NOT MEASUREMENT SENSITIVE

MIL-L-2104F
11 March 1992
SUPERSEDING
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1 August 1988

MILITARY 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 specification covers engine oils suitable for lubrication of reciprocating internal combustion engines of both spark-ignition and compression-ignition types and for power transmission fluid applications in equipment used in combat/tactical service (see 6.1).

1.2 Classification. The lubricating oils shall be of the following SAE viscosity grades (see 6.2):

Viscosity Grade	Military Symbol	NATO Code
SAE 10W	OE/HDO-10	O-237
SAE 30	OE/HDO-30	O-238
SAE 40	OE/HDO-40	---
SAE 15W-40	OE/HDO-15/40	O-1236

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards 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).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: USA Belvoir Research, Development, and Engineering Center, ATTN: STRBE-TSE, Fort Belvoir, VA 22060-5606 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 9150

SPECIFICATIONS

MILITARY

MIL-L-21260 - Lubricating Oil, Internal Combustion Engine, Preservative and Break-In.
MIL-L-46167 - Lubricating Oil, Internal Combustion Engine, Arctic.

STANDARDS

FEDERAL

FED-STD-313 - Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities.
FED-STD-791 - Lubricants, Liquid Fuels and Related Products; Methods of Testing.

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-290 - Packaging of Petroleum and Related Products.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents. The following other Government documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

U.S. DEPARTMENT OF LABOR (DOL)

OSHA 29 CFR 1910.1200 - Hazard Communication; Interpretation Regarding Lubricating Oils.

(Guideline CPL 2-2.38 may be obtained from OSHA Publication Office, Room S-4203, 200 Constitution Avenue, NW, Washington, DC 20210.)

U.S. BELVOIR RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER

Guide for the Qualification of Engine and Gear Lubricants

(The guide may be obtained from US Army Belvoir Research, Development, and Engineering Center, Attn: STRBE-FL, Ft. Belvoir, VA 22060-5606)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 92 - Flash and Fire Points by Cleveland Open Cup.
D 94 - Saponification Number of Petroleum Products.
D 97 - Pour Point of Petroleum Oils.
D 129 - Sulfur in Petroleum Products (General Bomb Method).
D 287 - API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method).
D 445 - Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity).
D 524 - Ramsbottom Carbon Residue of Petroleum Products.
D 664 - Neutralization Number by Potentiometric Titration.
D 808 - Chlorine in New and Used Petroleum Products (Bomb Method).
D 874 - Sulfated Ash from Lubricating Oils and Additives.
D 892 - Foaming Characteristics of Lubricating Oils.
D 1091 - Phosphorus in Lubricating Oils and Additives.
D 1317 - Chlorine in New and Used Lubricants (Sodium Alcoholate Method).
D 1500 - ASTM Color of Petroleum Products (ASTM Color Scale).
D 1552 - Sulfur in Petroleum Products (High-Temperature Method).
D 2270 - Calculating Viscosity Index from Kinematic Viscosity at 40 and 100 °C.
D 2622 - Sulfur in Petroleum Products (X-Ray Spectrographic Method).
D 2887 - Boiling Range Distribution of Petroleum Fractions by Gas Chromatography.
D 2896 - Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration.
D 3228 - Total Nitrogen in Lubricating Oils and Fuel Oils by Modified Kjeldahl Method.
D 3951 - Standard Practice for Commercial Packaging.
D 4047 - Phosphorus in Lubricating Oils and Additives by Quinoline Phosphomolybdate Method.
D 4057 - Manual Sampling of Petroleum and Petroleum Products.
D 4177 - Automatic Sampling of Petroleum and Petroleum Products.
D 4294 - Sulfur in Petroleum Products by Non-Dispersive X-Ray Fluorescence Spectrometry.
D 4624 - Measuring Apparent Viscosity by Capillary Viscometer at High Temperature and High-Shear Rates.
D 4628 - Analysis of Barium, Calcium, Magnesium, and Zinc in Unused Lubricating Oils by Atomic Absorption Spectrometry.
D 4683 - Measuring Viscosity at High Temperature and High Shear Rate by Tapered Bearing Simulator.
D 4684 - Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature.
D 4741 - Measuring Viscosity at High Temperature and High Shear Rate by Tapered-Plug Viscometer.
D 4927 - Elemental Analysis of Lubricants and Additive Components - Barium, Calcium, Phosphorus, Sulfur, and Zinc by Wavelength-Dispersive X-Ray Fluorescence Spectroscopy.
D 4951 - Determination of Additive Elements in Lubricating Oils by Inductively Couples Plasma Atomic Emission Spectrometry.
D 4998 - Evaluating Wear Characteristics of Tractor Hydraulic Fluids.
D 5119 - Evaluation of Automotive Engine Oils in the CRC L-38 Spark-Ignition Engine.

D 5185 - Determination of Additive Elements, Wear Metals and Contaminants in Used Lubricating Oils by Inductively-Coupled Plasma Atomic Emission Spectrometry.

ASTM Special Publication (STP) 315H

Engine Test Sequence IIIE
Caterpillar 1K Test Method
DDC 6V92TA Test Procedure

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

ALLISON TRANSMISSION DIVISION (ATD)

C-4 Fluid Specification.

(Application for copies should be addressed to EG&G Stationary Testing, Attn: ATF/Specialty Lab (C-4), 5904 Bandera Road, San Antonio, TX 78283-1993.)

CATERPILLAR INC., ENGINE DIVISION

Caterpillar TO-4, Fluid Requirements, VC 70 and Friction Material Compatibility.

MACK TRUCK INCORPORATED

T-7 Fluid Specification

(Application for copies should be addressed to Mack Truck Inc., 1999 Pennsylvania Ave, Hagerstown, MD 21740.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J300 - Engine Oil Viscosity Classification.
SAE J183 - Engine Oil Performance and Engine Service Classification (Other than "Energy Conserving").

(Application for copies should be addressed to SAE, 400 Commonwealth Drive, Warrendale, PA 15096.)

DEUTCHES INSTITUT FUR NORMUNG (DIN)

DIN 51581 - Determination of Evaporation Loss of Lubricating Oils.

(Application for copies should be addressed to Deutches Institut fur Normung e.V., Burggratenstr 4-10, D-100 Berlin 30, Germany T 26011.)

(Non-Government standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 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. Qualification will be granted to any manufacturer (original or reblender) of lubricating oils provided a "Manufacturing Facility Survey" (MFS) has been accepted by the qualifying activity (see 6.4) as described in the "Guide for Qualification of Engine and Gear Lubricants". Each manufacturing facility intended for the manufacture of products under this specification shall have a MFS. This is a one time requirement provided there is no change in facilities, blending method or equipment. Companies requesting rebrand approvals do not need an MFS to be qualified. Engine lubricating oils furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.4.1 and 6.4). The qualifying activity (see 6.4) may waive complete qualification testing or may require only partial qualification testing of grade SAE 40 oil if the contractor states in a written affidavit that the product has been formulated with base stocks, refining treatment, and additives the same as those used in the formulation of grade SAE 30 oil qualified under this specification.

3.1.1 Qualification period. Each SAE viscosity grade of oil which satisfies all the requirements of this specification shall be qualified for a period not exceeding four years from the date of its original qualification. The qualification period for each grade SAE 40 oil qualified in accordance with 3.1 shall not exceed that of the grade SAE 30 used in the qualification procedure. When the qualification period has expired, or whenever there is a change in the base stock, in the refining treatment or in the additives used in the formulation, each product must be requalified if the contractor wishes to maintain the formulation as a qualified product and be eligible to bid on government solicitations for this material.

3.1.2 Tolerances. The engine lubricating oil supplied under contract shall have the same base stocks and additives components, at the appropriate concentrations, as when qualified. The finished oil properties shall fall within permissible tolerances assigned by the qualifying activity to the properties listed in 3.5, of the product receiving qualification. The values resulting after the application of tolerances shall not exceed the maximum nor fall below the minimum limits specified herein (see table I and 3.4.1 through 3.4.9).

TABLE I. Finished oil requirements.

Property	Grade SAE 10W	Grade SAE 30	Grade SAE 40	Grade SAE 15W-40
Kinematic viscosity, cSt, @ 100°C				
min.	5.6	9.3	12.5	12.5
max.	<7.4	<12.5	<16.3	<16.3
@ 40°C 1/	X	X	X	X
Viscosity apparent, cP @°C 2/				
min.	3500@-25	----	----	3500@-20
max.	3500@-20	----	----	3500@-15
High-temperature/high-shear viscosity, min.	X	X	X	3.7
Pumpability, 30,000 cP, max. at temperature, °C	-25	----	----	-20
Viscosity index, min.	X	80	80	X
Pour point, °C, max.	-30	-18	-15	-23
Stable pour point, °C, max. 3/	-30	----	----	-23
Flash point, °C, min.	205	220	225	215
Evaporative loss, %	X	----	----	X
Other properties 1/				
Gravity	X	X	X	X
Carbon residue	X	X	X	X
Sulfur	X	X	X	X
Sulfated ash	X	X	X	X
Total acid number	X	X	X	X
Total base number	X	X	X	X
Phosphorus	X	X	X	X
Nitrogen	X	X	X	X
Metallic components	X	X	X	X

1/ Value shall be reported ("X" indicated report).
2/ Report the measured apparent viscosity for grade SAE 10W and SAE 15 W-40 oils at the minimum and maximum temperatures.
3/ After being cooled down to its pour point, the oil shall regain its homogeneity on standing at a temperature not more than 6 °C above the pour point. However, it should not exceed the indicated limits.

3.1.3 Pour-point depressant. No changes shall be made in either the type or concentration of the pour-point depressant after qualification testing and approval unless:

a. The oil is retested for conformity to the pour-point, stable pour point, borderline pumping temperature and all viscosities (see table I).
b. The qualifying activity (see 6.4) is informed of the proposed change(s) and of the retesting.

c. The qualifying activity approves the proposed change(s) in writing.

3.1.4 Material Safety Data Sheets. When applying for qualification, the manufacturer shall submit to the qualifying activity (see 6.4) Material Safety Data Sheets prepared in accordance with FED-STD-313. When FED-STD-313 is at variance with the 29 CFR 1910.1200, the CFR shall take precedence, modify and supplement FED-STD-313.

3.2 Materials. The engine lubricating oils shall be derived from petroleum fractions, synthetically prepared compounds or a combination of the two types of products. They may be virgin, rerefined 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 specified requirements. The contractor shall certify that no carcinogenic or potentially carcinogenic constituents are present as defined under the Hazard Communication Standard (29 CFR 1910.1200). Certification of this effect shall be made available to the contracting officer or the contracting officer's designated representative.

3.2.1 Toxic products and formulations. The engine lubricating oil shall have no adverse effect on the health of personnel when used for its intended purpose. Questions pertinent to this effect shall be referred by the contracting activity to the appropriate departmental medical service who will act as an advisor to the contracting agency.

3.3 Physical and chemical requirements.

3.3.1 Requirements for finished oil. The oils shall conform to the requirements specified in table I and 3.4.1 through 3.4.9.

3.3.2 Requirements for base stock. A 180 mL production sample of each base stock component used in formulating the finished oil, accompanied by the following property data, shall be submitted annually to the qualifying activity.

Viscosity
  at 100 °C, centistokes
  at 40 °C, centistokes
Viscosity index
Gravity, °API @ 60 °F
Pour point, °C
Carbon residue, mass%
Sulfated ash, mass%
Total acid number

Elemental content, mass %
Nitrogen, mass %
Chlorine, mass %
Sulfur, mass %
Color
Boiling point distribution, °C
  @ 1%, 5%, 10%, 50%, & 90% points
Saponification number
Flash point

3.4 Performance requirements. The oils shall conform to the respective requirements specified in 3.4.1 through 3.4.9.

3.4.1 Foaming. All SAE grades of oil shall demonstrate the following foaming characteristics when tested in accordance with 4.5, table II (ASTM D 892).

a. Initial test at 24 ±0.5 °C. Not more than 25 mL of foam shall remain immediately following the end of the 5-minute blowing period. No foam shall remain at the end of the 10-minute settling period.

b. Intermediate test at 93.5 ±0.5 °C. Not more than 150 mL of foam shall remain immediately following the end of the 5-minute blowing period. No foam shall remain at the end of the 10-minute settling period.
c. Final test at 24 ±0.5 °C. Not more than 25 mL of foam shall remain immediately following the end of the 5-minute blowing period. No foam shall remain at the end of the 10-minute settling period.

3.4.2 Stability and compatibility.

3.4.2.1 Stability. The oils shall show no evidence of separation or color change when they are tested in accordance with 4.5, table II (FED-STD-791, method 3470). A 180 mL sample of the finished lubricant to be qualified and used for this test shall be provided to the qualifying activity (see 6.4) at the time of qualification.

3.4.2.2 Compatibility. The oils shall be compatible with oils previously qualified under MIL-L-2104, MIL-L-21260, and MIL-L-46167. The oils shall show no evidence of separation when they are tested against selected reference oils in accordance with 4.5, table II (FED-STD-791, method 3470).

3.4.3 Oxidation and wear protection characteristics. The oils shall protect internal loaded engine components against excessive wear. Satisfactory performance in this respect shall be demonstrated when the oils are tested according to multiple test criteria and rated in accordance with 4.5, table II (Engine Test Sequence IIIE) and exhibit test results (single or average) meeting the following criteria:

Average rating @ 64 hrs.	
Viscosity increase, % max	750
Oil ring land deposits, min	1.5
Piston skirt varnish, min	8.7
Sludge, min	9.0
Stuck rings, max	None
Stuck lifter, max	None
Scuffing and wear at 64 hrs.	
Cam or lifter scuffing	None
Cam plus lifter wear, μm	
Average (max.)	64
Maximum	145

3.4.4 Bearing corrosion and shear stability.

3.4.4.1 Bearing corrosion. The oils shall be non-corrosive to alloy bearings. Satisfactory performance in this respect shall be demonstrated when the oils are tested in accordance with 4.5, table II (ASTM D 5119) and exhibit test results meeting the following criteria:

Bearing weight loss, milligrams (max.)	50
Piston skirt varnish rating, min	9.0

3.4.4.2 Shear stability. Grade SAE 15W-40 oil shall demonstrate shear stability by remaining within the respective viscosity range at 100 °C when tested in accordance with 4.5.2.

3.4.5 Ring-sticking, wear, and accumulation of deposits. The oils shall prevent the sticking of piston rings and port clogging, and shall minimize the wear of

cylinders, rings and loaded engine components such as cam shaft lobes, cam followers, valve rocker arms, rocker arm shafts, and the oil pump and fuel injection pump drive gears.

3.4.5.1 Four-stroke cycle diesel engine. Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 4.5, table II (Caterpillar 1K) and exhibit test results meeting the following criteria: (Only one test is required. However, the test limits are adjusted according to the number of tests submitted and equivalency to original limits.)

	1 Test	2 Tests	3 Tests
Top groove filling, % max.	24	27	29
WDK, demerits, max.	332	347	353
Top land heavy carbon, %, max.	4	5	5
Oil consumption, g/Kw-hr., max	0.5	0.5	0.5
Scuffing and ring sticking	None	None	None

3.4.5.2 Two-stroke cycle diesel engine. Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 4.5, table II (DDC 6V92TA) and exhibit test results meeting the following criteria: (Only one test is required. However, if more than one test is run, the test limits are adjusted according to the number of tests run, maximum of three tests, and equivalency to original limits.)

	1 Test	2 Tests	3 Tests
Piston, average % area			
Skirts tin removed	Report	Report	Report
Wrist pin slipper bushing copper exposed	Report	Report	Report
Average ring face distress, demerits (max.)			
Fire ring	0.33	0.34	0.36
Nos. 2 and 3 compression rings	0.28	0.29	0.30
Broken rings	None	None	None
Cylinder liner area			
Average liner distress, % area (max.)	60.0	63.5	65.0
Port plugging, % area, (max.)			
Average	2	2	2
Single cylinder	5	5	5

3.4.6 Friction retention characteristics and wear. The oils shall maintain a stable coefficient of friction and shall minimize distress and wear during use in power shift transmissions and other cooled friction compartments or hydraulic systems such as steering and disconnect clutches.

3.4.6.1 Slip time and torque. Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 4.5, table II (ATD C-4) and exhibit test results meeting the following nominal criteria as adjusted to accommodate slight changes in individual friction plate batches:

	Graphite	Paper	
	5500	0 - 5000	5000 - 10,000
Slip time at cycles, s (max.)	0.74	0.67	0.56
Mid-point coefficient of friction at cycles (min.)	0.097	0.066	0.086

3.4.6.2 Friction coefficient and wear. Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 4.5, table II (Caterpillar VC 70) and a test on each sequence exhibit results meeting the following nominal criteria as adjusted to accommodate slight changes in individual fluoroelastomer batches and performance of the reference oil:

	Sequence 1220	Sequence FRRET
Average dynamic coefficient, %	90-140	---
@ 3000 cycles	---	85-130
@ 8000 cylces	---	90-125
@ 15000 cycles	---	90-125
@ 25000 cycles	---	95-125
Average static coefficient, %	91-127	95-120
Disc wear, mm (max.)	0.04	---
Energy limit, %	25	---

3.4.6.3 Gear wear. Satisfactory performance shall be demonstrated when the oils are tested in accordance with 4.5, table II (ASTM D 4998), and exhibit test results, from three separate gear sets and three separate runs, meeting the following criteria:

Weight loss, mg	
Average of three runs, max.	100
Maximum single run	150

3.4.7 Seal compatibility. The oils shall minimize deterioration of seal and friction materials.

3.4.7.1 Effect on seals. Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 4.5, table II (ATD C-4) and exhibits test results meeting the following nominal criteria as adjusted to accommodate slight changes in individual elastomer batches:

a. Total immersion (Buna N)	
Volume changes, %	0 to +5
Hardness changes, points	0 ± 5
b. Dip cycle (Polyacrylate)	
Volume changes, %	0 to +10
Hardness change, points	0 to +5
c. Tip cycle (Silicone)	
Volume changes, %	0 to +5
Hardness changes, points	0 to -10
d. Total Immersion (fluoroelastomer)	
Volume changes, %	0 to +4
Hardness change, points	-4 to +4

3.4.8. Friction Material Compatibility. Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 4.5, table II (Cat Fluoroelastomer) and exhibit test results meeting the following nominal criteria as adjusted to accommodate slight changes in individual elastomer batches:

Loss of elongation, %, max. - Not to exceed the reference oil + 10 %; provided the candidate elongation is no greater than the control set.

3.4.9 Dispersancy characteristics. Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 4.5, table II (Mack T-7) and exhibits test results meeting the following criteria:

Average rate of viscosity increase during last 50 h, 0.040 cSt @ 100 C/h, max

3.5 Other requirements and tolerances for quality conformance testing. The following physical and chemical properties shall be tested in accordance with the appropriate methods listed in 4.5 to insure that purchased products are of the same compositions as the respective qualification samples and to identify the products. No specific values or limits are assigned in qualification testing, except as otherwise specified in table I and 3.4.1 through 3.4.9, but test results shall be reported for all properties listed. The qualifying activity (see 6.4) shall establish specific values and tolerances for subsequent quality conformance testing of the finished lubricant for these properties (see 6.3 and 6.4):

Viscosity, apparent and kinematic	Carbon residue
High-temperature/high-shear	Foaming
Viscosity index	Phosphorus
Pour point	Sulfur
Pumpability	Sulfated ash
Flash point	Metallic components
Gravity, °API @ 60 °F	Nitrogen

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure contractor and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material. The contractor is responsible to manufacture a product that complies with the requirements specified herein, and to be within the specific values/tolerances (see 3.1.2. and 6.3) assigned by the qualifying activity at the time of qualification.

4.2 Sampling.

4.2.1 Sampling for the examination of filled containers. Take a random sample of filled containers from each lot in accordance with MIL-STD-105, at inspection level II.

4.2.2 Sampling for tests. Take samples from bulk or packaged lots (see 6.5) for tests in accordance with ASTM D 4057 or D 4177, as appropriate.

4.3 Inspection. Perform inspection in accordance with FED-STD-791, method 9601. In addition to the inspection, the manufacturer shall provide certification of non-carcinogenicity as specified in 3.2 (i.e., materials are not considered carcinogenic or potentially carcinogenic) and shall provide Material Safety Data Sheets.

4.3.1 Examination of filled containers. Examine samples taken in accordance with 4.2.1 for compliance with MIL-STD-290 with regard to fill, closure, sealing, and leakage. Reject any container having one or more defects or under the required fill. If the number of defective or under filled containers exceeds the acceptance number for the appropriate sampling plan of MIL-STD-105, reject the lot (see 6.5) represented by the sample.

4.4 Classification of tests.

a. Qualification tests (see 4.4.1).
b. Quality conformance test (see 4.4.2).

4.4.1 Qualification tests. Qualification tests consist of tests for all of the requirements specified in section 3 and may be conducted in any plant or laboratory approved by the qualifying activity (see 6.4). Qualification tests shall be performed on each SAE viscosity grade except as specified in 4.4.1.1 through 4.4.1.6.

4.4.1.1 Stable pour-point. The stable pour-point test (FED-STD-791, method 203) shall be required only on grade SAE 10W and SAE 15W-40 oils.

4.4.1.2 Shear stability. Shear stability shall be required for only grade SAE 15W-40 oil.

4.4.1.3 Modified formulations. SAE 40 grade oils based on the formulation of a SAE grade 30 oil qualified under this specification may be qualified in accordance with 3.1.

4.4.1.4 Oxidation and wear protection. The qualifying activity (see 6.4), may waive Sequence IIIE testing of the candidate oil when acceptable supporting Sequence IIIE wear evaluations for formulations similar in additive technology to the candidate lubricant are presented to substantiate the wear protection characteristics.

4.4.1.5 Ring-sticking, wear, and accumulation of deposits. The two-stroke cycle diesel engine test (DDC 6V92TA) shall be required only for grade SAE 30, SAE 40, and SAE 15W-40 oils. Requirements for this test may be waived for oils formulated with a specific additive technology (detergent, dispersant, inhibitor system) provided satisfactory performance is demonstrated for the technology used in conjunction with various base stock-viscosity improver additive combinations. Satisfactory performance shall be demonstrated by conducting the following acceptable two-stroke cycle diesel engine tests:

a. One test each of three grade SAE 15W-40 oils formulated using the additive system, a viscosity index improver additive but with base stocks of different manufacture.

b. One test each of a grade SAE 15W-40 oil formulated using the additive system, a base stock employed in 4.4.1.5.a for each viscosity index improver additive to be used in conjunction with the additive system.

4.4.1.6 Friction retention characteristics and wear. Test for friction retention characteristics and wear shall be required only for grade SAE 10W, SAE 30, and SAE 15W-40 oils. The qualifying activity (see 6.4) may waive testing for those requirements when acceptable supporting friction retention characteristics and wear evaluations for formulations similar in additive technology to the candidate lubricant are presented to substantiate these performance requirements.

4.4.2 Quality conformance tests. Tests for quality conformance of individual lots (see 6.5) shall consist of tests for the following requirements using the test method listed in table II. The results obtained when using the test methods in table II must fall within the tolerances/specific values (see 3.1.2 and 6.3) assigned at time of qualification:

Viscosities	Foaming
High-temperature/high-shear	Phosphorus
Viscosity index	Sulfur
Pour point	Nitrogen
Pumpability	TAN
Flash point	TBN
Gravity, °API	Sulfated ash
Carbon residue	Metallic components

4.5 Test methods. Perform tests in accordance with table II and with 4.5.1 through 4.5.2, as applicable.

TABLE II. Test methods.

TEST	TEST METHOD			
	FED-STD-791	ASTM	SAE	DIN
Viscosity, kinematic		D 445		
Viscosity, apparent 1/			J300	
High temperature/high shear		D 4683, D 4624, D 4741		
Viscosity index		D 2270		
Pour point		D 97		
Stable pour point	203			
Pumpability		D 4684		
Flash point		D 92		
Evaporative loss 2/		D 2887		51581
Gravity, API		D 287		
Carbon residue		D 524		
Color		D 1500		
Acid number		D 664		
Base number		D 2896		
Phosphorus		D 1091, D 4047, D 4927, D 4951, D 5185		
Chlorine 3/		D 808, D 1317		
Sulfur 4/		D 129, D 1552, D 2622, D 4294, D 4927, D 4951, D 5185		
Nitrogen		D 3228		
Saponification number		D 94		
Sulfated residue		D 874		
Boiling range distribution		D 2887		
Metallic components		D 4628, D 4927, D 4951, D 5185		
Foaming		D 892		
Stability & compatibility	3470 5/			
Oxidation & wear characteristics		Sequence IIIE		
Dispersancy Characteristics		Mack T-7		
Bearing corrosion & shear stability		D 5119		
Ring-sticking, wear, & accumulations of deposits				
Four-stroke cycle diesel engine		Caterpillar 1K		
Two-stroke cycle diesel engine		DDC 6V92TA		
Friction retention characteristics & wear:				
Slip time & wear		ATD C-4 6/		
Friction coefficient & wear		Caterpillar VC 70 7/		
Friction material compatibility		Cat Fluoro-elastomer 8/		
Seal compatibility		ATD C-4 9/		
Gear wear		D 4998		

1/ Obtain the apparent viscosity using the method of test set forth by SAE J300, appendix A.
2/ ASTM D 2887 is the preferred method.
3/ ASTM D 808 is the preferred method.
4/ ASTM D 1552 is the preferred method. ASTM D 4294 is only for use with base stock.
5/ See 4.5.1 for clarifying instructions.
6/ Use procedure described in item 8 and 9 of C-4 specification.
7/ Use SEQ1220 and SEQFRRET of the VC 70 tests described in the Caterpillar TO-4 specification.
8/ Use the Caterpillar Fluoroelastomer Test described in section 2 of the TO-4 specification.
9/ Use procedure in item 5 of C-4 specification.

4.5.1 Stability and compatibility. Determine the stability and compatibility of the oils by the procedures for "Homogeneity and Miscibility" given in FED-STD-791, method 3470, as explained in 4.5.1.1 and 4.5.1.2. The procedures in 4.5.1.1 and 4.5.1.2 should be performed at the same time.

4.5.1.1 Stability. Determine the stability by subjecting an unmixed sample of oil to the prescribed cycle of temperature changes, then examine the sample for conformance to the requirements of 3.4.2.1. Record the test results on a copy of the "Homogeneity and Miscibility Test" form in the column marked "None".

4.5.1.2 Compatibility. Determine the compatibility of the oil with other oils previously qualified under MIL-L-2104, MIL-L-21260, and MIL-L-46167 by subjecting separate mixtures of the oil with selected reference oils designated by the qualifying activity (see 6.4) to the prescribed cycle of temperature changes, then examine the mixtures for conformance to the requirements of 3.4.2.2. Record the test results on the same copy of the "Homogeneity and Miscibility test" form (see 4.5.1.1) in the appropriate columns marked "1-30", "2-30", etc. Reference oils for conducting compatibility tests are to be obtained from the SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

4.5.2 Shear stability. Determine the shear stability of grade SAE 15W-40 oil by the following method:

a. Weigh 25 grams of used oil, obtained at 10 hours of testing in accordance with ASTM D 5119, into a 50 mL three-necked round bottom flask equipped with a thermometer, gas inlet tube, stirrer, and distillation side arm.
b. Heat the sample at 120 ±5 °C in a vacuum of 100 mm of mercury with a nitrogen sparge for one hour.
c. Filter the stripped sample through a 0.5 micron filter pad.
d. Determine the kinematic viscosity at 100 °C of the filtered sample using ASTM D 445. Check the resulting viscosity for conformance to the requirements of 3.4.4.2.

4.6 Inspection of packaging.

4.6.1 Quality conformance inspection of pack.

4.6.1.1 Unit of product. For the purpose of inspection, a complete pack prepared for shipment shall be considered a unit of product.

4.6.1.2 Inspection lot. The inspection lot shall be as defined in 6.5 packed for shipment.

4.6.1.3 Sampling. Samples for examination of packaging shall be selected at random from each inspection lot (see 6.5) in accordance with procedures prescribed in MIL-STD-105.

4.6.1.4 Examination. Samples selected in accordance with 4.6.1.3 shall be examined for the defects listed below.

101. Unit container not as specified (see 5.1).
102. Intermediate container when required, not as specified (see 5.1).
103. Quantity and arrangement of unit containers packed in intermediate containers not as specified (see 5.1).
104. Exterior container not as specified (see 5.1).
105. Quantity and arrangement of intermediate containers packed in exterior containers not as specified (see 5.1).
106. Marking not as specified (see 5.1).

5. PACKAGING

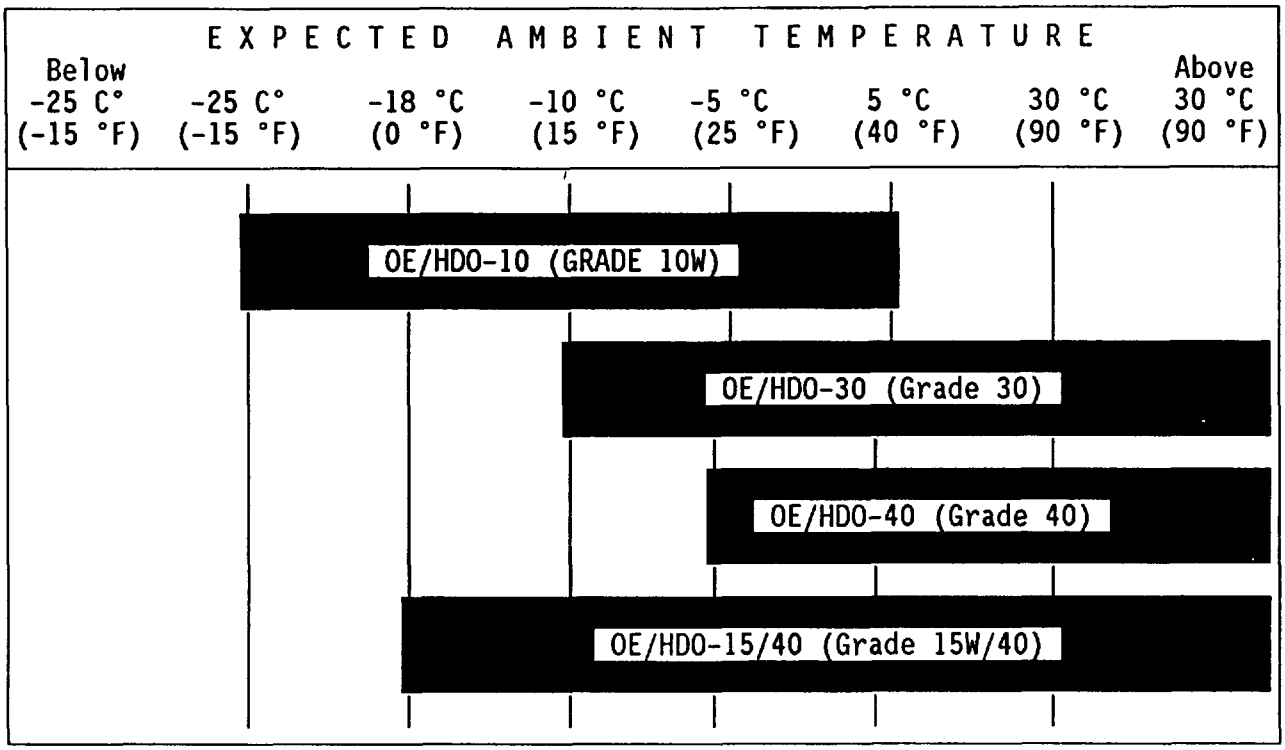
5.1 Unit, intermediate, and exterior packing and marking. Unit, intermediate, and exterior packing and marking of lubricating oil shall be in accordance with MIL-STD-290 (level B or C) or in accordance with ASTM D 3951 for commercial, as specified (see 6.2). Type and size of unit container shall be as specified (see 6.2 and 6.8).

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 grade SAE 10W oil is not to be used in high-output, two-cycle compression-ignition engines. The lubricating oils, except as mentioned above, covered by this specification are intended for the crankcase lubrication of reciprocating spark-ignition and compression-ignition engines used in all types of military combat/tactical ground equipment and for the crankcase lubrication of high-speed, high-output, supercharged compression-ignition engines used in all ground equipment. The oils are also intended for the same application in power transmissions, hydraulic systems, and non-hypoid gear units of engineer/construction equipment, materials handling equipment and combat/tactical ground equipment. The lubricating oils covered by this specification meet service classification CD-II of SAE J183 and are intended for all conditions of operational service, as defined by appropriate lubrication orders, when temperatures are above -25 °C. Recommended ambient temperature ranges for specific SAE grade oils are shown by table III.

TABLE III. Recommended ambient temperature range.



Note: For power transmission, hydraulic system and non-hypoid gear box applications, lubricants may be used at all temperature above the low temperature recommendation shown in table III.

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 2.1.1 and 2.2).
c. SAE grade of oil required (see 1.2).
d. Certification of non-carcinogenicity (see 3.2).
e. Quantity of oil required.
f. Type and size of containers required (see 5.1).
g. Level of packing required (see 5.1).

6.3 Other requirements and tolerances for quality conformance testing. Definite numerical values are not specified for certain of the physical and chemical properties listed in 3.5, and for which corresponding test methods are given in section 4. Values of some properties vary from one commercial brand of oil to another for the same SAE grade. These values are influenced by the source of the base stock, the identities and quantities of additives, etc. Definite numerical values are not always functionally important except, for some properties, within specified maximum and minimum limits. It is not possible (or necessary) to assign restrictive values in the specification before the testing of qualification samples. During qualification, test values will be determined which are characteristics of a particular product and which can serve thereafter to identify the product. Using the results of qualification testing, the qualifying activity (see 6.4) can set values, including permissible tolerances, for future quality conformance testing.

6.4 Qualification. Lubricating oils are submitted for qualification with the intent to manufacture and supply the products to the Federal Government. With respect to products requiring qualification, awards will be made only for products which are, at the time set for opening of bids, qualified for inclusion in the applicable qualified products list whether or not such products have actually been so listed by that date. The attention of the contractors is called to this requirement, 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 orders for the products covered by this specification. The activity responsible for the qualified products list is the U. S. Army Belvoir Research, Development, and Engineering Center, ATTN: STRBE-FL, Fort Belvoir, VA 22060-5606, and information pertaining to qualification of products may be obtained from that activity.

6.5 Definitions.

6.5.1 Bulk lot. An indefinite quantity of a homogeneous mixture of one SAE grade of oil offered for acceptance in a single, isolated container; or manufactured in a single plant run (not exceeding 24 hours), through the same processing equipment, with no change in the ingredient materials.

6.5.2 Packaged lot. An indefinite number of 55 gallon drums or smaller unit containers of identical size and type, offered for acceptance, and filled with a homogeneous mixture of one SAE grade of oil from a single, isolated container; or filled with a homogeneous mixture of one SAE grade of oil, manufactured in a single plant run (not exceeding 24 hours), through the same processing equipment, with no change in the ingredient materials.

6.6 Disposability. One or more of the following methods shall be used to accomplish disposal of new MIL-L-2104 products: reuse, recycling, or blended with burner fuel. The disposability will be as allowed under local and federal environmental regulations.

6.7 Material Safety Data Sheets. Contracting officers will identify those activities requiring copies of completed Material Safety Data Sheets prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313, appendix B.

6.8 Military part number. Engine oils furnished under this specification shall be identified by a military part number consisting of; a "M" prefix and specification number, a single digit "Dash Number" taken from table IV which indicates the container size, and the viscosity SAE grade of the lubricant. The military part number for SAE grade 10W lubricant to be furnished in 1-pint containers is shown in the following example:

M2104-1-10W

"M" prefix and specification number

Dash number from table IV indicating the container size.

SAE viscosity grade

TABLE IV. Dash number designations for use in military part numbers.

Dash number	Container size
1	1-Pint
2	1-Quart
3	1-Gallon
4	5-Gallon pail
5	55-Gallon drum
6	Bulk

6.9 Subject term (key word) listing.

Combat service
Heavy duty diesel
Internal combustion engine
Lubricating oil
Tactical service

6.10 International Standardization Agreement. Certain provisions of this specification are subject of international standardization agreement STANAGs 2845 and 1135. When amendment, revision or cancellation of this specification is proposed which would affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels, including departmental standardization office, if required.

6.11 Changes from previous issue. Asterisks (or vertical lines) are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

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

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

User activities:
Army - AT
Navy - OS
Air Force - 99

Preparing activity:
Army - ME

Project 9150-1090

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-L-2104F	2. DOCUMENT DATE (YYMMDD) 920311

3. DOCUMENT TITLE
Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (if applicable) (2) AUTOVON	7. DATE SUBMITTED

8. PREPARING ACTIVITY

a. NAME Betty Taylor	b. TELEPHONE (Include Area Code) (1) Commercial (703) 664-1866	(2) AUTOVON 354-1866
c. ADDRESS (Include Zip Code US Army Belvoir RDE Center ATTN: STRBE-TSE Fort Belvoir, VA 22060-5606	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	