32 @ 41°C | < 7 min | < 7 min | < 7 min | < 7 min | < 7 min | < 7 min | < 7 min | |
| ISO 46 @ 50°C | < 7 min | < 7 min | < 7 min | < 7 min | < 7 min | < 7 min | < 7 min | |
| ISO 68 @ 59°C | < 7 min | < 7 min | < 7 min | < 7 min | < 7 min | < 7 min | < 7 min | |
| Pump Wear max. (vanes + pins) | 15 mg | | 15 mg | | | | 15 mg | T6H20C |
| Pump Wear max. for 9 pistons | 300 mg | 300 mg | | | | | 300 mg | T6H20C |
| Shear Test (High VI only) | 15 % | 15 % | 15 % | | | | 15% | KRL (20 hrs) |
| T6H20C | [6] | [6] | [6] | | | | [6] | after 307 hrs |
| T6H20C | [6] | [6] | [6] | | | | [6] | after 608 hrs |

**Note:**
(5) Instructions available on request: Same as used in military specification MIL-H-24459 Appendixes A & B.
(6) Viscosity at 40°C (Start - End) > 40 cSt for ISO 46 (-8 cSt).

## General Motors Hydraulic Lubricant Standards

November 2004

| Specifications | Anti-wear Hydraulic Oil | | | | Zinc-Free Anti-wear Hydraulic Oil | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|
| **Product Code** | **LH-02-1-04** | **LH-03-1-04** | **LH-04-1-04** | **LH-06-1-04** | **LH-02-1-04** | **LH-03-1-04** | **LH-04-1-04** | **LH-06-1-04** | |
| ISO Viscosity grade | 22 | 32 | 46 | 68 | 22 | 32 | 46 | 68 | D2422 |
| Viscosity at 40°C, $mm^2/s$ | 19.8-24.2 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 19.8-24.2 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | D445 |
| Viscosity at 100°C $mm^2/s$ | 4.1 | 5.0 | 6.1 | 7.8 | 4.1 | 5.0 | 6.1 | 7.8 | D445 |
| Viscosity at 0°C $mm^2/s$ | 300 | 420 | 780 | 1400 | 300 | 420 | 780 | 1400 | D 5133 |
| Viscosity Index | 95 | | | | 95 | | | | D2270 |
| A.P.I. Gravity | Report | | | | Report | | | | D287 |
| Flash Point (COC), °C | 175 | 190 | | 195 | 175 | 190 | | 195 | D92 |
| Pour Point, °C | -21 | -18 | -15 | -12 | -21 | -18 | -15 | -12 | D97 |
| Foam | | | | | | | | | D892 |
| Sequence I | 50/0 | | | | 50/0 | | | | |
| Sequence II | 50/0 | | | | 50/0 | | | | |
| Sequence III | 50/0 | | | | 50/0 | | | | |
| Water separability, 30 mins., max. | 40/40/0 | | | | 40/40/0 | | | | D1401 |
| Air Release at 50°C (IP 313), mins. | 5 | | 10 | | 5 | | 10 | | D3427 |
| Copper Corrosion, 3 hrs at 100°C | 1b | | | | 1b | | | | D130 |
| Steel Corrosion, Method B | Pass | | | | Pass | | | | D665 |
| Life TOST, hrs to TAN of 2.0 mg KOH/g | 1500 | | | | 1500 | | | | D943 |
| Cleanliness, as received, max. | 19/16/13 | | | | 19/16/13 | | | | ISO 4406 |
| Acid number, max. | 1.0 | | | | 1.0 | | | | D664 |
| Zn in final product, ppm, max. | 1000 | | | | 10 | | | | D4628 |
| Water, as received, ppm max. | 200 | | | | 200 | | | | D6304 |
| Thermal stability | | | | | | | | | D2070 |
| Acid number change, % max. | +/- 50 | | | | +/- 50 | | | | |
| Viscosity change, 40/100°C, % max. | 5 | | | | 5 | | | | |
| Sludge, mg/100ml max. | 25 | | | | 25 | | | | |
| Cu rod colour (Cin. Mil), max. | 5 | | | | 5 | | | | |
| Cu weight loss, mg max. | 10 | | | | 10 | | | | |
| Steel rod colour (Cin. Mil), max. | No discolouration | | | | No discolouration | | | | |



Afton CHEMICAL

## General Motors Hydraulic Lubricant Standards – Cont'd

November 2004

| Specifications | Anti-wear Hydraulic Oil | | | | Zinc-Free Anti-wear Hydraulic Oil | | | | ASTM |
|---|---|---|---|---|---|---|---|---|---|
| Product Code | LH-02-1-04 | LH-03-1-04 | LH-04-1-04 | LH-06-1-04 | LH-02-1-04 | LH-03-1-04 | LH-04-1-04 | LH-06-1-04 | Test Method |
| Compatibility with SRE-NBR 1 seals DIN 53538 (168 hrs, 100°C) | | | | | | | | | D471 |
| Volume change % | 0 to 15 | 0 to 12 | | 0 to 10 | 0 to 15 | 0 to 12 | | 0 to 10 | |
| Shore A hardness change | 0 to -8 | 0 to -7 | | 0 to -6 | 0 to -8 | 0 to -7 | | 0 to -6 | |
| FZG A/8.3/90 | 10 Fail | | | | 10 Fail | | | | DIN 5182 |
| Filterability | | | | | | | | | TP-02100 |
| Without water, sec., max. | 600 | | | | 600 | | | | |
| With 2% water, max. | Not to exceed double the time without water | | | | Not to exceed double the time without water | | | | |
| Hydrolytic stability | | | | | | | | | D2619 |
| Cu weight loss, mg/cm$^2$ max. | 0.2 | | | | 0.2 | | | | |
| Acidity of water layer, mgKOH, max. | 4 | | | | 4 | | | | |
| Vickers 35VQ25 Pump Test | | | | | | | | | Vickers M-2952-S IP 281 |
| Ring Wear, mg, max. | 10 | | | | 10 | | | | |
| Vane Wear, mg, max. | 50 | | | | 50 | | | | |
| Denison Pump Test | | | | | | | | | T6H20C |
| Ring and vane wear | HF-0 Approval | | | | HF-0 Approval | | | | |
| Piston wear | | | | | | | | | |

# JCMAS HK (JCHASP 041:2004) Hydraulic Fluid for Construction Machinery

June 2007

| Requirements | Normal Temperature Use | | Low Temperature Use | | Test Method | |
|---|---|---|---|---|---|---|
| | VG32 | VG46 | VG32W | VG46W | ASTM | Others |
| ISO Viscosity grade | VG32 | VG46 | VG32 | VG46 | D2422 | ISO3448 |
| Physical and Chemical Properties | | | | | | |
| Flash Point, °C | Report | | | | D92 | ISO2592 |
| Kinematic Viscosity at 40°C, cSt | 28.8-35.2 | 41.4-50.6 | 28.8-35.2 | 41.4-50.6 | D445<br>D2270 | ISO3104<br>ISO2909 |
| Kinematic Viscosity at 100°C, cSt, min. | 5.0 | 6.1 | 5.3 | 6.8 | | |
| Viscosity Index, min. | 90 | 90 | 120 | 120 | | |
| Pour Point, °C, max. | -17.5 | -15 | -40 | -30 | D97 | ISO3016 |
| Low Temperature Viscosity (Brookfield), mPa.s | - | - | 5000 max. at -25°C | 5000 max. at -20°C | D2883 | JPI5S26 |
| Foaming Tendency / Stability | | | | | D892 | ISO6247 |
| at 24°C, ml, max. | 50 / 0 | | | | | |
| at 93.5°C, ml, max. | 50 / 0 | | | | | |
| at 24°C after 93.5°C, ml, max. | 50 / 0 | | | | | |
| Shear Stability, Viscosity Loss Ratio at 100°C, %, max. | - | | 10 | | D5821 | JPI5S29 |
| Oxidation Stability (TOST:95°C, 1000 hrs.) | | | | | D943 | ISO4263 |
| Acid Number Increase, mgKOH/g, max. | 1.0 | | | | | |
| Rust-Preventing, Characteristics (synthetic sea water, 24 hrs.) | No rust to be identified | | | | D665 | ISO7120 |
| Elastomer Compatibility (NBR, 120°C, 240 hrs.)(1) | | | | | D2240<br>D471 | ISO13226 |
| Change in Hardness, Grade, min. | -25 | | | | | |
| Change in Tensile, %, max. | -50 | | | | | |
| Change in Elongation, %, max. | -50 | | | | | |
| Change in Volume, %, max. | 0 - +30 | | | | | |
| Elastomer Compatibility (AU, 120°C, 240 hrs.)(2) | | | | | D2240<br>D471 | ISO13226 |
| Change in Hardness, Grade | -5 to +5 | | | | | |
| Change in Tensile, %, max. | -30 | | | | | |
| Change in Elongation, %, max. | -30 | | | | | |
| Change in Volume, % | -5 to +5 | | | | | |
| Aniline Point, °C, min. | 90 | | | | D611 | ISO2977 |
| Filterability, Komatsu Method, mins., max. | 25 for 1st test and 30 for 2nd test | | | | - | JCMAS P043 |
| Copper Corrosion (100°C, 3 hrs), max. | 1 | | | | D130 | ISO2160 |

**Note:**

(1) NBR in this specification is a low nitrile type elastomer specified in ISO13226.

(2) AU in this specification is a urethane type elastomer specified in JCMAS P040.



Afton CHEMICAL

## JCMAS HK (JCHASP 041:2004) Hydraulic Fluid for Construction Machinery – Cont'd

2004

| Requirements | Normal Temperature Use | | Low Temperature Use | | Test Method | |
|---|---|---|---|---|---|---|
| | VG32 | VG46 | VG32W | VG46W | ASTM | Others |
| Mechanical Test Requirements | | | | | | |
| Load Carrying Capacity | | | | | D2783 | JP15S32 |
| Four-Ball weld load, 30g/1200rpm/75°C/ 1 hr, N, min. | 1235 | | | | | |
| Wear Preventive Properties | | | | | | |
| Load Carrying capacity | | | | | | JP15S40 |
| Four-Ball scar diameter, mm, max. | 0.6 | | | | | |
| Load Carrying Capacity | | | | | D5182 | DIN51354 Part 2 |
| FZG A/8, 3/90, Stage, min. | 8 | | | | | |
| High pressure piston Pump Test(3) | | | | | | |
| Komatsu HPV 35+35 Pump Test (34.3MPa/2100rpm/95°C/62.5L/500 hrs.) | Pass (evaluate change of flow rate and used oil and wear of pump parts) | | | | | JCMAS P044 |
| OR Rexworth A2F10 Pump Test(3) (35MPa/1500rpm/80°C/13L/Cu Cat./500 hrs.) | | | | | | JCMAS P045 |
| Viscosity Increase Ratio, %, max. | 10 | | | | | D445 |
| Acid Number Increase, mgKOH/g, max. | 2.0 | | | | | D974 |
| Sludge, 0.8 μ Filter, mg/100ml, max. | 10 | | | | | JIS B 9931 |
| Vane Pump Test(4) | | | | | D6973 | |
| Vickers 35VQ25 Pump Test | | | | | | |
| Ring Wear, mg, max. | 75 | | | | | - |
| Vane Wear, mg, max. | 15 | | | | | - |
| OR Vickers V104C Pump Test | | | | | D2882 | |
| Wear (ring + vane), mg, max. | 50 | | | | | - |
| Friction Characteristics | | | | | | JCMAS P047 |
| Micron Clutch Test, min. | 0.08 | | | | | |
| OR SAE No.2 clutch Test (1000 cycles), $\mu_s$, min.(5) | 0.07 | | | | | JCMAS P047 |

**Note:**

(3) High pressure piston pump performance are evaluated in komatsu HPV35 or Rexroth A2F10.

(4) Vane pump performance are evaluated in Vickers 35VQ25 or Vickers V104C.

(5) Friction characteristics performance are evaluated in micro clutch test or SAE No 2 Test.

# SAE MS1004 Type H Hydraulic Oil Specifications

October 2010

| Specifications | HL Rust and Oxidation | | | | | | | HM Anti-wear | | | | | | | HC (AW + Coolant Compatible) | | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity grade | 10 | 15 | 22 | 32 | 46 | 68 | 100 | 10 | 15 | 22 | 32 | 46 | 68 | 100 | 10 | 15 | 22 | 32 | 46 | 68 | 100 | D2422 |
| Viscosity at 40°C, mm²/s | ISO Grade +/- 10% | | | | | | | ISO Grade +/- 10% | | | | | | | ISO Grade +/- 10% | | | | | | | D445 |
| Viscosity Index, min. | Report | | | | | | | 95 | | | | | | | 95 | | | | | | | D2270 |
| Density @ 15°C, g/ml | To be specified by supplier | | | | | | | To be specified by supplier | | | | | | | To be specified by supplier | | | | | | | D287 |
| Flash Point (COC), °C, min. | 125 | | 165 | 175 | 185 | 195 | 205 | 125 | | 165 | 175 | 185 | 195 | 205 | 125 | | 165 | 175 | 185 | 195 | 205 | D92 |
| Pour Point, °C, max. | -30 | -25 | -21 | -18 | -15 | -12 | -1 | -30 | -25 | -21 | -18 | -15 | -12 | -1 | -30 | -25 | -21 | -18 | -15 | -12 | | D97 |
| Foam | | | | | | | | | | | | | | | | | | | | | | D892 |
| Seq I, max. | 50/0 | | | | | | | 50/0 | | | | | | | 50/0 | | | | | | | |
| Seq II, max. | 50/0 | | | | | | | 50/0 | | | | | | | 50/0 | | | | | | | |
| Seq III, max. | 50/0 | | | | | | | 50/0 | | | | | | | 50/0 | | | | | | | |
| Water separability @ 54°C, min., max. | 30 | | 30 | | | 60 | | 30 | | 30 | | | 60 | | 30 | | 30 | | | 60 | | D1401 |
| Water separability @ 82°C, min., max. | | | | | | | 60 | | | | | | | 60 | | | | | | | 60 | D1401 |
| Air Release (IP 313), mins., max. | 5 | | | | 10 | | | 5 | | | | 10 | | | 5 | | | | 10 | | | D3427 |
| Copper Corrosion, 3 hrs. at 100°C, max. | 2 | | | | | | | 2 | | | | | | | 2 | | | | | | | D130 |
| Steel Corrosion, Method A or B | Pass | | | | | | | Pass | | | | | | | Pass | | | | | | | D665 |
| 1000 hrs. TOST, TAN mg KOH/g, max. run w/at water for environmentally acceptable fluids | 2 | | | | | | | 2 | | | | | | | 2 | | | | | | | D943-04A |
| Oxidation stability, max increase in TAN at 1500h mg KOH/g | 2.0 | | | | | | | 2.0 | | | | | | | 2.0 | | | | | | | D943 |
| Cleanliness, as received, max. | 19/16/13 | | | | | | | 19/16/13 | | | | | | | 19/16/13 | | | | | | | ISO 4406 |
| Neutralization number, mg KOH/g, max. | To be specified by supplier | | | | | | | To be specified by supplier | | | | | | | To be specified by supplier | | | | | | | D664 |
| Water content, ppm, max. | 200 | | | | | | | 200 | | | | | | | 200 | | | | | | | D95 |
| Metals content by ICP, ppm | To be specified by supplier | | | | | | | To be specified by supplier | | | | | | | To be specified by supplier | | | | | | | D5185 |
| Sulfur | To be specified by supplier | | | | | | | To be specified by supplier | | | | | | | To be specified by supplier | | | | | | | D4294 |
| Coolant Compatibility Test | | | | | | | | | | | | | | | | | | | | | | |
| Volume of MRF seperated from hydraulic fluid in 1h, ml | N/A | | | | | | | N/A | | | | | | | $\geq 2$ | | | | | | | |
| Water content of oil phase, % | | | | | | | | | | | | | | | $\leq 0.5$ | | | | | | | |

# SAE MS1004 Type H Hydraulic Oil Specifications – Cont'd

October 2010

| Specifications | HL Rust and Oxidation | | | | | | | HM Anti-wear | | | | | | | HC (AW + Coolant Compatible) | | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity grade | 10 | 15 | 22 | 32 | 46 | 68 | 100 | 10 | 15 | 22 | 32 | 46 | 68 | 100 | 10 | 15 | 22 | 32 | 46 | 68 | 100 | D2422 |
| Thermal stability | | | | | | | | | | | | | | | | | | | | | | D2070 |
| Acid number change, %, max. | +/- 50 | | | | | | | +/- 50 | | | | | | | +/- 50 | | | | | | | |
| Viscosity change, 40/100°C, %, max. | 5 | | | | | | | 5 | | | | | | | 5 | | | | | | | |
| Sludge, mg/100ml, max. | 25 | | | | | | | 25 | | | | | | | 25 | | | | | | | |
| Cu rod colour (Cin. Mil), max. | 5 | | | | | | | 5 | | | | | | | 5 | | | | | | | |
| Cu weight loss, mg, max. | 10 | | | | | | | 10 | | | | | | | 10 | | | | | | | |
| Steel rod colour (Cin. Mil), max. | No discolouration | | | | | | | No discolouration | | | | | | | No discolouration | | | | | | | |
| Compatibility with SRE-NBR 1 seals DIN 53538 (168 hrs, 100°C)(1) | | | | | | | | | | | | | | | | | | | | | | D471 |
| Volume change % | 0 to 18 | | 0 to 15 | 0 to 12 | | 0 to 10 | | 0 to 18 | | 0 to 15 | 0 to 12 | | 0 to 10 | | 0 to 18 | | 0 to 15 | 0 to 12 | | 0 to 10 | | |
| Shore A hardness change | 0 to -10 | | 0 to -8 | 0 to -7 | | 0 to -6 | | 0 to -10 | | 0 to -8 | 0 to -7 | | 0 to -6 | | 0 to -10 | | 0 to -8 | 0 to -7 | | 0 to -6 | | |
| FZG A/8.3/90[4] | | | | | | | | | | | | 11 fail | | | | | | | 11 fail | | | D5182 |
| Hydrolytic stability | | | | | | | | | | | | | | | | | | | | | | D2619 |
| Cu weight loss, mg/cm² max. | 0.2 | | | | | | | 0.2 | | | | | | | 0.2 | | | | | | | |
| Acidity of water layer, mg KOH, max. | 4 | | | | | | | 4 | | | | | | | 4 | | | | | | | |
| Vickers 35VQ25 Pump Test | | | | | | | | | | | | | | | | | | | | | | D2882 |
| Ring + Vane Wear, mg, max. | | | | | | | | 90 | | | | | | | 90 | | | | | | | |
| Parker Hannifin-Denison Vane and Piston Pump Test | HF-1 | | | | | | | HF-0 | | | | | | | HF-0 | | | | | | | T 6HZOC |

**Note:**

(1) The definition of compatibility for types of elastomers other then NBR 1 (e.g. FPM, EPDM, AU) may be agreed between the supplier and the end-user.

# AGMA 9005-E02 Anti Scuff / Anti-wear E.P. Oils

December 2002

| Test | ASTM Test Method | Requirements | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity grade | D2422 | 32 | 46 | 68 | 100 | 150 | 220 | 320 | 460 | 680 | 1000-3200 | > 3200 |
| Viscosity at 40°C, $mm^2/s$ | D445 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90.0-110 | 135-165 | 198-242 | 288-352 | 414-506 | 612-748 | 900-2420 | 2880-3520 |
| Viscosity at 100°C, $mm^2/s$ | D445 | Report | | | | | | | | | | |
| Viscosity index, min. | D2270 | 90 | | | | | | | | 85 | | Report |
| Bulk fluid dynamic viscosity at cold start-up, mPa/s, max. | D2983 | 150,000 | | | | | | | | | | |
| Flash Point, °C, min. | D92 | 180 | | | 200 | | | | | | | |
| Resistance to aging at 121°C - max., % increase in kinematic viscosity at 100°C | D2893 | 6 | | | | | | 8 | 10 | 15 | Report | |
| Water content, ppm, max. | D6304 | 300 | | | | | | | | | | Report |
| Foam suppression | D892 | | | | | | | | | | | |
| Volume of foam (ml), max., after: | | 5 Minutes Blow | | | | | | 10 Minutes Settle | | | 5 Minutes Blow | 10 Minutes Settle |
| Seq I at 24°C | | 50 | | | | | | 0 | | | 75 | 10 |
| Seq II at 93.5°C | | 50 | | | | | | 0 | | | 75 | 10 |
| Seq III at 24°C | | 50 | | | | | | 0 | | | 75 | 10 |
| Cleanliness | None visual | Must be free of visible suspended or settled contaminants at the time it is installed for use | | | | | | | | | | |
| Water separation | D2711 (Procedure B) | | | | | | | | | | | |
| % $H_2O$ in oil after 5 hr test, max. | | 2.0 | | | | | | | 2.0 | | | Report |
| Cuff after centrifuging, ml, max. | | 1.0 | | | | | | | 4.0 | | | Report |
| Total free $H_2O$ collected during entire test starting with 90 ml $H_2O$, ml, min. | | 80.0 | | | | | | | 50.0 | | | Report |
| Rust prevention, Part B | D665 | Pass | | | | | | | | | | |
| Copper corrosion prevention, 3 hrs @ 100°C, rating, max. | D130 | 1b | | | | | | | | | | |
| Scuffing load capacity, FZG visual method, A/8.3/90, fail stage, min. | D5182 | 10 | | 12 | | | >12 | | | | | |

## AIST Requirements No. 224 Lead Free E.P. Gear Oil 2010

| Test | Limits |
|---|---|
| A.P.I. Gravity, D287 | 25 min. |
| Viscosity Index, D2270 | 95 min. |
| Precipitation Number, D91 | Trace |
| Pour Point, D97 | -9°C max. (based on viscosity) |
| Flash Point (COC), D92 | |
| ISO Grade 150 and up | 232.2°C min. |
| ISO Grade 68 and 100 | 204.4°C min. |
| 3 hrs. Copper Strip Corrosion, D130 | 1b max. |
| Rust Test (A & B), D665 | Pass |
| S-200 Oxidation - 312 hrs. at 121°C (250°F) | |
| Viscosity Increase at 100°C (210°F) | 6% max. |
| Precipitation Number After Test | 0.1 max. |
| Demulsibility, D2711 | |
| Free Water | 80.0 ml min. |
| Emulsion | 1.0 ml max. |
| $H_2O$ in Oil | 2.0% max. |
| Four-Ball E.P. Test, D2783 | |
| Load Wear Index | 45 kg min. |
| Weld Point | 250 kg min. |
| Four-Ball Wear Test, D2266 | |
| 20 kg. at 1800 rpm for 1 hr, 55°C | Scar Diameter 0.35 mm max. |
| Timken Load Arm Test, D2782 | 60 lbs min. |
| FZG - Four Square Gear Test | 11th stage min. |

## Chinese National Specification – GB 5903-2011

| Technical Requirements and Test Methods of L-CKB | | | | | | |
|---|---|---|---|---|---|---|
| Test | Chinese Method | ISO/ASTM (Equivalent) | Performance Specs | | | |
| ISO Viscosity grade | GB/T 3141 | ISO 3448 | 100 | 150 | 220 | 320 |
| Viscosity @ 40°C, $mm^2/s$ | GB/T 265 | ASTM D445 | 90.0-11.0 | 135-165 | 198-242 | 288-352 |
| Viscosity Index, min. | GB/T 1995[(1)] | ASTM D2270 | 90 min. | | | |
| Flash Point (Open cup, COC), °C | GB/T 3536 | ASTM D92 | 180 min. | 200 min. | | |
| Pour Point, °C | GB/T 3535 | ASTM D97 | -8 max. | | | |
| Water, % wt | GB/T 260 | ASTM D95 | Trace max. | | | |
| Mechanical Impurity, % wt | GB/T 511 | Russian ГОСТ6370 | 0.01 max. | | | |
| Copper Corrosion @ 100°C, 3 hrs | GB/T 5096 | ASTM D130 | 1 max. | | | |
| Rust Test Synthetic Sea Water | GB/T 11143 | ASTM D665B | No rust | | | |
| Oxidation Stability, Time for TAN to 2.0 mgKOH/g, hrs | GB/T 12581 | ASTM D943 | 750 min. | | 500 min. | |
| RPVOT @ 150°C, min. | SH/T 0193 | ASTM D2272 | Report | | | |
| Foam | GB/T 12579 | ASTM D892 | | | | |
| Seq I, 24°C | | | 75/10 max. | | | |
| Seq II, 93.5°C | | | 75/10 max. | | | |
| Seq III, 24°C (after) | | | 75/10 max. | | | |
| Demulsibility (82°C) | GB/T 8022 | ASTM D2711 | | | | |
| Water in Oil, % vol | | | 0.5 max. | | | |
| Emulsion layer, ml | | | 2.0 max. | | | |
| Total Separated Water, ml | | | 30.0 min. | | | |

**Note:**
(1) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.



Afton CHEMICAL

## Chinese National Specification – GB 5903-2011 – Cont’d

<table>
<tr><th colspan="14">Technical Requirements and Test Methods of L-CKC</th></tr>
<tr><th colspan="2">Test</th><th>Chinese Method</th><th>ISO/ASTM (Equivalent)</th><th colspan="11">Performance Specs</th></tr>
<tr><td colspan="2">ISO Viscosity Grade</td><td>GB/T 3141</td><td>ISO 3448</td><td>32</td><td>46</td><td>68</td><td>100</td><td>150</td><td>220</td><td>320</td><td>460</td><td>680</td><td>1000</td><td>1500</td></tr>
<tr><td colspan="2">Viscosity @ 40°C, mm²/s</td><td>GB/T 265</td><td>ASTM D445</td><td>28.8-35.2</td><td>41.4-50.6</td><td>61.2-74.8</td><td>90.0-110</td><td>135-165</td><td>198-242</td><td>288-352</td><td>414-506</td><td>612-748</td><td>900-1100</td><td>1350-1650</td></tr>
<tr><td colspan="2">Appearance</td><td>Visual (1)</td><td>-</td><td colspan="11">Bright & Clear</td></tr>
<tr><td colspan="2">Viscosity @ 100°C, mm²/s</td><td>GB/T 265</td><td>ASTM D445</td><td colspan="11">Report</td></tr>
<tr><td colspan="2">Viscosity Index</td><td>GB/T 1995 (2)</td><td>ASTM D2270</td><td colspan="8">90 min.</td><td colspan="3">85 min.</td></tr>
<tr><td colspan="2">Temperature for Apparent Viscosity to 1500,000 mPa·s, °C</td><td>GB/T 11145</td><td>ASTM D2983</td><td colspan="11">(3)</td></tr>
<tr><td colspan="2">Pour Point, °C</td><td>GB/T 3535</td><td>ASTM D97</td><td colspan="4">-12 max.</td><td colspan="4">-9 max.</td><td colspan="3">-5 max.</td></tr>
<tr><td colspan="2">Flash Point (Open Cup, COC), °C</td><td>GB/T 3536</td><td>ASTM D92</td><td colspan="3">180 min.</td><td colspan="8">200 min.</td></tr>
<tr><td colspan="2">Water, % wt</td><td>GB/T 260</td><td>ASTM D95</td><td colspan="11">Trace max.</td></tr>
<tr><td colspan="2">Mechanical Impurity, % wt</td><td>GB/T 511</td><td>Russian ГОСТ6370</td><td colspan="11">0.02 max.</td></tr>
<tr><td colspan="2">Foam</td><td rowspan="4">GB/T 12579</td><td rowspan="4">ASTM D892</td><td colspan="9"></td><td colspan="2"></td></tr>
<tr><td></td><td>Seq I 24°C</td><td colspan="9">50/0 max.</td><td colspan="2">75/10 max.</td></tr>
<tr><td></td><td>Seq II 93.5°C</td><td colspan="9">50/0 max.</td><td colspan="2">75/10 max.</td></tr>
<tr><td></td><td>Seq III 24°C (after)</td><td colspan="9">50/0 max.</td><td colspan="2">75/10 max.</td></tr>
<tr><td colspan="2">Copper Corrosion @ 100°C, 3 hrs</td><td>GB/T 5096</td><td>ASTM D130</td><td colspan="11">1 max.</td></tr>
<tr><td colspan="2">Demulsibility (82°C)</td><td rowspan="4">GB/T 8022</td><td rowspan="4">ASTM D2711</td><td colspan="7"></td><td colspan="4"></td></tr>
<tr><td></td><td>Water in Oil, % vol</td><td colspan="7">2.0 max.</td><td colspan="4">2.0 max.</td></tr>
<tr><td></td><td>Emulsion layer, ml</td><td colspan="7">1.0 max.</td><td colspan="4">4.0 max.</td></tr>
<tr><td></td><td>Total Separated Water, ml</td><td colspan="7">80.0 min.</td><td colspan="4">50.0 min.</td></tr>
</table>

**Note:**
(1) A sample of 30ml-50ml is put into a clean measuring cylinder for 10 minutes at ambient temperature, then observed under normal light.
(2) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.
(3) This item shall be tested according to the user’s requirements.

## Chinese National Specification – GB 5903-2011 – Cont'd

| Technical Requirements and Test Methods of L-CKC – Cont'd | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Chinese Method** | **ISO/ASTM (Equivalent)** | **Performance Specs** | | | | | | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 32 | 46 | 68 | 100 | 150 | 220 | 320 | 460 | 680 | 1000 | 1500 |
| Rust Test @ Synthetic Sea Water | GB/T 11143 | ASTM D665B | No rust | | | | | | | | | | |
| Oxidation Stability (95°C, 312hrs) | SH/T 0123 | ASTM D2893 | | | | | | | | | | | |
| Increase of Viscosity @ 100°C, % | | | 6 max. | | | | | | | | | | |
| Precipitate, ml | | | 0.1 max. | | | | | | | | | | |
| Timken, OK Load, N (lb) | GB/T 11144 | ASTM D2782 | 200 (45) min. | | | | | | | | | | |
| FZG, Failure Load Stage | SH/T 0306 | IP 334-80 | 10 min. | | 12 min. | | | > 12 min. | | | | | |
| Shear Stability (gear test) (90°C/6 stages/2980rpm, 20hr/800g sample) Viscosity @ 40°C after shear, $mm^2/s$ | SH/T 0200 | IP351-81 | To stay within the range of each viscosity grade | | | | | | | | | | |

# Chinese National Specification – GB 5903-2011 – Cont'd

**Technical Requirements and Test Methods of L-CKD**

| Test | Chinese Method | ISO/ASTM (Equivalent) | Performance Specs | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 68 | 100 | 150 | 220 | 320 | 460 | 680 | 1000 |
| Viscosity @ 40°C, mm²/s | GB/T 265 | ASTM D445 | 61.2-74.8 | 90.0-110 | 135-165 | 198-242 | 288-352 | 414-506 | 612-748 | 900-1100 |
| Appearance | Visual (1) | - | Bright & Clear | | | | | | | |
| Viscosity @ 100°C, mm²/s | GB/T 265 | ASTM D445 | Report | | | | | | | |
| Viscosity Index | GB/T 1995 (2) | ASTM D2270 | 90 min. | | | | | | | |
| Temperature for Apparent Viscosity to 1500,000 mPa·s, °C | GB/T 11145 | ASTM D2983 | (3) | | | | | | | |
| Pour Point, °C | GB/T 3535 | ASTM D97 | -12 max. | | -9 max. | | | | -5 max. | |
| Flash Point (Open Cup, COC), °C | GB/T 3536 | ASTM D92 | 180 min. | 200 min. | | | | | | |
| Water, % wt | GB/T 260 | ASTM D95 | Trace max. | | | | | | | |
| Mechanical Impurity, % wt | GB/T 511 | Russian ГОСТ6370 | 0.02 max. | | | | | | | |
| Foam | GB/T 12579 | ASTM D892 | | | | | | | | |
| Seq I 24°C | | | 50/0 max. | | | | | | | 75/10 max. |
| Seq II 93.5°C | | | 50/0 max. | | | | | | | 75/10 max. |
| Seq III 24°C (after) | | | 50/0 max. | | | | | | | 75/10 max. |
| Copper Corrosion @ 100°C, 3 hrs | GB/T 5096 | ASTM D130 | 1b max. | | | | | | | |
| Demulsibility (82°C) | GB/T 8022 | ASTM D2711 | | | | | | | | |
| Water in Oil, % vol | | | 2.0 max. | | | | | | | 2.0 max. |
| Emulsion layer, ml | | | 1.0 max. | | | | | | | 4.0 max. |
| Total Separated Water, ml | | | 80.0 min. | | | | | | | 50.0 min. |

**Note:**
(1) A sample of 30ml-50ml is put into a clean measuring cylinder for 10 minutes at ambient temperature, then observed under normal light.
(2) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.
(3) This item shall be tested according to the user's requirements.



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# Chinese National Specification – GB 5903-2011 – Cont'd

| Technical Requirements and Test Methods of L-CKD – Cont'd | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Chinese Method** | **ISO/ASTM (Equivalent)** | | | | | | | | |
| ISO Viscosity Grade | GB/T 3141 | ISO 3448 | 68 | 100 | 150 | 220 | 320 | 460 | 680 | 1000 |
| Rust Test @ Synthetic Sea Water | GB/T 11143 | ASTM D665B | No rust | | | | | | | |
| Oxidation Stability (95°C, 312hrs) | SH/T 0123 | ASTM D2893 | | | | | | | | |
| Increase of Viscosity @ 100°C, % | | | 6 max. | | | | | | | Report |
| Precipitate, ml | | | 0.1 max. | | | | | | | Report |
| Timken, OK Load, N (lb) | GB/T 11144 | ASTM D2782 | 267 (60) min. | | | | | | | |
| FZG, Failure Load Stage | SH/T 0306 | IP 334-80 | 12 min. | | | > 12 min. | | | | |
| Shear Stability (gear test) (90°C/6 stages/2980rpm, 20hr/800g sample) Viscosity @ 40°C after shear, mm²/s | SH/T 0200 | IP351-81 | To stay within the range of each viscosity grade | | | | | | | |
| 4 Ball Test | GB/T 3142 | ASTM D2783 | | | | | | | | |
| Weld Load Pd, N (kgf) | | | 2450 (250) min. | | | | | | | |
| LWI, N (kgf) | | | 411 (45) min. | | | | | | | |
| Wear Scar (196N, 1 hr, 54°C, 1800rpm), mm | SH/T 0189 | ASTM D4172 | 0.35 max. | | | | | | | |

# DIN 51517 Part 3 - Lubricating Oils CLP

August 2011

| Lubricant Type | CLP 32 | CLP 46 | CLP 68 | CLP 100 | CLP 150 | CLP 220 | CLP 320 | CLP 460 | CLP 680 | CLP 1000 | CLP 1500 | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity grade | 32 | 46 | 68 | 100 | 150 | 220 | 320 | 460 | 680 | 1000 | 1500 | - |
| Viscosity at 40°C, mm²/s | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90-110 | 135-165 | 198-242 | 288-352 | 414-506 | 612-748 | 900-1100 | 1350-1650 | DIN EN ISO 3104 |
| Viscosity Index | 90 | | | | | | | | 85 | | | DIN/ISO 2909 |
| Flash Point (COC), °C | 180 | | | 200 | | | | | | | | DIN EN ISO 2592 |
| Pour Point °C | -12 | | | | -9 | | | | -3 | | | DIN/ISO 3016 |
| Neutralisation Number, mg KOH/g | Report | | | | | | | | | | | DIN 51558-1 |
| Density at 15°C, kg/m³ | Report | | | | | | | | | | | DIN 51757 |
| Water Content, % | <0.1 max | | | | | | | | | | | DIN 51777-2 |
| Foam after 10 mins., Sequence I, II & III | 100/10 | | | | | | | 150/60 | | | | ISO 6427 |
| Water Separability @ 54°C, mins., max. | 30 | 30 | 30 | - | - | - | - | - | - | - | - | DIN ISO 6614 |
| Water Separability @ 82°C, mins., max. | - | - | - | 30 | 30 | 30 | 30 | 45 | 60 | 60 | 60 | |
| Copper Corrosion, 3 hrs at 100°C | 1 max. | | | | | | | | | | | DIN EN ISO 2160 |
| Steel Corrosion, Method A | Pass | | | | | | | | | | | DIN/ISO 7120 |
| Oxidation Stability, 95°C for 312 hrs | | | | | | | | | | | | DIN EN ISO 4263-4 |
| Increase in viscosity at 100°C, % | 6 max. | | | | | | | | | | | |
| Precipitation number, % | 0.1 max. | | | | | | | | | | | |
| FZG Scuffing Test, A/8.3/90 | 12 Fail min. | | | | | | | | | | | DIN ISO 14635-1 |
| FAG FE-8 bearing wear test | | | | | | | | | | | | DIN 51819-3 |
| Roller wear, mg | 30 max. | | | | | | | | | | | |
| Cage wear, mg | Report | | | | | | | | | | | |
| Compatibility with Seals SRE-NBR 28, 7 days @ 100°C | | | | | | | | | | | | DIN ISO 1817 |
| Relative change in volume, % max. | 0 to +10 | | | | | | | | | | | |
| Change of Shore A hardness, % max. | 10 to +5 | | | | | | | | | | | |
| Change of Tensile strength, % max. | 30 | | | | | | | | | | | |
| Change of Elongation, % max. | 40 | | | | | | | | | | | |

# Siemens Specification for Flender Gear Oils Revision 14

December 2013

| Sustainability proofs of performance (to be established by test results) | To use for the test the following Viscosity of a homologous row | | | Quantity of test oil (Litre) | Mineral oils | PG oils | Other oils |
|---|---|---|---|---|---|---|---|
| | Lowest | Defined | Highest | | | | |
| | Obtained Limits | | | | | | |
| AFZG Scuffing test in accordance with DIN ISO 14635-1 (a/8.3/90) (b) | A | | | ≈5 | A | A | A |
| | Criteria: Failure load stage > 12 | | | | | | |
| FE-8 rolling bearing test in accordance with DIN 51819-3 (D-7,5/80-80) (b) | A | | | ≈5 | A | A | A |
| | Roller wear: mwk50 < 30mg and mwkmax <60mg as well as the declaration of the grade ß, Cage wear: report | | | | | | |
| Compatibility with internal coating (P22-8050, Nuvopur Aqua Primer 510.1.6.1400) in accordance to “Test specification for oil compatibility with the gear inside coating in Flender gear units”. Revision 1 (b) | A | | | 2 + 2 | A | A | A |
| | Test and evaluation are carried out by the paint manufacturer | | | | | | |
| Compatibility with liquid sealing compound (Loctute128068) (b) | A | | | 1 | A | A | A |
| | Test and evaluation are carried out by the sealing compound manufacturer | | | | | | |
| FLENDER - oil foam test in acc. ISO 12152<br>– Original oil<br>– with mixtures of 2% and 4%<br>I: Mineral oil, PAO, synth. Ester with Castrol Alpha SP 220S Running-in-oil<br>II: PG with Trbol 1390 running-in-oil (b) | | | A | ≈5 | A | A | A |
| | Total volume 1 minute after motor was switched off: ≤115%<br>Air-oil dispersion 5 minutes after motor was switched off: ≤110% | | | | | | |
| FVA micropitting test FVA 54 VII Two tests are to be carried out on the working and non-working flanks of a gear pair, tooth form C, at 90°C oil injection temperature, on the FZG gear test rig. (b) | A | | | 70 | A | A | A |
| Number of LS10-steps in the endurance test, which are regarding $F_{fg}$ and GF evaluabe: z10 | Load Stage test: Both flanks after LS9: $F_{fg}$ < 7,5 µm and GF < 15%<br>Endurance test:<br>• At least two regarding $F_{fg}$ and GF evaluable LS10-steps, if necessary endurance test can run on the back flank also<br>• $(F_{fg\ total} - F_{fg\ after\ LS8}) / z10 \leq 2$ µm<br>• $(GF_{total} - GF_{after\ LS8}) / z10 \leq 5\%$ | | | | | | |
| Compatibility with elastomer shaft seals Static test<br>a) 72 NBR 902<br>b) 75 FKM 585<br>c) 75 FKM 260466<br>Test has to be carried out in accordance with test description FB 73 11 008 “Static and dynamic compatibility tests of oils with Freudenberg Simmerrings for the approval of use in FLENDER GEAR UNITS”. Revision 05 (b) (c) | A<br>A<br>A | | A<br>A<br>A | 1 + 1<br>1 + 1<br>1 + 1 | A<br>A | A<br>A<br>A | A<br>A<br>A |
| | Test and evaluation are carried out by the elastomer manufacturer | | | | | | |

## Siemens Specification for Flender Gear Oils Revision 14

December 2013

| Sustainability proofs of performance (to be established by test results) | To use for the test the following Viscosity of a homologous row: Lowest | Defined | Highest | Quantity of test oil (Litre) | Mineral oils | PG oils | Other oils |
|---|---|---|---|---|---|---|---|
| | Obtained Limits | | | | | | |
| Compatibility with elastomer shaft seals<br>Dynamic test<br>a) 72 NBR 902 / 2 RWDR (n=2000 rpm)<br>b) 75 FKM 585 / 2 RWDR (n=3000 rpm)<br>c) 75 FKM 585 / 3 RWDR (n=3000 rpm)<br>d) 75 FKM 585 / 3 RWDR (n=1500 rpm)<br>e) 75 FKM 260466 / 2 RWDR (n=3000 rpm) | A<br>A<br>A<br>A<br>A | | | 2<br>2<br>2<br>2<br>2 | A<br>A | A<br><br>A<br>B<br>A | A<br><br>A<br>B<br>A |
| Test has to be carried out in accordance with test description FB 73 11 008 "Static and dynamic compatibility tests of oils with Freudenberg Simmerrings for the approval of use in FLENDER GEAR UNITS". Revision 05 [b] [c] | Test and evaluation are carried out by the elastomer manufacturer | | | | | | |
| FE-8 rolling bearing test in accordance with (d-7,5/80-xx)<br>xx - individually defined oil temperature | | B | | ≈5 | B | B | B |
| | Roller wear: mwk50 <30mg and wmkmax <60mg as well as the declaration of the grade ß, Cage wear: report | | | | | | |
| FVA micropitting test FVA 54 VII<br>Two tests are to be carried out on the working and non-working flanks of a gear pair, tooth form C, at individually defined oil injection temperature, on the FZG gear test rig. [b] | | B | | 70 | B | B | B |
| | Load Stage test: Both flanks after LS9: $F_{fg}$ < 7,5 µm and GF < 15%<br>Endurance test:<br>• At least two regarding $F_{fg}$ and GF evaluable LS10-steps, if necessary endurance test can run on the back flank also<br>• $(F_{fg\ total} - F_{fg\ after\ LS8}) / z10 \le 2$ µm<br>• $(GF_{total} - GF_{after\ LS8}) / z10 \le 5\%$ | | | | | | |
| Number of LS10-steps in the endurance test, which are regarding $F_{fg}$ and GF evaluabe: z10 | | | | | | | |
| Compatibility with elastomer shaft seals<br>Dynamic test<br>a) 72 NBR 902 / 2 RWDR (n=2000 rpm)<br>b) 75 FKM 585 / 2 RWDR (n=3000 rpm)<br>c) 75 FKM 585 / 3 RWDR (n=3000 rpm)<br>d) 75 FKM 585 / 3 RWDR (n=1500 rpm)<br>e) 75 FKM 260466 / 2 RWDR (n=3000 rpm) | | B<br>B<br>B<br>B | | 2<br>2<br>2<br>2 | B<br>B | B<br><br>B<br>B | B<br><br>B<br>B |
| Test has to be carried out in accordance with test compatibility tests of oils with Freudenberg Simmerrings for the approval of use in FLENDER GEAR UNITS", Revision 05 with individually defined oil temperature | Test and evaluation are carried out by the elastomer manufacturer | | | | | | |

**Note:**

(1) Flender has a basic requirment for oil to meet CLP quality in accordance with DIN 51517 Part III. Latest DIN specification is dated June 2009.

(2) Must use specified laboratory as mandated by Siemens.

(3) For details on seals ratings please refer to the Freudenberg Test Document FB 73 11 008 Revision 5.



Afton CHEMICAL

## ISO 12925-1:1996 Enclosed Gears of Category CKC

1996*

| Test | Specifications | | | | | | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity grade | VG 32 | VG 46 | VG 68 | VG 100 | VG 150 | VG 220 | VG 320 | VG 460 | VG 680 | VG 1000 | VG 1500 | ISO 3448 |
| Appearance | Bright & Clear | Bright & Clear | Bright & Clear | Bright & Clear | Bright & Clear | Bright | Bright | Bright | Bright | Bright | Bright | (1) |
| Viscosity index, min. | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 85 | 85 | 85 | ISO 2909 |
| Pour Point °C, max. | -12 | -12 | -12 | -12 | -9 | -9 | -9 | -9 | -3 | -3 | -3 | ISO 3016 |
| Flash Point °C, min. | 180 | 180 | 180 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | ISO 2592 |
| Foaming tendancy / stability, max. ml | 100/10 | 100/10 | 100/10 | 100/10 | 100/10 | 100/10 | 100/10 | 100/10 | 100/10 | 100/10 | 100/10 | ISO 6247 |
| Copper corrosion, 3 hrs at 100°C, max. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ISO 2160 |
| Demulsibility: Method: Appendix X2 modification (90 ml water at start): | | | | | | | | | | | | ASTM D2711 |
| Free water, min. ml | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | |
| Emulsion, max. ml | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| Water-in-oil, max. ml | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| Rust Test: Methods A and B | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | ISO 7120 |
| Oxidation stability at 95°C | | | | | | | | | | | | ASTM D2893 |
| Viscosity increase at 100°C, max. % | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | |
| Precipitation number, max. | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | |
| Load-carrying property FZG A/8, 3/90 °C Fail stage, min. | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | DIN 51354-2 |

**Note:**

(1) There is presently no accepted test method. Visual observation is to be reported as indicated. The objective is to ensure that the lubricant does not appear turbid or contain suspended or settled impurities.

ISO 12925-1 Standard also covers other types of gear oils. Refer to official standard for further information.

*cor.1:2002 (E) - issued 15 February 2002.

## SEB 181226 Industrial Gear Specifications

September 2007-09

| Specifications | CLP Type Oils | | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|
| ISO Viscosity grade | 68 | 100 | 150 | 220 | 320 | 460 | 680 | D2422 |
| Viscosity at 40°C, $mm^2/s$ | 64.6-71.4 | 95-105 | 142.5-157.5 | 209-231 | 304-336 | 437-483 | 646-714 | 51562-1 |
| Viscosity Index, min. | 90 | | | | | | | ISO 2909 |
| Density @ 15°C, g/ml | Report | | | | | | | 51757 |
| Flash Point (COC), °C, min. | 210 | | | | | | | ISO 2592 |
| Pour Point, °C, max. | -15 | | -12 | -9 | | -6 | -3 | ISO 3016 |
| Water separability @ 54°C, mins., max. | 10 | | | | | | | ISO 6614 |
| Water separability @ 82°C, mins., max. | | 10 | 20 | | 30 | | 40 | ISO 6614 |
| Air Release (IP 313), mins., max. | 15 | 20 | | 25 | 40 | 55 | 75 | ISO 9120 |
| Foam | | | | | | | | ISO 6247 |
| Sequence I | 50/0 | | | | | | | |
| Sequence II | 50/0 | | | | | | | |
| Sequence III | 50/0 | | | | | | | |
| Copper Corrosion, 3 hrs. at 125°C, max. | 1 | | | | | | | ISO 2160 |
| Steel Corrosion, Method A or B | Pass | | | | | | | 51585 |
| Aging behaviour, TAN after 1000 hrs. at 95°C, mg KOH/g max. | 1.5 | | | | | | | 51587/51558-1 |
| Neutralization number, mg KOH/g max. | Report | | | | | | | 51558-1 |
| Water content, % volume | Below limit of quantitive detectability | | | | | | | ISO 3733 |
| Content of undissolved matter, max. mg/kg | 50 | | | | | | | SEB 181322 |
| Compatibility with SRE-NBR 1 seals DIN 53538 (168 hrs, 100°C) | | | | | | | | 53521 |
| Volume change % | 0 to 8 | | | | | | | 53538-1 |
| Shore A hardness change | 0 to -6 | | | | | | | 53505 |
| FZG A/8.3/90, min. | 12 Pass | | | | | | | DIN ISO 14635-1 |
| FAG FE-8 roller bearing wear, 80kN | | | | | | | | 51819-3 |
| Roller wear, mg, max. | 30 | | | | | | | |
| Cage wear, mg | Report | | | | | | | |
| Conradson Carbon residue, % max. | Report | | | | | | | 51551-1 |
| Halogen content, % | 0.01 | | | | | | | 51408-1 |
| PCB content, mg/kg | Current detection limit | | | | | | | 12766 |
| PAK (PAH) content, mg/kg | 10 | | | | | | | GC-MS-Analysis |

## GM Lubricant Standards for Industrial Gear

2004

| Property | Value | | | | | | | Test Method | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Product Code LR-104 | 06 | 10 | 15 | 22 | 32 | 46 | 68 | ISO | ASTM | DIN | Other |
| ISO Viscosity Grade | 68 | 100 | 150 | 220 | 320 | 460 | 680 | 3448 | D2422 | 51519 | BS 4231 |
| AGMA Grade | 2EP | 3EP | 4EP | 5EP | 6EP | 7EP | 8EP | | | | AGMA 9005 |
| Kinematic Viscosity at 40 °C, min/max. | 61.2<br>74.8 | 90.0<br>110 | 135<br>165 | 198<br>242 | 288<br>352 | 414<br>506 | 612<br>748 | 3104<br>3105 | D445 | 51550<br>51561<br>51562 | IP 71<br>BS 188 |
| Kinematic Viscosity at 100 °C | Report | | | | | | | | | | |
| Viscosity Index, min. | 90 | | | | | | | 2909 | D2270 | | IP226 |
| Pour Point, °C max. | -15 | -15 | -15 | -10 | -10 | -5 | 0 | 3016 | D97 | | IP 15 |
| Flash Point, °C min. | 190 | 190 | 200 | 200 | 210 | 210 | 210 | 2592 | D92 | | IP 36 |

| Property | Value | Test Method | | | |
|---|---|---|---|---|---|
| | For all product codes: | ISO | ASTM | DIN | Other |
| Copper Corrosion (3 hrs at 100°C), max. | 1b | 2160 | D130 | 51759 | IP 154 |
| Thermal Stability | | | D2070 (except 75 ml of oil 101°C, 72 hrs) | | Cin. Mil. Proc. B |
| Acid Number Change, max. | 0.15 (report for 680) | | | | |
| Vis, Change, 40/100°C, % max. | 5 (10 for 680) | | | | |
| Sludge, mg/100 ml max. | 25 | | | | |
| Cu Rod Colour (Cin. Mil.), max. | 5 | | | | |
| Copper Weight Loss, mg max. | 10 | | | | |
| Steel Rod Colour (Cin. Mil.) | No Discolouration | | | | |



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## GM Lubricant Standards for Industrial Gear - Cont'd

2004

| Property | Value | Test Method | | | |
|---|---|---|---|---|---|
| | For all product codes: | ISO | ASTM | DIN | Other |
| Oxidation Stability (121 rather than 95°C)<br>Vis. increase at 100°C, %, max.<br>Photos of glassware after test. | 6<br>(12% for ISO 680)<br>Report | | D2893 | | |
| FZG Test, failure stage min. | 12 | | D5182 | 51354 | IP 166<br>IP 334 |
| Cleanliness, as received, max. | 20/18/14 | 4406<br>1117 | | | |
| Timken OK Load, kg, min. | 27 | | D2782 | | IP 240 |
| Rust Preventing Characteristics | Pass (no Rust) | 7120 | D665B | 51585 | IP 135 |
| Demulsibility<br>Water in Oil after 5 hrs, %, max.<br>Emulsion After Cntrfg., ml max.<br>Total Free Water, ml, min. | 1.0<br>2.0<br>60 | | D2711<br>X2 | | |
| Foaming Tendency (per D892)<br>Sequence I, II and III, max. | 50/0 | 6247 | D892 | 51566<br>E | IP 146 |
| Four-Ball EP<br>Load Wear Index, kg min.<br>Weld Load, kg min. | 45<br>250 | | D2783 | | |
| Four-Ball Wear (20 kg load)<br>Wear Scar Diameter, mm max. | 0.35 | | D4172 | | |
| Compatability With SRE-NBR 1<br>Seals (DIN 53538), (168 hrs, 100°C<br>Volume change, %<br>Shore A hardness change | -10 to 10<br>-7 to 10 | 1817<br>868<br>6072<br>7619 | D471 | 53521<br>53505 | CETOP<br>RP 81H<br>IP 278<br>BS 4832 |

# GM Lubricant Standards for Industrial Gear - Cont'd

2004

| Property | Value | Test Method | | | |
|---|---|---|---|---|---|
| | For all product codes: | ISO | ASTM | DIN | Other |
| A.P.I Gravity | Report | | D287 | | |
| Preciption Number, max. | Report | | D91 | | |
| Water, as received, ppm max. | 200 | 3733 | D6304 | | |
| Base Stocks Requirements | | | | Virgin or Refefined | |
| Tot. PolyNuclear Aromatics, ppm max. | 1000 | | | | EPA SW-846 TN 8270* |
| Residual Elements (As, B, Ca, Mn, Mg, Na, Fe, Ni, Si, Cu, Sn, Cd, Cr, Pb, Ba, Zn), ppm max total/ each | 25/2 | | D5185 | | |
| P, ppm max. | 5 | | | | |
| Total Chlorinated Biphenyls | Not Detectable | | | | EPA SW-846 TN 8082* |
| Total Organic Halogens, ppm max | 5 | | | | EPA SW-846 TN 9253* |
| Mutagenicity | | | E 1687 | | Modified Ames (or skin painting) |
| Fold Increase | Report | | | | |
| Mutagenicity Index, max | 1 | | | | |
| Mutag. Potency Index, max | Report | | | | |

* or other methods as agreed upon by the LS2 committee and supplier

# Fives Cincinnati Machine Gear Lubricant Specifications

| Specifications | P-63 (C-68) | P-76 (C-100) | P-77 (C-150) | P-74 (C-220) | P-59 (C-320) | P-35 (C-460) | P-34 (C-680) | P-78 (C-1000) | P-39 (Worm Gear Oil) | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|
| A.P.I Gravity (at 60°F) | 22 Min. (Typ) | 22 Min. (Typ) | 22 Min. (Typ) | 22 Min. (Typ) | 22 Min. (Typ) | 22 Min. (Typ) | 22 Min. (Typ) | 22 Min. (Typ) | 22 Min. (Typ) | ASTM D287 |
| Viscosity System | ISO VG 68 | ISO VG 68 | ISO VG 150 | ISO VG 220 | ISO VG 320 | ISO VG 460 | ISO VG 680 | ISO VG 1000 | ISO VG 220-1000 | ASTM D2422 |
| (SUS at 100°F) | 317-389 | 481-588 | 722-882 | 1047-1283 | 1533-1876 | 2214-2719 | 2837-3467 | 4815-5885 | | ASTM D2161 |
| (Centistokes at 40°C) | 61.2-74.8 | 90-110 | 135-165 | 198-242 | 288-352 | 414-506 | 612-748 | 900-1100 | ISO 320 288-352 | ASTM D445 |
| | | | | | | | | | ISO 460 414-506 | |
| | | | | | | | | | ISO 680 612-748 | |
| | | | | | | | | | ISO 1000 900-1100 | |
| Viscosity Index | 85 Min. | 85 Min. | 85 Min. | 85 Min. | 85 Min. | 80 Min. | 80 Min. | 85 Min. | 85 Min. | ASTM D2270 |
| Flash (C.O.C) | 340°F Min. | 380°F Min. | 380°F Min. | 380°F Min. | 380°F Min. | 380°F Min. | 380°F Min. | 380°F Min. | 380°F Min. | ASTM D92 |
| Pour Point | 10°F Max. | 10°F Max. | 10°F Max. | 10°F Max. | 10°F Max. | - | - | 10°F Max. | 30°F Max. | ASTM D97 |
| Timken E.P. Test, Lbs | 45 Min. | 45 Min. | 45 Min. | 45 Min. | 45 Min. | 45 Min. | 45 Min. | 45 Min. | - | ASTM D2782 |
| Rust Test | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | ASTM D665 |
| **Thermal Stability Test** | | | | | | | | | | |
| Precipitate or Sludge | None | None | None | None | None | None | None | None | 25 mg/100 ml Max. | |
| Viscosity | 5% Max. Increase | 5% Max. Increase | 5% Max. Increase | 5% Max. Increase | 5% Max. Increase | 5% Max. Increase | 5% Max. Increase | 5% Max. Increase | 5% Max. Increase | ASTM D2161 (P-74) |
| **Condition of Steel Rod** | | | | | | | | | | |
| Visual | 1.5 Max. | 1.5 Max. | 1.5 Max. | 1.5 Max. | 1.5 Max. | 1.5 Max. | 1.5 Max. | 1.5 Max. | 1.5 Max. | CM Colour Class |
| Deposits | 3.5 mg. Max. | 3.5 mg. Max. | 3.5 mg. Max. | 3.5 mg. Max. | 3.5 mg. Max. | 3.5 mg. Max. | 3.5 mg. Max. | 3.5 mg. Max. | 3.5 mg. Max. | |
| Metal Removed | 1.0 mg. Max | 1.0 mg. Max | 1.0 mg. Max | 1.0 mg. Max | 1.0 mg. Max | 1.0 mg. Max | 1.0 mg. Max | 1.0 mg. Max | 1.0 mg. Max | |
| **Condition of Copper Rod** | | | | | | | | | | |
| Visual | 5 Max. | 5 Max. | 5 Max. | 5 Max. | 5 Max. | 5 Max. | 5 Max. | 5 Max. | 5 Max. | CM Colour Class |
| Deposits | 6.0 mg. Max. | 6.0 mg. Max. | 6.0 mg. Max. | 6.0 mg. Max. | 6.0 mg. Max. | 6.0 mg. Max. | 6.0 mg. Max. | 6.0 mg. Max. | 10.0 mg. Max. | |
| Metal Removed | 5.0 mg. Max. | 5.0 mg. Max. | 5.0 mg. Max. | 5.0 mg. Max. | 5.0 mg. Max. | 5.0 mg. Max. | 5.0 mg. Max. | 5.0 mg. Max. | 10.0 mg. Max. | |

# Air Compressor Lubricant Standard DIN 51506

October 2012

| Oil Classifications | Compressed Air Temperature °C maximum | |
|---|---|---|
| | For compressors on moving equipment for brakes, signals and tippers | For compressors with storage tanks and pipe network systems |
| VDL | 220 | 220 |
| VC<br>VCL | 220 | 160(1) |
| VB<br>VBL | 140 | 140 |

**Note:**

(1) Some types of compressors up to 180°C with VCL or engine oils.

## Air Compressor Lubricant Standard DIN 51506

October 2012

| Lube Oil Group | VB and VBL | | | | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|
| ISO Viscosity grade | 22 | 32 | 46 | 68 | 100 | 150 | 220 | 320 | 460 | |
| Kinematic Viscosity, min.<br>at 40°C, mm²/s, max. | 19.8<br>to<br>24.2 | 28.8<br>to<br>35.2 | 41.4<br>to<br>50.6 | 61.2<br>to<br>74.8 | 90<br>to<br>110 | 135<br>to<br>165 | 198<br>to<br>242 | 288<br>to<br>352 | 414<br>to<br>506 | DIN 51562-1 |
| at 100°C, mm²/s, min. | Report | | | | | | | | | |
| Flash Point (COC), °C, min. | 175 | | 195 | | 205 | 210 | 225 | | 255 | ISO 2592 |
| Pour Point, °C, max. | -9 | | | | | -3 | 0 | | | ISO 3016 |
| Ash, % m/m, max. | VB: 0.02 oxide ash | | | | | | | | | ISO 6245<br>DIN 51675 |
| Water soluble acids | Neutral | | | | | | | | | DIN 51558 |
| TAN, mg KOH/g max. | VB: 0.15 (VBL to specified by supplier) | | | | | | | | | DIN 51558 Part 1 |
| Water, % Mass | 0.05 max. | | | | | | | | | DIN 51777-2 |
| % Mass CRC max. after air aging | 2.0 | | | | | 2.5 | | | | DIN 51352 Part 1 |
| % Mass CRC max. of 20% distillation residue | Not required | | | | | | | | | DIN 51535 |

**Note:**

Grades VB and VC are pure mineral oils. Grade VDL contains additives to increase aging resistance.

Grades VBL and VCL are HD type engine oils which are used as mineral oils.



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## Air Compressor Lubricant Standard DIN 51506

September 1985

| Lube Oil Group | VDL | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|
| ISO Viscosity grade | 32 | 46 | 68 | 100 | 150 | |
| Kinematic Viscosity | | | | | | DIN 51562-1 |
| at 40°C, mm²/s | 28.8 to 35.2 | 41.4 to 50.6 | 61.2 to 74.8 | 90 to 110 | 135 to 165 | |
| at 100°C, mm²/s, min. | Report | | | | | |
| Flash Point (COC), °C, min. | 175 | 195 | | 205 | 210 | ISO 2592 |
| Pour Point, °C, max. | -9 | | | | -3 | ISO 3016 |
| Ash, % mass, max. | Sulphated ash to be specified by supplier | | | | | DIN 51575 |
| Water soluble acids | Neutral | | | | | DIN 51558 |
| TAN, mg KOH/g, max. | To be specified by supplier | | | | | DIN 51558 Part 1 |
| Water, % mass | 0.05 max. | | | | | DIN 51777-2 |
| % mass CRC max. after air aging | Not required | | | | | DIN 51352 Part 1 |
| % mass CRC max. after air/$Fe_2O_3$ aging | 2.5 | | 3.0 | | | DIN 51352 Part 2 |
| % mass CRC max. of 20% distillation residue | 0.3 | | | | 0.6 | DIN 51356 |
| Kinematic Viscosity at 40°C max. of 20% distillation residue mm²/s | Maximum of five times the value of the new oil | | | | | DIN 51535 |

# General Motors Compressor Lubricant Standards

November 2004

| Specifications Type | Compressor and turbine oils | | | | Synthetic compressor / turbine oil - ester based | | | | Synthetic compressor / turbine oil - non ester | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Product Code | LJ-03-1-04 | LJ-04-1-04 | LJ-06-1-04 | LJ-10-1-04 | LJ-03-2-04 | LJ-04-2-04 | LJ-06-2-04 | LJ-10-2-04 | LJ-03-3-04 | LJ-04-3-04 | LJ-06-3-04 | LJ-10-3-04 | |
| ISO Viscosity grade | 32 | 46 | 68 | 100 | 32 | 46 | 68 | 100 | 32 | 46 | 68 | 100 | - |
| Viscosity at 40°C, $mm^2/s$ | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90-110 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90-110 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90-110 | D445 |
| Viscosity at 100°C, $mm^2/s$ | Report | | | | | | | | | | | | D445 |
| Viscosity Index | 95 | | | | 85 | | | | 120 | | | | D2270 |
| A.P.I. Gravity | Report | | | | | | | | | | | | D287 |
| Flash Point (COC), °C | 190 | | | 195 | 200 | | | | 210 | | | | D92 |
| Pour Point, °C | -10 | | | | -20 | | | -15 | 25 | | | -20 | D97 |
| Auto ignition temperature, °C min. | N/A | | | | 350 | | | | 350 | | | | D2155 |
| Foam | | | | | | | | | | | | | D892 |
| Sequence I | 50/0 | | | | | | | | | | | | |
| Sequence II | 50/0 | | | | | | | | | | | | |
| Sequence III | 50/0 | | | | | | | | | | | | |
| Water Seperability, 30 mins., max. | 40/40/0 | | | | 40/37/3 | | | | 40/40/0 | | | | D1401 |
| Copper Corrosion, 3 hrs. at 100°C | 1b | | | | 1b | | | | 1b | | | | D130 |
| Steel Corrosion, Method B | Pass | | | | | | | | | | | | D665 |
| Life TOST, hrs. to TAN of 2.0 mg KOH/g | 2000 | | | | Report | | | | 2000 | | | | D943 |
| Cleanliness, as received, max. | 20/17/14 | | | | | | | | | | | | ISO 4406 |
| Thermal stability | | | | | | | | | | | | | D2070 |
| Acid Number change, %, max. | +/- 50 (or 0.15) | | | | | | | | | | | | |
| Viscosity change, 40/100°C, % max. | 5 | | | | | | | | | | | | |
| Sludge, mg/100ml, max. | 25 | | | | | | | | | | | | |
| Cu rod colour (Cin. Mil), max. | 5 | | | | | | | | | | | | |
| Cu weight loss, mg max. | 10 | | | | | | | | | | | | |
| Steel Rod Colour (Cin. Mil), max. | No Discolouration | | | | | | | | | | | | |

# General Motors Compressor Lubricant Standards – Cont'd

November 2004

<table>
<tr><th>Specifications Type</th><th colspan="4">Compressor and turbine oils</th><th colspan="4">Synthetic compressor / turbine oil - ester based</th><th colspan="4">Synthetic compressor / turbine oil - non ester</th><th rowspan="2">ASTM Test Method</th></tr>
<tr><th>Product Code</th><th>LJ-03-1-04</th><th>LJ-04-1-04</th><th>LJ-06-1-04</th><th>LJ-10-1-04</th><th>LJ-03-2-04</th><th>LJ-04-2-04</th><th>LJ-06-2-04</th><th>LJ-10-2-04</th><th>LJ-03-3-04</th><th>LJ-04-3-04</th><th>LJ-06-3-04</th><th>LJ-10-3-04</th></tr>
<tr><td>Four-Ball wear 40kg, mwsd, mm, max.</td><td colspan="12">0.4</td><td>D4172</td></tr>
<tr><td>Aniline point</td><td colspan="12">Report</td><td>D611</td></tr>
<tr><td>Compatibility with SRE-NBR 1 seals (168 hrs, 100°C)</td><td colspan="12"></td><td rowspan="3">D471<br>(DIN 53538)</td></tr>
<tr><td>Volume change %</td><td colspan="12">-10 to 10</td></tr>
<tr><td>Shore A hardness change</td><td colspan="12">-7 to 10</td></tr>
<tr><td>Conradson Carbon residue, % max.</td><td colspan="12">0.05</td><td>D189</td></tr>
</table>



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# SAE MS I003-2 Compressor Oils

January 2004

| Requirements | Mineral oil based | | | | | | Ester based | | | | | | Polyalphaolefin based | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type of lubricating oil | DAA | DAB | DAC | DAG | DAH | DAJ | DEA | DEB | DEC | DEG | DEH | DEJ | DPA | DPB | DPC | DPG | DPH | DPJ | |
| ISO Viscosity Classifications | VG 32-320 | | | | | | VG 32-150 | | | | | | VG32-100 | | | | | | D2422 |
| Kinematic Viscosity at 40°C, $mm^2/s$ | ISO Grade ± 10% | | | | | | ISO Grade ± 10% | | | | | | ISO Grade ± 10% | | | | | | D445 |
| Viscosity Index | Report | | | | | | Report | | | | | | 130 min | | | | | | D2270 |
| Pour Point, °C | ≤ -4 | | | | | | ≤ -20 | | | | | | ≤ -35 | | | | | | D97 |
| Flash Point, °C | VG 32 ≥ 175 | | | | | | VG 32 ≥ 220 | | | | | | VG 32 ≥ 210 | | | | | | D92 |
| | VG 46 ≥ 185 | | | | | | VG 46 ≥ 230 | | | | | | VG 46 ≥ 230 | | | | | | |
| | VG 68 ≥ 195 | | | | | | VG 68 ≥ 240 | | | | | | VG 68, 100 ≥ 250 | | | | | | |
| | VG 100 - 320 ≥ 205 | | | | | | VG 100 - 150 ≥ 250 | | | | | | | | | | | | |
| Demulsibility | 40/37/3 | | | | | | 40/37/3 | | | | | | 40/37/3 | | | | | | D1401 |
| Demulsibility | - | | | | | | | | | | | | | | | | | | D2711 |
| Water in oil after 5 hrs | - | | | | | | Report | | | Report | | | Report | | | ≤ 1% | | | |
| Emulsion after centrifuge | - | | | | | | Report | | | Report | | | Report | | | ≤ 2 ml | | | |
| Total free water | - | | | | | | Report | | | Report | | | Report | | | ≥ 60 ml | | | |
| Water content, ppm | ≤ 200 | | | | | | ≤ 500 | | | | | | ≤ 500 | | | | | | D95<br>D1744 |
| Corrosive effect on steel | Not exceeding degree of corrosion ISO 7120 - 0 - A | | | | | | Not exceeding degree of corrosion ISO 7120 - 0 - A | | | | | | Not exceeding degree of corrosion ISO 7120 - 0 - A | | | | | | D665A |
| Corrosive effect on copper 3 hrs at 100°C | Not exceeding degree of corrosion 1B: ISO 2160 - 100A3 | | | | | | Not exceeding degree of corrosion 1B: ISO 2160 - 100A3 | | | | | | Not exceeding degree of corrosion 1B: ISO 2160 - 100A3 | | | | | | D130 |
| Foam Volume, in ml. | | | | | | | | | | | | | | | | | | | D892 |
| Sequence I | ≤ 20/0 | | | | | | ≤ 20/0 | | | | | | ≤ 20/0 | | | | | | |
| Sequence II | ≤ 50/0 | | | | | | ≤ 50/0 | | | | | | ≤ 50/0 | | | | | | |
| Sequence III | ≤ 50/0 | | | | | | ≤ 50/0 | | | | | | ≤ 50/0 | | | | | | |
| Oxidation stability TAN < 2 hrs | 1000 | 2000 | 3000 | 1000 | 2000 | 3000 | 1000 | 1500 | 2000 | 1000 | 1500 | 2000 | 2000 | 3000 | 4000 | 2000 | 3000 | 4000 | D943 |
| Auto Ignition Temperature, °C | | | | | | | 380 min | | | | | | | | | | | | E-659 |

## SAE MS I003-2 Compressor Oils – Cont'd

February 2012

| Requirements | Ester based | | | | | | Ester based | | | | | | Polyalphaolefin based | | | | | | ASTM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type of lubricating oil | DAA | DAB | DAC | DAG | DAH | DAJ | DEA | DEB | DEC | DEG | DEH | DEJ | DPA | DPB | DPC | DPG | DPH | DPJ | Test Method |
| Density at 15°C in g/ml | Report | | | | | | Report | | | | | | Report | | | | | | D4052<br>D1298 |
| Four-Ball Wear Test (40kg load) wear scar diameter, mm | NA | | ≤ 0.5 | | | | - | | ≤ 0.5 | | | | - | | ≤ 0.5 | | | | D4172 |
| Behaviour towards sealant. Relative change in % volume | -10 to +10 | | | | | | -10 to +10 | | | | | | -10 to +10 | | | | | | D471 |
| Behaviour towards sealant. Change in Shore hardness | -7 to +10 | | | | | | -7 to +10 | | | | | | -7 to +10 | | | | | | D471 |
| Level of Contamination by solid particles, max. | 20/18/14 | | | | | | 20/18/14 | | | | | | 20/18/14 | | | | | | ISO 4406 |
| Thermal Stability | - | | | | | | | | | | | | | | | | | | D2070 |
| Comparative IR Scan | Report | | | | | | Report | | | | | | Report | | | | | | |
| Acid Number Change | 0.15 or +- 50% | | | | | | 0.15 | | | | | | 0.15 | | | | | | |
| Viscosity Change | ≤ 5% | | | | | | ≤ 5% | | | | | | ≤ 5% | | | | | | |
| Sludge, mg / 100 ml | ≤ 25 | | | | | | ≤ 25 | | | | | | ≤ 25 | | | | | | |
| Copper rod colour | ≤ 5 | | | | | | ≤ 5 | | | | | | ≤ 5 | | | | | | |
| Copper weight loss, mg | ≤ 10 | | | | | | ≤ 10 | | | | | | ≤ 10 | | | | | | |
| Steel rod colour (Cinn, Mil.) | 1 max. | | | | | | 1 max. | | | | | | 1 max. | | | | | | |
| Neutralization number to be run on base oil only,mg KOH/g | - | | | | | | 0.5 max. | | | | | | 0.1 max. | | | | | | D664 |
| | - | | | | | | | | | | | | - | | | | | | D974 |
| Conradson Carbon residue to be run on base oil only, max. | - | | | | | | 0.05% | | | | | | - | | | | | | D189 |



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# DIN 51515 Part 1 and Part 2

February 2010

| Specifications | DIN 51515-1 L-TD - for normal service | | | | DIN 51515-2 L-TG - for high temperature service | | ASTM Test Method |
|---|---|---|---|---|---|---|---|
| ISO Viscosity grade | 32 | 46 | 68 | 100 | 32 | 46 | - |
| Viscosity at 40°C, $mm^2/s$ | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 90.0-110.0 | 28.8-35.2 | 41.4-50.6 | ISO 3104 |
| Viscosity Index, min. | 90 | | | | 90 | | ISO 2909 |
| Density at 15°C g/ml | To be given by supplier | | | | To be given by supplier | | ISO 3675 |
| Flash Point (COC), °C, min. | 185 | 185 | 205 | 215 | 185 | 185 | ISO 2592 |
| Pour Point, °C, max. | -6 | | | | -6 | | ISO 3016 |
| Neutralisation Value mg KOH/g | To be given by supplier | | | | To be given by supplier | | ISO 6618 |
| Foam | | | | | | | ISO 6247 |
| Sequence I | 450/0 | | | | | | |
| Sequence II | 50/0 | | | | | | |
| Sequence III | 450/0 | | | | | | |
| Air Release (IP 313), mins., max. | 5 | 5 | 6 | No limit | 5 | | DIN 9120 |
| Steam Demulsibility, sec., max. | 300 | | | | 300 | | DIN 51589-1 |
| Copper Corrosion | | | | | | | ISO 2160 |
| 3 hrs at 100°C | 2 max. | | | | | | |
| 3 hrs at 125°C | | | | | 2 max. | | |
| Steel Corrosion, Method A | Pass | | | | Pass | | ISO 7120 |
| Life TOST, hrs. to TAN of 2.0 mg KOH/g, min. | 3000 | | 2500 | 2000 | 3500 | | ISO 4263-1 |
| RPVOT, mins., min. | | | | | 750 | | ASTM D2272 |
| RPVOT (modified), % of time in unmodified test, min. | | | | | 85 | | ASTM D2272 |
| Purity, min. | 20/17/14 | | | | 20/17/14 | | ISO 4406 |
| Water content, mg/kg, max. | 150 | | | | 150 | | ISO 12937 |
| Ash (oxide ash), % mass | To be given by supplier | | | | To be given by supplier | | ISO 6245 |



Afton CHEMICAL

## AIST Turbine Standard Requirements

| Specifications | 120 Turbine Oil | | | | 125 R&O Circulating Oil | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|
| Viscosity | Suitable for turbine application | | | | Suitable for application | | | | |
| Viscosity Index, min. | 100 | | | | 80 | | | | D567 |
| A.P.I. Gravity, min. | 30 | | | | 20 | | | | D287 |
| Pour Point, °F, max. | 20 (depending on location) | | | | 20 (lower, dependent upon application) | | | | D97 |
| Flash Point (COC), °F, min. | 375 | | | | 375 | | | | D92 |
| Rust Prevention, Method A | Pass | | | | Pass | | | | D665 |
| Oxidation Test | Not to exceed 2.0 neutralization number at 2000 hrs | | | | Not to exceed 2.0 neutralization number after 1000 hrs | | | | D943 |
| RPVOT, mins., min. | 120 | | | | | | | | D2272 |
| Emulsion Characteristics @ 130°F | Minutes | ml Oil | ml Water | ml Emulsion | Minutes | ml Oil | ml Water | ml Emulsion | D1401 |
| | ≤ 20 | 40 | 37 | 3 | ≤40 | 40 | 37 | 3 | |
| Vickers 104E Pump Test | | | | | | | | | D2271 |
| Vane pump, wear loss, mg, max. | 250 | | | | | | | | |
| Demulsibility @ 125 °F | | | | | | | | | D2711 |
| Free water, ml, max. | | | | | 36 | | | | |
| Emulsion, ml, max. | | | | | 1 | | | | |
| Water in oil, %, max. | | | | | 2 | | | | |

## British Standard Specifications BS 489: 1999 R&O Turbine Oils

| Test | TO | TO | TO | TO | ASTM Test Method | |
|---|---|---|---|---|---|---|
| ISO Viscosity grade (BS 4231) | 32 | 46 | 68 | 100 | BS reference | Technically identical with |
| Kinematic Viscosity, at 40°C, mm²/s | | | | | BS EN ISO 3104 | IP71 |
| min. | 28.8 | 41.4 | 61.2 | 90 | | |
| max. | 35.2 | 50.6 | 74.8 | 110 | | |
| Viscosity Index, min. | 90 | | | | BS 2000: Part 226 | IP 226/77 |
| Flash Point (COC), °C, min. | 185 | | | | BS EN 22592 | IP 34 |
| Pour Point, °C, max. | -6 | | | | BS 2000: Part 15 | IP 15 |
| Demulsification number, sec., max. | 300 | 300 | 360 | 360 | BS 2000: Part 19 | IP 19 |
| Copper Corrosion Classifications | 1 | | | | BS EN ISO 2160 (3 hrs. at 100°C) | IP 154 (3 hrs. at 100°C) |
| Acid Number mgKOH/g, max. | 0.45 | | | | BS 2000 : Part 177 | IP 1 Method A |
| Rust-Preventing Characteristics | Pass | | | | BS 2000 : Part 135 Procedure B (24 hr test), as amended by appendix A | IP 135 procedure B (24 hr test), as amended by appendix A |
| Foaming Characteristics: Foaming Tendency, ml | | | | | BS2000: Part 146 | IP 146 |
| Sequence I, max. | 400 | 400 | 400 | 400 | | |
| Sequence II, max. | 50 | 50 | 100 | 100 | | |
| Sequence III, max. | 400 | 400 | 400 | 400 | | |
| Foam Stability after 10 mins., ml | | | | | | |
| Sequence I, max. | Nil | Nil | 20 | 30 | | |
| Sequence II, max. | Nil | Nil | 10 | 10 | | |
| Sequence III, max. | Nil | Nil | 20 | 30 | | |
| Air Release Value, minutes to 0.2% air content at 50°C, max. | 5 | 6 | 7 | 10 | BS 2000: Part 313 | IP 313 |
| Oxidation Characteristics: Total Oxidation Products | | | | | BS 2000: Part 280 | IP 280 |
| (TOP) % (m/m), max. | 0.70 | 0.80 | 0.80 | 0.80 | | |
| Sludge % (m/m), max. | 0.30 | 0.35 | 0.35 | 0.35 | | |



Afton CHEMICAL

## SEB Turbine Specifications

| Specifications | SEB 181229-1 Sep-07 | | | | SEB 181229-2 Sep-07 | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|---|
| Turbine type | TD Gas and Steam turbine oils for normal temperature range | | | | TDP Gas and Steam EP turbine oils for normal temperature range | | | | |
| ISO Viscosity grade | ISO 32 | ISO 46 | ISO 68 | ISO 100 | ISO 32 | ISO 46 | ISO 68 | ISO 100 | |
| Kinematic Viscosity, at 40°C, $mm^2/s$ | 32 ± 3.2 | 46 ± 4.6 | 68 ± 6.8 | 100 ± 10 | 32 ± 3.2 | 46 ± 4.6 | 68 ± 6.8 | 100 ± 10 | BS EN ISO 3104 |
| Viscosity Index, min. | 90 | | | | 90 | | | | ISO 2909 |
| Density at 15°C $kg/m^3$ | Report | | | | Report | | | | DIN 51757 |
| Flash Point (COC), °C, min. | 185 | | 205 | 205 | 185 | | 205 | 205 | DIN EN ISO 2592 |
| Pour Point, °C, max. | -12 | | -9 | | -12 | | -9 | | ISO 3016 |
| Zinc content | Zinc free | | | | Zinc free | | | | |
| Neutralisation Value, mgKOH/g | Report | | | | Report | | | | DIN 51558-1 |
| Foam | | | | | | | | | ISO 6247 |
| Sequence I | 450/0 | | | | 450/0 | | | | |
| Sequence II | 100/0 | | | | 100/0 | | | | |
| Sequence III | 450/0 | | | | 450/0 | | | | |
| Air Release at 50°C, mins., max. | 5 | 5 | 6 | 10 | 5 | 5 | 6 | 10 | DIN 51381 |
| Demulsibility with Water | | | | | | | | | DIN ISO 6614 |
| Time to 40.37.3 at 54°C, mins., max. | 30 | | | | 30 | | | | |
| Time to 40.37.3 at 40°C, mins., max. | Report | | | | Report | | | | |
| Steam Demulsibility, sec., max. | 300 | | | | 300 | | | | DIN 51589-1 |
| Copper Corrosion | | | | | | | | | DIN EN ISO 2160 |
| 3 hrs at 100°C, rating, max. | 1 | | | | 1 | | | | |
| 24 hrs 150°C, rating | Report | | | | Report | | | | |
| Steel Corrosion, Method A | Pass | | | | Pass | | | | DIN EN ISO 2160 |
| Life TOST | | | | | | | | | DIN 51587 |
| TAN after 500 hrs, mgKOH/g, max. | 1 | | | | 1 | | | | |
| TAN after 1000 hrs, mgKOH/g, max. | 2 | | | | 2 | | | | |
| Ash (oxide ash), % mass | Report | | | | Report | | | | DIN EN ISO 6245 |
| Water Content, % | None | | | | None | | | | DIN ISO 3733 |
| Purity, max. | 19/17/14 | | | | 19/17/14 | | | | ISO 4406 |
| FZG A/8.3/0.9, | | | | | | | | | DIN 51354-2 |
| Failure load stage | | | | | ≥ 8 | | | | |
| Work related weight change, mg/kWh | | | | | Report | | | | |
| IR Diagram | is to be provided | | | | is to be provided | | | | DIN 51451 |
| Content of PCB, mg/kg | ≤ current detection limit | | | | ≤ current detection limit | | | | DIN 51527-1 |
| Content of Total Halogens, % mass, max. | 0.1 | | | | 0.1 | | | | DIN 51577-2 |
| Content of Lead, & mass | ≤ current detection limit | | | | ≤ current detection limit | | | | DIN 51827 |
| Content of PAK (PAH), mg/kg, max. | 10 | | | | 10 | | | | GCMS Analysis |



Afton CHEMICAL

## GEK Turbine Specifications

| Specifications | GEK 107395a | GEK 32568H | GEK 32568H | GEK 46506E | ASTM Test Method |
|---|---|---|---|---|---|
| | May-01 | April-13 | April-13 | March-07 | |
| Turbine type | Single shaft STAG, high temperature | Gas, High temperature | Gas, High temperature, PAG | Steam | |
| ISO Viscosity grade | ISO 32 | - | - | ISO 32 | - |
| Viscosity at 40°C, mm²/s | 28.8-35.2 | 28.8 - 35.2 | 23.0-26.0 | 29.6-36.3 | D445 |
| Viscosity at 100°C mm²/s | - | - | - | 5.09-5.74 | |
| Viscosity index, min. | 98 | 95 | 125 | - | D2270 |
| Density at 15°C kg/m³ | 0.83 to 0.88 | | - | - | D1298 |
| Flash Point (COC), °C, min. | 215 | 215 | 230 | 191 | D93 |
| Pour Point, °C, max. | -12 | -12 | -40 | - | D97 |
| Colour, max. | 2 | 2 | 2 | - | D1500 |
| Neutralisation Value mg KOH/g, max. | 0.2 | 0.2 | - | 0.2 | D664 / D974 |
| Foam | - | | | - | D892 |
| Seq I | 50/0 | 50/0 | 25/0 | | |
| Seq II | 50/0 | 50/0 | 0/0 | | |
| Seq III | 50/0 | 50/0 | 0/0 | | |
| Air Release, mins., max. | 5 | 5 | 1.0 | - | D3427 |
| Demulse Time to 40.37.3 at 54°C, mins., max. | 30 | - | - | - | D1401 |
| Copper Corrosion, 3 hrs @ 100°C, max. | 1B | 1B | 1B | - | D130 |
| Steel Corrosion, Method A | | Pass | Pass | Pass | D665 |
| Steel Corrosion, Method B | Pass | - | - | - | |
| Life TOST, hrs. to TAN of 2.0 mg KOH/g, min. | 7000 | 5000 | - | > 2000 | D943 |
| Specific Gravity | - | - | Report | - | D4052 |
| (TAN) Total Acid Number, max. | - | - | 0.20 | - | D974 |
| Oxidation Characteristics 212°F/100°C Viscosity Change @ 121°C, 13 days, max. | - | - | 3.0% | - | D2893B |
| Oxidation Stability by rotating Pressure Vessel (minutes), min. | - | - | 500 | - | D2272 |
| Oxidation Stability by rotating Pressure Vessel (Modified), min. | - | - | 85% of time in unmodified test | - | D2272 |
| Thermal Conductivity, 40°C, watts/m K, min. | - | - | 0.1 | - | PLTL-73 |

## GEK Turbine Specifications – Cont'd

| Specifications | GEK 107395a | GEK 32568H | GEK 46506E | ASTM Test Method |
|---|---|---|---|---|
| | May-01 | April-13 | March-07 | |
| Turbine type | Single shaft STAG, high temperature | Gas, high temperature | Steam | |
| RPVOT, minutes, min.<br>RPVOT (modified), % of time in unmodified test, min. | 1000<br>85 | 500<br>85 | >250 | D2272<br>D2272 |
| Carbon residue Ramsbottom, %, max. | 0.10 | | | D524 or equivalent |
| A.P.I. Gravity | 29-39 | 29 - 39 | | D287 |
| Water content, % wt., max. | 0.02 | | 0.01 | ASTM E203 |
| Evaporation Loss (149°C), % wt., max. | 6 | | | ASTM D972 |
| AIGN, °C, min. | 357 | | | ASTM E659 |
| Thermal stability, Change in Viscosity, %<br>Total Precipitation | Report | | | CM Thermal Test A |
| Panel Coker Test, 320°F sump, 400°F panel | Report - Coking Value | | | FTM 791a-3462 |
| Volatility / Oil thickening | Report | | | DIN 51356 |

## OEM Turbine Specifications 1

| Specifications | ALSTOM HTGD 90 117 V0001 X January 2012 | | | Solar ES 9-224 W 1st February 2007 | | ASTM Test Method |
|---|---|---|---|---|---|---|
| ISO Viscosity grade | ISO 32 | ISO 46 | ISO 68 | ISO 32 | ISO 46 | - |
| Viscosity at 40°C, $mm^2/s$ | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 28.8-35.2 | 41.4-50.6 | D445 |
| Viscosity index | > 90 | | | | | D2270 |
| Density at 15°C $kg/m^3$, max. | 880 | | 900 | | | D941 / D1298 |
| Flash Point (COC), °C, min. | 200 | | 200 | 199 | | D92 |
| Fire Point | | | | 227 | 232 | |
| Auto ignition temperature, °C, min. | | | | 310 | | E659 |
| Pour Point, °C, max. | -9 | | - 6 | | | D97 |
| Neutralisation Value mg KOH/g | | | | | | D664 / D974 |
| Without EP additive, max. | 0.2 | | | | | |
| With EP additive, max. | 0.3 | | | | | |
| Foam | | | | | | D892 |
| Sequence I | 300/0 | | | 50/0 | | |
| Sequence II | 50/0 | | | 50/0 | | |
| Sequence III | 300/0 | | | 50/0 | | |
| Air Release at 50°C, min, max. | 4 | | 7 | 5 | 6 | D3427 |
| Demulse Time to 40.37.3 at 54°C, mins., max. | < 30 | | | 30 max. to 40-40-0 | | D1401 |
| Steam Demulsibility, sec., max. | < 300 | | | | | DIN 51589-1 |
| Copper Corrosion, 3 hrs. at 100°C, max. | 2 | | | 1b | | D130 |
| Steel Corrosion, Method B | Pass | | | Pass | | D665 |
| Life TOST, hrs. to TAN of 2.0 mg KOH/g | | | | 2000 min. | | D943 |
| Life TOST, hrs. to TAN of 0.5 mg KOH/g | 2000 min. | | | | | D943 |
| RPVOT, mins. | > 300 | | | Report | | D2272 |
| Purity | Class --/18/15 | | | 16/14/12 | | ISO4406 |
| Water content mg/kg, max. | < 200 | | | | | D1533 / D1744 |



Afton CHEMICAL

## OEM Turbine Specifications 1 – Cont'd

| Specifications | ALSTOM HTGD 90 117 V0001 X January 2012 | Solar ES 9-224 W 1st February 2007 | | ASTM Test Method |
|---|---|---|---|---|
| Filterability | | | | ISO 13357-2 |
| Level 1% | At least 93 | | | |
| Level 2% | At least 85 | | | |
| Zinc Content, ppm, max. | 5 | 0.005% wt. | | Optional |
| FZG A/8.3/90, failure load stage | ≥ 8 (1) | ≥ 6 | ≥ 7 | D5182 |
| Four-Ball wear, 40kg/1 hr/75°C/1200rpm, mwsd, mm, max. | | 0.90 | | D4172 |
| Electrical Resistivity, min. at 20°C, Ωm | | Report | | D4308 / D1169 |

**Note:**
(1) Additional requirements on turbine oils used in gear boxes.

## OEM Turbine Specifications 2

| Specifications | Siemens TLV 9013 04<br>May 2010<br>Turbine Oils with normal thermal stability | | Siemens TLV 901305<br>May 2010<br>Turbine Oils with higher thermal stability | | ASTM Test Method |
|---|---|---|---|---|---|
| ISO Viscosity grade | ISO 32 | ISO 46 | ISO 32 | ISO 46 | - |
| Viscosity at 40°C, $mm^2/s$ | 28.8-35.2 | 41.4-50.6 | 28.8-35.2 | 41.4-50.6 | D445 |
| Viscosity index | ≥ 90 | | ≥ 90 | | D2270 |
| Density at 15°C $kg/m^3$, max. | Report | | Report | | D941 / D1298 |
| Flash Point (COC), °C, min. | > 200 | | > 200 | | D92 |
| Pour Point, °C, max | -6 | | -6 | | D97 |
| Neutralisation Value mg KOH/g, max. | 0.30 | | 0.30 | | D974 |
| Foam Sequence I | ≤ 450/0 | | ≤ 450/0 | | D892 |
| Air Release at 50°C, mins., max. | 4 | | 4 | | D3427 |
| Demulse Time to 40.37.3 at 54°C, mins., max. | 30 | | 30 | | D1401 |
| Steam Demulsibility, sec., max. | 300 | | 300 | | DIN 51589-1 |
| Copper Corrosion, 3 hrs at 100°C, max. | 2 | | 2 | | D130 |
| Steel Corrosion, Method B | Pass | | Pass | | D665 |
| Life TOST, hrs to TAN of 2.0 mg KOH/g, min. | 3000 | | 3000 | | D943 |
| RPVOT, mins., min. | | | 750 | | D2272 |
| Purity | ≤ 20/17/14 | | ≤ 20/17/14 | | ISO4406 |
| Water content mg/kg, max. | 200 | | 200 | | D1533 / D1744 |
| FZG Test, A/8.3/90 failure load stage | ≥ 8(1) | | ≥ 8(1) | | D5182 |

**Note:**
(1) Additional requirements on turbine oils used in gear boxes.

## MAN TED 10000494596 001 02 - Turbine Specification Lubrication Properties

November 2011

| Parameter | Requirement | Test Method |
|---|---|---|
| Viscosity | **ISO VG 46 (Standard** MAN Diesel & Turbo SE)<br>ISO VG 32 and ISO VG 68<br>*Only with approval by* MAN Diesel & Turbo SE | DIN 51 562-1<br>DIN EN ISO 3104<br>ASTM D445 |
| Viscosity index | min. 95 | DIN ISO 2909<br>ASTM D2270 |
| Density | at 15 °C (59 °F) : ≤ 0.90 g/cm³ | DIN 51 757<br>ISO 3675<br>ASTM D1298 |
| Appearance | light and clear | visually<br>10 cm layer thickness |
| Colour | ≤ 2 | DIN ISO 2049<br>ASTM D1500 |
| Flashpoint | ≥ 180°C (355°F) | DIN ISO 2592<br>ASTM D92 |
| Pour Point | At least 10°C lower than the minimum ambient temperature of the oil system, in no case, however, higher than **-9°C (16°F)** | DIN EN ISO 3016<br>ASTM D97 |
| Total acid number (TAN) | without EP additive : ≤ 0.25 mg KOH/g<br>with EP additive : ≤ 0.35 mg KOH/g | ASTM D664 |
| Neutralization index | without EP additive : ≤ 0.25 mg KOH/g<br>with EP additive : ≤ 0.35 mg KOH/g | DIN 51 558-1<br>ASTM D974<br>DIN EN ISO 2160<br>ISO 6618 / 6619 |
| Ash (oxide ash) | ≤ 0.01% by mass | DIN EN ISO 6245<br>ASTM D482 |
| Metals / Organometalic compounds | Zn / Cu : ≤ 5 mg/kg<br>Others : ≤ 10 mg/kg | optional |
| Water content | ≤ 150 mg/kg | DIN 51 777-1<br>DIN EN ISO 12937<br>ATSM D1744 |
| Water separation property after steam treatment | ≤ 300 sec | DIN 51 589 |
| Water seperation property at 54°C | 40-40-0: ≤ 20 min | DIN ISO 6614<br>ASTM D1401 |
| Air release property at 50°C (122°F) | ≤ 5 min / ISO VG 68: ≤ 6 min | DIN ISO 7120<br>ISO 9120<br>ASTM D3427 |
| Corrosive effect on copper | 100 °C / 3h : ≤ 2 | DIN EN ISO 2160<br>ASTM D3427 |
| Corrosion protection properties in synthetic seawater | Method B : Passed | DIN ISO 7120<br>ASTM D665 |
| Solid foreign matter | 0.45 µm filter: ≤ 50 mg/kg | Membrane filtration |
| Fouling class | ≤ 17 / 15 / 12<br>≤ 6<br>≤ 7 | ISO 4406<br>NAS 1638<br>SAE AS 4059 |
| Foaming characteristics<br>Foam formation<br>Foam stability (10 min) | <br>≤ 150 / 50 / 150 ml<br>0 / 0 / 0 ml | DIN 51 566<br>ASTM D892<br>(Sequence 1 - 3)<br>ISO 6247 - Seq. 1 |

## MAN TED 10000494596 001 02 - Turbine Specification Load carrying capacity / load stage

December 2011

| Parameter | Requirements | Test Method |
|---|---|---|
| Load carrying capacity (load stage) | **Specified by the competent design departments for machines with gear unit depending on the machine type (see Point 1).**<br>• For machinery without **special gear** unit requirements a load stage of ≥ **6** shall be maintained in any case (1)<br>• Load stage ≥ **7** shall be observed for screw compressor units<br>• As a standard rule, load stage ≥ **8** shall be observed for machinery with **load gear unit requirements**<br>• In case of **higher load stage requirements** which have to be stipulated by the gear unit manufacturer, special lubricants with high load carrying capacity have to be selected. | ASTM D5182<br>ISO 14 635 – 1<br>IP 334 |

## MAN TED 10000494596 001 02 - Turbine Specification Oxidation and temperature stability properties

December 2011

| Parameter | Standard requirements | Higher requirements | Test Method |
|---|---|---|---|
| TOST aging stability<br>Load carrying capacity (load stage) | ≥ 4000 hrs | ≥ 6000 hrs (1) | DIN 51 587<br>ASTM D943<br>ISO 4263 |
| RPVOT oxidation stability<br>*(Rotating Pressure Vessel Oxidation Test)* | ≥ 450 min. | ≥ 600 min. (1) | ASTM D2272 |
| Temperature stabilitiy<br>behaviour of turbine oils (2) | Good stability, low tendency to form films | | MAN – LTAT<br>(in-house standard method) |

**Note:**

(1) Turbines and turbo compressors with higher thermal requirements.

(2) This MAN Diesel & Turbo SE in-house investigation method is applied by department RMC as a standard feature for testing the suitability of hitherto unknown products or new formulations.

# Chinese National Turbine Specifications GB11120-2011 December 2011
## Technical requirements of L-TSA and L-TSE

| Test | Performance Specifications | | | | | | | Test Method |
|---|---|---|---|---|---|---|---|---|
| | Class A | | | Class B | | | | |
| ISO Viscosity Grade | **32** | **46** | **68** | **32** | **46** | **68** | **100** | GB/T 3141 |
| Appearance | Clear & Bright | | | Clear & Bright | | | | Visual |
| Colour, rating | Report | | | Report | | | | GB/T 6540 |
| Viscocity @ 40°C, mm²/s | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 28.8.35.2 | 41.4-50.6 | 61.2-74.8 | 90-110.0 | GB/T 265 |
| Viscosity Index | 90 min. | | | 85 min. | | | | GB/T 1995[a] |
| Pour Point[b], °C | -6 max. | | | -6 max. | | | | GB/T 3535 |
| Density @ 20°C, kg/m³ | Report | | | Report | | | | GB/T 1884<br>GB/T 1885[c] |
| Flash Point (COC), °C | 186 min. | | 195 min. | 186 min. | | 195 min. | | GB/T 3536 |
| Acid Number, mg KOH/g | 0.2 max. | | | 0.2 max. | | | | GB/T 4945[d] |
| Water content, %wt | 0.02 max. | | | 0.02 max. | | | | GB/T 11133[e] |
| Foam (Tendency/Stability)[f], ml/ml<br>Seq I 24°C<br>Seq II 93.5°C<br>Seq III 24°C (after) | <br>450/0 max.<br>50/0 max.<br>450/0 max. | | | <br>450/0 max.<br>100/0 max.<br>450/0 max. | | | | GB/T 12579 |
| Air Release @ 50°C, minute | 5 max. | | 6 max. | 5 max. | 6 max. | 8 max. | – | SH/T 0308 |
| Copper Corrosion @ 100°C, 3 hrs | 1 max. | | | 1 max. | | | | GB/T 5096 |
| Rust Test @ 24 hrs | No Rust | | | No Rust | | | | GB/T 11143[B] |
| Demulsibility (Time for emulsion to 3ml)<br>54°C, minute<br>82°C, minute | <br>15 max.<br>– | | <br>30 max.<br>– | <br>15 max.<br>– | | <br>30 max.<br>– | <br>–<br>30 max. | GB/T 7305 |
| RPVOT[g], minutes | Report | | | Report | | | | SH/T 0193 |
| Oxidation Stability<br>TAN after 1000hrs, mg KOH/g | 0.3 max. | 0.3 max. | 0.3 max. | Report | Report | Report | – | GB/T 12581 |
| Time for TAN to 2.0 mg KOH/g, hrs | 3500 min. | 3000 min. | 2500 min. | 2000 min. | 2000 min. | 1500 min. | 1000 min. | GB/T 12581 |
| Sludge after 1000hrs, mg | 200 max. | 200 max. | 200 max. | Report | Report | Report | – | SH/T 0565 |
| Load Capacity[h]<br>FZG (A/8.3/90), Fail Stage | 8 min. | 9 min. | 10 min. | – | | | | GB/T 19936.1 |
| Filterability | | | | | | | | |
| Dry, % | 85 min. | | | Report | | | | SH/T 0805 |
| Wet | Pass | | | Report | | | | |
| Cleanliness[i] | -/18/15 | | | Report | | | | GB/T 14039 |

**Note:**

(a) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.

(b) It can be negotiable with the supplier for lower temperature.

(c) Test method can also use SH/T 0604.

(d) Test method can also use GB/T 7304 and SH/T 0163. In case of disputed results, it is required to use method GB/T 4945 for determination.

(e) Test method can also use GB/T 7600 and SH/T 0207. In case of disputed results, it is required to use method GB/T 11133 for determination

(f) Record the foam at 300s for Seq I and III. Record the foam at 60s for Seq II.

(g) This value is useful for oil monitoring. If is below 250min, it's abnormal.

(h) Test method can also use SH/T 0306. In case of disputed results, it is required to use method GB/T 19936.1 for determination.

(i) The automatic particle can be calibrate by GB/T 18854. (Recommend using DL/T 432 to calculate and measure particle.

# Chinese National Turbine Specifications GB11120-2011 December 2011
# Technical requirements of L-TGA and L-TGE

| Test | Performance Specifications | | | Performance Specifications | | | Test Method |
|---|---|---|---|---|---|---|---|
| | L-TGA | | | L-TGE | | | |
| ISO Viscosity Grade | **32** | **46** | **68** | **32** | **46** | **68** | GB/T 3141 |
| Appearance | Clear & Bright | | | Clear & Bright | | | Visual |
| Colour, rating | Report | | | Report | | | GB/T 6540 |
| Viscocity @ 40°C, $mm^2/s$ | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | GB/T 265 |
| Viscosity Index | 90 min. | | | 90 min. | | | GB/T 1995[(a)] |
| Pour Point[(f)], °C | -6 max. | | | -6 max. | | | GB/T 3535 |
| Density @ 20°C, $kg/m^3$ | Report | | | Report | | | GB/T 1884<br>GB/T 1885[(c)] |
| Flash Point (COC), °C<br>Open Cup (COC),°C<br>Close Cup (PMCC), °C | <br>186 min.<br>170 min. | | | <br>186 min.<br>170 min. | | | <br>GB/T 3536<br>GB/T 261 |
| Acid Number, mg KOH/g | 0.2 max. | | | 0.2 max. | | | GB/T 4945[(d)] |
| Water content, %wt | 0.02 max. | | | 0.02 max. | | | GB/T 11133[(e)] |
| Foam (Tendency/Stability)[(f)], ml/ml<br>Seq I 24°C<br>Seq II 93.5°C<br>Seq III 24°C (after) | <br>450/0 max.<br>50/0 max.<br>450/0 max. | | | <br>450/0 max.<br>50/0 max.<br>450/0 max. | | | GB/T 12579 |
| Air Release @ 50°C, mins. | 5 max. | | 6 max. | 5 max. | | 6 max. | SH/T 0308 |
| Copper Corrosion @ 100°C, 3 hrs | 1 max. | | | 1 max. | | | GB/T 5096 |
| Rust Test @ 24 hrs | No Rust | | | No Rust | | | GB/T 11143(B) |
| RPVOT[(g)], minutes | Report | | | Report | | | SH/T 0193 |
| Oxidation Stability<br>TAN after 1000hrs, mg KOH/g<br>Time for TAN to 2.0 mg KOH/g, hrs<br>Sludge after 1000hrs, mg | <br>0.3 max.<br>3500 min.<br>200 max. | <br>0.3 max.<br>3000 min.<br>200 max. | <br>0.3 max.<br>2500 min.<br>200 max. | <br>0.3 max.<br>3500 min.<br>200 max. | <br>0.3 max.<br>3000 min.<br>200 max. | <br>0.3 max.<br>2500 min.<br>200 max. | <br>GB/T 12581<br>GB/T 12581<br>SH/T 0565 |
| Load Capacity FZG CA/8.3 (90). Fail stage | - | | | 8 min. | 9 min. | 10 min. | GB/T 19936.1[(h)] |
| Filterability | | | | | | | |
| Dry, % | 85 min | | | 85 min | | | SH/T 0805 |
| Wet | Pass | | | Pass | | | |
| Cleanliness[(i)] | -/17/14 max. | | | -/17/14 max. | | | GB/T 14039 |

**Note:**

(a) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.

(b) It can be negotiable with the supplier for lower temperature.

(c) Test method can also use SH/T 0604.

(d) Test method can also use GB/T 7304 and SH/T 0163. In case of disputed results, it is required to use method GB/T 4945 for determination.

(e) Test method can also use GB/T 7600 and SH/T 0207. In case of disputed results, it is required to use method GB/T 11133 for determination

(f) Record the foam at 300s for Seq I and III. Record the foam at 60s for Seq II.

(g) This value is useful for oil monitoring. If is below 250 min., it's abnormal.

(i) The automatic particle can be calibrate by GB/T 18854. (Recommend using DL/T 432 to calculate and measure particle.

(h) Test method can also use SH/T 0306. In case of disputed results, it is required to use method GB/T 19936.11 for determination



Afton CHEMICAL

## Chinese National Turbine Specifications GB11120-2011 December 2011
## Technical requirements of L-TGSB

| Test | Performance Specifications L–TGSB | | | Test Method |
|---|---|---|---|---|
| ISO Viscosity Grade | **32** | **46** | **68** | GB/T 3141 |
| Appearance | Clear & Bright | | | Visual |
| Colour, rating | Report | | | GB/T 6540 |
| Viscocity @ 40°C, $mm^2/s$ | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | GB/T 265 |
| Viscosity Index | 90 min. | | | GB/T 1995[(a)] |
| Pour Point[(b)], °C | -6 max. | | | GB/T 3535 |
| Density @ 20°C, $kg/m^3$ | Report | | | GB/T 1884<br>GB/T 1885[(c)] |
| Flash Point (COC), °C<br>Open Cup (COC),°C<br>Close Cup (PMCC), °C | <br>200 min.<br>190 min. | | | <br>GB/T 3536<br>GB/T 261 |
| Acid Number, mg KOH/g | 0.2 max. | | | GB/T 4945[(d)] |
| Water content, %wt | 0.02 max. | | | GB/T 11133[(e)] |
| Foam (Tendency/Stability)[(f)], ml/ml<br>Seq I 24°C<br>Seq II 93.5°C<br>Seq III 24°C (after) | <br>450/0 max.<br>50/0 max.<br>450/0 max. | | | GB/T 12579 |
| Air Release @ 50°C, mins. | 5 max. | | 6 max. | SH/T 0308 |
| Copper Corrosion @ 100°C, 3 hrs | 1 max. | | | GB/T 5096 |
| Rust Test @ 24 hrs | No Rust | | | GB/T 11143(B) |
| Demulsibility (time for emulsion to 3ml) 54°C, minute | 30 max. | | | GB/T 7305 |
| RPVOT, minutes | 750 min. | | | SH/T 0193 |
| Modified RPVOT [(g)], % | 85 min | | | SH/T 0193 |
| RPVOT[(g)], minutes | 750 min. | | | SH/T 0193 |
| High Temperature Oxidation Stability (175°C, 72h)<br>Viscosity Change, %<br>TAN Change, mgKOH/g<br>Metal Weight Change, $mg/cm^2$<br>Steel<br>Aluminium<br>Cadmium<br>Copper<br>Magnesium | <br>Report<br>Report<br><br>±0.250<br>±0.250<br>±0.250<br>±0.250<br>±0.250 | | | ASTM D4636[(h)] |
| Oxidation Stability<br>Time for TAN to 2.0 mg KOH/g, hrs | 3500 min. | 3000 min. | 2500 min. | GB/T 12581 |
| Filterability<br>Dry, %<br>Wet | <br>85 min<br>Pass | | | SH/T 0805 |
| Cleanliness[(j)] | -/17/14 max. | | | GB/T 14039 |

**Note:**
(a) Test method can also use GB/T 2541. In case of disputed results, it is required to use method GB/T 1995 for determination.
(b) It can be negotiable with the supplier for lower temperature.
(c) Test method can also use SH/T 0604.
(d) Test method can also use GB/T 7304 and SH/T 0163. In case of disputed results, it is required to use method GB/T 4945 for determination.
(e) Test method can also use GB/T 7600 and SH/T 0207. In case of disputed results, it is required to use method GB/T 11133 for determination
(f) Record the foam at 300s for Seq I and III. Record the foam at 60s for Seq II.
(g) Clean & dry nitrogen is led into 300ml oil sample at 121°C, 2L/H for 48 hours.Test the oil sample according to SH/T 0193, the result is expressed as the ratio of handled oil sample to fresh oil sample, and stated as a percentage.
(h) Test method can also use GJB 563. In case of disputed results, it is required to use method ASTM D4636 for determination.
(j) The automatic particle counter can be calibrate by GB/T 18854. (Recommend using DL/T 432 to calculate and measure particle.


Afton CHEMICAL

## ASTM D4304 – 13 – Turbine Specification 2013

| Property | ASTM Test Method | Limits | | | |
|---|---|---|---|---|---|
| Physical:<br>ISO–viscosity grade<br>ASTM Colour, rating | D2422<br>D1500 | 32<br>Report | 46<br>Report | 68<br>Report | 100<br>Report |
| Specific Gravity at 15.6/15.6°C<br>Flash point °C, min.<br>Pour point, °C, max. | D4052<br>D92<br>D97[a] | Report<br>180<br>-6 | Report<br>180<br>-6 | Report<br>180<br>-6 | Report<br>180<br>-6 |
| Water Content, m%, max.<br>Viscosity, cSt (mm2/s) 40°C | D6304<br>D445 | 0.02<br>28.8–35.2 | 0.02<br>41.4–50.6 | 0.02<br>61.2–74.8 | 0.02<br>90–110 |
| Visual examination at 20°C | – | Clear & Bright | | | |
| Chemical:<br>Total Acid Number, mg KOH/g, max.<br>performance | D974[b] | Report | Report | Report | Report |
| Emulsion characteristics:<br>at 54°C, minutes to 3 mL emulsion, max.<br>at 82°C, minutes to 3 mL emulsion, max. | D1401[c] | 30<br>– | 30<br>– | 30<br>– | –<br>60 |
| Foaming characteristics:<br>Sequence 1, tendency/stability, mL, max. | D892 | 50/0 | 50/0 | 50/0 | 50/0 |
| Air release, 50°C, minutes max. | D3427 | 5 | 5 | 8 | 17 |
| Rust preventing characteristics | D665, Procedure B | Pass | Pass | Pass | Pass |
| Copper corrosion, 3 hrs at 100°C, max. | D130 | 1 | 1 | 1 | 1 |
| Oxidation stability[D]<br>Hours to neut. No. 2.0 min.<br>Minutes to 175 kPa drop, min. | D943<br>D2272 | 2000<br>350 | 2000<br>350 | 1500<br>175 | 1000<br>150 |
| 1000-h TOST Sludge, mg, max. | D4310 | 200 | 200 | 200 | – |
| Elastomer compatability SRE NBR1, or SRE-NBR-28P or SRE-NBR-28PX (168 ± 2h at 100°C ± 1°C) | ISO 6072 | | | | |
| Volume change % min. to max. | | -4 to 15 | -4 to 15 | -4 to 15 | N/A |
| Volume change % min. to max. | | -8 to 8 | -8 to 8 | -8 to 8 | N/A |
| 1000-h TOST, Total acid number, mg KOH/g, max. | D4310 | Report | Report | Report | |
| Cleanliness at the delivery stage, max. | ISO 4406 | 18/16/13 | 18/16/13 | 18/16/13 | 18/16/13 |

**Note:**
(a) Lower pour point may be required for some applications.
(b) Test Method D664 may be ued as an alternative test method.
(c) Applies only to steam turbine oils and combined cycle turbine oils.
(d) Test Method D943 is the accepted test method for oxidation stability of new steam turbine oils. It is recognized that Test Method D943 is a lengthy procedure. Test Method D2272 is a shorter test for quality control. See X1.3.6 for significance of Test Method D2272.

There are additional requirements for type II and III turbine oils.

# ISO 8068 – Turbine Specification – L-TSA and L-TGA September 2006

| Property | Unit | Viscocity class | | | Test Method |
|---|---|---|---|---|---|
| | | 32 | 46 | 68 | |
| Viscosity class | – | 32 | 46 | 68 | ISO 3448 |
| Colour | Rating | Report | | | ISO 2049 |
| Appearance | Rating | Clear & Bright | | | visual |
| Kinematic viscosity at 40°C<br>– min.<br>– max. | $mm^2/s$ | 28,8<br>35,2 | 41,4<br>50,6 | 61,2<br>74,8 | ISO 3104 |
| Viscosity index (min.) | | 90 | 90 | 90 | ISO 2909 |
| Pour Point (max.) [(a)] | °C | - 6 | - 6 | - 6 | ISO 3016 |
| Density at 15 °C | kg/m3 | Report | | | ISO 12185 or ISO 3675 |
| Flash point (minimum)<br>– open cup<br>– closed cup | °C | 186<br>170 | 186<br>170 | 186<br>170 | ISO 2592<br>ISO 2719 |
| Total acid number (max.) [(b)] | mg KOH/g | 0,2 | 0,2 | 0,2 | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (max.) | % *(m/m)* | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (max.)[(C)]<br>– sequence I at 24°C<br>– sequence II at 93°C<br>– sequence III at 24°C after 93°C | ml/ml<br>ml/ml<br>ml/ml | 450/0<br>50/0<br>450/0 | 450/0<br>50/0<br>450/0 | 450/0<br>50/0<br>450/0 | ISO 6247 |
| Air release time at 50°C (max.) | min | 5 | 5 | 6 | ISO 9120 |
| Copper corrosion (3hrs at 100°C) (max). | Rating | 1 | 1 | 1 | ISO 7120 (B) |
| Corrosion-preventitive properties (24 hrs) | Rating | Pass | | | ISO 7120 (B) |
| Demulsibility [(d)]<br>(maximum time to reach 3 ml emulsion at 54°C) | min | 30 | 30 | 30 | ISO 6614 |
| Oxidation stability (rotating pressure vessel) (min.) [(e)] | min | Report | | | ASTM D2272-02 |
| Oxidation stability ('TOST') [(f)]<br>– total acid number at 1,000 hrs (max.)<br>– time for total acid number 2 mg KOH/g (min.)<br>– sludge after 1,000 hrs (max.) | mg KOH/g<br>h<br>mg | 0,3<br>3,500<br>200 | 0,3<br>3,000<br>200 | 0,3<br>2,500<br>200 | ISO 4263-1 |
| Oxidation stability [(f)]<br>– total oxygen-containing products, TOP (max.)<br>– sludge (max.) | % *(m/m)*<br>% *(m/m)* | 0,40<br>0,25 | 0,50<br>0,30 | 0,50<br>0,30 | ISO 7624 |
| Filterability (dry) (min.) | % | 85 | 85 | 85 | ISO 13357-2 |
| Filterability (wet) (max.) | % | Pass | | | ISO 13357-1 |
| Cleanliness at the delivery stage [(g)] (max.) | Rating | – / 17 / 14 | | | ISO 4406 |

**Note:**
(a) Lower values may be negotiated between the end user and the supplier.
(b) In case of dispute, ISO 6618 applies.
(c) The stability of the foam is recorded at 300s for the first and third sequences, and at 60s for the second sequence.
(d) Applies only to TSA, lower limits for emulsion volume or time may be specified.
(e) This value is useful for the follow-up in service. Should not normally be below 250 min.
(f) Either of the two methods.
(g) ISO 11500[(8)], using an automatic particle counter calibrated according to ISO 11171[(9)], is the preferred test method for counting and sizing particles.



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# ISO 8068 – Turbine Specification – L-TSE and L-TGE September 2006

| Property | Unit | Viscocity class | | | Test Method |
|---|---|---|---|---|---|
| | | 32 | 46 | 68 | |
| Viscosity class | – | 32 | 46 | 68 | ISO 3448 |
| Colour | Rating | Report | | | ISO 2049 |
| Appearance | Rating | Clear & Bright | | | visual |
| Kinematic viscosity at 40°C<br>– min.<br>– max. | $mm^2/s$ | 28,8<br>35,2 | 41,4<br>50,6 | 61,2<br>74,8 | ISO 3104 |
| Viscosity index (min.) | | 90 | 90 | 90 | ISO 2909 |
| Pour Point (max.) (a) | °C | - 6 | - 6 | - 6 | ISO 3016 |
| Density at 15 °C | kg/m3 | Report | | | ISO 12185 or ISO 3675 |
| Flash point (minimum)<br>– open cup<br>– closed cup | °C | 186<br>170 | 186<br>170 | 186<br>170 | ISO 2592<br>ISO 2719 |
| Total acid number (max.) (b) | mg KOH/g | 0,2 | 0,2 | 0,2 | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (max.) | % *(m/m)* | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (max.)(C)<br>– sequence 1°C at 24°C<br>– sequence 2°C at 93°C<br>– sequence 3°C at 24°C after 93°C | ml/ml<br>ml/ml<br>ml/ml | 450/0<br>50/0<br>450/0 | 450/0<br>50/0<br>450/0 | 450/0<br>50/0<br>450/0 | ISO 6247 |
| Air release time at 50°C (max.) | min | 5 | 5 | 6 | ISO 9120 |
| Copper corrosion (3hrs at 100°C) (max.) | Rating | 1 | 1 | 1 | ISO 7120 (B) |
| Corrosion-preventitive properties (24 hrs) | Rating | Pass | | | ISO 7120 (B) |
| Demulsibility (d)<br>(maximum time to reach 3 ml emulsion at 54°C) | min | 30 | 30 | 30 | ISO 6614 |
| Oxidation stability (rotating pressure vessel) (min.) (e) | min | Report | | | ASTM D2272-02 |
| Oxidation stability ('TOST')<br>– total acid number at 1,000 hrs (max.)<br>– time for total acid number 2 mg KOH/g (min.)<br>– sludge after 1,000 hrs (max.) | mg KOH/g<br>h<br>mg | 0,3<br>3,500<br>200 | 0,3<br>3,000<br>200 | 0,3<br>2,500<br>200 | ISO 4263-1 |
| Filterability (dry) (min.) | % | 85 | 85 | 85 | ISO 13357-2 |
| Filterability (wet) (max.) | % | Pass | | | ISO 13357-1 |
| Load-carrying capacity – FZG test (A/8,3/90)<br>Failure-load stage (min.) (f) | rating | 8 | 9 | 10 | ISO 14635-1 |
| Cleanliness at the delivery stage (g) (max.) | Rating | – / 17 / 14 | | | ISO 4406 |

**Note:**
(a) Lower values may be negotiated between the end user and the supplier.
(b) In case of dispute, ISO 6618 applies.
(c) The stability of the foam is recorded at 300s for the first and third sequences, and at 60s for the second sequence.
(d) Applies to TSE only.
(e) This value is useful for the follow-up in service. Should not normally be below 250 min.
(f) Higher failure load stages may be requested by some manufacturers/users.
(g) ISO 11500[8], using an automatic particle counter calibrated according to ISO 11171[9], is the preferred test method for counting and sizing particles.

## ISO 8068 – Turbine Specification – L-TGB and L-TGSB September 2006

| Property | Unit | Viscocity class | | | Test Method |
|---|---|---|---|---|---|
| | | 32 | 46 | 68 | |
| Viscosity class | – | 32 | 46 | 68 | ISO 3448 |
| Colour | Rating | Report | | | ISO 2049 |
| Appearance | Rating | Clear & Bright | | | visual |
| Kinematic viscosity at 40°C<br>– min.<br>– max. | $mm^2/s$ | 28,8<br>35,2 | 41,4<br>50,6 | 61,2<br>74,8 | ISO 3104 |
| Viscosity index (min.) | | 90 | 90 | 90 | ISO 2909 |
| Pour Point (max.) (a) | °C | - 6 | - 6 | - 6 | ISO 3016 |
| Density at 15 °C | kg/m3 | Report | | | ISO 12185 or ISO 3675 |
| Flash point (minimum)<br>– open cup<br>– closed cup | °C | 200<br>190 | 200<br>190 | 200<br>190 | ISO 2592<br>ISO 2719 |
| Total acid number (max.) (b) | mg KOH/g | 0,2 | 0,2 | 0,2 | ISO 6618 or ISO 6619 or ISO 7537 |
| Water content (max.) | % *(m/m)* | 0,02 | 0,02 | 0,02 | ISO 6296 or ISO 12937 |
| Foaming (tendency/stability) (max.)(C)<br>– sequence 1°C at 24°C<br>– sequence 2°C at 93°C<br>– sequence 3°C at 24°C after 93°C | ml/ml<br>ml/ml<br>ml/ml | 450/0<br>50/0<br>450/0 | 450/0<br>50/0<br>450/0 | 450/0<br>50/0<br>450/0 | ISO 6247 |
| Air release time at 50°C (max.) | min | 5 | 5 | 6 | ISO 9120 |
| Copper corrosion (3hrs at 100°C) (max). | Rating | 1 | 1 | 1 | ISO 7120 (B) |
| Corrosion-preventitive properties (24 hrs) | Rating | Pass | | | ISO 7120 (B) |
| Demulsibility (d)<br>(maximum time to reach 3 ml emulsion at 54°C) | min | 30 | 30 | 30 | ISO 6614 |
| Oxidation stability (rotating pressure vessel) (min.) | min | 750 | 750 | 760 | ASTM D2272-02 |
| Oxidation stability (rotating pressure vessel) (min.) (e) | % | 85 | 85 | 85 | ASTM D2272-02 |
| Oxidation stability at high temperatures<br>(72 h at 175°C)<br>– Viscosity change (max.)<br>– Acid number change (max.)<br>– Metal specimen mass change<br>– Steel<br>– Aluminium<br>– Cadmium<br>– Copper<br>– Magnesium | %<br>mg KOH/g<br>$mg/cm^2$ | Report<br>Report<br><br>±0,250<br>±0,250<br>±0,250<br>±0,250<br>±0,250 | Report<br>Report<br><br>±0,250<br>±0,250<br>±0,250<br>±0,250<br>±0,250 | Report<br>Report<br><br>±0,250<br>±0,250<br>±0,250<br>±0,250<br>±0,250 | ASTM D4636 according to “alternative procedure 2” |
| Oxidation stability (‘TOST’)<br>– time for total acid number 2 mg KOH/g (min.) | h | 3,500 | 3,000 | 2,500 | ISO 4263-1 |
| Filterability (dry) (min.) | % | 85 | 85 | 85 | ISO 13357-2 |
| Filterability (wet) (max.) | % | Pass | | | ISO 13357-1 |
| Cleanliness at the delivery stage (max.) | Rating | – / 17 / 14 | | | ISO 4406 |

**Note:**

(a) Lower values may be negotiated between the end user and the supplier.

(b) In case of dispute, ISO 6618 applies.

(c) The stability of the foam is recorded at 300s for the first and third sequences, and at 60s for the second sequence.

(d) Applies to TGSB only.

(e) Nitrogen blown RPVOT is performed by treatment of 300ml of oil at 121°C, by bubbling clean and dry nitrogen for 48h at the rate of 3 l/h. The result is expressed as the percent of life versus the sample without treatment.

(f) ISO 11500(8), using an automatic particle counter calibrated according to ISO 11171(9), is the preferred test method for counting and sizing particles.

## Russian National Turbine Specifications Tp-22s — November 2011

| Control | | Value by Grade 1 | Value by Grade 2 | Test Method |
|---|---|---|---|---|
| Kinematic Viscosity, $mm^2/s$ | | | | GOST 33 or ASTM D445 |
| | at 40°C | 28.8-35.2 | | |
| | at 50°C | 20-23 | | |
| Viscosity Index, at least | | 95 | 90 | GOST 25371 |
| Acid Value, mg KOH/g | | 0.04-0.07 | | GOST 11362 or GOST 5985 |
| Oxidation stability, not more than 130°C, 24 hours and 5 $dm^3/h$ oxygen rate: | | | | GOST 981 with additions pursuant to Section 4.2 of this Specification |
| | Sediment, % wt | 0.005 | | |
| | Acid Value mg KOH/g | 0.10 | | |
| | Volatile acids, mg KOH/g | 0.02 | | |
| At 150°C, 16 hours and 3 $dm^3/h$ oxygen rate: | | | | |
| | Sediment, % wt | 0.01 | | |
| | Acid Value mg KOH/g | 0.15 | | |
| | Volatile acids, mg KOH/g | 0.15 | | |
| Demulsification time, s (not more than) | | 180 | | GOST 12068 |
| Steel rod corrosion | | None | | GOST 19199 with additions pursuant to Section 4.3 of this Specification |
| Flash point in open bowl, °C (at least) | | 186 | | GOST 4333 or ASTM D92 |
| Pour point, °C (not more than) | | -15 | | GOST 20287 |
| Sulfur content, % wt (not more than) | | 0.5 | | GOST 1437 |
| Content of water soluble acids and bases | | None | | GOST 6307 |
| Mechanical impurities, % (not more than) | | 0.005 | | GOST 6307 |
| Colour by TsNT colourimeter, TsNT units | | 1.5 | 2.5 | GOST 20284 ASTM D1500 |
| Water Content, % (not more than) | | None | | GOST 2477 |
| Phenol content in base oil, $mg/dm^3$ (not more than) | | 20 | | GOST 1057 |
| Density at 15°C, $kg/m^3$ (not more than) | | 903 | | GOST R 51069 or ASTM D1298 |

**Note:**
- For Grade 1, “oxidation stability” (item 4) at 130°C, 24 hours and 5$dm^3$/hour oxygen rate must be measured til October 1, 2002
- “Phenol content in base oil” must be measured for oil batches that were selectively treated with phenol.

# European Slideway Specifications

| Specifications | AFNOR E 60-203 Lubricants, industrial oils and related products: lubricants for lubrication and control of machine tools and similar equipment, characteristics | | | | | | | ASTM Test Method |
|---|---|---|---|---|---|---|---|---|
| Issue Date | **February 1983** | | | | | | | |
| | **L-G requirements** | | | | | **L-HG requirements** | | |
| ISO Viscosity grade, Kinematic Viscosity at 40°C, mm²/s | 32 | 68 | 100 | 150 | 220 | 32 | 68 | NFT 60-100 |
| Kinematic Viscosity at 100°C, mm²/s | Report | | | | | Report | | NFT 60-100 |
| Viscosity Index, min. | 85 | | | | | 95 | | NFT 60-136 |
| Colour | Report | | | | | Report | | NF M 60-104 |
| Ash Content | Report | | | | | Report | | NF M 07-045 |
| Saponification no. | Report | | | | | Report | | NFT 60-110 |
| Neutralisation No., mg KOH/g | Report | | | | | ≤0.05 | | NFT 60-112 |
| Density at 15°C, kg/m³ | Report | | | | | Report | | NFT 60-101 |
| Flash Point (COC) °C, min. | 160 | 180 | | | | 160 | 180 | NF M 07-019 |
| Pour Point, °C, max. | -9 | | | | -6 | -9 | | NFT 60-105 |
| Aniline Point, °C, min. | 95 | | | | | 95 | | NF M 07-021 |
| Water Content, % mass, max. | 0.05 | | | | | 0.05 | | NFT 60-113 |
| Air Release @ 50°C, min. | | | | | | Report | | NFT 60-149 |
| Foam, ml, max. | | | | | | | | NFT 60-129 |
| Sequence I | Report | | | | | 100/10 | | |
| Sequence II | Report | | | | | 100/10 | | |
| Sequence III | Report | | | | | 100/10 | | |
| Water separation, time to 40/37/3, mins. | | | | | | Report | | NFT 60-125(7) |
| Copper Corrosion, 3 hrs @ 100°C, rating | < 3 (3 hrs @ 60 °C) | | | | | < 2 | | NFM 07-015 |
| Steel Corrosion, Method A, rating | Pass | | | | | Pass | | NFT 60-151 |
| Oxidation Resistance | Report | | | | | Report | | NFT 60-150 |
| FZG A/8.3/90 | | | | | | Report | | DIN 51354 |
| Friction Test (method given by supplier) | Discuss with Supplier | | | | | Discuss with Supplier | | |
| Compatibility with cutting fluid (method given by supplier) | Discuss with Supplier | | | | | Discuss with Supplier | | |
| Compatibility with elastomers | | | | | | Discuss with Supplier | | NFE 48-610 |

## European Slideway Specifications – Cont'd

| Specifications | ISO 19 378 (2003) Lubricants, industrial oils and related products: (Class L) - Machine Tool Lubricants - Categories and Specifications | | | | ISO 11158 Lubricants, industrial oils and related products: (Class L) - Family H (Hydraulic Systems) - Specifications for categories HH, HL, HM, HV and HG | | ASTM Test Method |
|---|---|---|---|---|---|---|---|
| **Issue Date** | **01/03/2003 First Edition** | | | | **September 2009** | | |
| | **GA and GB requirements** | | | | **HG requirements** | | |
| ISO Viscosity grade, Kinematic Viscosity at 40°C, mm²/s | 68 | 100 | 150 | 220 | 32<br>28.8 - 35.1 | 68<br>61.2 - 74.8 | ISO 3104 |
| Viscosity Index | Report | Report | Report | Report | Report | | ISO 2909 |
| Appearance | Clear & Bright | Clear & Bright | Bright | Bright | Clear & Bright | | Visual |
| Neutralisation No., mg KOH/g | Report | Report | Report | Report | Report | | ISO 6618 |
| Colour | | | | | Report | | ISO 2049 |
| Density at 15°C, kg/m³ | Report | Report | Report | Report | Report | | ISO 3675 |
| Flash Point (COC), °C, min. | 180 | 180 | 180 | 180 | 175 | 195 | ISO 2592 |
| Pour Point, °C, max. | -9 | -9 | -3 | -3 | -18 | -12 | ISO 3016 |
| Cleanliness, rating | | | | | Discuss with Supplier | | ISO 4406 |
| Water Content, % mass, max. | | | | | 0.025 | | ISO 6296 |
| Oxidation Stability | | | | | | | ISO 4263-1 |
| Increase in acid number after 1000 hrs, max. | | | | | 2.0 | | |
| Insoluble sludge, mg, max. | | | | | Report | | |
| Foam, ml, max | | | | | | | ISO 6247 |
| Sequence I | | | | | 150/10 | | |
| Sequence II | | | | | 80/10 | | |
| Sequence III | | | | | 150/10 | | |
| Copper Corrosion, 3 hrs @ 100°C, rating | < 2 | | | | ≤2 | | ISO 2160 |
| Steel Corrosion, Method A, rating | Pass | | | | Pass (Method A & B) | | ISO 7120 |
| FZG A/8.3/90, failure load stage | | | | | ≥10 | | ISO 14635-1 |
| Wear protection, vane pump, max. | | | | | | | ISO 20763 |
| Weight loss on cam rings, mg | | | | | 120 | | |
| Weight loss on vanes, mgs | | | | | 30 | | |
| Friction Test (method given by supplier) | Discuss with Supplier | | | | Discuss with Supplier | | |
| Compatibility with cutting fluid (method given by supplier) | Discuss with Supplier | | | | Discuss with Supplier | | |
| Compatibility with construction materials | Discuss with Supplier | | | | | | ISO 1817 |
| Elastomer combatibility, NBRI, 182 hrs @ 100°C | | | | | | | ISO 6072 |
| Relative increase in volume | | | | | 0 to 12 | 0 to 10 | |
| Change in Shore A hardness | | | | | 0 to -7 | 0 to -6 | |
| Antiwear Properties | Report | | | | | | ASTM D4172-B Conditions |



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## US Slideway Specifications

| Specifications | GM LS2 (04) GM Lubricants standard No. LW-03-1-04, LW-06-1-04, LW-22-1-04 Light, Medium and Heavy Way Oils | | | SAE MS 1007 Lubricants, industrial oils and related products, Type E Slideway Lubricants Specification | | ASTM Test Method |
|---|---|---|---|---|---|---|
| | 30-Nov-04 | 30-Nov-04 | 30-Nov-04 | 2012 | | |
| Test | LW-03-1-04, Light | LW-06-1-04, Medium | LW-22-1-04, Heavy | | | |
| ISO Viscosity grade | 32 | 68 | 220 | 32 - 320 | 460 - 1000 | D2422 |
| Kinematic Viscosity | | | | | | ASTM D445 |
| @ 100°C, cSt | Report | Report | Report | | | |
| @ 40°C, cSt | 28.8 - 35.2 | 61.2 - 74.8 | 198 - 242 | ISO VG +/- 10% | ISO VG +/- 10% | |
| Viscosity Index | Report | Report | Report | | | ASTM D2270 |
| A.P.I. Gravity | Report | Report | Report | | | ASTM D287 |
| Density @ 15°C, g/ml | | | | Report | Report | ASTM D4052 |
| Neutralisation No., mg KOH/g, max. | | | | Report | Report | ASTM D664 |
| Flash Point (COC), °C, min. | 190 | 190 | 200 | 175 | 210 | ASTM D92 |
| Pour Point, °C, max. | -15 | -10 | -10 | 10 | 10 | ASTM D97 |
| Sediment | Nil | Nil | Nil | | | ASTM D473 |
| Water content, ppm, max. | 500 | 500 | 500 | 250 | 250 | ASTM D6304 |
| Precipitation Number, max. | 0.05 | 0.05 | 0.05 | | | ASTM D91 |
| Cleanliness, as received, max. | 20/18/14 | 20/18/14 | 20/18/14 | 21/19/15 | 21/19/15 | ISO 4406 |
| Base Oil Requirments | | | | | | |
| Residual Elements (As, B, Ca, Mn, Mg, Na, Fe, Ni, Si, Cu, Sn, Cd, Cr, Pb, Ba, Zn), ppm max. total/each | 25/2 | 25/2 | 25/2 | | | ASTM D5185 |
| Residual Elements P, ppm max. | 5 | 5 | 5 | | | ASTM D5185 |
| Water Separation, T to 40/37/3, mins., max. | 30 | 30 | 30 | Report | Report | ASTM D1401 |
| Demulsibility | | | | | | ASTM D2711 |
| Water in Oil After 5 hrs., % max. | 1 | 1 | 1 | 1 | 1 | |
| Emulsion After Cntrfg., ml max. | 2 | 2 | 2 | 2 | 2 | |
| Total Free Water, ml min. | 60 | 60 | 60 | 60 | 60 | |
| Content of undissolved matter, % m/m, max. | | | | Below detectability | Below detectability | DIN 51592 |
| Ames Mutagenicity | | | | | | E1687 |
| Fold Increase | | | | Report | | |
| Mutagenicity Index, max. | | | | 1 | | |
| Mutagenicity Potency Index | | | | Report | | |
| Content Compatability | | | | To be discussed with supplier | | |

## US Slideway Specifications – Cont'd

| Specifications | GM LS2 (04) GM Lubricant Standard No. LW-03-1-04, LW-06-1-04, LW-22-1-04 Light, Medium and Heavy Way Oils | | | SAE MS 1007 Lubricants, industrial oils and related products, Type E Slideway Lubricants Specification | | ASTM Test Method |
|---|---|---|---|---|---|---|
| | 30-Nov-04 | 30-Nov-04 | 30-Nov-04 | May 2001 | | |
| Test | LW-03-1-04, Light | LW-06-1-04, Medium | LW-22-1-04, Heavy | | | |
| Copper Corrosion, 3 hrs @ 100°C, max. | 1b | 1b | 1b | 2 | | ASTM D130 |
| Steel Corrosion, rating | | | | | | ASTM D665 |
| Method A | | | | Pass | | |
| Method B | Pass | Pass | Pass | Report | | |
| Timken OK Load, kg, min. | 16 | 16 | 27 | 16 | 27 | ASTM D2782 |
| CM Stick-Slip Frictional Test, ratio of static to kinetic friction, max. | 0.8 | 0.8 | 0.8 | 0.8 | | ASTM D2877 |
| Tackifier added | Report | Report | Report | Report | | |

## US Slideway Specifications – Cont'd

| Specifications | MAG Cincinnati Machine P-53 | MAG Cincinnati Machine P-47 | MAG Cincinnati Machine P-50 | MIL-A-A-59113 | | ASTM Test Method |
|---|---|---|---|---|---|---|
| | Combination Hydraulic & Way Oil | Heavy-Medium Way Oil | Heavy-Medium Way Oil | Lubricating oil, machine tool slideways | | |
| | 2000 | 2000 | 2000 | 30 December 1997 | | |
| | | | | Type 1 - Medium | Type 2 - Heavy | |
| Kinematic Viscosity | | | | | | ASTM D445 |
| @ 40°C, cSt | 28.8 - 35.2 | 61.2 - 74.8 | 198 - 242 | 61.0 - 75.0 | 195.0 - 238.0 | |
| A.P.I. Gravity | 20 to 30 | 18 to 27 | 18 to 27 | | | ASTM D287 |
| Neutralisation No., mg KOH/g, max. | 0.60 | 1.7 | 1.7 | | | ASTM D974 |
| Flash Point (COC), °F, min. | 315 | 350 | 350 | 330 | 350 | ASTM D92 |
| Fire Point, °F, min. | 355 | 360 | 410 | | | ASTM D92 |
| Pour Point, °F, max. | | | | 20 | 20 | ASTM D97 |
| CCMB (procedure 24 hrs @ 101°C) | | | | | | CCMB |
| Neutralisation Number, max, inc. | 0.2 | 0.5 | 0.5 | | | |
| Sludge | None | | | | | |
| Steel Rod Rating, max. | 1.5 | | | | | |
| Copper Rod Rating, max. | 5 | | | | | |
| Steel Rod Deposit, mg, max. | 3.5 | | | | | |
| Copper Rod Deposit, mg, max. | 6.0 | | | | | |
| Steel metal removed, mg, max. | 1.0 | | | | | |
| Copper metal removed, mg, max. | 5.0 | | | | | |
| Copper Corrosion, 3 hrs @ 100°C, max. | | | | 1 | | ASTM D130 |
| Steel Corrosion, rating | | | | | | ASTM D665 |
| Method A | | | | Pass | | |
| CM Stick-Slip Frictional Test, ratio of static to kinetic friction, max. | 0.8 | 0.8 | 0.8 | 0.8 | | |
| Tackifier added | | | | Report | | |



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## Chinese National Slideway Specifications

| Specifications | GB 11118.1-94 (L-HG Multifunction) Chinese national specification, hydraulic fluids, mineral oil and synthetic hydrocarbon type | SH/T 0361-98 (L-G Slideway) Chinese national specification slideway oil | ASTM Test Method | |
|---|---|---|---|---|
| **Issue Date** | **1994** | **1998** | **Chinese** | **ASTM** |
| ISO Viscosity grade | ISO 32, 68 | ISO 32 - 320 | | |
| Kinematic Viscosity @ 40°C, cSt | ISO VG +/- 10% | ISO VG +/- 10% | GB/T 265 | D445 |
| Viscosity Index, min. | 95 | Report | GB/T 1995<br>GB/T 2541 | D2270 |
| Density at 20°C, kg/m³ | - | Report | GB/T 1884<br>GB/T 1885 | D1298 |
| Neutralisation Number, mgKOH/g | Report | Report | GB/T 4945 | D664 |
| Appearance (transparency) | - | Clear | Visual | |
| Flash Point (COC), °C | ≥ 160°C (ISO 32)<br>≥ 180°C (ISO 68) | ≥ 150°C (ISO 32)<br>≥ 160°C (ISO 46)<br>≥ 180°C (ISO 68 + above) | GB/T 3536 | D92 |
| Pour Point, °C, max. | ≤ -6°C | ≤ -9°C (ISO 32-150)<br>≤ -3°C (ISO 220-320) | GB/T 3535 | D97 |
| Colour | Report | - | GB/T 6540 | D1500 |
| Water Content, % wt. | trace | trace | GB/T 260 | D95 |
| Mechanical Impurity, % wt. | None | None (ISO 32-150)<br>0.01 (ISO 220-320) | GB/T 511 | Russian TOCT 6370 |
| Seal Compatibility Index | Report | - | SH/T 0305 | IP 278/72 (88) |
| Elastomer Compatibility | - | Report | GB/T 1690-92 | ISO 1817-85 |
| Copper Corrosion, rating, max | 1 (@ 100°C, 3 hrs) | 2 (@ 60°C, 3 hrs) | GB/T 5096 | D130 |
| Saponification number, mgKOH/g | Report | - | GB/T 8021 | D94 |
| Rust Test | | | GB/T 11143 | D665A |
| Distilled water | No rust | No rust | | |
| Foam, ml, max. | | | GB/T 12579 | D892 |
| Sequence I 24°C | ≤ 150 / 10 | - | | |
| Sequence II 93.5°C | ≤ 150 / 10 | - | | |
| Sequence III 24°C (after) | ≤ 150 / 10 | - | | |
| Demulsibility @ 54°C, min. | Report | - | GB/T 7305 | D1401 |
| Oxidation Stability | | | GB/T 12581 | D943 |
| TAN after 1000 hrs, mgKOH/g, max. | 2.0 | - | | |
| Insoluble sludge, mg | Report | - | SH/T 0565 | D4310 |
| RPVOT (or RBOT) @ 150°C, min. | Report | - | SH/T 0193 | D2272 |
| FZG (A/8.3/90), FLS | ≥ 10 | - | SH/T 0306 | IP 334-80 |
| Anti-wear Performance, Four-Ball wear scar, mm, max. | Report (392N, 1 hr) | 0.5 (200N, 1 hr) | SH/T 0189 | D4172 |
| Stick-Slip (Difference of static and dynamic friction coefficient), max. | 0.08 | Report | Appendix A of SH/T 0361 | |
| Metalworking Fluid Compatibility | - | Report | - | |

Specification Handbook

# Off Road

# Contents Off Road


**STOU Specifications:**

John Deere J27 .......... 2
Massey Ferguson CMS M1139 .......... 3
Massey Ferguson CMS M1144 .......... 3
Massey Ferguson M1145 .......... 3
Ford M2C 159 B .......... 4
Ford M2C 159 C .......... 4
FNH 82009201/ 2 / 3 .......... 4

**UTTO Specifications:**

John Deere J20C .......... 5
John Deere J20D .......... 5
Massey Ferguson CMS M1135 .......... 6
Massey Ferguson CMS M1141 .......... 6
Massey Ferguson CMS M1143 .......... 7
Massey Ferguson CMS M1145 .......... 7
Ford M2C 86 B .......... 8
Ford M2C 86 C .......... 8
Ford M2C 134 D .......... 8
FNHA-2-C-200.00 .......... 8
NH 410B .......... 8
NH 410C .......... 8
NH 420A .......... 8
J I Case MS 1205 .......... 9
J I Case MS 1206 .......... 9
J I Case MS 1210 .......... 9
J I Case MS 1207 .......... 10
J I Case MS 1209 .......... 10
CNH MAT 3505 .......... 10
CNH MAT 3505 .......... 11
CNH MAT 3525 .......... 12
CNH MAT 3526 .......... 12
Fiat AF87 .......... 13

**TO-4 Specifications:**

Caterpillar TO - 4 Transmission and Drive Train Fluid Requirements .......... 14
Allison C4 .......... See ATF chapter
Allison TES 439 .......... See ATF chapter

## STOU Specifications [1] - John Deere J27

| Test | John Deere J27 (Jan 1992) |
|---|---|
| SAE Classification, J300D | 10W-30, 15W-40 |
| Engine Performance | |
| API | CD / CE |
| CCMC | D4 / D5 |
| Kinematic Viscosity at 100°C, $mm^2/s$ | Relevant SAE J300 Limits |
| Cold Cranking Viscosity (CCS), mPa·s, max. | |
| at -20°C (10W-30) | 3500 |
| at -15°C (15W-40) | 3500 |
| Pumpability Viscosity (MRV), mPa·s, max. | |
| at -20°C (10W-30) | 30,000 |
| at -15°C (15W-40) | 30,000 |
| Shear Stability, JDQ102, viscosity at 100°C, $mm^2/s$, min. | 7.1 |
| Pour Point, °C, max. | -33 (10W-30)<br>-30 (15W-40) |
| Total Base Number, mgKOH/g, min. (ISO 3771) | 8 |
| Foaming, JDQ 33 | |
| Sequence I, ml, max. | 25/0 |
| Sequence II, ml, max. | 50/0 |
| Sequence III, ml, max. | 25/0 |
| Foam break time, s, max. | 30 |
| Water Sensitivity, JDQ 19 | |
| Solids, % volume, max. | 0.1 |
| Additive loss, % mass, max. | 15 |
| Rust protection, JDQ 22, hrs, min. | 100 |
| Oil Compatibility, JDQ 23 | |
| Additive Separation | None |
| Foaming Characteristics | |
| Sequence I, ml, max. | 25/0 |
| Sequence II, ml, max. | 50/0 |
| Sequence III, ml, max. | 25/0 |
| Foam break time, s, max. | 30 |
| Oxidation Stability | |
| Evaporation loss, %, max. | 5 |
| Viscosity increase at 100 °C, %, max. | 10 |
| Sludge information | None |
| Additive separation | None |
| John Deere brake performance, JDQ 96 | Pass |
| John Deere PTS Clutch performance, JDQ 94 | Pass |
| John Deere spiral bevel & final drive performance, JDQ 95 | Pass |
| Allison transmission performance, DDAD C-4[2] | Pass |
| ZF front axle performance, tests specified by ZF | Pass |
| Field test performance, >1yr or >1000 hrs | Pass |

**Note:**

(1) STOU = Super Tractor Oil Universal, for use in engine, transmission, driveline and hydraulics.

(2) Allison C4 no longer list friction modified fluids.



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# STOU Specifications - Massey Ferguson CMS M1139/44/45

| Test | Massey Ferguson CMS M1139 (April 1978) | Massey Ferguson CMS M1144 (June 1994) | Massey Ferguson M1145 (Sept 2004) |
|---|---|---|---|
| SAE Classification, J300D | | 5W-30, 10W-30, 10W-40, 15W-30, 15W-40, 20W-40 | 5W-30, 10W-30, 10W-40, 15W-30, 15W-40, 20W-40 |
| Engine Performance | | | |
| API | CD | CD/ CE | |
| CCMS | | D4/ D5 | |
| Kinematic Viscosity, 100°C, $mm^2/s$ | 10.1 - 12.0 | Relevant SAE classification | Relevant SAE classification |
| Kinematic Viscosity at 100°C after shearing, CEC L14A78 (250 Cycles), $mm^2/s$ | | 9.0 | |
| Viscosity -18°C (Brookfield), mPa·s, max. | 8000 | | |
| Pour Point, °C, NF T 60-105 | -30°C | -10 °C below MRV limit defined by SAE J300d grade | |
| Flash point, COC, °C | | -200°C | |
| Foaming, ASTM D892 | | | |
| Sequence I, ml, max. | 100/0 | Report | |
| Sequence II, ml, max. | 100/0 | Report | |
| Sequence III, ml, max. | 100/0 | Report | |
| Foaming with 1% water added | | | |
| Sequence I, ml max. | 100/0 | | |
| Sequence II, ml max. | 100/0 | | |
| Sequence III, ml max. | 100/0 | | |
| Water content, ppm, max | | 400 | |
| Dry filterability, NF E 48-690, 5 micron filter, 1 bar (Afnor) | | 1.5 max | |
| Wet filterability, NF E 48-691, 5 micron filter, 1 bar (Afnor) | | Report | |
| Copper strip corrosion, ASTM D130, 3 hrs at 150°C | 1A | | |
| Copper corrosion, 3 hrs at 100°C, NF M 07-015 | | 1A | |
| Rust prevention, MF rust test | Pass | | See UTTO section for full Massey Ferguson (GIMA) CMS M1145 limits |
| Rust prevention, ASTM D665B | | No rust | |
| Oxidation test, 100 hrs at 150°C | | | |
| Viscosity Increase at 100°C, %, max. | 10 | | |
| Sludging | None | | |
| Oxidation test, 100 hrs at 150°C, CEC L48T94 | | | |
| KV100°C change, % | | 25 max | |
| Total Acid Number change, % | | 75 max | |
| Deposits | | None | |
| Seal Test, ford RDR 008 nitrile, 168 hrs at 120°C | | | |
| Volume change, % | 0 to +5 | | |
| Hardness change, (+ 21 days at 95°C), max. | 10 | | |
| 4-Ball wear | | | |
| Wear Scar Diameter, (1 hr at 65°C 1500rpm 40kg), mm, max. | 0.4 | | |
| 4-Ball wear | | | |
| Wear Scar Diameter, (1 hr at 40daN), mm max. | | 0.4 | |
| 4-Ball EP test, ASTM D2783 | | | |
| Load Wear Index, kg, min. | 55 | 45 | |
| Vickers 104C vane pump test, NF E 48-617, ring and vane weight loss, mg, max. | | 80 mg | |
| IAE Gear rig, 2000rpm, 110°C, 1pt (0.57L)/s | | | |
| Scuff load, kg, min. | 52 | | |
| Wet brake test | Pass | | |
| IPTO Clutch test | Pass | | |
| Transmission test | Pass | | |
| Materials compatibility, various | | Pass | |
| Friction test, proprietary test | | Pass | |

| STOU Specifications - Ford M2C 159 B/C, FNH 82009201/2/3 | | | |
|---|---|---|---|
| **Test** | **Ford M2C 159 B (July 1984)** | **Ford M2C 159 C (Sept 1991)** | **FNH 82009201/ 2/ 3 (Aug 1995)** |
| SAE Classification, J300D | 10W-30, 15W-30, 20W-40 | 10W-30, 15W-30, 20W-40 | 10W-30, 15W-30, 20W-40 |
| Engine performance | API CD/ SE | API CE/ SF | API CF-4 |
| Kinematic Viscosity at 100°C, $mm^2/s$ | B1 = 10W-30<br>B2 = 15W-30<br>B3 = 20W-40 | C1 = 10W-30<br>C2 = 15W-30<br>C3 = 20W-40 | /1 = 10W-30<br>/2 = 15W-30<br>/3 = 20W-40 |
| Kinematic Viscosity change at 100°C | | | |
| after shearing, IP 294/77 (30 passes), %, max. | -10% | -10% | -10% |
| after 100 hrs@ 150°C, max. | 10% | 10% | 10% |
| Pumpability Viscosity (MRV), mPa·s | Relevant SAE classification | | |
| Flash point, °C, min. | 190 | 190 | 190 |
| Foaming, ASTM D892 | | | |
| Sequence I, ml, max. | 20/0 | 20/0 | 20/0 |
| Sequence II, ml, max. | 50/0 | 50/0 | 50/0 |
| Sequence III, ml, max. | 20/0 | 20/0 | 20/0 |
| Copper corrosion, ASTM D130 | | | |
| Rating after 3 hrs at 150°C | 1B | 1B | 1B |
| Copper weight loss after 48 hrs at 120°C, mg, max. | | 1 | 1 |
| Rust prevention, ASTM D665A | No rust | No rust | No rust |
| Seal test, Ford ATRR-100 Buna N, 70 hrs at 125°C | | | |
| Volume change, % | 0 - 10% | 0 - 10% | 1 - 10% |
| Hardness change, max. | ± 10 points | ± 10 points | ± 10 points |
| 180° bend test | No cracks | No cracks | No cracks |
| 4-ball wear | | | |
| Wear scar diameter, (1 hr, 65°C, 1500rpm, 40kg), mm, max. | 0.4 | 0.4 | 0.4 |
| Water sensitivity | | | |
| Sediment volume, ml, max. | 0.1 | 0.1 | 1.1 |
| Water separation, max. | Trace | Trace | Trace |
| Wet brake noise/ capacity test(1) | Pass | Pass | Pass |
| PTO Clutch test(1) | Pass | Pass | Pass |
| Transmission test(1) | Pass | Pass | Pass |
| Hydraulic pump and relief valve protection(1) | Pass | Pass | Pass |
| Itching/ Shifting quality(1) | | | Pass |
| 2000 hrs field test(1) | | | Pass |
| 660 hrs Jenkins cycle test(1) | | | Pass |
| 400 cycle stall test(1) | | | Pass |
| 450 cycle high energy test(1) | | | Pass |

**Note:**

(1) Ford/ FNH, at its option, may conduct the following tests on oils supplied to these specifications.

## UTTO[1] Specifications - John Deere J20C/D

| Test | John Deere (Revised Nov 2000) J20C | John Deere (Revised Nov 2000) J20D [2] |
|---|---|---|
| Kinematic Viscosity at 100°C, $mm^2/s$, min. | 9.1 | 7 |
| Shear stability, JDQ102, viscosity at 100°C, $mm^2/s$, min. | 7.1 | 5 |
| Brookfield Viscosity, ASTM D2983, mPa·s | | |
| at -20°C | 5500 | 1500 |
| at -35°C | 70000 | |
| at -40°C | | 20000 |
| Flash point, °C, min. | 200 | 150 |
| Pour Point, °C, max. | -36 | -45 |
| Foaming, JDQ 33 | | |
| Sequence I, ml, max. | 25/0 | 25/0 |
| Sequence II, ml, max. | 50/0 | 50/0 |
| Sequence III, ml, max. | 25/0 | 25/0 |
| Foam break time, s, max. | 30 | 60 |
| Water sensitivity, JDQ 19 | | |
| Solids, % volume, max. | 0.1 | 0.1 |
| Additive loss, % mass, max. | 15 | 15 |
| Rust prevention, JDQ 22, hrs, min. | 100 | 100 |
| Oil Compatibility, JDQ 23 : | | |
| Additive Separation | None | None |
| Foaming Characteristics | | |
| Sequence I, ml, max. | 25/0 | 25/1 |
| Sequence II, ml, max. | 50/0 | 50/1 |
| Sequence III, ml, max. | 25/0 | 25/1 |
| Foam break time, s, max. | 30 | 60 |
| Oxidation Stability | | |
| Evaporation loss, %, max. | 5 | 10 |
| Viscosity increase at 100 °C, %, max. | 10 | 20 |
| Sludge formation | None | None |
| Additive separation | None | None |
| Low temperature filtration, JDQ 24 | | Equal or better than JD reference |
| John Deere brake performance, JDQ 96 | Pass | Pass |
| John Deere PTS Clutch performance, JDQ 94 | Pass | Pass |
| John Deere Hydraulic pump performance, JDQ 84 | Pass | Pass |
| John Deere spiral bevel & final drive performance, JDQ 95 | Pass | Pass |
| Allison transmission performance, DDAD C-4[3] | Pass | Pass |

**Note:**

(1) UTTO = Universal Tractor Transmission Oil, not for use in engine.

(2) J20D low viscosity UTTO for cold climates. Earlier UTTO specification versions on file.

(3) Allison C4 no longer list friction modified fluids.



Afton CHEMICAL

## UTTO Specifications - Massey Ferguson CMS M1135/41

| Test | Massey Ferguson CMS M1135 (May 1969 - Europe) | Massey Ferguson CMS M1141 (June 1986) |
|---|---|---|
| Kinematic Viscosity at 100°C, $mm^2/s$ | 10.3-11.7 | 9.6 max |
| Shear stability, Viscosity at 100°C, ASTM 3945, $mm^2/s$, min. | | 7.3 |
| Brookfield Viscosity, ASTM D2983, mPa·s | | |
| at -18°C | 10000 | 4000 |
| at -34°C | | 70000 |
| Pour point, °C, max. | -26 | -37 |
| Flash point, °C, min. | | 200 |
| Viscosity Index, min. | 95 | 130 |
| Foaming, ASTM D892 | | |
| Sequence I, ml, max. | 100/0 | 50/0 |
| Sequence II, ml, max. | 100/0 | 50/0 |
| Sequence III, ml, max. | 100/0 | 50/0 |
| Copper strip corrosion, ASTM D130 | | |
| 3 hrs at 121°C | 1A | |
| 1 hr at 150 °C | | 1B |
| Rust prevention | | |
| MF rust test | Pass | |
| ASTM D1748, hrs, min. | | 100 |
| Oxidation test, 100 hrs at 150°C | | |
| Viscosity increase at 100°C, %, max. | 10 | 15 |
| Sludging | No Sludge | No Sludge |
| Seal compatibility, Pioneer MP 802 Nitrile seals, 168 hrs, 120°C | | |
| Volume change, % | -2% to +5% | |
| Hardness change (after 21 days at 95°C), max. | 10 IRHD | |
| Seal compatibility, Ford ATRR-100 Nitrile, 168 hrs, 120°C | | |
| Volume change, % | | 0.5% to 10% |
| Hardness change (after 21 days at 95°C), max. | | 10 IRHD |
| 4-ball wear test | | |
| Wear scar diameter (1 hr, 65°C, 1500rpm, 40kg), mm, max. | 0.4 | 0.4 |
| 4-ball EP test, ASTM D2783 | | |
| Load Wear Index, kg, min. | | 38 |
| Weld point, kg, min. | | 200 |
| IAE Gear rig, 2000rpm, 110 °C, 1pt (0.57L) /s | | |
| Scuff load, kg, min. | 61 | |
| MF four square rig test | No scuffing | |
| Functional tests | Pass | Pass |



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## UTTO Specifications - Massey Ferguson M1143/5

| Test | Massey Ferguson M1143 (June 1994) | Massey Ferguson M1145 (Sept 2004) |
|---|---|---|
| Kinematic Viscosity at 100°C, mm²/s | 13.5 max | 13.5 max |
| Shear stability, Viscosity at 100°C, mm²/s, min. | | |
| KO shear, CEC L14A78 (250 Cycles) | 9 | 9 |
| KRL shear, CEC L45A99, 20 hrs | | 6.8 |
| Brookfield Viscosity, ASTM D2983, mPa·s | | |
| at -18°C | 4000 | 4000 |
| at -34°C | | |
| Pour point, °C, max. | -34 | -33 |
| Flash point, °C, min. | 200 | 200 |
| Water content, ppm | 400 | 400 |
| Foaming, ASTM D892 | | |
| Sequence I, ml, max. | 50/0 | 50/0 |
| Sequence II, ml, max. | 50/0 | 50/0 |
| Sequence III, ml, max. | 50/0 | 50/0 |
| Dry Filterability, NF E 48-690, 5micron filter, 1 bar (Afnor), max. | 1.5 | 1.5 |
| Wet Filterability, NF E 48-690, 5micron filter, 1 bar (Afnor) | Report | Report |
| Copper strip corrosion, ASTM D130, 3 hrs at 100°C | 1A | 1A |
| Rust prevention, ASTM D665B | No rust | No rust |
| Oxidation test, 192 hrs at 150°C, CEC L48T94 | | |
| Viscosity increase at 100°C, %, max. | 25 | 25 |
| Total Acid Number change, %, max. | 75 | 75 |
| Deposits | None | None |
| Seal compatibility, CEC L39T96 | | |
| RE1, Flouro elastomers, 168 hrs at 150°C | | |
| Variation in hardness, DIDC, point | 0 to +5 | 0 to +5 |
| Variation in tensile strength, % | -50 to 0 | -50 to 0 |
| Variation in elongation rupture, % | -60 to 0 | -60 to 0 |
| Variation in volume, % | 0 to +5 | 0 to +5 |
| RE2, ACM elastomers, 168 hrs at 150°C | | |
| Variation in hardness, DIDC, point | -5 to +5 | -5 to +5 |
| Variation in tensile strength, % | -15 to +10 | -15 to +10 |
| Variation in elongation rupture, % | -35 to +10 | -35 to +10 |
| Variation in volume, % | -5 to +5 | -5 to +5 |
| RE3, Silicone elastomers, 168 hrs at 150°C | | |
| Variation in hardness, DIDC, point | -25 to 0 | -25 to 0 |
| Variation in tensile strength, % | -30 to +10 | -30 to +10 |
| Variation in elongation rupture, % | -20 to +10 | -20 to +10 |
| Variation in volume, % | 0 to +30 | 0 to +30 |
| RE4, NBR elastomers, 168 hrs at 150°C | | |
| Variation in hardness, DIDC, point | -5 to +5 | -5 to +5 |
| Variation in tensile strength, % | -20 to 0 | -20 to 0 |
| Variation in elongation rupture, % | -50 to 0 | -50 to 0 |
| Variation in volume, % | -5 to +5 | -5 to +5 |
| 4-ball wear, 1 hr, 65 °C, 1500rpm, 40kg | | |
| Wear scar diameter, mm, max. | 0.4 | 0.4 |
| 4-ball EP test, ASTM D2783 | | |
| Load Wear Index, kg, min. | 45 | 47 |
| Weld point, kg, min. | | |
| FZG A/8.3/90, CEC L07A85, Load stage, min. | 9 | 9 |
| Vickers 104C pump test, mg, max. | 80 | |
| Vickers 35VQ25 pump test, mg, max. | | |
| Cam wear, mg, max. | | 40 |
| Vane wear, mg, max. | | 15 |
| Friction Test, proprietary test | Pass | Pass |
| Materials compatibility, various | Pass | Pass |



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## UTTO Specifications (1) - Ford M2C 86B/C and Ford M2C 134D

| Test | Ford M2C 86 B (Oct 1980) | Ford M2C 86 C (Oct 1987) | Ford M2C 134 D(1) (Nov 1989) | FNHA-2-C-200.00 (Rev. B, July 1994) |
|---|---|---|---|---|
| Kinematic Viscosity, 100°C, mm²/s, min. | 10.5 - 11.6 (99°C) | 9 | 9 | 8 |
| Shear Stability, ASTM D3945, 30 cycles | | -16% | -16% | 7mm²/s, min |
| Brookfield Viscosity, ASTM D2983, mPa·s | | | | |
| at -18°C | 9230 | 4000 | 4000 | |
| at -40°C | | | | 17000 |
| Pour Point, °C, max. | -27 | -37 | -37 | -45 |
| Flash Point, °C, min. | 219 | 190 | 190 | 160 |
| Viscosity Index, min. | 105 | - | - | 210 |
| Foaming, ASTM D892 | | | | |
| Sequence I, ml, max. | 100/0 | 20/0 | 20/0 | 50/0 |
| Sequence II, ml, max. | 100/0 | 50/0 | 50/0 | 100/0 |
| Sequence III, ml, max. | 100/0 | 20/0 | 20/0 | 50/0 |
| Copper corrosion, ASTM D130 | | | | |
| 3 hrs at 99°C | 1B | | | |
| 3 hrs at 150°C | | 2B | 2B | 2B |
| Copper weight loss after 48 hrs at 120°C, mg, max. | | | 1 | 1 |
| Rust Protection | | | | |
| Falex Pin corrosion (FLTM BJ 15-1) | No rust | | | |
| ASTM D665A | | No rust | No rust | No rust |
| Oxidation Test, 100 hrs at 150°C | | | | |
| Viscosity Increase at 100°C, % max. | 5 | 10 | 10 | 10 |
| Seal test, Ford ATRR-100 Buna N, 70 hrs at 125°C | | | | |
| Volume change, % | | 0 to +10 | 0 to +10 | 0 to +10 |
| Hardness change, max. | | ± 10 points | ± 10 points | ± 10 points |
| 180° bend test | | No cracks | No cracks | No cracks |
| 4-Ball wear | | | | |
| wear scar diameter, 1 hr, 65°C, 1500rpm, 40kg, mm, max. | | 0.4 | | |
| wear scar diameter, 1 hr, 85°C, 1500rpm, 40kg, mm, max. | | | 0.4 | 0.4 |
| Water Sensitivity | | | | |
| Sediment volume, ml, max. | | 0.1 | 0.1 | 0.1 |
| Water Separation, max. | | Trace | Trace | Trace |
| Compatibility 50/50 mix | Pass | Pass | Pass | |
| Wet brake tests, Various | Pass | Pass | Pass | Pass |
| PTO clutch tests, Various | Pass | Pass | Pass | Pass |
| Transmission tests, Various | Pass | Pass | Pass | Pass |
| Hydraulic pump tests, Various | Pass | Pass | Pass | Pass |
| Driveline durability tests, Various | Pass | Pass | Pass | |
| Gear wear | Pass | Pass | Pass | |
| Dynamic co-efficient of friction | | | | 0.095 - 0.135 |
| Static co-efficient of friction | | | | 0.085 - 0.110 |

**Note:**

(1) FNHA-2-C-201.00 = Ford M2C 134D specification. Superseded by Case MAT 3525.

## UTTO Specifications - NH 410B/C, 420A

| | NH 410B | NH 410C | NH 420A |
|---|---|---|---|
| Details | 10W30 fluid to meet requirements of Ford M2C 134D | Fluid to meet the requirements of Case MAT 3505 | 20W30 fluid to meet the requirements of Ford M2C 86B |
| Requirements | See UTTO Ford M2C 134D (superseded) | See UTTO Case MAT 3505 | See UTTO Ford M2C 86B |
| Relevant CNH genuine fluid | Ambra Multi-G | Mastertran Tractor fluid | Ambra Multi-F |



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## UTTO Specifications - J I Case MS 1205/6/10

| Test | J I Case MS 1205 (Oct 1978) | J I Case MS 1206 (April 1982) | J I Case MS 1210 (April 1980) |
|---|---|---|---|
| Kinematic Viscosity at 100°C, $mm^2/S$, min. | 11.1 | 8.8 | 6.65 |
| Shear stability | | | |
| % Viscosity loss at 99°C, max. | 10 | | 10 |
| After gear and driveline tests, $mm^2/s$, min. | | 7.5 | |
| Brookfield Viscosity, ASTM D2983, mPa·s | | | |
| at -18°C | 5600 | | 1950 |
| at -20°C | | 4000 | |
| Cold Cranking Viscosity (CCS) at -18°C, mPa·s, max. | | | 1800 |
| API Gravity at 16°C | 26-30 | 26-30 | 26-39 |
| Pour point, °C, max. | -32 | -34 | -46 |
| Flash point, °C, min. | 193 | 190 | 182 |
| Viscosity Index, min. | 140 | 140 | 120 |
| Foaming, ASTM D892 | | | |
| Sequence I, ml, max. | 25/0 | 25/0 | 25/0 |
| Sequence II, ml, max. | 50/0 | 50/0 | 50/0 |
| Sequence III, ml, max. | 25/0 | 25/0 | 25/0 |
| Foaming, ASTM D892, Wet, 0.5% water | | | |
| Sequence I, ml, max. | | 25/0 | |
| Sequence II, ml, max. | | 50/0 | |
| Sequence III, ml, max. | | 25/0 | |
| Copper corrosion, ASTM D130, 3 hrs 150°C | 1B | 1B | 1B |
| Rust, humidity cabinet | Pass | Pass | Pass |
| Heat stability, 70 hrs at 125°C | Pass | Pass | Pass |
| Seal Compatibility | Pass | Pass | Pass |
| Water tolerance, various | Pass | Pass | Pass |
| Compatibility 50/50 mix | Pass | Pass | Pass |
| Hydraulic pump tests, various | Pass | Pass | Pass |
| Gear wear | Pass | Pass | Pass |

## UTTO Specifications - J I Case MS 1207/9, CNH MAT 3505

| Test | J I Case MS 1207 (Nov 1986) | J I Case MS 1209 (Aug 1999) (1) | CNH MAT 3505 (Rev. Dec 2002) (2) |
|---|---|---|---|
| Kinematic Viscosity at 100°C, $mm^2/S$, min. | 6.2 | 6.2 | 6.75 |
| Brookfield Viscosity, ASTM D2983, mPa·s | | | |
| at -20°C | 3500 | 4500 | 4900 |
| at -30°C | 15000 | 25000 | 30000 |
| API Gravity at 16°C | Report | Report | 28-32 |
| Pour point, °C, max. | -37 | -37 | -36 |
| Flash point, °C, min. | 195 | 195 | 195 |
| Viscosity Index, min. | 95-115 | 95-115 | 95-115 |
| Colour, ASTM | 6 - 8 Aug | 5.5-7.5 | 5.5-7.5 |
| Trace sediment, % volume, max. | 0.005 | 0.005 | 0.005 |
| Sulfated ash, % mass | 1.15-1.3 | | |
| Aniline point, °C | 91-110 | 91-110 | 91-110 |
| Water content, %, max. | 0.1 | 0.1 | 0.1 |
| Elemental analysis, % mass | | | |
| Barium | Report | Report | 0.002 max. |
| Calcium | 0.38 min. | 0.29 min. | 0.29 - 0.35 |
| Chlorine | 0.01 max. | 0.01 max. | 0.0075 max. |
| Magnesium | Report | Report | 0.002 max. |
| Nitrogen | Report | Report | 0.03 - 0.05 |
| Phosphorus | 0.3 min. | 0.04 min. | 0.04 - 0.06 |
| Silicon | Report | Report | 0.002 max. |
| Sodium | Report | Report | 0.002 max. |
| Sulphur | Report | Report | 0.75 |
| Zinc | 0.01 max. | 0.01 max. | 0.005 max. |
| Foaming, ASTM D892 | | | |
| Sequence I, ml, max. | 50/10 | 50/10 | 50/10 |
| Sequence II, ml, max. | 50/10 | 50/10 | 50/10 |
| Sequence III, ml, max. | 50/10 | 50/10 | 50/10 |
| Foaming, ASTM D892, wet, 1% water | | | |
| Sequence I, ml, max. | 50/0 | 50/0 | 50/10 |
| Sequence II, ml, max. | 50/0 | 50/0 | 50/10 |
| Sequence III, ml, max. | 50/0 | 50/0 | 50/10 |
| Oxidation - corrosion, 190 hrs at 135°C | at 135°C | at 145°C | |
| Aluminium, loss or deposit, mg, max. | 1 | 1 | 1 |
| Copper, loss or deposit, mg, max. | 8 | 8 | 5 |
| Brass, loss or deposit, mg, max. | 5 | 5 | 5 |
| Steel, loss or deposit, mg, max. | 1 | 1 | 1 |
| Precipitation number after testing | 0.01 max. | 0.01 max. | 0.01 |
| Glassware rating | A or B | A or B | A or B |
| Water tolerance, 7 days with 1% water | | | |
| Precipitate volume, ml, max. | 0.2 | 0.2 | 0.2 |
| Centrifuged volume, ml, max. | 0.1 | 0.1 | 0.1 |
| Fluid clarity | Clear | Clear | Clear |
| Nephelometric Turbidity Units, NTU, max. | 75 | 75 | 75 |
| Four square gear performance, µ inch, max. | 35 | | |
| Gear wear, mass loss, mg, max. | Lower than reference fluid L-3089A | Lower than reference fluid L-3939B | |

**Note:**

(1) To qualify for requirements of Hy-Tran Ultra®.

(2) Supersedes J I Case MS 1209, both Zn free.

## UTTO Specifications - J I Case MS 1207/9, CNH MAT 3505 - Cont'd

| Test | J I Case MS 1207 (Nov 1986) | J I Case MS 1209 (Aug 1999) (1) | CNH MAT 3505 (Rev. Dec 2002) (2) |
|---|---|---|---|
| FZG low speed wear, D4998, mass loss, mg, max. | | | 50 |
| Gear wear, load stage pass, ASTM D5182, min. | | | 7 |
| Air release, minutes at 50°C, max. | | 13.5 | 13.5 |
| Filterability, Case MT 807 | Pass | Pass | Pass |
| Fluid Compatibility, 72 hrs at 125°C | | | |
| 50:50 mix with reference | L-3623 | L-3939B | L-3939B |
| Evaporation loss, % mass, max. | 5 | 5 | 5 |
| Viscosity change at 100°C, %, max. | 10 | 10 | 10 |
| Sludge formation or additive separation | None | None | None |
| 50:50 mix with reference | L-3744 | L-6384 | L-6384 |
| Evaporation loss, % mass, max. | 5 | 5 | 5 |
| Viscosity change at 100°C, %, max. | 10 | 10 | 10 |
| Sludge formation or additive separation | None | None | None |
| Corrosion resistance | | | |
| Galvanic corrosion, 10 dats at 50% humidity, FTMS 5322.1 | Pass | Pass | Pass |
| Humidity corrosion, 100 hrs | Pass | Pass | Pass |
| Elastomer compatibility | | | |
| MS 560 reference elastomer, 70 hrs, 125°C | | | |
| Volume change, % | 0 to +10 | | |
| Hardness change, points | -5 to +5 | | |
| C70 and C90 reference elastomers, 70 hrs, 125°C | | | |
| Volume change, % | 0 to +5 | | |
| Hardness change, points | -5 to +5 | | |
| C70 and C90 reference elastomers, 14 days, 125°C | | | |
| Tensile strength change, % | 0 to -40 | | |
| Ultimate elongation change, % | 0 to -70 | | |
| P70 and P90 reference elastomer, 70 hrs, 125°C | | | |
| Volume change, % | | 0 to +10 | 0 to +10 |
| Hardness change, points | | -5 to +5 | -5 to +5 |
| Hydrolytic stability | | | |
| Fluid appearance after test | | Haze permitted, no clumps or gel | Haze permitted, no clumps or gel |
| Copper specimen appearance, D130 | | 1A or 1B | 1A or 1B |
| Volume of separated matter, ml, max. | | 1 | 1 |
| Fluid cleanliness | Level 2 | Level 2 | |
| Hydraulic pump test, Case ES A7626 | | Pass | Pass |
| Frictional performance | | Pass | Pass |
| Brake noise (chatter) | Pass | Pass | Pass |
| Gear performance | Pass | Pass | Pass |
| Driveline durability | Pass | | |

**Note:**

(1) To qualify for requirements of Hy-Tran Ultra®.

(2) Supersedes J I Case MS 1209, both Zn free.



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## UTTO Specifications - CNH MAT 3525/6

| Test | CNH MAT 3525 [1] (Rev. D Sept 2001) (134-D fluid) | CNH MAT 3526 (Rev. B Sept 2001) (F200-A fluid) |
|---|---|---|
| Kinematic Viscosity, $mm^2/s$, ASTM D445 | | |
| at 100°C | 9.1 - 9.8 | 8.5 - 9.0 |
| at 40°C, typical | 55 | 35 |
| Shear Stability | | |
| 30 passes, min, %, ASTM D3945 | -16 | |
| Transmission/Hydraulic oil shear test, $mm^2/s$, min, CNH 86548393 | | 7.9 |
| Brookfield Viscosity, ASTM D2983, mPa·s, max. | | |
| at - 18°C | 4000 | 17000 @ -40°C |
| Viscosity Index, min. | 130 | 185 |
| Thermal stability, 100 hrs at 150°C, % viscosity change, max. | 10, No sludge | 10, No sludge |
| Pour point, °C, ASTM D97, max. | -37 | -45 |
| Flash point, °C, ASTM D92, min. | 190 | 160 |
| Foaming, ASTM D892 | | |
| Sequence I, ml, max. | 20/0 | 50/0 |
| Sequence II, ml, max. | 50/0 | 50/0 |
| Sequence III, ml, max. | 20/0 | 50/0 |
| Copper corrosion, ASTM D130, 3 hrs at 150°C, max. | 2B | 2B |
| Volatility, 48 hrs at 120°C, weight loss, %, max. | 1 | 1 |
| Rust protection, ASTM 665A | No rust | No rust |
| 4-Ball wear, 1 hr, 85°C, 1500 rpm, 40 kg, ASTM D2266, mm, max. | 0.4 | 0.4 |
| Seal test, P70 and P90 reference elastomers, 70 hrs at 125°C | | |
| Volume, % | -3 to +7 | -3 to +7 |
| Hardness change, max. | -5 to +5 | -5 to +5 |
| Water sensitivity, CNH test | | |
| Sediment volume, ml, max. | 0.1 | 0.1 |
| Water separation, ml | Trace | Trace |
| Jenkins cycle test, 600 hrs | Pass | Pass |
| Tandem pump durability test | Pass | Pass |
| 16 x 16 inching/shifting test | Pass | Pass |
| 16 x 16 transmission, 400 cycle stall test | Pass | Pass |
| 16 x 16 transmission, 450 cycle high energy test | Pass | Pass |
| Field test, 2000 hrs | Pass | Pass |
| Brake test | Pass | Pass |
| PTO clutch test | Pass | Pass |
| Dynamic co-efficient of friction | 0.095 - 0.135 | 0.095 - 0.135 |
| Static co-efficient of friction | 0.085 - 0.110 | 0.085 - 0.110 |
| Oil compatibility | Pass | Pass |

**Note:**
(1) Supersedes Ford M2C 134D and FNHA-2-C-201.00.



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## UTTO Specification - Fiat AF87

| Test | Fiat AF87 (Nov 1977) |
|---|---|
| Kinematic Viscosity, $mm^2/s$, ASTM D445 | |
| at 37.8°C | 105 - 125 |
| at 50°C | 60 - 70 |
| at 98.9°C | 12.9 - 16.6 |
| Apparent viscosity at -17°C, ASTM D2602, mPa·s | 4500 - 9600 |
| Pour point, °C, ASTM D97, max. | -25 |
| Viscosity index, ASTM D1500, max. | 125 |
| Colour, ASTM D1500, max. | 8 |
| Appearance | Clear |
| Foaming, ASTM D892 | |
| Sequence I, ml, max. | 50/0 |
| Sequence II, ml, max. | 50/0 |
| Sequence III, ml, max. | 50/0 |
| Oxidation at 150°C, FIAT 50520, hrs, min. | 60 |
| Gear wear using FZG rig, FIAT 50526/01 | |
| Specific wear, mg | 0.1 |
| Load stage pass, min. | 11 |
| Co-efficient of friction on disc at 100°C, FIAT 50545 | |
| Dynamic co-efficient on paper disc | 0.08 - 0.15 |
| Static co-efficient on paper disc, max. | 0.085 |
| Dynamic co-efficient on Cu-Sn sintered disc | 0.06 - 0.13 |
| Static co-efficient on Cu-SN sintered disc, max. | 0.055 |
| Seal compatibility, TO 125-70 elastomers, 70 hrs at 125°C, FIAT 50413 | |
| Volume change, % | ± 8 |
| Hardness change, IRW, max. | ± 8 |
| Effect on bronze, 120°C for 100 hrs, FIAT 50516/1 | Pass |
| Sulfated ash, % mass, ASTM D874 | 1.4 - 1.8 |
| Sulphur, % mass, ASTM D126 | 0.8 - 1.0 |
| Calcium, % mass, FIAT 50540 | 0.35 - 0.42 |
| Zinc, % mass, FIAT 50540 | 0.145 - 0.175 |
| Phosphorous, % mass, FIAT 50540 | 0.125 - 0.155 |
| Impurities, including water, % mass, max, ASTM D96 | 0 |

## Caterpillar TO - 4 Transmission and Drive Train Fluid Requirements

| | Requirements | | Test Method | |
|---|---|---|---|---|
| Viscometric Properties | SAE J300 Viscosity Grade | ASTM D2983 Maximum Temperature (°C) for Brookfield Viscosity of 150,000 mPa·s | ASTM D4684 Low Temp. Pumpability (MRV TP-1) 30,000 Centipoise Max, Temp. °C | ASTM D4683 (or Equiv) High Temp High Shear Viscosity at 150°C and $10^6 s^{-1}$ min. mPa·s |
| SAE J300 requirements plus additional low temp. and high temp. high shear requirements as shown opposite<br><br>Caterpillar does not recommend oils that contain viscosity improvers in this application | 10W | -35 | -25 | 2.1 |
| | 30 | -25 | -15 | 2.9 |
| | 40 | -20 | -10 | 3.7 |
| | 50 | -15 | -5 | 4.5 |
| Wear Properties | | | | |
| Gear wear | Average of three separate runs 100mg max. No single run with more than 150 mg weight. | | ASTM D4998 (FZG Machine - ‘A’ gears, low speed, 100 rpm, 121°C, load stage 10, 20 hrs). | |
| Gear Scuffing | LSP [(1)] 8 min (SAE 10W and SAE 30 grades)<br>≥ LSP 10 min (SAE 40 and SAE 50 grades) | | ASTM DS:82<br>FZG Visual ‘A’ gears, $8.3 ms^{-1}$, 90 °C | |
| Pumps | Total combined weight loss for vane and ring, < 90mg Pump parts, especially rings should not have evidence of unusual wear or stress in contact areas. | | Vikers pump test procedure for mobile systems as defined in publication form M-2952-S. | |
| Friction Properties | | | | |
| Link Model 1158 Oil/Friction Test Machine<br>Dynamic Coefficient of Friction<br>Static Coefficient of Friction<br>Energy Capability<br>Wear Properties - (7 friction disc-steel reaction plate combinations evaluated separately - 3 paper, 2 sintered bronze, 2 fluroelastomer friction discs.) | The results of each friction disc-reaction plate combination for the candidate oil must be within the allowable range of variation from the reference test oil. | | Caterpillar VC 70 Standard Test Method. | |

**Note:** (1) LSP = Load Stage Pass.

## Caterpillar TO - 4 Transmission and Drive Train Fluid Requirements

| | Requirements | Test Method |
|---|---|---|
| Physical Properties | | |
| Rust Control | Less than 6 rust spots per linear inch on two out of three test specimens | Modified International Harvester BT-9 (175 hours under dynamic humidity conditions) |
| Copper Corrosion | 1A max. | ASTM D130 (2 hrs at 100°C) |
| Fluid Compatibility | No sedimentation or precipitation | Mix 50 mls test oil with 50 mls reference oil; heat to 204°C, cool to ambient; centrifuge for 30 min at 6000G |
| Homogeneity | No sedimentation or precipitation | Test oil held at -32°C for 24hrs, warmed to ambient, centrifuged |
| Foam, tendency/stability, mls | Sequence I - 25/0<br>Sequence II - 50/0<br>Sequence III - 25/0 | ASTM D892 Part 1: No water added<br>Part 2: 0.1% water in oil |
| Flash Point | 160°C min. | ASTM D92 |
| Fire Point | 175°C min. | ASTM D92 |
| Elastomer Compatibility | | |
| Fluoroelastomer | Av. Elongation of elastomer in aged test oil must not be greater than Av. Elongation with reference oil | ASTM D471 (240 hrs; 150°C) |
| | D Elongation with test oil must be less than or equal to D Elongation with reference oil + 10% | |
| Allison C-4 Elastomer Test | See Allison C-4 Specifications | See Allison C-4 Specifications |
| Oxidation Test | | |
| Thermal Oxidation Stability (THOT) | See Allison C-4 Specifications | GM 6137 October 1990, Appendix E (ie DEXRON® IIE) (Fluoroelastomer input seal, production cooler, 35% silver) |
| Sludge/varnish on parts | Nil | |
| Total Acid Number Increase | 4.0 max. | |
| Carbonyl Absorbance diff | 0.75 max. | |
| Further inspection | Fluoroelastomer input seal should not fail. Copper bushings should not undergo mechanical failure due to corrosion attack. Cooler will not be graded. | |
| Viscosity after test | | |
| Kinematic Viscosity, $mm^2/s$ | Report | ASTM D445 |
| Viscosity, mPa·s | Report | ASTM D2983[(1)] |
| Viscosity, mPa·s | Report | ASTM 4684[(1)] |
| Viscosity, mPa·s, 150°C, $10^6 s^{-1}$ | Report | ASTM D683 |

**Note:**
(1) At the max. temperature specified in Section 4 of Cal T0-4 Specification for the appropriate viscosity grade.

Specification Handbook

# Engine Tests

# Contents Engine Tests

**European Tests:**

PCMO

Mercedes Benz M111 Fuel Economy Test....3

Mercedes Benz M111 Sludge....4

Mercedes Benz M271 Sludge....5

Mercedes Benz M271 Wear....6

Mercedes Benz OM 602 A....7

Mercedes Benz OM 611 DE22 LA....8

Mercedes Benz OM 646 LA....9

Peugeot DV4 TD....10

Peugeot TU3M Valve Train Scuffing....11

Peugeot TU5JP-L4....12

VW Intercooled T/C Diesel....13

VW TDi Diesel....14

VW T4 (PV 1449)....15

HDDO

MAN D2876 LF04 (Meistersinger II)....16

Mercedes Benz OM 364 LA....17

Mercedes Benz OM 441 LA....18

Mercedes Benz OM 501 LA....19

MWM KD 12E (MWM-B)....20

Volvo D12D....21



Afton CHEMICAL

# Contents

**US Tests:**

PCMO

Ball Rust Test ....22

Sequence IIIF ....23

Sequence IIIG....24

Sequence IVA....25

Sequence VG ....26

Sequence VIB....27

Sequence VID....28

Sequence VIII ....29

Roller-Follower Wear Test....30

HDDO

Caterpillar 1K....31

Caterpillar 1M-PC....32

Caterpillar 1N ....33

Caterpillar 1P....34

Caterpillar C13 ....35

Cummins M11 - HST (obsolete)....36

Cummins M11 - EGR (obsolete) ....37

Cummins ISB ....38

Cummins ISM....39

Detroit Diesel 6V-92TA ....40

Mack T-8 / T-8E ....41

Mack T-10 (obsolete)....42

Mack T-11 ....43

Mack T12 ....44



Afton CHEMICAL

# Mercedes Benz M111 Fuel Economy Test

## CEC L-54-T-96

**Equipment Used:** 2.0L M111 E20 gasoline engine 4 cylinder.

**Purpose:** It uses flying flush oil system for changing oils without engine shutdown and enables to compare oils against a base line calibration oil. The test last 24 hours.

**Test Conditions:** The test procedure is based upon the ECE R15-04 and EUDC emissions test cycles. It uses flying flush oil systems to compare oils against a base line calibration oil.

**Method of Rating:** Fuel consumption through the test cycle is compared against that of a base line calibration oil.

Reduction in fuel consumption is expressed as a % fuel economy benefit.

# Mercedes Benz M111 Sludge

## CEC L-53-T-95

**Equipment Used:**

Mercedes Benz M111 E20, 4 cylinder 2.0L gasoline injection with 4 valves per cylinder.

Special engine required (bearings, piston rings, tappets, cams, timing chain, timing cover - cylinders differ in hardware set up).

Modified gear box by-passed by one piece main shaft arrangement or standard gear box is used.

**Purpose:**

To evaluate the performance of engine oils in comparison with a reference oil (RL 140) to control the formation of black sludge on engine internal surfaces. Also measured are piston deposits and cam wear.

**Test Conditions:**

No run in.

Phase 1: 48 hours of cyclic cold stage (includes 6 starts at -40°C ambient air temperature 25°C).

Phase 2: 1 hour power curve.

Phase 3: 75 hour alternating stage ($2^1/_2$ min. 3750 rpm. W.O.T.; $2^1/_2$ min. 3850 rpm. W.O.T.).

Phase 4: 100 hours full cyclic stage based on M102E procedure with 10 steps of varying speed, load and temperature.

Fuel: RF-86-A-96.

**Method of Rating:**

Black sludge (CRC Manual No.12).
Cam wear.

**Other:**

Due to hardware shortages among others reasons, the M111 sludge is/will be unavailable soon. ACEA accepted M271 sludge test as an interim test to screen sludge for all ACEA categories Ax/Bx and Cx.

Piston cleanliness (DIN 51361 Part No. 2).

# Mercedes Benz M271 Sludge

## MB In-house Method

**Equipment Used:** 16 valve, 4 cylinder, 1.81 M271 E18 engine with port injection, intercooling and compressor supercharging.

**Purpose:** To evaluate an oil's ability to keep the engine free from sludge deposits.

**Test Conditions:** Following a 2.5 hour break-in, the engine is run for 250 hours with alternating hot and cold cycles. The maximum oil temperature is 145°C.

**Method of Rating:** Sludge rating of rocker cover, cylinder head, front cover, oil pan.

**Other:** Allowed by ACEA as an interim test to demonstrate sludge performance of oils in ACEA categories Ax, Bx and Cx due to non-availability of M111 sludge test.

# Mercedes Benz M271 Wear

## MB In-house Method

**Equipment Used:** 16 valve, 4 cylinder, 1.81 M271 E18 engine with port injection, intercooling and compressor supercharging.

**Purpose:** To evaluate the ability of the oil to protect those components in the engine that are susceptible to wear.

**Test Conditions:** Following a 20.5 hour break-in, the engine is run for 250 hours with alternating test conditions. The maximum oil temperature is 145°C.

| | |
|---|---|
| Duration, hrs. | 250 |
| Max. Torque, Nm | 240 |
| Max. Power, kW | 120 |
| Coolant Outlet Temperature, °C | 95 |
| Max. Oil Temperature, °C | 145 |

**Method of Rating:** Cam wear, piston ring wear, ring sticking, timing chain elongation, bore polishing, ring sticking, bearing wear.

# Mercedes Benz OM 602 A

## CEC L-51-A-98

**Equipment Used:** Mercedes Benz OM 602 A indirect injection, 5 cylinder in-line, turbocharged.

**Purpose:** To evaluate the performance of engine oils in respect of cam and cylinder wear under a combination of stop and go, medium speed and high speed operating conditions.

**Test Conditions:** Complex test cycle of 60 mins., which is repeated 200 times giving a test duration of 200 hours.

Currently 23 stages per cycle which includes 16 ramps.
Max. oil temperature: 142°C.
Min. oil temperature: 52°C.

**Method of Rating:** Cylinder and cam wear.

Oil viscosity increase.

Piston cleanliness.

Bore polish.

Engine sludge.

**Other:** Test no longer available.

## Mercedes Benz OM 611 DE22 LA

**Equipment Used:**

OM 611 DE22 LA 4 cylinder turbocharged and intercooled, 16V common rail direct injection engine.

**Purpose:**

To evaluate the protection offered by the oil against engine wear, sludge and piston deposits.

**Test Conditions:**

| | |
|---|---|
| Test length | 300 hrs |
| Power, max. | 105kW at 4200 rpm |
| Load, max. | 315 Nm |
| Low sulphur fuel | (< 10ppm) |

**Method of Rating:**

Valve train wear.

Bearing wear.

Cylinder wear.

Piston cleanliness.

Engine sludge.

Viscosity increase.

**Other:**

Test no longer available.

# Mercedes Benz OM 646 LA

## CEC L-099-08

**Equipment Used:** 4 cylinder Diesel, 2.2L, VTG turbocharger, I/C Direct Injection - 340Nm 110kW

**Purpose:** OM 646 LA has been developed in replacement of OM 602 A and aims at evaluating the ability of an oil to control and prevent cam and tappet wear, cylinder wear, bore polishing (part ACEA oil sequences) and many others parameters such as piston cleanliness or engine sludge.

**Test Conditions:** 300 hrs alternating cycles using a fuel containing 5% RME and less than 10 ppm of sulphur. Oil samples taken every 50 hrs.

**Method of Rating:**

Valvetrain wear.

Cylinder wear.

Bore polishing.

Piston cleanliness.

Engine sludge.

# Peugeot DV4 TD

## CEC-L-093

**Equipment Used:** 1.4L, 4 cylinder DV4 TD engine with Bosch EDC 16 common rail injection system.

**Purpose:** To evaluate an engine oil's ability to control piston cleanliness and disperse soot in passenger car diesel engines.

**Test Conditions:** 120 hour test with 240 dual phase cycles.

| | Phase 1 | Phase 2 |
|---|---|---|
| Duration, mins. | 2 | 28 |
| Speed, rpm | 1100 | 400 |
| Max. Torque, Nm | 155 | |
| Boost Air Pressure, mbar | 710 | |
| Boost Air Temperature, °C | 120 | |
| Oil Gallery Temperature | 120 | |
| Oil Charge, g | 4200 | |

**Method of Rating:** Piston merit at end of test, increase in KV100 at 6% soot.

# Peugeot TU3M Valve Train Scuffing

## CEC L-38-A-94

**Equipment Used:**

OHC Peugeot TU3M, 4 cylinder gasoline engine, 1360cc, fitted with batch approved cams and followers.

**Purpose:**

The method is used to evaluate the performance of engine oils in respect of valve train scuffing in a combination of hot and cold running conditions.

**Test Conditions:**

The test comprises two individual sequences run under different test conditions.

Total test duration: 100 hrs.

| | Part A | Part B |
|---|---|---|
| Duration, hrs. | 40 | 60 |
| Engine Speed, rpm. | 1500 | 3000 |
| Engine Torque, Nm. | 10 | 35 |
| Oil Temp., °C | 40 | 100 |
| Coolant Out Temp., °C | 45 | 90 |
| Fuel Consumption, kg/hr. | 1.5 | 4.0 |

Fuel: RF 83-A-91

**Method of Rating:**

The data is reported as ratings of the rocker pads according to the CEC M-02-A-78 test method and cam nose wear.

# Peugeot TU5JP-L4

## CEC-L-88-A-02

**Equipment Used:** In-line 4 cylinder gasoline TU5JP engine with multi-point fuel injection and catalyst system at L4 depollution level.

**Purpose:** To evaluate high temperature deposits, ring sticking and oil thickening control in a test that simulates high speed European highway driving.

**Test Conditions:** Total test length of 72 hours consisting of 6 x 12 hour, 2 stage cycles. Stage 1 is at wide open throttle, with an engine speed of 5600 rpm and oil temperature of 150°C and Stage 2 is at idle. No oil top-up.

| | Stage 1 | Stage 2 |
|---|---|---|
| Duration, hrs. | 11 hrs 50 mins | 10 mins |
| Speed, rpm. | 5600 | Idle |
| Power, kW. | 62 | |
| Coolant Outlet Temperature, °C | 110 | |
| Exhaust Temperature, °C | 860 | |
| Oil Temperature, °C | 150 | |
| Fuel Specifications | RF 83-A-91 | |

**Method of Rating:** Ring sticking.

Piston varnish.

Absolute viscosity increase.

# VW Intercooled T/C Diesel

## CEC L-46-T-93

**Equipment Used:** VW 4 cylinder, 1.6L, turbocharged and intercooled diesel engine.

**Purpose:** Diesel detergency test for passenger car turbocharged diesel engines run under high load conditions.

**Test Conditions:**

| | |
|---|---|
| Duration, hrs. | 50 |
| Speed, rpm. | 4500 |
| Power, kW (bhp) | 55 (75) |
| Oil Temperature, °C | 130 |
| Water Temperature, °C | 90 |
| Fuel Sulphur, % | 0.3 |

**Method of Rating:** Pistons rated for groove and land deposits and for ring sticking.

**Other:** Test no longer available.

# VW TDi Diesel

## CEC L-78-T-99

**Equipment Used:** VW 4 cylinder, 1.9L, turbocharged, intercooled diesel engine with direct injection.

**Purpose:** Diesel detergency test for passenger car diesel engines run under high load conditions.

**Test Conditions:**

| | |
|---|---|
| Duration, hrs. | 54 |
| Speed, rpm. | 4500 |
| Power, kW (bhp) | 82 (110) |
| Oil Temperature, °C | 145 |
| Water Temperature, °C | 90 |
| Fuel Sulphur, % | 0.3 |

Test oil charge: 4.5L

No oil top-up.

**Method of Rating:** Pistons rated for groove and land deposits and for ring sticking.

# VW T4 (PV 1449)

**Equipment Used:** 4 cylinder VW PV 1449 engine with digifant injection and ignition control.

**Purpose:** To evaluate the lubricant's ability to withstand oil oxidation and TBN depletion under extended service conditions.

**Test Conditions:** A 2-phase test consisting of 48 x 4 hour, 3 stage cycles, followed by 56 hours steady state, with no oil top-up.

| | Phase 1 | | | Phase 2 |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Duration, hrs. | 192 | | | 56 |
| Duration, min. | 120 | 72 | 48 | |
| Load, Nm. | 159 | 80 | idle | 80 |
| Temperature | high | high | low | high |

**Method of Rating:** Piston rating.

Relative and absolute viscosity increase.

TBN depletion.

# MAN D2876 LF04 (Meistersinger II)

**Equipment Used:**

6 cylinder MAN D2876 LF04 turbocharged Euro III engine with EGR, intercooler and reduced sump capacity.

**Purpose:**

To evaluate the improvement in piston cleanliness, ring sticking and engine deposits of the test oil versus a reference oil.

**Test Conditions:**

Total test duration: 400 hours.
Break-in followed by 4 x 100 hour, 2 stage cycles: 35 hours at max. power then 65 hours at max. torque.

| | Stage 1 | Stage 2 |
|---|---|---|
| Duration, hrs. | 35 | 65 |
| Speed, rpm. | 1900 | 1125 |
| Power, kW. | 338 | |
| Torque, Nm. | | 2100 |
| Oil Charge, L | 30 | |

**Method of Rating:**

Piston cleanliness.

Ring sticking.

Cylinder wear.

Engine deposits.

Sludge.

Valve train wear.

Soot related viscosity increase.

# Mercedes Benz OM 364 LA

## CEC L-42-T-99

**Equipment Used:** Mercedes Benz OM 364 LA, 4L turbocharged, intercooled diesel engine.

**Purpose:** To evaluate piston deposits, wear, sludge, varnish, oil consumption.

**Test Conditions:** The engine is run according to a cyclic procedure. Total duration 300 hours consisting of 3 x 100 hour phases of 20 x 2.5 hour cycles plus 50 hours steady state.

| | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|---|---|---|---|---|
| Duration, hrs. | 1.5 | 0.5 | 0.5 | 50 |
| Speed, rpm. | 2400 | 1500 | 1000 | 2400 |
| Power, kW (bhp) | 102 (137) | 70 (94) | 30 (40) | 102 (137) |
| Coolant Outlet Temp., °C | 105 | | | |
| Intake Air Temp., °C | 30 | | | |
| Oil Temperature, °C | 126 | | | |
| Oil Charge, kg. | 5.2 | | | |
| Fuel Specifications | RF 90-A-92 (0.25 to 0.30% S) | | | |

**Method of Rating:** Pistons rated for cleanliness.

Cylinder liners rated for bore polish and wear.

Cams and followers rated for wear.

Oil consumption reported.

**Other:** Test no longer supports current MB or ACEA specifications.

# Mercedes Benz OM 441 LA

## CEC L-52-T-97

**Equipment Used:**

Mercedes Benz OM 441 LA EURO II V6, turbocharged and intercooled 250 kW engine with electronically controlled fuel pump.

**Purpose:**

To evaluate the performance of engine oils in respect of performance in low emission, high performance diesel engines.

**Test Conditions:**

Total test duration: 400 hours
50 hours cyclic (4 stages) followed each time by 50 hours constant speed/load.

| | Stage 1 | Stage 2 | Stage 3 | Stage 4 | Constant Speed |
|---|---|---|---|---|---|
| Speed, rpm. | 1900 | 1330 | 1140 | 2120 | 1900 |
| Duration, hrs. | 1.0 | 0.5 | 0.5 | 0.5 | 50 |
| Power, kW (bhp) | 250 (335) | 210 (281) | 185 (248) | 2 (3) | 250 (335) |
| Coolant Outlet Temp., °C | 105 | | | | |
| Intake Air Temp., °C | 25 | | | | |
| Oil Temperature, °C | > 123 | | | | |
| Oil Charge, kg. | 16.1 | | | | |
| Fuel Specifications | RF 93-T-95 (0.05 % S) | | | | |

**Method of Rating:**

Piston cleanliness.

Bore polish.

Cylinder wear.

Oil consumption.

Sludge.

Inlet system deposits.

Turbocharger boost pressure drop.

# Mercedes Benz OM 501 LA

**Equipment Used:** Euro V, V6 11.9L turbocharged engine with intercooler.

**Purpose:** To evaluate an oil's ability to prevent piston deposits and maintain engine cleanliness in a low emission, high performance engine.

**Test Conditions:** A 300 hour test with alternating and steady state cycles.

| | |
|---|---|
| Duration, hrs. | 300 hrs |
| Max. Power, kW | 350 |
| Max. Torque, Nm | 2300 |
| Exhaust Gas Temperature, °C | 525 |
| Coolant Outlet Temperature, °C | 103 |
| Oil Temperature, °C | 125 |
| Fuel | <10ppm S with 5% FAME |

**Method of Rating:** Piston cleanliness, engine cleanliness, oil consumption.

# MWM KD 12E (MWM-B)

## CEC L-12-A-76, DIN 51361

**Equipment Used:**

MWM KD 12E, single cylinder, naturally aspirated 850cc diesel engine. Compression ratio 22 to 1.

**Purpose:**

To assess high performance diesel engine oils with respect to their influence on piston cleanliness.

**Test Conditions:**

| | |
|---|---|
| Duration, hrs. | 50 |
| Speed, rpm. | 2200 |
| Power, kW (bhp) | 10.7 (14.3) |
| Coolant Out Temp., °C | 110 |
| Oil Sump Temp., °C | 110 |
| Fuel Sulphur, % (1) | 1 |

**Method of Rating:**

The three ring grooves and the first and second lands are assessed for deposits.

Reporting of piston skirt and piston undercrown is optional.

The piston rings are also checked for ring sticking.

A final piston cleanliness rating is determined based on the five individual ring zone assessments.

**Note:**

(1) To CEC RF-91-A-81 specifications.

# Volvo D12D

## Volvo TC415

| | |
|---|---|
| **Equipment Used:** | A 6 cylinder, 12.1L, 460hp D12D Euro 3 engine. |
| **Purpose:** | To evaluate an oil's ability to prevent piston deposits. |
| **Test Conditions:** | 6 hour break-in followed by 400 hours consisting of a 12 step alternating cycle.<br><br>The fuel used is <10ppm sulphur<br>Max. power = 338kW<br>Max. torque = 2200Nm |
| **Method of Rating:** | Piston cleanliness, ring riding, bore polish and oil consumption. |

# Ball Rust Test

## ASTM D6557

**Equipment Used:** Custom-built bench rig, consisting of a temperature controlled shaker table and hydraulic lifter check valve balls.

**Purpose:** To evaluate a lubricant's ability to prevent corrosion of iron engine parts.

**Test Conditions:** The test simulates short trip service under typical winter conditions and correlates to the obsolete Sequence IID engine test. The oil is kept at a temperature of 40°C. The balls are submerged in the oil for 18 hours, during which time an air and acid mix is injected into the oil under controlled flow rates.

**Method of Rating:** The balls are rated either optically or by a computer or video system, for surface discolouration.

## Sequence IIIF

### ASTM D6984

**Equipment Used:** 1996-97 3800 Series II General Motors V-6 gasoline engine, with an overhead valve design and equipped with an external oil sump cooler.

**Purpose:** The test simulates high-speed service, under relatively high ambient conditions and evaluates the oil's performance with regards to oxidation induced oil thickening, piston deposits and valve train wear.

**Test Conditions:** The 80 hour long test is broken into 10 hour segments; at the end of each segment, an oil sample is taken and fresh oil is added.

| | |
|---|---|
| Duration, hrs. | 80 hrs |
| Speed, rpm. | 3600 |
| Power, kW. | ~75 |
| Torque, Nm | 200 |
| Coolant Outlet Temperature, °C | 122 |
| Oil Temperature, Filter Block °C | 155 |
| Air to Fuel Ratio | 15.0:1 |

**Method of Rating:** Piston deposits, camshaft and lifter wear and increase in KV @ 40°C of the used oil.

**Other:** 60 hr rating applicable to API SJ and API CH-4

# Sequence IIIG

**Equipment Used:** 1996-97 3800 Series II General Motors V-6 gasoline engine, with an overhead valve design and equipped with an external oil sump cooler.

**Purpose:** The test simulates high-speed service, under relatively high ambient conditions and evaluates the oil's performance with regards to oxidation induced oil thickening, piston deposits and valve train wear.

**Test Conditions:** The 100 hour long test is broken into 20 hour segments; at the end of each segment, an oil sample is taken and measured for KV @ 40, and fresh oil is added.

| | |
|---|---|
| Duration, hrs. | 100 |
| Speed, rpm. | 3600 |
| Power, kW. | ~94 |
| Torque, Nm | 250 |
| Coolant Outlet Temperature, °C | 115 |
| Oil Temperature, Filter Block °C | 150 |
| Air to Fuel Ratio | 15.0:1 |

**Method of Rating:** Piston deposits, camshaft and lifter wear, increase in KV @ 40°C of the used oil and low temperature used oil viscometrics.

# Sequence IVA

**Equipment Used:**

1994 Nissan KA24E, in-line 4 cylinder engine with two inlet and one exhaust valve per cylinder.

**Purpose:**

Designed to simulate excessive engine idling, this test measures the ability of an oil to control camshaft lobe wear in engines equipped with an overhead valve train and sliding cam followers.

**Test Conditions:**

A 100 hour long test, consisting of 100 x 2 stage cycles.

| | Stage 1 | Stage 2 |
|---|---|---|
| Duration, mins. | 50 | 10 |
| Speed, rpm. | 800 | 1500 |
| Torque, Nm. | 25 | 25 |
| Power, kW | 2.1 | 3.9 |
| Coolant Outlet Temperature, °C | 50 | 55 |
| Oil Temperature, °C | 49 | 59 |

**Method of Rating:**

Camshaft wear.

# Sequence VG

## ASTM D6593

**Equipment Used:** 1994 4.6L Ford V8 engine with two valves per cylinder.

**Purpose:** Evaluates an oil's ability to prevent sludge and varnish formation in a moderate temperature, high engine idling application.

**Test Conditions:** A 216 hour test, 3 stage test, consisting of 54 cycles, each lasting 4 hours.

| | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|
| Duration, mins. | 120 | 75 | 45 |
| Speed, rpm. | 1200 | 2900 | 700 |
| Manifold pressure, kPa | 66 | 69 | Record |
| Oil Temperature, °C | 68 | 100 | 45 |
| Coolant Outlet Temperature, °C | 57 | 85 | 45 |
| Rocker Temperature, °C | 29 | 85 | 29 |

**Method of Rating:** Engine sludge and varnish, piston skirt varnish and oil screen clogging.

# Sequence VIB

## ASTM D6837

**Equipment Used:** A 4.6L Ford V8 modular engine equipped with an external oil heating/cooling system.

**Purpose:** To evaluate the effect of a lubricant on the fuel consumption of a low friction engine.

**Test Conditions:** A baseline, 5W-30 oil is run first, and the fuel consumption is measured at 5 distinct speed/load/temperature conditions.

The test oil is then introduced, and is aged for 16 hours at Aging Phase 1 conditions, and then the fuel consumption of the test oil is measured under the same 5 speed/load/temperature conditions.

The test oil is then aged for a further 80 hours under Aging Phase 2 conditions, and then the fuel consumption at the 5 distinct conditions is measured again.

The baseline oil is then reintroduced and the fuel consumption at 5 distinct speed/load/temperature conditions is measured again.

Test length is approximately 134 hours.

| | Aging Stages | | Test Stages | | | | |
|---|---|---|---|---|---|---|---|
| | Phase 1 | Phase 2 | 1 | 2 | 3 | 4 | 5 |
| Speed, rpm | 1500 | 2250 | 1500 | 800 | 800 | 1500 | 1500 |
| Power, kW | 15.39 | 23.10 | 15.39 | 2.18 | 2.18 | 15.39 | 15.39 |
| Oil temperature, °C | 125 | 135 | 125 | 105 | 70 | 70 | 45 |
| Coolant Temperature, °C | 105 | 105 | 105 | 95 | 60 | 60 | 45 |

**Method of Rating:** FEI 1, relative fuel efficiency after 16 hours aging, and FEI 2 relative fuel efficiency after 96 hours aging, compared to the average fuel consumption of the baseline candidate oil run immediately before and after the candidate.



Afton CHEMICAL

# Sequence VIII

## ASTM D6709

**Equipment Used:**

Single cylinder, carburetted, CLR (Cooperative Lubricant Research) oil evaluation engine.

**Purpose:**

Tests an oil's copper, tin, and lead bearing corrosion control capabilities and evaluates shear stability under high temperature operating conditions.

**Test Conditions:**

Steady state test lasting 40 hours.

| | |
|---|---|
| Duration, hrs. | 40 |
| Speed, rpm. | 3150 |
| Oil Temperature, °C | 143 |

**Method of Rating:**

Connecting rod bearing weight loss, used oil kinematic viscosity, 10 hour stripped viscosity for multigrade oils.

# Sequence VID

## ASTM D7589

**Equipment Used:**

3.6L GM Engine (LY7) installed on a dynamometer test stand.

**Purpose:**

To evaluate the fuel economy benefit of a candidate oil in comparison with a baseline calibration oil. (SAE 20W-30)

**Test Conditions:**

The test length is 155 hours. A baseline calibration oil is run first measuring the fuel consumption, then the candidate oil is run and finally the reference oil is run again. When changing the oil from the candidate to the reference one, a flush is required with a special flushing oil. The test is based on 6 stages each of which has constant speed/torque/temperature conditions.

| Parameter | Stage 1 | Stage 2 | Stage 3 | Stage 4 | Stage 5 | Stage 6 |
|---|---|---|---|---|---|---|
| Speed tr/min | 2000 | 2000 | 1500 | 695 | 695 | 695 |
| Load Cell, NM | 105 | 105 | 105 | 20 | 20 | 40 |
| Nominal Power, kW | 22 | 22 | 16.5 | 1.5 | 1.5 | 2.9 |
| Oil Gallery, °C | 115 | 65 | 115 | 115 | 35 | 115 |
| Coolant-In, °C | 109 | 65 | 109 | 109 | 35 | 109 |

**Method of Rating:**

Test results are expressed as a percent change in weighted fuel consumption relative to the baseline oil. FEI 1 is made after 16 hours of oil aging and FEI 2 evaluation is made after 100 hours of oil aging.

# Roller-Follower Wear Test

## ASTM D5966

**Equipment Used:** GM 6.5L diesel engine.

**Purpose:** Evaluation of valve train wear not related to soot.

**Test Conditions:**

| | |
|---|---|
| Engine Speed, rpm. | 1000 |
| Power, kW (bhp) | 30 (41) - 34 (46) |
| Coolant Out Temp., °C | 120 |

# Caterpillar 1K

## ASTM D6750

**Equipment Used:** Single cylinder supercharged diesel engine (1Y540) using one piece aluminium piston.

**Purpose:** Diesel detergency test for high speed, severe supercharged conditions.

**Test Conditions:**

| | |
|---|---|
| Duration, hrs. | 252 |
| Engine Speed, rpm. | 2100 |
| Power, kW (bhp) | 67 (91) |
| Coolant Out Temp., °F | 200 |
| Inlet Air, °F/°C | 260/127 |
| Exhaust Gas, °F | 1025 |
| Inlet Air Pressure (in Hg) | 71.1 |
| Coolant Flow (galls. min). | 17.3 |
| Air Fuel Ratio | 28.0 |
| Fuel Injection Pressure (psi) | 15,000 |
| Fuel Sulphur, % | 0.35 min. |

**Method of Rating:** Parameters assessed include piston deposits, oil consumption, piston ring projections and wear, liner polish and wear, and oil deterioration.

# Caterpillar 1M-PC

## ASTM D6618

**Equipment Used:** Single cylinder supercharged diesel engine (1Y73).

**Purpose:** Evaluation of ring sticking, ring and cylinder wear and piston deposits.

**Test Conditions:**

| | |
|---|---|
| Duration, hrs. | 120* |
| Engine Speed, rpm. | 1800 |
| Power kW, (bhp) | 42 |
| Coolant Out Temp., °C | 88 |
| Fuel Sulphur, % | 0.4 |

* After 1 hour run-in

**Method of Rating:** Piston and liner inspected.

Cylinder liner and piston ring wear determined.

Piston grooves and lands rated for carbon deposits.



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# Caterpillar 1N

## ASTM D6750

**Equipment Used:**

Single cylinder supercharged diesel engine (1Y540) using one piece aluminium piston.

**Purpose:**

To determine acceptability of oils for Caterpillar engines, based on evaluation of oil consumption and piston deposits.

**Test Conditions:**

| | |
|---|---|
| Duration, hrs. | 252 |
| Engine Speed, rpm. | 2100 |
| Power, kW (bhp). | 67 (91) |
| Coolant Out Temp., °C | 93 |
| Fuel Injection Pressure (psi) | 15,000 |
| Fuel Sulphur, % | 0.05 |

**Method of Rating:**

Piston deposits rated to include top groove fill (TGF) %, top land heavy carbon (TLHC) % and weighted deposits (WDK).

No stuck piston rings or piston, ring or liner distress are allowed.

Average oil consumption measured.

# Caterpillar 1P

## ASTM D6681

**Equipment Used:**

Single cylinder, non-intercooled 1Y3700 engine.

**Purpose:**

Evaluation of piston deposits and oil consumption when using two-piece pistons with forged steel crown and aluminium skirt.

**Test Conditions:**

| | |
|---|---|
| Duration, hrs. | 360 |
| Power, kW (bhp). | 55 (74) |
| Engine Speed, rpm. | 1800 |
| Inlet Air Temp., °C | 60 |
| Oil Temp., °C | 130 |
| Fuel Injection Pressure (psi) | 28,000 |
| Fuel Sulphur, % | 0.03 – 0.05 |

**Method of Rating:**

Total Weighted Piston Deposits (WDP), Top Groove and Top Land Carbon (TGC and TLC) and oil consumption rated.

# Caterpillar C13

**Equipment Used:** A 2004 Caterpillar C13 ACERT, in-line 6 cylinder, 13L engine.

**Purpose:** Single stage test to determine an oils ability to minimize piston deposits and oil consumption.

**Test Conditions:**

| | |
|---|---|
| Duration, hrs. | 500 |
| Speed, rpm | 1800 |
| Inlet Manifold Temperature, °C | 40 |
| Coolant Outlet Temperature, °C | 88 |
| Oil Gallery Temperature, °C | 98 |
| Fuel Sulphur, ppm | 7-15 |

**Method of Rating:** Top groove carbon, top land carbon, 2nd ring carbon deposits and oil consumption.

# Cummins M11 - HST (obsolete)

## ASTM D6838

**Equipment Used:** 1994 Cummins M-11 330E engine which is electronically controlled and has been modified to provide over-fueling and retarded injection.

**Purpose:** To evaluate soot abrasive wear of the valve train, oil filter plugging and sludge formation on the rocker covers.

**Test Conditions:** 200 hour long test consisting of 2 x 100 hour cycles alternating 50 hour segments with retarded and standard timing. The engine runs 15% over-fuelled.

| | Stage 1 | Stage 2 |
|---|---|---|
| Duration, hrs. | 50 | 50 |
| Speed, rpm. | 1800 | 1600 |
| Coolant Outlet Temperature, °C | 88 | |
| Oil Temperature, °C | 115 | |
| Timing | Retarded | Standard |

**Method of Rating:** Crosshead wear at 4.5% soot.

Engine sludge.

Filter plugging.

**Other:** Test no longer available.

# Cummins M11 EGR (obsolete)

## D6975-03

**Equipment Used:** Cummins ISM 425 in-line 6 cylinder diesel engine which is turbocharged, aftercooled and has EGR.

**Purpose:** To evaluate the protection of an oil against soot related valve train wear, top ring wear, engine sludge and filter plugging in an high soot, EGR environment.

**Test Conditions:** 300 hour test length consisting of 3 x 100 hour 2 stage cycles, where Stage 1 generates soot and Stage 2 induces valve train wear.

| | Stage 1 | Stage 2 |
|---|---|---|
| Duration, hrs. | 50 | 50 |
| Speed, rpm. | 1800 | 1600 |
| Torque, Nm. | 1300 | 1930 |
| Inlet Manifold Temperature, °C | 80 | 65.5 |
| Coolant Outlet Temperature, °C | 65.5 | |
| Oil Temperature, °C | 115 | |
| Oil Charge, L | 30 | |

**Method of Rating:** Crosshead wear at 8.5% soot.

Top ring weight loss.

Engine sludge.

Filter plugging.

**Other:** Test no longer available.

# Cummins ISB

**Equipment Used:** 2004 US EPA emission compliant, in-line, 6 cylinder Cummins 5.9L B series engine.

**Purpose:** To evaluate an oils ability to inhibit soot-induced valve train wear on a sliding tappet platform equipped with EGR.

**Test Conditions:** A 350 hour test consisting of 2 stages. Stage 1 is a 100 hour long soot generation phase, to reach 3.25% soot. Stage 2 is 250 hours of cyclical operation to induce valve train wear.

| | Stage 1 | Stage 2 |
|---|---|---|
| Duration, hrs. | 100 | 250 |
| Speed, rpm | 1600 | 800 - 2600 variable |
| Injection timing, °BTDC | 15 nominal | variable |
| Inlet Manifold Temperature, °C | 68 | 68 |
| Coolant Outlet Temperature, °C | 99 | |
| Oil Sump Temperature, °C | 110 | |
| Oil Charge, kg | 14.5 | |
| Fuel sulphur, ppm | 10 | |

**Method of Rating:** Average camshaft wear, average mass loss of tappet, crosshead and adjusting screw.



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# Cummins ISM

**Equipment Used:** In-line 6 cylinder 11L Cummins ISM with EGR.

**Purpose:** To evaluate an oil's ability to protect and engine against wear, filter plugging and sludge deposits in a high soot environment.

**Test Conditions:** A 200 hour test alternating between 2 x 50 hour stages where Stage 1 is a soot generation phase and Stage 2 is run under heavy load conditions.

| | Stage 1 | Stage 2 |
|---|---|---|
| Duration, hrs. | 50 | 50 |
| Speed, rpm | 1800 | 1600 |
| Injection timing | Variable | Fixed |
| Inlet Manifold Temperature, °C | 80 | 66.5 |
| Coolant Outlet Temperature, °C | 65.5 | |
| Oil Gallery Temperature, °C | 115 | |

**Method of Rating:** Crosshead weight loss, filter plugging, sludge rating.

# Detroit Diesel 6V-92TA

## ASTM D5862

**Equipment Used:** Detroit Diesel 6V-92TA, 6 cylinder, two-stroke turbocharged diesel engine.

**Purpose:** Evaluation of ability of lubricant to protect critical cylinder components under typical conditions of use.

**Test Conditions:** Total test duration: 100 hrs consisting of 6 cycles. Half running at full load, the other half at full rated power.

| | Load Mode | Power Mode |
|---|---|---|
| Speed, rpm. | 1200 | 2300 |
| Power, kW (bhp). | 300 – 320 | 490 – 510 |
| Oil Sump Temp., °C | 112 – 119 | 123 – 131 |
| Oil Consumption, g/hr., max. | 340 | 340 |
| Coolant Out Temp., °C | 84 | 84 |

**Method of Rating:** Rings, liners, slipper bushings and piston skirts rated for distress which relates to overall engine life.

**Other:** Test no longer available.

# MACK T-8/T-8E

## ASTM D5967

**Equipment Used:** Mack E7-350, 6 cylinder turbocharged, intercooled diesel engine. 12L, 350 BHP.

**Purpose:** Evaluation of viscometric performance and soot loading of engine oils in turbocharged and intercooled diesel engines.

**Test Conditions:**

| | |
|---|---|
| Duration, hrs. | 250 at full load (T-8) |
| | 300 at full load (T-8E) |
| Speed, rpm. | 1800 |
| Torque, lb/ft. | 1010 – 1031 |
| Oil Sump Temp., °C | 102 – 107 |
| Coolant Out Temp., °C | 85 |
| Fuel Sulphur, % | 0.03 – 0.05 |

**Method of Rating:** Viscosity increases from used oil analysis are measured.

Test method also stipulates max. oil consumption of 0.0005 lbs/BHP/hr.

# Mack T-10 (obsolete)

## ASTM D6987

**Equipment Used:** Mack E-Tech 460 diesel engine equipped with EGR.

**Purpose:** To evaluate an oil's performance with respect to piston, liner and bearing wear in an EGR environment.

**Test Conditions:** A 300 hour test consisting of two stages. Stage 1 is a 75 hour soot generation phase, and Stage 2 is 225 hours at peak torque.

| | Stage 1 | Stage 2 |
|---|---|---|
| Duration, hrs. | 75 | 225 |
| Speed, rpm. | 1800 | 1200 |
| Power, kW. | ~257 | ~324 |
| Inlet Manifold Temperature, °C | 70 | 66 |
| Coolant Outlet Temperature, °C | 66 | 85 |
| Oil Temperature, °C | 88 | 113 |

**Method of Rating:** Piston ring and liner wear.

Lead content in used oil.

Oil consumption.

**Other:** Test no longer available.

# Mack T-11

## ASTM D7156

**Equipment Used:** In-line, 6 cylinder Mack E-Tech V-Mac III diesel engine with EGR, turbocharging and intercooling.

**Purpose:** To evaluate the viscosity increase and soot loading performance of engine oils in an EGR environment.

**Test Conditions:** Single stage test lasting 252 hours, with variable timing to hit three different soot windows at 96 hr, 192 hr and 252 hr.

| | |
|---|---|
| Duration, hrs. | 252 |
| Speed, rpm. | 1800 |
| Power, kW. | ~257 |
| Coolant Outlet Temperature, °C | 66 |
| Inlet Manifold Temperature, °C | 70 |
| Oil Temperature, °C | 88 |

**Method of Rating:** % soot in oil leading to a 12 cSt increase in KV@100.

# Mack T-12

**Equipment Used:** In-line 6 cylinder, 12L Mack E-TECH V-MAC III engine, turbocharged with heavy EGR.

**Purpose:** To determine an oils ability to minimize bearing corrosion, ring/liner wear and oil consumption.

**Test Conditions:** A 300 hour test consisting of two stages. Stage 1 is 100 hrs, 35% EGR, rated speed conditions to generate ~ 4.3% soot, then Stage 2 is 200 hrs, 15% EGR, peak torque conditions to generate wear and corrosion.

| | Stage 1 | Stage 2 |
|---|---|---|
| Duration, hrs. | 100 | 200 |
| Speed, rpm | 1800 | 1200 |
| EGR, % | 35 | 15 |
| Inlet Manifold Temperature, °C | 80 | 80 |
| Coolant Outlet Temperature, °C | 66 | 108 |
| Oil Gallery Temperature, °C | 88 | 116 |
| Fuel | ULSD 7 -15 ppm sulphur | |

**Method of Rating:** Increase in lead in oil, average liner wear, top ring weight loss.

Specification Handbook

# Rig Tests

Rig Tests

# Contents Rig Tests

## European Tests:


Denison T6H20C Vane/Piston Pump Test .......... 2
Dynamic Seal Test .......... 3
FE8 Rolling Bearing Lubricant Test Rig .......... 4
Flender Foam .......... 5
Four-Ball Extreme Pressure Test .......... 6
Four-Ball Wear Test .......... 7
FZG A10 Shock/Stage Test .......... 8
FZG Load-Carrying Capacity Test .......... 9
FZG Low Speed Test .......... 10
FZG Low Speed Wear Test (Verschleiss Test) .......... 11
FZG Pitting Test .......... 12
FZG Micropitting Test .......... 13
SSP180 Synchromesh Test .......... 14
Schmidt/Afton Tribo Tester Slideway Oil Test .......... 15
Shear Stability Test - Kurt Orban .......... 16
SKF Emcor (DIN 51802) .......... 17
The Brugger Test .......... 18
Timken Extreme Pressure Test .......... 19
VW Shear Stability Test .......... 20
Conestoga Pump Test .......... 21




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# Denison T6H20C Hydraulic Vane/Piston Pump Test

## A-TP-30533

**Scope:** To evaluate the wear and filter blocking performance of hydraulic fluids in controlled conditions with and without water contamination.

**Equipment:** Denison T6H20C Vane/Piston Pump Rig which circulates fluid while cycling the pump output pressure and maintaining fluid flow.

**Method:** The same fluid is used for two 300-hr test phases, first with < 0.05% water then with 1% water.

**Rating:** Rating is carried out by Denison at their factory in Vierzon, France.

**Specifications:** Denison Specifications TP-30283.

# Dynamic Seal Test

**Scope:** To assess sealing and wear capabilities of lubricants on oil seal materials.

**Equipment:** Test heads capable of applying different shaft speeds, temperatures and time duration to a fixed position test oil seal.

**Methods:** Test oil seal samples are held in plates that are in turn fixed to an oil chamber.

A shaft then fits through the test seal and the chamber is half filled with lubricant.

A cycle of conditions are then run.

**Ratings:** Visual wear and leakage during test is monitored. Other parameters are also rated including cracking, hardness and blistering.

**Results:** A pass or fail is derived from the rating.

# FE8 Rolling Bearing Lubricant Test Rig

## DIN 51819-3

**Scope:**

The Rolling Bearing Lubricant Test Rig FE8 can be used to study the tribological system “Rolling Bearing”.

The test rig can be adapted to the most diverse operating and environmental conditions. This makes it extremely versatile, allowing field applications as well as lubricants, materials and roller bearings to be studied under their specific operating conditions.

**Equipment:**

FE8 test rig with adaptors to run oil or grease lubricants and roller or ball bearings.

**Method:**

A bearing is run to specific conditions for an allotted time either using a grease or oil lubricant.

**Rating:**

A visual check for pitting of the bearing surfaces and post test weight loss, plus any increase in coefficient friction.



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# Flender Foam

**Scope:** To evaluate the behaviour of oils with regard to air absorption.

**Method:** The method consists of an enclosed gearbox with 1 litre of oil to be tested. The gear pair are used to mix the oil with the air and effect foam formation over a 5 minute period.

**Rating:** A visual rating on a numerical scale measuring the foam formation on top of the test oil.

**Significance:** The addition of suitable additives to reduce the effects of foaming thus reducing the possibilities of pitting and seizure.

# Four-Ball Extreme Pressure Test

## IP 239 & ASTM D2783

**Scope:** Covers three determinations of the load-carrying properties of lubricating fluids:

(a) Load-Wear Index
(b) Weld Point
(c) Wear

**Equipment:** A standardised machine design is used.

**Method:** The four-ball EP tester is operated with one steel ball rotating against three steel balls held stationary in the form of a cradle. The lubricant under test covers the lower three balls. The speed of rotation, loading and duration time is set dependant on method.

**Load-Wear Index:** An index of the ability of the lubricant to prevent wear at applied loads. The equation for load-wear index reflects the ability of a lubricant to carry a high load without welding and to allow only relatively small wear scars at loads below the weld point.

**Weld Point:** The lowest load in kilograms at which the rotating ball welds to the three stationary balls.

**Wear** The mean scar wear diameters are measured from the 3 stationary balls after running test conditions.

**Specifications:** The user should determine to his own satisfaction whether the results correlate with field performance or other bench test machines.

# Four-Ball Wear Test

## ASTM D4172

**Scope:** Covers a procedure for making a preliminary evaluation of anti-wear properties of fluid lubricants. Evaluation of greases using the same machine is detailed in Method D2266.

**Equipment:** A standardised machine design is used.

**Method:** Three 12.7 mm diameter steel balls are clamped together and covered with the lubricant under test. A fourth steel ball is pressed with a force of 147 or 392 N into the cavity formed by the three balls for the "three-point contact". The temperature of the test lubricant is regulated at 75°C and the top ball is rotated at 1200 rpm for 60 minutes. Lubricants are compared by using the average size of the scar diameters worn on the lower three clamped balls.

**Specifications:** The user of this method should determine to his own satisfaction whether the results of this procedure correlate with field performance or other bench test machines.



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# FZG A10 Shock/Stage Test

## FVA Research Project No. 243 CEC SG-T-084

**Scope:** To differentiate between lubricants with higher EP performance.

**Equipment:** (See FZG load carrying test).

**Method:** Special gears are run in a bath of candidate lubricant.

**(Stage Test)** The load on the tooth flanks is increased in stages from Stage 1 to load stage 10.

**(Shock Test)** The expected failure load is applied to an unused gear flank.

**Ratings:** The gears are inspected visually without removal at the end of each load stage.

The failure load stage is reached when the sum of the damaged area's width exceeds 10mm.

**Results:** Report the failure load stage as the result.

# FZG Load-Carrying Capacity Test

## DIN 51354/CEC L-07-A-95

**Scope:** Assess the relative load-carrying capacities of oils when used to lubricate steel/steel spur gears.

**Equipment:** The FZG spur gear test rig consists of a closed power circuit with drive and test gears connected by two torsion shafts. One of the shafts has a positive clutch for application of the load.

**Method:** Special gear wheels are run in the lubricant under test at a constant speed for a fixed time. The initial oil temperature is controlled but allowed to rise freely during each stage of the test. Loading is raised in stages. The test is continued until the damage load stage is reached, but if no damage occurs at load stage 12 the test is terminated.

**Ratings:** The gears are inspected visually, without removal, at the end of each load stage.

The failure load stage is determined by the summation of deep scoring, seizure lines or seizure areas on any of the gear teeth.

**Results:** The load stage in which failure occurs is reported together with the test conditions; e.g. A/8.3/90, where A = gear type, 8.3 = pinion speed at pitch circle in m/sec, and 90 = initial temperature in oil sump in °C. These are the usual conditions, but they can be changed as required.

**Specifications:** Results are reported in terms of the highest pass stage for the CEC method or the first fail load stage, for the DIN Method.

# FZG Low Speed Wear Test

**Scope:**

Based on a test originally developed by Chevron, this procedure has been adopted by ASTM D4998-89 for the evaluation of final drive lubricants for use in agriculture tractors and similar off-road applications.

**Method:**

Using the same test equipment and gear wheels as for the FZG load-carrying capacity test, this procedure requires a fixed load durability run to the following conditions.

| | |
|---|---|
| Lubricant Temp., °C | 121 |
| Load Stage | 10 |
| Motor Speed, r/min. | 100 ± 3 |
| Duration, Revolutions | 120,000 |

**Results:**

The data is reported as total weight loss for both test gears, together with the total number of teeth exhibiting wear. The precision of the method has not been determined.

**Note:**

CEC test method development working group has abandoned the method until further research studies are completed. This is due to poor discrimination.

# FZG Low Speed Wear Test (Verschleiss Test)

**Scope:** Evaluation of load carrying capacities of oils and effects on wear using spur gears.

**Equipment:** FZG test rig with a 25/1 gear reduction gearbox due to the low speed requirement.

**Method:** The test is split into 3 stages and uses steel spur gears dipped in approximately 2 litres of oil. The test set is weighed before test.

| Stage | Duration (Hrs) | Speed (RPM) | Temperature (°C) | Load (N/mm2) |
|---|---|---|---|---|
| 1 | 40 | 13 | 90 | 1814 |
| 2 | 40 | 13 | 120 | 1814 |
| 3 | 40 | 13 | 90 | 1814 |

**Result:** The result is determined by the weight loss after every stage

**Specification:** According to ZF AA05.468.017. Issued November 2005.



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# FZG Pitting Test

## FVA 2/IV

**Scope:** For testing suitable gear oils in the viscosity range from ISOVG 32 to ISOVG 220 to discriminate pitting performance.

**Equipment:** The FZG spur gear test rig consists of a closed power circuit with drive and test gears connected by 2 torsion shafts.

One of the shafts has a positive clutch for application of the load.

**Method:** FVA Project No 2/IV - A set of test gears are run in approximately 1.5 litres of fluid with a constant tooth loading for up to 300 hours. A visual inspection is carried out every 24 hours.

**Results:** The failure criteria is a pitting area on an individual tooth at least 4% of the active flank. This corresponds to approximately 5mm$^2$.

# FZG Micropitting Test

## FVA 54/I - IV

**Scope:** Evaluates the ability of gear lubricants to resist micropitting.

**Equipment:** An FZG gear rig is specially adapted to supply spray lubrication at a given rate and temperature to the test spur box.

**Method:** The two part procedure comprises a load stage test followed by an endurance test. During the load stage test, the ability of the gear lubricant tribological systems to resist micropitting is determined. The endurance test provides information on the progress of the damage after a higher number of load cycles.

**Results:** The gears are examined for weight loss, area of micropitting involute profile deviation.

# SSP180 Synchromesh Test

## CEC L-66-95

**Scope:** To determine the endurance life of synchromesh systems using different materials for manual gearboxes in automotive applications defined by wear and coefficient of friction.

**Equipment:** SSP 180 Synchromesh Test Rig, with measuring devices.

**Method:** After a short running in period a synchromesh is used to engage/disengage two individual revolving shafts.

The complete test comprises of 100000 cycles without clashing.

**Results:** The test is evaluated by clashing of the synchromesh, coefficient of friction and mechanical wear on the contact parts.



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# Schmidt/Afton Tribo Tester Slideway Oil Test

**Scope:** The method evaluates oil in respect of static friction and stick slip behaviour when used in machine slideway applications.

**Method:** A slideway supporting a sliding block is lubricated with the test oil. The slideway is gradually inclined until the sliding block begins to move. The angle at which the block moves 20 microns is used to calculate the 'Schmidt Coefficient of Friction'. Developed by the Hans Schmidt Tribology Laboratory for their original slideway test machine.

The method uses two combinations of test materials:

(a) Grey Cast Iron on Grey Cast Iron;

(b) SKC 3 plastic on Grey Cast Iron.

300 run-in cycles are carried out with the SKC 3 plastic test and 400 with the Grey Cast Iron test. After completing the run-in, 10 test cycles are carried out to determine the 'Schmidt Coefficient of Friction' of the oil.

**Results:** Graphical plots of all the run-in and test cycles are presented along with the calculated results of the 10 test cycles.

# Shear Stability Test - Kurt Orban

## CEC L-14-A-88

**Scope:** To correlate shear stability with the permanent viscosity drop expected in field service.

**Equipment:** Kurt Orban Injector rig.

**Method:** A sample of oil is subjected to 30 or 250 cycles of a two cylinder diesel injection pump and injector nozzle set to a pressure of 175 bar.



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## SKF Emcor

### DIN 51802

**Scope:** To evaluate rust and corrosion properties of a lubricant with the presence of water.

**Equipment:** Specially manufactered rig conisting of 8 test bearing housings connected on a common electric drive motor shaft.

**Method:** Bearings run in an oil/water mixture for 8 hrs. The rig then stands idle for a period of 16 hrs. This cycle is then repeated with a final running of 8 hrs before standing idle for 108 hrs. The bearings are then rated.

**Rating:** Bearings are visually rated on a scale of 1-5 depending on the amount of corrosion present.

**Significance:** Lubricant performance with the presence of water.

# The Brugger Test

**Scope:** The Brugger Test determines the load capacity of industrial, transmission and hydraulic lubricants. The test provides a useful technique for evaluating the wear protection of a lubricant under conditions of minimal lubrication.

**Equipment:** A Müller Weingarten Brugger Test Machine is used.

**Method:** A 25 mm diameter steel friction roller is rotated at 940 rpm (1.2 m/sec) against an 18 mm diameter fixed steel cylinder roller with a force of 400 N applied by a lever mechanism for 30 seconds. The surfaces are lubricated with a 5 ml sample poured over the assembly one minute before the start of the test.

**Results:** The result is reported in N/sqmm, calculated from the measurement of the wear scar.

**Specifications:** Typical pass criteria are:

| | |
|---|---|
| Hydraulic Oil | ≥ 30 N/sqmm |
| Transmission Oil | ≥ 50 N/sqmm |
| Grease | ≥ 30 N/sqmm |

**Significance:** The user should determine to his own satisfaction whether the results correlate with field performance or other bench test machines.

# Timken Extreme Pressure Test

## ASTM D2782

**Scope:**

Covers the determination of load-carrying capacity of lubricating fluids by means of the Timken Extreme-Pressure Tester.

**Equipment:**

The test uses the Timken Wear and Lubricant Testing Machine, in which a pivoted test block is applied to the periphery of a rotating cylinder (cup) in such a way that the pressure of application can be controlled.

**Method:**

The machine is operated with the steel cup rotating at 800 r/min. Two determinations are made: the minimum load that will rupture the lubricant film and cause scoring or seizure; and the maximum load (OK load) that will not rupture the lubricant film.

Testing is initiated at an applied load of 30 lbs and increased in increments of 10 lbs until scoring occurs. The load is then reduced by 5 lbs to determine the final score load and OK load values. Each load stage is run for a 10 minute duration and the lubricant temperature is brought to 38°C at the start of each stage.

**Specifications:**

The method is widely used for specifications purposes and is used to differentiate between lubricants having low, medium or high extreme-pressure characteristics. The results may not correlate with results from service.

# KRL Shear Stability Test

## CEC L45-A-99 Taper Roller Bearing Rig

**Scope:**

Determination of the mechanical shear stability of lubricants containing polymer additives such as gearbox, shock-absorber, automatic transmission and engine oils.

**Method:**

An adaptor, containing a standard single row taper roller bearing, is installed in a Four-Ball test machine. 40ml of test oil is introduced into a cup surrounding the bearing and the machine is run at 1500 r/min. with a 5 KN bearing axial load, for test durations of 4, 8 and 20 hours. The oil temperature is held at 60°C.

The percentage loss in kinematic viscosity of the oil after each test run is plotted against time.

**Significance:**

The method is being standardised for specifications purposes and is a rapid means of assessing the shear stability of a wide range of lubricants.

## Conestoga Pump Test

### ISO 20763 ASTM D7043

**Scope:**

For determination of steel on steel anti-wear properties of hydraulic fluids by means of performance in a vane type hydraulic pump. It covers a range of hydraulic fluids, both anhydrous and aqueous, Intended for applications where high speed sliding contacts, such as those found in a vane pump are encountered.

**Equipment:**

A Vickers type V-104-C 12 pump housing containing Conestoga internals is used to circulate a hydraulic fluid around a closed loop system.

**Method:**

ISO 20763 The test consists of a vane pump circulating hydraulic ASTM D7043-4a oil with a relief valve pressure of 14 Mpa and at a temperature to achieve a viscosity of 13mm2/s for anhydrous fluids and 30mm$^2$/s for aqueous at the pump inlet port.

**Rating:**

The vanes and cam ring from the test cartridge are weighed before and after test to determine weight loss.
A visual inspection is also carried out on the contact parts.

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## Afton Chemical Corporation
## Regional Headquarter Offices


**ASIA PACIFIC**
Afton Chemical Asia Pacific LLC
111 Somerset Road #09-05
Singapore
238164
T | 65 6732 0822
F | 65 6737 4123

**EMEAI**
Afton Chemical Limited
London Road, Bracknell
Berkshire RG12 2UW
England
T | 44 1344 304 141
F | 44 1344 420 666

**LATIN AMERICA**
Afton Chemical
Industria de Advitivos LTDA
Avendia Rio de Janeiro 901 (Parte)
CEP-20931-675
Brazil
T | 55 21 3295 4050
F | 55 21 2580 8647 & 2589 0531

**NORTH AMERICA**
Afton Chemical Corporation
500 Spring Street
Richmond
VA 23219
USA
T | 1 804 788 5800
F | 1 804 788 5184


For the latest version of the Specification Handbook please visit
www.aftonchemical.com