SAE International

INDUSTRIAL LUBRICANT STANDARD

SAE MS1004 OCT2010

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Superseding MS1004 SEP2000

Lubricants, Industrial Oils, and Related Products Type H (Hydraulic Fluids) - Specification

RATIONALE

The revision of SAE MS1004 was necessary to reflect changes to test limits, changes to test methods and additional standards that have been incorporated since SAE MS1004 was originally released in 2000.

FOREWORD

The SAE International Industrial Lubricants Committee has developed a number of industrial, non-production, lubricant performance specifications.

The purpose of these voluntary SAE specifications is to:

a. Define minimum performance requirements for industrial lubricants, where tests are available.

b. Provide lubricant suppliers with performance targets for key industrial lubricants.

c. Promote the availability of these lubricants to member companies and others who may wish to use these specifications.

d. Provide a user friendly classification system using common test standards and properties.

ISO Standard 6743, Lubricants, industrial oils and related products (class L) - Classification, is the foundation for these documents.

a. Performance characteristics and test procedures are specified.

b. For information, equivalent ISO, DIN, CEN, BSI, ASTM, AFNOR, CETOP, and IP test methods are referenced.[1]

[1] International Standards Organization (ISO)
Deutsches Institut fur Normung e. V. (DIN)
European Committee for Standardization (CEN)
American Society for Testing and Materials (ASTM)
Association of Francaise de Normalisation (AFNOR)
The Institute of Petroleum (IP) NOTE: Now combined with BSI
British Standards Institution (BSI), BS 2000: XXX where XXX is the corresponding IP number
European Committee on Hydraulic Oil and Pneumatics (CETOP)

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http://www.sae.org/technical/standards/ms1004_201010

See References, Section 2.

Industrial lubricant classifications targeted:

a. Index of lubricants and symbols (SAE MS1000)

b. General purpose and total loss lubricants (SAE MS1001)

c. Gear oils (SAE MS1002)

d. Compressor oils (SAE MS1003)

e. Hydraulic fluids (SAE MS1004)

f. Fire resistant hydraulic fluids (SAE MS1005)

g. Lubricants for spindle bearings and associated clutches (SAE MS1006)

h. Slideway lubricants (SAE MS1007)

i. Metal removal fluids (SAE MS1008)

j. Lubricants for pneumatic tools (SAE MS1009)

k. Turbine oils (SAE MS 1010)

l. Lubricating greases (SAE MS1011)

NOTE 1: Environmental and/or health and safety regulations will present additional specifications to these standards. Contact individual end users regarding requirements in these areas.

NOTE 2: There can be issues related to the quality of industrial lubricants that fall outside of the scope of this specification.

1. SCOPE

See Table 1.

TABLE 1 - SCOPE, FIELD OF APPLICATION, AND SYMBOLS

Code Letter	General Applications	Composition and Properties	Symbol	Typical Applications
H	Hydraulic Systems	Non-Inhibited refined mineral oils	HH	
		Refined mineral oils with improved anti-rust and anti-oxidation properties	HL	General Hydraulic systems where operating pressures less than 10 MPa and anti-wear additives may be incompatible
		Oils of HL type with improved anti-wear properties	HM	General hydraulic systems which include highly loaded components
		Oils of HL type with improved viscosity temperature properties	HR	
		Oils of HM type with improved viscosity/ temperature properties	HV	Construction and marine equipment
		Synthetic fluids with no specific fire resistant properties	HS	Special properties
		Oils of HM type with improved aqueous metal removal fluid (coolant) compatibility	HC	
	Hydraulic slide way systems	Oils of HM type with anti-stick/slip properties	HG	Machines with combined hydraulic and plain bearing way lubrication systems where vibration or intermittent sliding (stick/slip) at low speed is to be minimized.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D 92	Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D 95	Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
ASTM D 97	Test Methods for Pour Point of Petroleum Products
ASTM D 130	Method for Detection of Copper Corrosion from Petroleum Products by Copper Strip Tarnish Test
ASTM D 445	Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
ASTM D 471	Test Method for Rubber Property—Effect of Liquids
ASTM D 664	Test Method for Neutralization Number by Potentiometric Titration
ASTM D 665A&B	Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water and Synthetic Sea Water
ASTM D 892	Test Method for Foaming Characteristics of Lubricating Oils
ASTM D 943	Test Method for Oxidation Characteristics of Inhibited Mineral Oils
ASTM D 974	Test Method for Neutralization Number by Color-Indicator Titration
ASTM D 1298	Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
ASTM D 1401	Test Method for Water Separability of Petroleum Oils and Synthetic Fluids
ASTM D 2070	Test Method for Thermal Stability of Hydraulic Oils
ASTM D 2140	Test Method for Carbon-Type Composition of Insulating Oils of Petroleum Origin
ASTM D 2270	Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 and 100 °C
ASTM D 2422	Classification of Industrial Fluid Lubricants by Viscosity System
ASTM D 2619	Test Method for Hydrolytic Stability of Hydraulic Fluids (Beverage Bottle Method)
ASTM D 3238	Test Method for Calculation of Carbon Distribution and Structural Group Analysis of Petroleum Oils by the N-D-M Method
ASTM D 3427	Test Method for Air Release Properties of Petroleum Oils

ASTM D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter

ASTM D 4289 Test Method for Elastomer Compatibility of Lubricating Greases and Fluids

ASTM D 4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X-ray Fluorescence Spectrometry

ASTM D 4951 Test Method for Determination of Additive Elements in Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectroscopy

ASTM D 5182 Test Method for Evaluating the Scuffing Load Capacity of Oils (FZG Visual Method)

ASTM D 5185 Test Method for 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 Spectroscopy (ICP-AES)

ASTM D 6304 Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration

ASTM D6973 Test Method for Indicating Wear Characteristics of Petroleum Hydraulic Fluids in a High Pressure Constant Volume Vane Pump

ASTM E 1687 Test Method for Determining Carcinogenic Potential of Virgin Base Oils in Metalworking Fluids

2.1.2 BS Publications

Available from British Standards Institution, Customer Services, 389 Chiswick High Road, London W4 4AL, United Kingdom, Tel: +44-0-20-8996-9001, www.bsi-global.com. Also online from ILI Website (http://www.info.com).

BS 188 Determination of the Viscosity of Liquids

BS 2000:PTA226 Methods of Test for Petroleum and its Products—Petroleum Products—Calculation of Viscosity Index from Kinematic Viscosity

BS 4231 Viscosity Grades of Industrial Liquid Lubricants

2.1.3 Caterpillar Publications

Available from www.caterpillar.com.

MG 1004-303 Metalworking Fluid Compatibility Test for Petroleum Products

2.1.4 CETOP Publications

Available from the European Oil Hydraulic and Committee Website (http://www.cetop.org).

CETOP RP67HAnti Wear Vane Pump Test for Hydraulic Fluids

2.1.5 Denison Publication

Available from Denison Hydraulics, 14 Route Dubois blanc - BP 539 18105 Vierzon Cedex, France, www.denisonhydraulics.com.

Denison T6H2OC Combined Vane and Piston Pump Test

2.1.6 DIN Publications

Available from Deutsches Institut für Normung e.V., Burggrafenstrasse 6, 10787 Berlin, Germany, www.din.de. Also online from ILI Website (http://www.info.com).

DIN 51 354 Part 2 Mechanical testing of lubricants by the FZG gear rig test method; Method A/8, 3/90 for testing lubricating oils

DIN 51 373 Testing of fire resistant heat transfer fluids—Determination of resistance to oxidation including an assessment of the catalyst plates

DIN 51 381 Determination of air release properties of lubricating oils and hydraulic fluids

DIN 51 389 Part 2 Determination of lubricants; Mechanical testing of hydraulic fluids in the vane-cell-pump; Method A for anhydrous hydraulic fluids

DIN 51 519 ISO viscosity classes for industrial liquid lubricants

DIN 51 558 Part 1 Determination of neutralization number of petroleum products by color indicator titration

DIN 51 561 Testing of mineral oils, liquid fuels and related liquids; measurement of viscosity using the Vogel-Ossag viscometer, temperature range approximately 10 to 150 °C (cancelled)

DIN 51 562 Part 1 Determination of kinematic viscosity using the standard design Ubbelohde viscometer

DIN 51 566 Determination of foaming characteristics of lubricating oils (cancelled)

DIN 51 569 Determination of viscosity of mineral oils, liquid fuels and related liquids at temperatures from –55 to approximately 10 °C using the Vogel-Ossag viscometer

DIN 51 585 Testing the corrosion-inhibiting properties of steam turbine oils and hydraulic oils containing additives

DIN 51 587 Determination of aging behavior of steam turbine oils and hydraulic oils containing additives

DIN 51 599 Determination of demulsification capacity of lubricating oils using the stirring method

DIN 51 757 Determination of density of petroleum products and related products

DIN 51 759 Determination of the corrosive effect of liquid petroleum product on copper by the copper strip test (superseded by ISO 2160)

DIN 53 505 Shore hardness testing A and D of rubber, elastomers and plastics

DIN 53 521 Determination of the resistance of rubber and elastomer to liquids, vapors and gases

2.1.7 Eaton (Vickers) Publications

Available from http://www.eaton.com/EatonCom/Markets/Hydraulics/ProductsCategory/Pumps/index.htm
AT5373 35VQ25 Method for Wear Characteristics of Petroleum Hydraulic Fluids in a High Pressure Constant Volume Vane Pump (M-2952-S)

2.1.8 EPA Publications

Available from Standard Test Methods of the U.S. Environmental Protection Agency. SW-846 Methods are available online (Website: http://www.epa.gov/epaoswer/hazwaste/test/8xxx.htm).

EPA SW 846, Method 8082 Polychlorinated Biphenyls (PCB's) by Gas Chromatography

EPA SW 846, Method 8121 Chlorinated Hydrocarbons by Gas Chromatography: Capillary Column Technique

EPA SW 846, Method 8270D Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry

2.1.9 IP Publications

Available from http://www.intertek-cb.com/news/IP_Methods.shtml. Europe +44 1708.680.248, North America 713.844.3263, Asia Pacific: +65 6322 8228

IP 4 Petroleum Products—Determination of Ash

IP 15 Petroleum Products—Determination of Pour Point

IP 19 Determination of Demulsibility Characteristics of Lubricating Oil

IP 36 Open Flash and Fire Point—Cleveland Method

IP 71 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

IP 74 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation

IP 135 Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water

IP 139 Test Method for Neutralization Number by Color-Indicator Titration

IP 146 Determination of Foaming Characteristics of Lubricating Oils

IP 154 Corrosiveness to Copper—Copper Strip Method

IP 160 Density of Crude Oils and Petroleum Products—Hydrometer Method

IP 166 Determination of Load-Carrying Capacity of Lubricants—IAE Gear Machine Method

IP 177 Test Method for Neutralization Number by Potentiometric Titration

IP 226 Petroleum Products—Calculation of Viscosity Index from Kinematic Viscosity

IP 278 Determination of Seal Compatibility Index of Petroleum Oils

IP 313 Air Release Properties of Hydraulic, Turbine and Lubricating Oils

IP 334 Determination of Load Carrying Capacity of Lubricants—FZG Gear Machine Method

2.1.10 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 868 Plastics and ebonite—Determination of indentation hardness by means of a durometer (Shore Hardness)

ISO 1817 Rubber vulcanized—Determination of the effect of liquids

ISO 2160 Petroleum products—Corrosiveness to copper—Copper strip test

ISO 2592 Petroleum products; determination of flash and fire points; Cleveland open cup method

ISO 2909 Petroleum products; determination of viscosity index from kinematic viscosity

ISO 3016 Petroleum products; determination of pour point

ISO 3104 Petroleum products—Transparent and opaque liquids—Determination of kinematic viscosity and calculation of dynamic viscosity

ISO 3448 Industrial liquid lubricants—ISO viscosity classification

ISO 3675 Crude petroleum and liquid petroleum products—Laboratory determination of density or relative density—Hydrometer method

ISO 3733 Petroleum products and bituminous materials; determination of water; distillation method

ISO 4406 Hydraulic fluid power—Fluids—Method for coding level of contamination by solid particles

ISO 4263 Petroleum products—Inhibited mineral oils—Determination of oxidation characteristics

ISO 6072 Hydraulic fluid power—Compatibility between elastomeric materials and fluids

ISO 6247 Petroleum products—Lubricating oils—Determination of foaming characteristics

ISO 6614 Petroleum oils and synthetic fluids—Determination of demulsibility characteristics

ISO 6618 Petroleum products and lubricants—Neutralization number—Color indicator titration method

ISO 6743-4 Lubricants, industrial oils and related products (class L); classification part 4: Family H (hydraulic systems)

ISO 7120 Petroleum products and lubricants—Petroleum oils and other fluids—Determination of rust—Preventing characteristics in the presence of water

ISO 7619 Rubber—Determination of indentation hardness by means of pocket hardness meters

ISO 9120 Petroleum and related products—Determination of air-release properties of steam turbine and other oils—Impinger method

3. CONCEPT

The hydraulic fluids defined by this specification are refined mineral oils with improved anti-rust and anti-oxidation properties, type HL; oils with improved anti-wear properties, Type HM; and oils with improved compatibility with aqueous metal removal fluids, Type HC.

Types HH, HR, HS, HV and HG are not addressed in this document.

4. REQUIREMENTS AND TESTING

See Table 2.

TABLE 2 - TYPE H (HYDRAULIC OILS)

Property Type of Hydraulic Oil	Requirements HL (Rust and Oxidation)	Requirements HM (Anti-wear)	Requirements HC (AW +coolant compatible	Testing as specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards IP[(1)]/BS/ ANSI/Other
Base Oil Specifications: Paraffinic, Naphthenic, Aromatic Content	Report	Report	Report			D 3238-05 D 2140-03	
Total PNA, ppm (most tests speciate)	100 Max.	100 Max.	100 Max.				EPA SW-846 METH 8270D-98
Total PCB, ppm	1 Max.	1 Max.	1 Max.				EPA SW-846 METH 8082A-96
Total Organic Halogens, ppm	5 Max.	5 Max.	5 Max.				EPA SW-846 METH 8121
Ames Mutagenicity:						E 1687-04	
Fold Increase	Report	Report	Report				
Mutagenicity Index	1 Max.	1 Max.	1 Max.				
Mutagenicity, Potency Index	Report	Report	Report				
Corrosive effect on steel	Not exceeding degree of corrosion ISO 7120 - O - A	Not exceeding degree of corrosion ISO 7120 - O - A	Not exceeding degree of corrosion ISO 7120 - O - A	7120-1987	51 585	D 665-06A or B	IP 135-2006
Corrosive effect on copper 3 h at 100 °C	Not exceeding degree of corrosion 2 ISO 2160 - 100A3	Not exceeding degree of corrosion 2 ISO 2160 - 100A3	Not exceeding degree of corrosion 2 ISO 2160 - 100A3	2160-1998	51 759	D 130-04e1	IP 154-2000
Mechanical testing by the vane pump 35VQ25 method (loss in mg)					51 389 part 2	D 6973	AT5373 MS-2952-S
Ring + vanes,	NA	≤90	≤90				
Parker Hanifin -Denison T6H2OC combined vane and piston Pump Test	HF-1	HF-0	HF-0				Parker Hanifin - Denison T6H2OC
Oxidation stability, maximum increase in TAN at 1500 h in mg KOH/g	2.0	2.0	2.0	4263 Pt 1-2003 Pt 2-2003 Pt 3-2006	51 373 51 587	D 943-04A	
D943 run w/out water for environmentally acceptable fluids, maximum increase in TAN. 1000 h	2.0	2.0	2.0				

TABLE 2 - TYPE H (HYDRAULIC OILS) (CONTINUED)

Property Type of Hydraulic Oil	Requirements HL (Rust and Oxidation)	Requirements HM (Anti-wear)	Requirements HC (AW +coolant compatible	Testing as specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards IP[1]/BS/ Other
Behavior towards the SRE-NBR 1 sealant* 70 and 168 h at 60 °C Relative change % in volume[2]	VG 10 & 15 0 to 18 VG 22 0 to 15 VG 32 & 46 0 to 12 VG 68 & 100 0 to 10	VG 10 & 15 0 to 18 VG 22 0 to 15 VG 32 & 46 0 to 12 VG 68 & 100 0 to 10	VG 10 & 15 0 to 18 VG 22 0 to 15 VG 32 & 46 0 to 12 VG 68 & 100 0 to 10	1817-2005 6072-2002	53 521	D 471-06 D4289-03	IP 278
Change in Shore A hardness * or other seal materials as agreed upon between user and supplier	VG 10 & 15 0 to –10 VG 22 0 to –8 VG 32 & 46 0 to –7 VG 68 & 100 0 to –6	VG 10 & 15 0 to –10 VG 22 0 to –8 VG 32 & 46 0 to –7 VG 68 & 100 0 to –6	VG 10 & 15 0 to –10 VG 22 0 to –8 VG 32 & 46 0 to –7 VG 68 & 100 0 to –6	1817-2005 868-2003 7619 Pt 1,2-2004	53 521 in conjunction with 53 505	D 471-06	
Air release properties, in minutes at 50 °C	VG ≤ 32 ≤5 VG ≥ 46 ≤10	VG ≤ 32 ≤5 VG ≥ 46 ≤10	VG ≤ 32 ≤5 VG ≥ 46 ≤10	9120-1997	51 381	D 3427-06	IP 313-2001
Foam Volume, in mls at 25 °C at 50 °C at 25 °C after heating to 50 °C Report time to settle to 0 foam	 ≤50/0 ≤50/0 ≤50/0	 ≤50/0 ≤50/0 ≤50/0	 ≤50/0 ≤50/0 ≤50/0	6247-1998	51 566	D 892-06	IP 146-2006
Water separability, in minutes at 54 °C to (40/39/1)	VG 10 & 15 ≤ 30 VG 22, 32, & 46 ≤ 30 VG 68 ≤ 60 VG 100 ≤ 60 (at 82 °C)	VG 10 & 15 ≤ 30 VG 22, 32, & 46 ≤ 30 VG 68 ≤ 60 VG 100 ≤ 60 (at 82 °C)	VG 10 & 15 ≤ 30 VG 22, 32, & 46 ≤ 30 VG 68 ≤ 60 VG 100 ≤ 60 (at 82 °C)	6614-1999	51 599	D 1401-02	IP 19-2003
Coolant Compatibility Test Volume of MRF separated from hydraulic fluid in 1 h, mls Water content of oil phase, %	NA	NA	 ≥ 2 ≤0.5%				Caterpillar MG 1004-303
Gear rig test by the FZG method; minimum passing stage	NA	VG 46 <---> VG100 ≥ 11	VG 46 <---> VG100 ≥ 11		51 354 Part 2	D 5182	IP 166 IP 334
Thermal Stability Acid Number Change, % max Viscosity change, % max Sludge, mg/100 mls max Cu rod Color (Cin. Mil.) max Cu weight loss, mg max Steel rod color (Cin. Mil.) max	 ±50 5 25 5 10 No discoloration	 ±50 5 25 5 10 No discoloration	 ±50 5 25 5 10 No discoloration			D 2070	