SAE International

SURFACE VEHICLE STANDARD

SAE J2359 FEB2013

Issued 1998-11
Cancelled 2013-02

Superseding J2359 NOV1998

Lubricating Oil, Internal Combustion Engine, Military Combat/Tactical Service

RATIONALE

SAE J2359 was originally issued November 1998 as a means to leverage non-government standard organizations such as SAE to better align military needs with commercial manufacturers and suppliers. Unfortunately, because of the relatively rapid changes in the API heavy-duty diesel engine oil service categories, mainly driven by emission requirements, the commercial and military requirements have become increasingly out of sync. This inconsistency has led to very little interest among industry and support of these documents. Furthermore, because of military uniqueness of the requirements, the administration of these documents is most efficiently handled within the Department of Defense, under current procedures for military performance requirements/specifications.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

1. ***Scope***—This SAE Standard covers engine military oils suitable for lubrication of reciprocating internal combustion engines of both spark-ignition and compression-ignition types, and for power transmission fluid applications in combat/tactical service equipment (see 7.1). This document is equivalent to MIL-PRF-2104G when all requirements are met.

1.1 Classification—The lubricating oils shall be of the following viscosity grades shown in Table 1 (see 7.1):

TABLE 1—VISCOSITY GRADES

SAE Viscosity Grade	Military Symbol	NATO Code
10W	OE/HDO-10	0-237
30	OE/HDO-30	0-238
40	OE/HDO-40	—
15W-40	OE/HDO-15/40	0-1236

2. ***References***

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

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

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

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

2.1.2 ALLISON TRANSMISSION DIVISION (ATD) PUBLICATION—Available from EG&G Stationary Testing, Attn: ATF/Specialty Lab (C-4), 5904 Bandera Road, San Antonio, TX 78283-1993.

TES-228—C-4 Fluid Specification

2.1.3 ANSI PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI Z1.4—Sampling Procedures and Tables for Inspections by Attributes

2.1.4 AMERICAN SOCIETY FOR QUALITY CONTROL (ASQC) PUBLICATION—Available from American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53201-4606.

ASQC Z1.4—Sampling Procedures and Tables for Inspections by Attributes

2.1.5 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 92—Flash and Fire Points by Cleveland Open Cup
ASTM D 94—Saponification Number of Petroleum Products
ASTM D 97—Pour Point of Petroleum Oils
ASTM D 129—Sulfur in Petroleum Products (General Bomb Method)
ASTM D 130—Detection of Copper Corrosion from Petroleum Products, by the Copper Strip Tarnish Test
ASTM D 287—API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)
ASTM D 445—Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)
ASTM D 524—Ramsbottom Carbon Residue of Petroleum Products
ASTM D 664—Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration
ASTM D 808—Chlorine in New and Used Petroleum Products (Bomb Method)
ASTM D 874—Sulfated Ash from Lubricating Oils and Additives
ASTM D 892—Foaming Characteristics of Lubricating Oils
ASTM D 1091—Phosphorus in Lubricating Oils and Additives
ASTM D 1317—Chlorine in New and Used Lubricants (Sodium Alcoholate Method)
ASTM D 1500—ASTM Color of Petroleum Products (ASTM Color Scale)
ASTM D 1552—Sulfur in Petroleum Products (High-Temperature Method)
ASTM D 2270—Calculating Viscosity Index from Kinematic Viscosity at 40 and 100 C
ASTM D 2622—Sulfur in Petroleum Products (X-Ray Spectrographic Method)
ASTM D 2887—Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
ASTM D 2896—Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration
ASTM D 3228—Total Nitrogen in Lubricating Oils and Fuel Oils by Modified Kjeldahl Method
ASTM D 3951—Standard Practice for Commercial Packaging
ASTM D 4047—Phosphorus in Lubricating Oils and Additives by Quinoline Phosphomolybdate Method
ASTM D 4057—Manual Sampling of Petroleum and Petroleum Products
ASTM D 4177—Automatic Sampling of Petroleum and Petroleum Products
ASTM D 4294—Sulfur in Petroleum Products by Non-Dispersive X-Ray Fluorescence Spectrometry
ASTM D 4485—Standard Specification for Performance of Engine Oils
ASTM D 4624—Measuring Apparent Viscosity by Capillary Viscometer at High Temperature and High-Shear Rates
ASTM D 4628—Analysis of Barium, Calcium, Magnesium, and Zinc in Unused Lubricating Oils by Atomic Absorption Spectrometry
ASTM D 4629—Trace Nitrogen in Liquid Petroleum Hydrocarbons by Syringe/Inlet Oxidative Combustion and Chemiluminescence Detection
ASTM D 4683—Measuring Viscosity at High Temperature and High Shear Rate by Tapered Bearing Simulator
ASTM D 4684—Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature
ASTM D 4739—Base Number Determination by Potentiometric Titration
ASTM D 4741—Measuring Viscosity at High Temperature and High Shear Rate by Tapered-Plug Viscometer
ASTM D 4927—Elemental Analysis of Lubricants and Additive Components - Barium, Calcium, Phosphorus, Sulfur, and Zinc by Wavelength-Dispersive X-Ray Fluorescence Spectroscopy

ASTM D 4951—Determination of Additive Elements in Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry
ASTM D 4998—Evaluating Wear Characteristics of Tractor Hydraulic Fluids
ASTM D 5119—Evaluation of Automotive Engine Oils in the CRC L-38 Spark-Ignition Engine
ASTM D 5185—Determination of Additive Elements, Wear Metals and Contaminants in Used Lubricating Oils by Inductively-Coupled Plasma Atomic Emission Spectrometry
ASTM D 5480—Motor Oil Volatility by Gas Chromatography
ASTM D 5533—Evaluation of Automotive Engine Oils in the Sequence IIIE, Spark-ignition Engine
ASTM D 5800—Evaporation Loss of Lubricating Oil at the NOACK Method
ASTM D 5862—DDC 6V92TA Test Procedure
ASTM D 5950—Pour Point, Automatic
ASTM D 5966—Roller Follower Wear Test
ASTM D 5967—Evaluation of Diesel Engine Oils in the Mack T-8 Diesel Engine
ASTM D 5968—Corrosion Bench Test
ASTM Special Publication (STP) 315H includes:
Caterpillar 1M-PC Test Procedure—ASTM Research Report D02-1320
Caterpillar 1N Test Procedures—ASTM Research Report D02-1321
HEUI Engine Oil Aeration Test

2.1.6 CATERPILLAR INC., ENGINE DIVISION (CAT.) PUBLICATION—Available from Caterpillar, Component Development, Technical Center - C, P.O. Box 1875, Peoria, IL 61656-1875.

Caterpillar TO-4, Fluid Requirements, VC 70.

2.1.7 GOVERNMENT PUBLICATIONS

2.1.7.1 *Military and Federal Publications*—Available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-PRF-2104—Lubricating Oil, Internal Combustion Engine, Military Combat/Tactical Service
MIL-L-21260—Lubricating Oil, Internal Combustion Engine, Preservative and Break-In
MIL-L-46167—Lubricating Oil, Internal Combustion Engine, Arctic
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
NATO STANAG 2835
NATO STANAG 2845

2.1.7.2 *U.S. Department of Labor (DOL) (OSHA)*—Available from OSHA Publication Office, Room S-4203, 200 Constitution Avenue, NW, Washington, DC 20210.

OSHA 29 CFR 1910.1200—Hazard Communication; Interpretation Regarding Lubricating Oils

2.1.7.3 *US Mobility Technology Center*—Available from US Army Tank Automotive and Armament Command, Attn: AMSTRA-TR-0/210, Warren, MI 48397-5000.

Guide for the Qualification of Engine and Gear Lubricants

3. Definitions

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

3.2 Packaged Lot—An indefinite number of 208.175 L (55-gal drum) or smaller unit containers of identical size and type, offered for acceptance, and filled with a homogeneous mixture of one grade of oil from a single, isolated container; or filled with a homogeneous mixture of one grade of oil manufactured in a single plant run (not exceeding 24 h), through the same processing equipment, with no change in the ingredient materials.

4. Requirements

4.1 Qualification

4.1.1 QUALIFICATION—GENERAL—Engine lubricating oils furnished under this specification shall be products that are qualified by the qualifying activity (see 7.4) for listing on the applicable qualified products list at the time of contract award (see 5.1.1 and 7.4). Qualification will be granted by the qualifying activity (see 7.4) to any manufacturer (original or reblender) of lubricating oils provided a "Manufacturing Facility Survey" (MFS) has been accepted 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. The qualifying activity (see 7.4) may waive complete qualification testing or may require only partial qualification testing of SAE 40 grade 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 SAE 30 grade oil qualified under this specification.

4.1.2 QUALIFICATION PERIOD—Each 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 SAE 40 grade oil qualified in accordance with 4.1 shall not exceed that of the SAE 30 grade 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 retested if the contractor wishes to maintain the formulation as a qualified product and be eligible to bid on government solicitations for this material.

4.1.3 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 4.5, 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 2 and 4.4.1 through 4.4.11).

4.1.4 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 2).
b. The qualifying activity (see 7.4) is informed of the proposed change(s) and of the retesting.
c. The qualifying activity approves the proposed change(s) in writing.

TABLE 2—FINISHED OIL REQUIREMENTS

Property	SAE Grade 10W	SAE Grade 30	SAE Grade 40	SAE Grade 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	2.9	3.7	3.7
Pumpability, 60 000 cP, max. @ temperature, °C	–30	—	—	–25
Viscosity index, min.	X	80	80	X
Pour point, °C, max.	–30	–18	–15	–25
Stable pour point, °C, max.(3)	–30	—	—	–25
Flash point, °C, min.	205	220	225	215
Evaporative loss, %	18	—	—	15
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
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 grades 10W and 18W-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.

4.1.5 MATERIAL SAFETY DATA SHEETS—When applying for qualification, the manufacturer shall submit to the qualifying activity (see 7.4) a sample of the product tested (see 4.4.2.1) and include Material Safety Data Sheets prepared in accordance with FED-STD-313. When FED-STD-313 is at variance with the OSHA 29 CFR 1910.1200, the CFR shall take precedence, modify, and supplement FED-STD-313.

4.2 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 stocks used shall not be considered carcinogenic or potentially carcinogenic as defined under the Hazard Communication Standard 29 CFR 1910.1200.

4.3 Physical and Chemical Requirements

4.3.1 REQUIREMENTS FOR FINISHED OIL—The oils shall conform to the requirements specified in Table 2 and 4.4.1 through 4.4.10.2.

4.3.2 REQUIREMENTS FOR BASE STOCK—(Optional for non-military procurement)—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.

a. Viscosity
   at 100 °C, centistokes (mm^2/s)
   at 40 °C, centistokes (mm^2/s)
b. Viscosity index
c. Gravity, API @ 60 °F
d. Pour point, °C
e. Carbon residue, mass %
f. Sulfated ash, mass %
g. Total acid number
h. Elemental content, mass %
i. Nitrogen, mass %
j. Chlorine, mass %
k. Sulfur, mass %
l. Color
m. Boiling point distribution, °C
   @ 1%, 5%, 10%, 50%, & 90% points
n. Saponification number
o. Flash point

4.4 Performance Requirements—The oils shall conform to the respective requirements specified in 4.4.1 through 4.4.11.

4.4.1 FOAMING—All grades of oil shall demonstrate the following foaming characteristics when tested in accordance with 5.1.2, Table 3 (ASTM D 892).

a. Initial test at 24 °C ± 0.5 °C. Not more than 10 mL of foam shall remain immediately following the end of the 5-min blowing period. No foam shall remain at the end of the 10-min settling period.
b. Intermediate test at 93.5 °C ± 0.5 °C. Not more than 20 mL of foam shall remain immediately following the end of the 5-min blowing period. No foam shall remain at the end of the 10-min settling period.
c. Final test at 24 °C ± 0.5 °C. Not more than 10 mL of foam shall remain immediately following the end of the 5-min blowing period. No foam shall remain at the end of the 10-min settling period.
d. Test at 150 °C ± 0.5 °C. Not more than 50 mL of foam shall remain immediately following the end of the blowing period. No foam (0) shall remain at the end of the 1-min settling period. Option A is not allowed (CG-4 requirement).

4.4.2 STABILITY AND COMPATIBILITY

4.4.2.1 *Stability*—The oils shall show no evidence of separation or color change when they are tested in accordance with 5.1.2, Table 3 (FED-STD-791, Method 3470). A 1 L sample of the finished lubricant to be qualified and used for this test shall be provided to the qualifying activity (see 7.4) at the time of qualification.

4.4.2.2 *Compatibility*—The oils shall be compatible with oils previously qualified under MIL-PRF-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 5.1.2, Table 3 (FED-STD-791, Method 3470).

4.4.3 OXIDATION AND WEAR PROTECTION CHARACTERISTICS—The oils shall protect internal loaded engine components against excessive wear and oxidation. Satisfactory performance in this respect shall be demonstrated when the oils are tested according to multiple test criteria and rated in accordance with 5.1.2, Table 3 (ASTM D 5533) and exhibit test results (single or average) meeting the criteria in Table 4:

4.4.4 ROLLER FOLLOWER WEAR TEST ASTM D 5966—The oils shall protect internal loaded diesel engine components against excessive wear caused by the presence of soot. Satisfactory performance in this respect shall be demonstrated when the oils are tested according to multiple test criteria and rated in accordance with 5.1.2, Table 3 (6.2 L test) and exhibit averaged test results meeting the criteria in Table 5:

4.4.5 BEARING CORROSION AND SHEAR STABILITY

4.4.5.1 *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 5.1.2, Table 3 (ASTM D 5119) and exhibit test results meeting the criteria in Table 6:

4.4.5.2 *Shear Stability*—SAE 15W-40 grade oil shall demonstrate shear stability by exhibiting a viscosity at 100 °C of 13.0 cSt minimum, on any of the samples taken, when tested in accordance with 5.1.2.2.

4.4.6 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.

TABLE 3—TEST METHODS

Test	Test Methods FED-STD-791	Test Methods ASTM	Test Methods SAE
Viscosity, Kinematic		D 445	
Viscosity, Apparent[1]			J300
High Temperature/High Shear		D 4624, D 4683[2], D 4741	
Viscosity Index		D 2270	
Pour Point		D 97[2], D 5950	
Stable Pour Point	203		
Pumpability		D 4684	
Flash Point		D 92	
Evaporative Loss		D 5480[2], D 5800	
Gravity, API		D 287	
Carbon Residue		D 524	
Color		D 1500	
Acid Number		D 664	
Base Number		D 2896, D 4739[2]	
Phosphorus		D 1091[2], D 4047, D 4927, D 4951, D 5185	
Chlorine		D 808[2], D 1317	
Sulfur		D 129, D 1552[2], D 2622, D 4294, D 4927, D 4951, D 5185	
Nitrogen		D 3228[2], D 4629	
Saponification Number		D 94	
Sulfated Residue		D 874	
Boiling Range Distribution		D 2887	
Metallic Components		D 4628, D 4927, D 4951[2], D 5185	
Foaming		D 892	
Engine Oil Aeration		HEUI	
Stability and Compatibility	3470[3]		
Oxidation and Wear Characteristics		D 5533 (III E)	
Dispersancy Characteristics		D 5967 (Mack T-8)	
Bearing Corrosion and Shear Stability		D 5119 (L-38)	
Ring-Sticking, Wear, and Deposits			
Four-Stroke Cycle Diesel Engine-LS		Caterpillar 1N	
Four-Stroke Cycle Diesel Engine-HS		Caterpillar 1M-PC	
Two-Stroke Cycle Diesel Engine		D 5862 (DDC 6V92TA)	
Friction Retention Characteristics and Wear:			
Slip Time and Wear		ATD C-4[4]	
Friction Coefficient and Wear		Caterpillar VC-70[5]	
Seal Compatibility		ATD C-4[6]	
Metal Corrosion	5308		
Copper Corrosion		D 130	
Roller Follower Wear Test		D 5966	

1. Obtain the apparent viscosity using the method of test set forth by SAE J300.
2. Denotes preferred method.
3. See 5.1.2.1 for clarifying instructions.
4. Use procedure described in item 8 and 9 of C-4 specification.
5. Use test SEQs 1220 and FRRET (VC-70) described in the Caterpillar TO-4 specification.
6. Use procedure in item 5 of C-4 specification.

TABLE 4—ASTM D 5533 LIMITS (III E)

Average Rating at 64 h	1 test	2 Tests	3 Tests
Viscosity increase, Hours to 375% avg max	67.5	65.1	64.0
Oil ring land deposits, avg. min	2.6	2.6	2.6
Piston skirt varnish, avg. min	8.7	8.7	8.7
Sludge, avg. min	9.0	9.0	9.0
Stuck rings, avg. max	None	None	None
Stuck lifter, avg max	None	None	None
Scuffing and wear at 64 h			
Cam or lifter scuffing	None	None	None
Cam plus lifter wear, µm			
Average (avg max.)	64	64	64
Maximum (Avg)	145	145	145

TABLE 5—ASTM D 5966 LIMITS (ROLLER FOLLOWER WEAR TEST)

	1 Test	2 Test	3 Test
Pin Wear, µm, avg. max.	11.4	12.4	12.7
mils, avg. max	0.45	0.49	0.50

TABLE 6—ASTM D 5119 LIMITS (L-38)

	1 Test	2 Test	3 Test
Bearing weight loss, milligrams (max.)	43.7	48.1	50.0

4.4.6.1 *Four-Stroke Cycle Diesel Engine—Low Sulfur Fuel*—Satisfactory performance shall be demonstrated when the oils that meet the criteria of 5.1.1.7 are tested with low-sulfur fuel and rated in accordance with 5.1.2, Table 3 (Caterpillar 1N) 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.) See Table 7.

TABLE 7—1N TEST LIMITS

	1 Test	2 Tests	3 Tests
Top groove filling, % avg. max	20	23	25
WDN, demerits, avg. max	286	311.7	323.0
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-liners, avg max	None	None	None
Stuck rings, avg. max	None	None	None

4.4.6.2 *Four-Stroke Cycle Diesel Engine—Higher Sulfur Fuel*—Satisfactory performance shall be demonstrated when the oils are tested with higher-sulfur fuel and rated in accordance with 5.1.2, Table 3 (Caterpillar 1M-PC) and exhibit test results meeting the following criteria: (Only one test is required, however, when three or more tests are run, one test may be discarded and the average calculated from the remaining test results. This average result must meet the criteria in Table 8.

TABLE 8—1M-PC TEST LIMITS

Top groove filling, % max.	70
WTD, avg, max.	240
Ring Side Clearance Loss, mm, max	0.013
Piston Ring Sticking	None
Piston, Ring, and Liner Scuffing	None

4.4.6.3 *Two-Stroke Cycle Diesel Engine*—Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 5.1.2, Table 3 (ASTM D 5862) and exhibit test results meeting the criteria in Table 9: (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.)

TABLE 9—ASTM D 5862 (DDC 6V92TA)

	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, AVG	0.33	0.34	0.36
Nos. 2 and 3 compression rings, avg	0.28	0.29	0.30
Broken rings, avg	None	None	None
Cylinder liner area			
Average liner distress, % area (avg max.)	60.0	63.5	65.0
Port plugging, % area, (avg max.)			
Average	2	2	2
Single cylinder	5	5	5

4.4.7 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.

4.4.7.1 *Slip Time and Torque*—Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 5.1.2, Table 3 (ATD C-4) and exhibit test results meeting the nominal criteria in Table 10, as adjusted to accommodate slight changes in individual friction plate batches:

TABLE 10—C-4 FRICTION TEST LIMITS

	Graphite 0-5500 cycles	Paper 0-10 000 cycles	Paper 10 000
Slip time at cycles, s (max.)	0.74	0.67	Report
Mid-point coefficient (min.)	0.097	0.080	Report

4.4.7.2 *Friction Coefficient and Wear*—Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 5.1.2, Table 3 (Caterpillar VC 70) and a test on each sequence exhibit results meeting the nominal criteria in Table 11 as adjusted to accommodate slight changes in individual fluoroelastomer batches and performance of the reference oil:

TABLE 11—VC-70 TEST LIMITS

	Sequence 1220	Sequence FRRET
Average dynamic coefficient, %	90-140	—
@ 3000 cycles	—	85-130
@ 8000 cycles	—	90-125
@ 15 000 cycles	—	90-125
@ 25 000 cycles	—	95-125
Average static coefficient, %	91-127	—
Disc wear, mm (max)	0.04	—
Energy limit, %	25	—

4.4.8 SEAL COMPATIBILITY—The oils shall minimize deterioration of seal and friction materials.

4.4.8.1 *Effect on Seals*—Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 5.1.2, Table 3 (ATD C-4) and exhibits test results meeting the nominal criteria in Table 12, as adjusted to accommodate slight changes in individual elastomer batches:

TABLE 12—C-4 SEALS TEST LIMITS

Buna N:	
Volume changes, %	0 to +5
Hardness changes, points	0 ± 5
Polyacrylate:	
Volume changes, %	0 to +10
Hardness change, points	0 to +5
Silicone:	
Volume changes, %	0 to +5
Hardness changes, points	0 to –10
Fluoroelastomer:	
Volume changes, %	0 to +4
Hardness change, points	4 to +4
Ethyl Acrylic:	
Volume changes, %	+12 to +28
Hardness change, points	–6 to –18

4.4.9 DISPERSANCY CHARACTERISTICS—Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 5.1.2, Table 3 ASTM D 5967 (Mack T-8) and exhibits test results meeting the criteria in Table 13:

TABLE 13—ASTM D 5967 TEST LIMITS (MACK T-8)

	1 test	2 test	3 test
Viscosity increase, cSt max			
from min. corrected to 3.8% Soot by TGA	11.5	12.5	13.0
Oil Consumption, gm/Bhp·h, max.	0.0005	0.0005	0.0005

4.4.10 METAL AND COPPER CORROSION

4.4.10.1 Metal Corrosion—Satisfactory performance shall be demonstrated when the oils are tested and rated in accordance with 5.1.2, Table 3 (Corrosion Bench Test ASTM D 5968) and exhibits test results meeting the following criteria:

a. Cu ppm max—20
b. Pb, ppm, max—60

4.4.10.2 Copper Corrosion, ASTM D 130—Satisfactory performance shall be demonstrated when the oils are rated in accordance with 5.1.2, Table 3 (Copper Corrosion, ASTM D 130). The copper coupons used in 4.4.10.1 shall be rated according to ASTM D 130 and the oil shall exhibit copper strip discoloration not exceeding ASTM No. 3 when compared to ASTM Copper Strip Corrosion Standard.

4.4.11 HEUI ENGINE OIL AERATION TEST—Satisfactory performance shall be demonstrated when the oils are tested in accordance with 5.1.2, Table 3 (HEUI) and exhibit test results meeting the following criteria:

a. HEUI A Foam Stability @ 20 h % max – 10

4.5 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 5.1.2 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 2 and 4.4.1 through 4.4.10.2, but test results shall be reported for all properties listed. The qualifying activity (see 7.4) shall establish specific values and tolerances for subsequent quality conformance testing of the finished lubricant for these properties (see 7.3 and 7.4):

a. Viscosity, apparent and kinematic
b. High-temperature/high-shear
c. Viscosity index
d. Pour point
e. Pumpability
f. Flash point
g. Gravity, API at 60 °F
h. Chlorine
i. Carbon residue
j. Foaming
k. Phosphorus
l. Sulfur
m. Sulfated ash
n. Metallic components
o. Nitrogen

5. Verification

5.1 Classification of Inspections—The inspection requirements specified herein are classified as follows:

a. Qualification inspections (see 5.1.1).
b. Conformance inspections (see 5.1.3).

5.1.1 QUALIFICATION INSPECTIONS—Qualification inspections consist of tests for all of the requirements specified in Section 4 and may be conducted in any plant or laboratory that follows the ASTM procedures and referencing requirements where appropriate. Qualification inspections shall be performed on each viscosity grade except as specified in 5.1.1.1 through 5.1.1.8.

5.1.1.1 *Stable Pour-Point*—The stable pour-point test (FED-STD-791, Method 203) shall be required only on SAE grades 10W and 15W-40 oils.

5.1.1.2 *Shear Stability*—Shear stability shall be required for only SAE 15W-40 grade oil.

5.1.1.3 *Modified Formulations*—SAE 40 grade oils based on the formulation of an SAE 30 grade oil qualified under this specification may be qualified in accordance with 4.4.1.

5.1.1.4 *Oxidation and Wear Protection*—The qualifying activity (see 7.4), may waive ASTM D 5533 testing of the candidate oil when acceptable supporting ASTM D 5533 wear evaluations for formulations similar in additive technology to the candidate lubricant are presented to substantiate the wear protection characteristics.

5.1.1.5 *Ring-Sticking, Wear, and Accumulation of Deposits*—The two-stroke cycle diesel engine test ASTM D 5862 (DDC 6V92TA) shall be required only for SAE grades 30, 40, and 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 SAE 15W-40 grade oils formulated using the additive system, a viscosity index improver additive but with base stocks of different manufacture.
b. One test each of an SAE 15W-40 grade oil formulated using the additive system, a base stock employed in 5.1.1.5.a for each viscosity index improver additive to be used in conjunction with the additive system.

5.1.1.6 *Friction Retention Characteristics and Wear*—Test for friction retention characteristics and wear shall be required only for SAE grades 10W, 30, and 15W-40 oils. The qualifying activity (see 7.4) 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.

The 1N test shall be required only on 15W/40.

5.1.1.7 *Four-Stroke Cycle Diesel Engine (1N)*—Low Sulfur Fuel

5.1.1.8 *HEUI Engine Oil Aeration*—The HEUI test shall be required only when a satisfactory sequence IV foam test (SEQ IV D892) is not available.

5.1.2 QUALIFICATION INSPECTION METHODS—Perform tests in accordance with Table 3 and with 5.1.2.1 through 5.1.2.2, as applicable.

5.1.2.1 *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 5.1.2.1.1 and 5.1.2.1.2. The procedures in 5.1.2.1.1 and 5.1.2.1.2 should be performed at the same time.

5.1.2.1.1 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 4.4.2.1. Record the test results on a copy of the "Homogeneity and Miscibility Test" form in the column marked "None".