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METRIC
MIL-PRF-2104H
12 JULY 2004
SUPERSEDING
MIL-PRF-2104G
10 February 1997

PERFORMANCE SPECIFICATION

LUBRICATING OIL, INTERNAL COMBUSTION ENGINE, COMBAT/TACTICAL SERVICE

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This performance specification covers engine oils suitable for lubrication of reciprocating compression-ignition internal combustion engines and for power transmission fluid applications in combat/tactical service equipment (see 6.1).

1.2 Classification. The lubricating oils are of the following viscosity grades as defined in SAE J300:

SAE Viscosity Grade	Military Symbol	NATO Code
40	OE/HDO-40	---
15W-40	OE/HDO-15/40	O-1236
5W-40	OE/HDO-5/40	---

Comments, suggestions, or questions on this document should be addressed to Tank-automotive and Armaments Command, 6501 E. 11 Mile Road, Warren, MI 48397-5000 or emailed to standardization@tacom.army.mil Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at www.dodssp.daps.mil

AMSC N/A FSC 9150

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2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2 and 6.6).

INTERNATIONAL STANDARDIZATION AGREEMENTS

STANAG 1135 - Fuels, Oils, Lubricants and Petroleum Handling Equipment.

(Copies of this document are available online at http://assist.daps.dla.mil/quicksearch/ or www.dodssp.daps.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues are these documents cited in the solicitation or contract.

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Guide for the Qualification of Engine and Gear Lubricants.

(Copies of the guide may be obtained from USA RDE Command, ATTN: AMSRD-TAR-D (MS-110), 6501 E. 11 Mile Road, Warren, MI 48397-5000.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

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ASTM INTERNATIONAL

ASTM D 92	-	Flash and Fire Points by Cleveland Open Cup, Standard Test Method (DoD adopted).
ASTM D 97	-	Pour Point of Petroleum Products, Standard Test Method (DoD adopted).
ASTM D 130	-	Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish, Standard Test Method (DoD adopted).
ASTM D 287	-	API Gravity of Crude Petroleum and Petroleum Products, (Hydrometer Method), Standard Test Method (DoD adopted).
ASTM D 445	-	Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity), Standard Test Method (DoD adopted).
ASTM D 874	-	Sulfated Ash, from Lubricating Oils and Additives, Standard Test Method (DoD adopted).
ASTM D 892	-	Foaming Characteristics of Lubricating Oils, Standard Test Method (DoD adopted).
ASMT D 4485	-	Standard Specification for Performance of Engine Oils.
ASTM D 4629	-	Trace Nitrogen in Liquid Petroleum Hydrocarbons by Syringe/Inlet Oxidative Combustion and Chemiluminescence Detection, Standard Test Method (DoD adopted).
ASTM D 4683	-	Measuring Viscosity at High Shear Rate and High Temperature by Tapered Bearing Simulator, Standard Test Method.
ASTM D 4684	-	Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature, Standard Test Method (DoD adopted).
ASTM D 5185	-	Determination of Additive Elements, Wear Metals, and Contaminants in Used Lubricating Oils and Determination of Selected Elements in Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), Standard Test Method (DoD adopted).
ASTM D 5293	-	Apparent Viscosity of Engine Oils Between -5 and -35 Degrees C Using the Cold-Cranking Simulator, Standard Test Method.
ASTM D 5800	-	Evaporation Loss of Lubricating Oils by the Noack Method, Standard Test Method.
ASTM D 5862	-	Evaluation of Engine Oils in Two-Stroke Cycle Turbo-Supercharged 6V92TA Diesel Engine, Standard Test Method.
ASTM D 5950	-	Pour Point of Petroleum Products (Automatic Tilt Method), Standard Test Method.

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ASTM D 5966 - Evaluation of Engine Oils for Roller Follower Wear in Light-Duty Diesel Engine, Standard Test Method.
ASTM D 5967 - Evaluation of Diesel Engine Oils in T-8 Diesel Engine, Standard Test Method.
ASTM D 6278 - Shear Stability of Polymer Containing Fluids Using a European Diesel Injector Apparatus, Standard Test Method.
ASTM D 6594 - Evaluation of Corrosiveness of Diesel Engine Oil at 135 Degrees C, Standard Test Method.
ASTM D 6750 - Evaluation of Engine Oils in a High-Speed, Single-Cylinder Diesel Engine 1K Procedure (0.4% Fuel Sulfur) and 1N Procedure (0.04% Fuel Sulfur), Standard Test Method.
ASTM D 6894 Evaluation of Aeration Resistance of Engine Oils in Direct-Injected Turbocharged Automotive Diesel Engine, Standard Test Method.
ASTM D 6922 - Determination of Homogeneity and Miscibility in Automotive Engine Oils, Standard Test Method.
ASTM D 6975 - Cummins M11 EGR, Standard Test Method.
ASTM D 6984 - Evaluation of Automotive Engine Oils in the Sequence IIIF, Spark-Ignition Engine, Standard Test Method.
ASTM D 6987 - Evaluation of Engine Oils in the T-10 Exhaust Gas Recirculation Diesel Engine, Standard Test Method.
ASTM RR D02-1379 - Global Engine Oil Service Specification DHD-1 Characteristic, Standard Test Method.
ASTM RR D02-1517 - Research Report for Mini-Rotary Viscosity and Yield Stress of Highly Sooted Diesel Engine Oils, Standard Test Method.

(Copies of these documents are available from ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or website: http:/www.astm.org)

ALLISON TRANSMISSION DIVISION (ATD)/GENERAL MOTORS CORPORATION (GM)

C-4 - Heavy-Duty Automatic Transmission Fluid Specification (TES-228).
GMN10055 - DEXRON®-III, H revision, Automatic Transmission Fluid Specification.

(Copies of these documents are available from Southwest Research Institute C4 Coordinator, Specialty and Driveline Fluids Lab, P.O. Box 28510, San Antonio, TX 78223-0510, or website: www.swri.org)

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CATERPILLAR INC., ENGINE DIVISION (CAT.)

TO-4/TO-4M - Transmission and Drive Train Fluid Requirements.

(Copies of these documents are available from Caterpillar Inc., Corporate Fluids Engineering, Mail Code: H2000, P.O. Box 610, Mossville, IL 61552-0610.)

PERFORMANCE REVIEW INSTITUTE (PRI)

Procedures of the Engine Oil Review Committee

(Copies of these documents are available from Secretary of the Lubricants Review Institute (LRI), Performance Review Institute, 161 Thornhill Road, Warrendale, PA 15086-7527 or website: www.pri.sae.org)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J300 - Engine Oil Viscosity Classification.

(Copies of these documents are available from SAE World Headquarters, 400 Commonwealth Drive Warrendale, PA 15096-0001 USA, or website: www.sae.org)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. The lubricating oils furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.1.1 and 6.3). Any change in the formulation of a qualified product will necessitate its requalification.

3.2 Design, materials, and manufacturing processes. Unless otherwise specified, the design, materials and manufacturing process selection is the prerogative of the contractor as long as all articles submitted to the Government fully meet the operating, interface, support and ownership, and environmental requirements specified.

3.2 1 Materials. Lubricating oils shall be derived from petroleum fractions, synthetically prepared compounds or a combination of the two types of products. They may be virgin, re-refined stocks or a combination thereof. The stocks shall be compounded with such functional additives (detergents, dispersants, oxidation inhibitors, corrosion inhibitors, etc) as are necessary to meet the specification requirements.

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3.2.2 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.3 Operating requirements. The lubricating oil shall meet all the finished oil and operating requirements as specified in 3.3.1 through 3.3.16 and conform to the rheological and physical requirements specified in Table I.

TABLE I. Finished oil requirements.

Property		SAE Grade 40	SAE Grade 15W-40	SAE Grade 5W-40
Kinematic viscosity, cSt[1] @ 100°C	min.	12.5	12.5	12.5
	max.	<16.3	<16.3	<16.3
Low temperature cranking viscosity, cP[2] @ °C	min.	----	7000@-25	6200@-35
	max.	----	7000@-20	6600@-30
High-temperature/high-shear viscosity, cP, @ 150ºC min.		----	3.7	3.7
Low temperature pumping viscosity, cP @ °C, max.		----	60 000@-25	60 000@-35
Pour point, ºC, max.		-15	-25	-40
Flash point, ºC, min.		225	215	210
Evaporative loss, %, max.		----	15	15
Sulfated ash, %, max.		1.5	1.5	1.5

NOTES: 1. cSt = mm^2/s
2. cP = mPa*s

3.3.1 Foaming/aeration. All grades of oils shall meet the oil foaming/aeration properties of Table II and IIA, reducing the potential for loss of oil pressure and the associated malfunction or damage of oil operated and lubricated components (see 4.3.3.1).

TABLE II. Properties of foaming.

Rated or measured parameter	Primary performance criteria
Sequence I, foam/settling, mL, max.	10/0
Sequence II, foam/settling, mL, max.	20/0
Sequence III, foam/settling, mL, max.	10/0

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TABLE IIA. Properties of aeration.

Rated or Measured Parameter	Primary performance criteria
Aeration (EOAT), volume, %, max.	8.0 (MTAC)[1]

NOTE: 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. See ASTM D 4485, Annex A1 for additional information.

3.3.2 Shear stability. Multi-viscosity oils shall resist permanent viscosity loss from high shear conditions in accordance with Table III, particularly those containing polymeric viscosity modifiers (see 4.3.3.2).

TABLE III. Shear stability performance.

Rated or measured parameter	Primary performance criteria
Kinematic viscosity after shearing, cSt, min.	12.5

3.3.3 Piston deposits and scuffing control. All grades of oils shall prevent the buildup of aluminum and/or steel ring belt deposits, including those of the piston crown and lands, piston ring grooves, piston undercrown and piston skirts in accordance with Table IV (see 4.3.3.3).

TABLE IV. Piston deposits and scuffing performance.

Material	Rated or measured parameter	Primary performance criteria		
		One-Test	Two-Test	Three-Test
Aluminum	Weighted Piston 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 (see note), max.	0.5	0.5	0.5
	Piston, Ring, and Liner Scuffing	None	None	None
Steel	Weighted Piston 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, (0-360 h), g/h, max.	12.4	12.4	12.4
	Final Oil Consumption, (312-360 h), g/h, max.	14.6	14.6	14.6
	Piston, Ring, and Liner Scuffing	None	None	None

NOTE: g/kW-h, grams per kilowatt hour.

3.3.4 Sludge control, filterability and sliding valvetrain wear protection. All grades of oils shall prevent the formation and accumulation of sludge, keeping these deposits adequately dispersed, in accordance with Table V so not to induce filter plugging or excessively high filter delta pressure. Furthermore, all grades of oils shall minimize the wear of valvetrains designed with sliding contacts (see 4.3.3.4).

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TABLE V. Properties of sludge control, filterability and sliding valvetrain wear.

Rated or measured parameter	Primary performance criteria		
	One-test	Two-test	Three-test
Avg. crosshead weight loss, milligrams (mg), max.	20.0	21.8	22.6
Avg. top ring weight loss, mg, max.	175	186	191
Oil filter delta pressure, @ 250 h, kPa, max.	275	320	341
Avg. engine sludge, Coordinating Research Council (CRC) merits, min.	7.8	7.6	7.5

3.3.5 Soot control. All grades of oils shall minimize the viscosity increase and filter plugging tendency in accordance with Table VI due to high soot loading (see 4.3.3.5).

TABLE VI. Properties of soot control.

Rated or measured parameter	Primary performance criteria		
	One-test	Two-test	Three-test
Relative viscosity at 4.8% soot, max.	1.8	1.9	2.0

NOTE: Relative viscosity = (viscosity at 4.8 % soot) ÷ (viscosity of new oil sheared in ASTM D 6278).

3.3.6 Used oil pumpability. Lubricating oil shall minimize the effects of combustion blow-by products, soot accumulation, and other in-service contaminants in accordance with Table VII, on used oil pumpability (see 4.3.3.6).

TABLE VII. Properties of used oil pumpability.

Requirement	Rated or measured parameter	Primary performance criteria
A	Viscosity after 75 h of Mack T-10 test, tested @ -20ºC, mPa-s, max.	25 000
B[1]	Viscosity after 75 h of Mack T-10 test, tested @ -20ºC, mPa-s, max.	25 000
	Yield stress, pascal (Pa)	< 35

NOTE: Normally only need to meet performance requirement A, (see 4.3.3.6 for need to meet the other than normal requirement, requirement B).

3.3.7 Two-stroke cycle diesel engine performance. All grades of oils shall minimize two-stroke cycle diesel engine ring and liner distress, port plugging, and piston skirt distressing in conformance with Table VIII (see 4.3.3.7).

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TABLE VIII. Properties two stroke cycle diesel engine.

Rated or measured parameter	Primary performance criteria		
	One-test	Two-test	Three-test
Avg. ring face distress, demerits, max.			
Fire ring, avg.	0.33	0.34	0.36
Nos. 2 and 3 compression ring, avg.	0.28	0.29	0.30
Broken rings, avg.	None	None	None
Cylinder liner area			
Liner distress, % area, avg., max.	60.0	63.5	65.0
Port plugging, % area, avg., max.			
Avg.	2	2	2
Single cylinder	5	5	5

3.3.8 Evaporation loss. All grades of oil shall meet the finished oil requirements in Table I for evaporation loss (see 4.3.3.8).

3.3.9 Sulfated ash. All grades of oil shall meet the finished oil requirements in Table I for sulfated ash (see 4.3.3.9).

3.3.10 Flash point. The oils of this specification shall meet the requirement in Table I for minimum flash point (see 4.3.3.10).

3.3.11 Rolling valvetrain wear control. All grades of oils shall minimize the wear of valvetrains in accordance with Table IX when designed with rolling contacting interfaces (see 4.3.3.11).

TABLE IX. Valvetrain wear control criteria.

Rated or measured parameter	Primary performance criteria		
	One-test	Two-test	Three-test
Avg. pin wear, µm, max.	7.6	8.4	9.1

3.3.12 Frictional characteristics and wear. All grades of oils shall maintain a stable coefficient of friction and shall minimize distress and wear in accordance with Table X during use in power shift transmissions and other cooled friction components or hydraulic systems such as steering braking and disconnect clutches (see 4.3.3.12).

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TABLE X. Properties of frictional characteristics and wear.

Rated or measured parameter	Primary performance criteria
Allison Graphite and Paper Friction Test Mid-point dynamic friction coefficient (see notes 1, 2, and 4.3.3.12a)	Measured mid-point dynamic friction coefficient 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 (see notes 1, 2, and 4.3.3.12a)	Slip time shall be less than or equal to the maximum acceptable slip time criteria
Caterpillar TO-4/TO-4M, SEQ1220 Average dynamic coefficient, % Average static coefficient, % Disc wear, mm, max. Energy limit, m/s, min. (see note 3 and 4.3.3.12b)	 90.0 – 140.0 91.0 – 127.0 0.04 25
Caterpillar TO-4/TO-4M, SEQFRRET Average dynamic coefficient, % @ 3000 cycles @ 8000 cycles @ 15 000 cycles @ 25 000 cycles (see note 3 and 4.3.3.12c)	 85.0 – 130.0 90.0 – 125.0 90.0 – 125.0 95.0 – 125.0
Caterpillar TO-4M, EHD Film-Forming Test % of Elastohydrodynamic (EHD) reference film thickness at 2 m/s, @ 70ºC @ 100ºC @ 130ºC (see note 3 and 4.3.3.12d)	 ≥ 90 ≥ 96 ≥ 98

NOTES: 1. 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.

2. Maximum acceptable slip time (tmax)
   a. Allison Paper Friction Test: $t_{max} = 0.1108 - 0.6012\mu$
   b. Allison Graphite Friction Test: $t_{max} = 1/[-221*(\mu-0.1421)^2 + 1.756]$
   c. Where μ is the minimum acceptable coefficient at mid-point.

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

3.3.13 Piston ring, liner, and bearing wear control. All grades of oils shall minimize piston ring, cylinder liner, and bearing wear in accordance with Table XI (see 4.3.3.13).

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TABLE XI. Properties of piston ring liner and bearing wear control.

Rated or measured parameter	Primary performance criteria
Merit rating, min.	1000

3.3.14 High temperature/high shear viscosity. The oils of this specification shall meet the high temperature/high shear viscosity requirement in Table I (see 4.3.3.14).

3.3.15 Kinematic viscosity. The oils of this specification shall meet the kinematic viscosity requirement in Table I (see 4.3.3.15).

3.3.16 Oxidation and nitration control. All grades of oils shall maintain a consistent viscosity in accordance with Table XII in service during undesired thermal and chemical reactions (i.e. oxidation and nitration) (see 4.3.3.16).

TABLE XII. Property of oxidation and nitration control.

Rated or measured parameter	Primary performance criteria
Kinematic viscosity @ 40°C, % increase, max.	275(MTAC)[1]

NOTE: 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. See ASTM D 4485, Annex A1 for additional information.

3.4 Interface requirements. The oils of this specification shall meet the following interface requirement.

3.4.1 Homogeneity and miscibility. All grades of oils shall remain homogeneous and miscible with each other over ambient and operating temperatures typical for the application defined herein (see 1.1). No evidence of separation shall be detected when the candidate oil is diluted with standard reference oils and submitted to the prescribed cycle of temperature changes outlined in the test procedure designated in 4.3.4.1.

3.4.2 Elastomer seal compatibility. All grades of oils shall minimize the deterioration, softening, and/or excessive hardening of elastomer seals in accordance with Table XIII (see 4.3.4.2).

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TABLE XIII. Properties of elastomer seal compatibility.

Material designation	Volume change limits	Hardness change limits
V1	0 to 20	-15 to 0
V2	0 to 12	-7 to +3
V3	0 to 22	-14 to 0
P1	0 to 8	-10 to 0
P2	0 to 8	-11 to +3
P3	0 to 4	-8 to +4
F1	0 to 3	-5 to +4
F2	0 to 4	-2 to +5
N1	0 to 5	-12 to +12
N2	0 to 6	-9 to +5

3.4.3 Corrosion control. All grades of oils shall inhibit the corrosive chemical attack on metal and metal alloyed components in accordance with Table XIV at high temperatures, particularly those of bushings, bearings, and oil coolers (see 4.3.4.3).

TABLE XIV. Properties of corrosion control.

Rated or measured parameter	Primary performance criteria
Copper, mg/kg (ppm) increase, max. (see note 1)	20
Lead, mg/kg (ppm) increase, max.	120
Tin, mg/kg (ppm) increase, max.	50
Copper strip coupon rating, max. (see note 2)	3

NOTES: 1. Milligrams per kilogram (mg/kg), Parts per million (ppm).
2. The rating system in test method ASTM D 130 is used to rate the copper strip coupon.

3.5 Environmental requirements. The oils of this specification shall meet the following environmental requirements.

3.5.1 Low temperature cranking viscosity. The oils of this specification shall meet the low temperature cranking viscosity requirement in Table I (see 4.3.5.1).

3.5.2 Low temperature pumping viscosity. The oils of this specification shall meet the low temperature-pumping requirement in Table I (see 4.3.5.2).

3.5.3 Pour point. The oils of this specification shall meet the pour point requirement in Table I (see 4.3.5.3).

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4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspections (see 4.1.1).
b. Conformance inspections (see 4.1.2).

4.1.1 Qualification inspections. Qualification inspections shall consist of all verifications listed in table XV. Testing may be conducted in any plant or laboratory approved by the qualifying activity (see 6.2 and 6.3).

4.1.2 Conformance inspections. Conformation inspection shall include the examination and tests from Table XV as defined in the contract. When manufactured for the fulfillment of military contracts, all grades of oil shall use the same base stocks and additives, at the appropriate concentrations, as when qualified. Satisfactory performance shall be demonstrated when oils are tested in accordance with 4.3.1 and the finished oil properties fall within the permissible tolerances.

TABLE XV. Qualification/conformance requirements/verification.

Title	Requirements	Verification
Operating requirements	3.3	4.3.3
Foaming/aeration	3.3.1	4.3.3.1
Shear stability	3.3.2	4.3.3.2
Piston deposits and scuffing control	3.3.3	4.3.3.3
Sludge control, filterability and sliding valvetrain wear protection	3.3.4	4.3.3.4
Soot control	3.3.5	4.3.3.5
Used oil pumpability	3.3.6	4.3.3.6
Two-stroke cycle diesel engine performance	3.3.7	4.3.3.7
Evaporation loss	3.3.8	4.3.3.8
Sulfated ash	3.3.9	4.3.3.9
Flash point	3.3.10	4.3.3.10
Rolling valvetrain wear control	3.3.11	4.3.3.11
Frictional characteristics and wear	3.3.12	4.3.3.12
Piston, ring, liner, and bearing wear control	3.3.13	4.3.3.13
High temperature/high shear viscosity	3.3.14	4.3.3.14

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TABLE XV. Qualification/conformation requirements/verification – Continued.

Title	Requirements	Verification
Kinematic viscosity	3.3.15	4.3.3.15
Oxidation and nitration control	3.3.16	4.3.3.16
Interface requirements	3.4	4.3.4
Homogeneity and miscibility	3.4.1	4.3.4.1
Elastomer seal compatibility	3.4.2	4.3.4.2
Corrosion control	3.4.3	4.3.4.3
Environmental requirements	3.5	4.3.5
Low temperature cranking viscosity	3.5.1	4.3.5.1
Low temperature pumping viscosity	3.5.2	4.3.5.2
Pour point	3.5.3	4.3.5.3

4.2 Order of inspection. The inspection sequence may be in any order except that the operational test shall be last.

4.3 Verification methods. The types of verification methods included in this section are visual, inspection, measurement, sample tests, full-scale demonstration tests, simulation, modeling, engineering evaluation, component properties analysis, and similarity to previously-approved or previously-qualified designs.

4.3.1 Verification alternatives. The manufacturer may propose alternative test methods, techniques, or equipment, including the application of statistical process control, tool control, or cost-effective sampling procedures, to verify performance. See the contract for alternatives to replace verifications required by this specification.

4.3.2 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in applicable test method document or applicable paragraph(s) in the specification.

4.3.3 Operating requirements verification.

4.3.3.1 Foaming/aeration. All oil grades shall demonstrate compliance with 3.3.1 when tested in accordance with the following standards:

a. Foaming - Test Procedure ASTM D 892 (Option A is not allowed).
b. Aeration - Test Procedure ASTM D 6894, Engine Oil Aeration Test (EOAT).

4.3.3.2 Shear stability. SAE grades 5W-40 and 15W-40 shall demonstrate compliance with 3.3.2 when tested in accordance with standard test procedure ASTM D 6278.

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4.3.3.3 Piston deposits and scuffing. All oil grades shall demonstrate compliance with 3.3.3 when tested in accordance with the following standard test procedures:

a. Aluminum - ASTM D 6750 (CAT 1K)
b. Steel - ASTM D 6684 (CAT 1P)

4.3.3.4 Sludge control, filterability, and sliding valvetrain wear protection. All oil grades shall demonstrate compliance with 3.3.4 when tested in accordance with the test procedure ASTM D 6975 (M11 EGR).

4.3.3.5 Soot control. All oil grades shall demonstrate compliance with 3.3.5 when tested in accordance with standard test procedure ASTM D 5967 (Mack T-8E).

4.3.3.6 Used oil pumpability. SAE oil grades 5W-40 and 15W-40 shall demonstrate compliance with 3.3.6. Normal requirement A is to be tested in accordance with the standard test procedures in ASTM D 4684. However, if the test for requirement A detects yield stress, then the additional requirement properties of B need to be tested in accordance with the modified ASTM D 4684.

4.3.3.7 Two-stroke cycle diesel engine performance. All oil grades shall demonstrate compliance with 3.3.7 when tested and rated in accordance with the standard test procedure ASTM D 5862 (DDC 6V92TA), with the exception that ratings from any five of the six cylinders shall be averaged.

4.3.3.8 Evaporation loss. All oil grades shall demonstrate compliance with 3.3.8 when tests in accordance with standard test procedure ASTM D 5800.

4.3.3.9 Sulfated ash. All oil grades shall demonstrate compliance with 3.3.9 when tested in accordance with standard test procedure ASTM D 874.

4.3.3.10 Flash point. All oil grades shall demonstrate compliance with 3.3.10 when tested in accordance with standard test procedure ASTM D 92.

4.3.3.11 Rolling valvetrain wear control. All oil grades shall demonstrate compliance with 3.3.11 when tested in accordance with the test procedure ASTM D 5966, Roller Follower Wear Test (RFWT).

4.3.3.12 Frictional characteristics and wear. All oil grades shall demonstrate compliance with 3.3.12 when tested in accordance with the selected test procedures from Allison Transmission specification C-4 Heavy-Duty Automatic Transmission Fluid Specification (TES – 228) and Caterpillar TO-4/TO-4M Transmission and Drive Train Fluid Requirements. Verification of the 40 grade lubricant shall be demonstrated when tested in accordance with test procedure a, b, and c below while verification of the multi-viscosity grades 5W-40 and 15W-40

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lubricants shall be demonstrated when tested in accordance with test procedures a, b, c, and d below.

a. Allison C-4 Graphite and Paper-Composite Friction Test.
b. Caterpillar TO-4 or TO-4M, SEQ1220.
c. Caterpillar TO-4 or TO-4M, SEQFRRET.
d. Caterpillar TO-4M, EHD Film-Forming Capability Test.

4.3.3.13 Piston ring, liner, and bearing wear control. All oil grades shall demonstrate compliance with 3.3.13 when tested in accordance with the standard test procedure ASTM D 6987 (T-10).

4.3.3.14 High temperature/high shear viscosity. All oil grades shall demonstrate compliance with 3.3.14 when the high temperature/high shear viscosity requirements in Table I when tested in accordance with standard test procedure in ASTM D 4683.

4.3.3.15 Kinematic viscosity. All oil grades shall demonstrate compliance with 3.3.15 and Table I when tested in accordance with standard test procedure in ASTM D 445.

4.3.3.16 Oxidation and nitration control. All oil grades shall demonstrate compliance with 3.3.16 when tested in accordance with standard test procedure in ASTM D 6984.

4.3.4 Interface requirements verification.

4.3.4.1 Homogeneity and miscibility. All oil grades shall demonstrate compliance with 3.4.1 when tested in accordance with standard test procedure ASTM D 6922.

4.3.4.2 Elastomer seal compatibility. All oil grades shall demonstrate compliance with 3.4.2 when tested and rated in accordance with elastomers as specified in GMN10055 DEXRON®-III, H revision, Automatic Transmission Fluid specification.

4.3.4.3 Corrosion control. All oil grades shall demonstrate compliance with 3.4.3 when subjected to high temperatures tested in accordance with standard test procedure ASTM D 6594, (135ºC (275ºF)) High Temperature Corrosion Bench Test (HTCBT).

4.3.5 Environmental requirements verification.

4.3.5.1 Low temperature cranking viscosity. All oil grades shall demonstrate compliance with 3.5.1 and Table I when tested in accordance with standard test procedure ASTM D 5293.

4.3.5.2 Low temperature pumping viscosity. All oil grades shall demonstrate compliance with 3.5.2 and Table I when tested in accordance with standard test procedure ASTM D 4684.

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4.3.5.3 Pour point. All oil grades shall demonstrate compliance with 3.5.3 and Table I when tested in accordance with standard test procedure ASTM D 97 or ASTM D 5950.

4.3.6 Product conformance verification. Production items delivered for fulfillment of military contracts shall meet the finished oil tolerances in Table XVI with respect to those values presented at the time of qualification (see 6.3).

TABLE XVI. Product conformance criteria.

Test method	Rated or measured parameter	Primary conformance criteria		
		SAE 40	SAE 15W-40	SAE 5W-40
ASTM D 92	Flash point, ºC min.	225	215	210
ASTM D 97or D 5950	Pour point, ºC, max.	-15	-25	-40
ASTM D 287	Gravity, APIº	± 1.0		
ASTM D 445	Viscosity, cSt @ 100ºC @ 40ºC	 ± 0.5 ± 15		
ASTM D 892 (see note 1)	Sequence I, foam/settling, mL, max. Sequence II, foam/settling, mL, max. Sequence III, foam/settling, mL, max.	10/0 20/0 10/0		
ASTM D 4629	Nitrogen	-15% to +20%		
ASTM D 4684	Low temperature pumping viscosity, cP, max.	---	60 000 @ -25ºC	60 000 @ -35ºC
ASTM D 5185	Elements (see note 2) Value ≥ 100 parts per million Value ≤ 100 parts per million	 -10% to +15% -15% to +20%		
ASTM D 5185	Phosphorus	±10%		
ASTM D 5293	Low temperature cranking viscosity, cP	---	7000 min @ -25ºC 7000 max @ -20ºC	6200 min @ -35ºC 6600 max @ -30ºC

NOTES: 1. Option A is not allowed.
2. Ca, Mg, Zn, Na, Cu, B, S, Mo, Cl, Si and any other with concentration of more than 50 parts per million, except C, H, and O.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the military services service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

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6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The lubricating oils covered by this specification are intended for the crankcase lubrication of reciprocating compression-ignition engines, powershift transmissions, hydraulic systems, and non-hypoid gear units of engineer/construction equipment, materials handling equipment and all types of combat/tactical ground equipment. Although this specification has been developed to meet a wide range of lubricating functions, it is brought to the attention of military Program Managers (PM) and their associated contracting personnel the requirement to ensure that equipment, whether military unique or commercially-off-the-shelf (COTS), are compatible with military standard lubricants (see AR 70-12 and MIL-HDBK-838 for additional guidance). Lubricating oils covered by this specification meet service classifications API CI-4 and include a modified DDC 6V92TA 2-cycle diesel engine test and selected transmission requirements. Oils meeting this specification have not been required to be tested in accordance with the complete Caterpillar TO-4/TO-4M or Allison C-4 requirements. Therefore, without further testing and verification, these oils cannot legitimately be marketed as meeting either the Caterpillar TO-4/TO-4M or Allison C-4 requirements. The combination of engine and powershift transmission requirements in this specification are not required of typical commercial heavy-duty diesel engine oils. These oils are intended for all conditions of operational service, as defined by appropriate lubrication orders. Recommended ambient temperature ranges for specific grade oils are shown in table XVII.

TABLE XVII. Recommended ambient temperature ranges for specific grade oils.

Ambient Temperature Range Usage																		
ºF	<-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120
ºC	<-46	-40	-34	-29	-23	-18	-12	-7	-1	4	10	16	21	27	32	38	44	49
	OE/HDO-15/40 (O-1236)																	
	OE/HDO - 5/40																	
	OE/HDO – 40																	

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6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2.1 and 2.3).
c. Qualification inspections requiring qualifying activity approval (see 3.1 and 4.1.1).
d. Conformation of finished oil criteria verification required (see 4.3.6).
e. Packaging requirements (see 5.1).
f. PIN (oil type, quantity of oil and type container) (see 6.4).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List No. 2104 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from the USA RDE Command, ATTN: AMSRD-TAR-D (MS-110), 6501 E. 11 Mile Road, Warren, MI 48397-5000.

6.4 Part or identifying number (PIN). The following PIN procedure is for Government purposes and does not constitute a requirement for the contractor (see 6.2). The PINs to be used in procurement of the lubricating oils acquired to this specification are created as follows:
Example of reference part number: M2104 R-II-2

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M 2104 X - X - X

Container size

1 = 946 mL (1-quart)
2 = 3.785L (1-Gallon)
3 = 18.925L (5-Gallon pail)
4 = 208.175L (55-Gallon drum)
5 = Bulk in gallons

SAE viscosity grade

I = 40
II = 15W-40
III = 5W-40

Base oil content

R = Contains a minimum of 25% re-refined base oil
V = Contains less than 25% re-refined base oil

Specification number

M prefix

6.5 Subject term (key word) listing.

Engine oil
Heavy duty diesel
Powershift
Tracked vehicles
Wheeled vehicles

6.6 International standardization agreement implementation. This specification implements STANAG 1135, "Interchangeability of fuels, lubricants and associated products used by the armed forces of the North Atlantic Treaty Nations". When amendment, revision, or cancellation of this specification is proposed, the preparing activity must coordinate the action with the U.S. National Point of Contact for the international standardization agreement, as identified in the ASSIST database at www.dodssp.daps.mil .

6.7 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

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Custodians:
Army - AT
Navy - SH
Air Force - 68

Preparing activity:
Army - AT

(Project 9150-1283)

Review activities:
Army - AR, MI, SM
Navy - AS, MC, SA, YD
Air Force - 03, 11, 99
DLA - GS, PS
CIV - 6FEE

Industry associations:
ASTM
EMA
API
PRI
SAE

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at www.dodssp.daps.mil.