SAE International™

INDUSTRIAL LUBRICANT STANDARD

SAE MS1005 JUN2010

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Superseding MS1005 JUN2001

Lubricants, Industrial Oils, and Related Products Type HF
Fire-Resistant Hydraulic Fluids—Specification

RATIONALE

The revision of SAE MS1005 was necessary to reflect changes to test limits, changes to test methods and additional standards that have been incorporated since SAE MS1005 was originally released.

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.

b. Provide lubricant suppliers with performance targets for a minimum number of key industrial lubricants.

c. Improve the availability of these lubricants to member companies.

d. Provide a plant oriented, 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

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

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/MS1005_201006

Industrial lubricant classifications targeted:

a. Lubricants, Industrial Oils and Related Products - Classification (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 MS1010)

l. Lubricating greases (SAE MS1011)

See SAE MS1000 - Index of lubricants and symbols.

NOTE 1: Environmental, Technical Reports, and/or health and safety regulations may present additional specifications to the supplier. EXAMPLE: Factory Mutual Research Corporation, Spray Flammability of Hydraulic Fluids and Development of a Test Method.

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

1. SCOPE

ISO 7745 shall be used for providing detailing, operational characteristics, advantages, disadvantages, and factors affecting the choice to be made among fire-resistant fluids.

TABLE 1 - SCOPE AND FIELD OF APPLICATION

Code letter	General Applications	More specific applications	Composition and properties	Symbol	Remarks
H	Hydraulic systems	Applications where fire-resistant fluids are required	Oil-in –water emulsions	HFAE	Typically more than 80% water content
			Chemical solutions in water	HFAS	Typically more than 80% water content
			Water-in-oil emulsions	HFB	
			Water polymer solutions	HFC	Typically less than 80% water content
			Synthetic fluids containing no water and consisting of phosphate esters	HFDR	Fluids in these categories should be selected carefully, taking into account possible environmental or health hazards
			Synthetic fluids containing no water and consisting of chlorinated hydrocarbons	HFDS	
			Synthetic fluids containing no water and consisting of mixtures of HFDR and HFDS fluids	HFDT	
			Synthetic fluids containing no water and of other compositions	HFDU	
			Vegetable Oils and esters of vegetable oils - biodegradable fluids	HETG	

HFAE, HFC, HFDR, HFDU and HETG oils are covered in this specification. HFAS, HFB and HFDS fluids are not addressed.

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 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE MS1000 Lubricants, Industrial Oils, and Related Products—Classification

SAE MS1001 Lubricants, Industrial Oils, and Related Products Type A Lubricants for General Purpose and Total Loss Systems

SAE MS1002 Lubricants, Industrial Oils, and Related Products Type C (Gears) Specification

SAE MS1004 Lubricants, Industrial Oils, and Related Products Type H (Hydraulic Fluids) - Specification

SAE MS1005 Lubricants, Industrial Oils, and Related Products Type HF Fire-Resistant Hydraulic Fluids - Specification

SAE MS1006 Lubricants, Industrial Oils, and Related Products Type F Lubricant for Spindle Bearings, and Associated Clutches - Specification

SAE MS1007 Lubricants, Industrial Oils, and Related Products Type G Slideway Lubricants - Specification

SAE MS1008 Lubricants, Industrial Oils and Related Products Type M (Metal Removal Fluids) - Specification

SAE MS1011 Lubricants, Industrial Oils and Related Products - Type X (Greases) - Specification

2.1.2 Publications

Referenced ASTM, BS, CEN, DIN, IP, ISO, and VDMA Standard hardcopies are available from the ILI Website (http://www.ili-info.com) or by contacting ILI at:

Europe
ILI, Index House, Ascot, Berkshire, SL5 7EU, UK
Tel: +44 (0)1344 636400 Fax: +44 (0)1344 291194
Email: databases@ili.co.uk

USA
ILI, 610 Winters Avenue, Paramus, NJ 07652, USA
Tel: 201-986-1131 Fax: 201-986-7886
Email: sales@ili-info.com

2.1.3 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

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 482 Test Method for Ash from Petroleum Products

ASTM D 664 Test Method for Neutralization Number of Petroleum Products by Potentiometric Titration

ASTM D 665A Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water

ASTM D 665B Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Synthetic Sea Water

ASTM D 892 Test Method for Foaming Characteristics of Lubricating Oils

ASTM D 943 Standard Test Method for Oxidation Characteristics of Inhibited Mineral Oils

ASTM D 974 Test Method for Acid and Base 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 1744 Test Method for Determination of Water in Liquid Petroleum Products by Karl Fischer Reagent

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°C and 100°C

ASTM D 2422 Classification of Industrial Fluid Lubricants by Viscosity System

ASTM D 2619 Test Method of Hydrolytic Stability of Hydraulic Fluids (Beverage Bottle Method)

ASTM D 2896 Standard Test Method for Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration

ASTM D 3238 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 3707 Test Method for Storage Stability of Water-in-Oil Emulsions by the Oven Test Method

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

ASTM D4289 Standard 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 4927 Test Method for Elemental Analysis of Lubricant & Additive Components - Barium, Calcium, Phosphorus, Sulfur & Zinc By Wavelength-Dispersive X-Ray Fluorescence Spectroscopy

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

ASTM D 5182 Test Method for Evaluating the Scuffing (Scoring) 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 5621 Test Method for Sonic Shear Stability of Hydraulic Fluid

ASTM D 6046 Standard Classification of Hydraulic Fluids for Environmental Impact

ASTM D 6278 Standard Test Method for Shear Stability of Polymer Containing Fluids Using a European Diesel Injector Apparatus

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

ASTM D 7236 Test Method for Flash Point by Small Scale Closed cup Tester (Ramp Method)

ASTM E 70 Test Method for PH of Aqueous Solutions with the Glass Electrode

ASTM E 659 Test Method for Autoignition Temperature of Liquid Chemicals

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

2.1.4 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.

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 4056 Determination of Autoignition Temperature

BS 4231 Classification for Viscosity Grades of Industrial Liquid Lubricants

BS 4385 Methods for Determination of Water in Crude Petroleum, Petroleum Products and Bituminous Materials by Distillation (Superseded by ISO 9029)

BS EN 15751 Automotive fuels. Fatty acid methyl ester (FAME) fuel and blends with diesel fuel. Determination of oxidation stability by accelerated oxidation method

2.1.5 CETOP Publications

Hardcopies of referenced Standards are not in the ILI database but may be special ordered by contacting ILI as referenced in 2.1.2 or by contacting the European Oil Hydraulic and Pneumatics Committee (Website: http://www.cetop.org) at:

British Fluid Power Association
Cheriton House
Cromwell Business Park
Banbury Road
Chipping Norton
GB-Oxfordshire OX7 5SR
Phone: +44 (1608) 647900
Fax: +44 (1608) 647919
E-Mail: enquiries@BFPA.co.uk
http://www.BFPA.co.uk.

CETOP R 39 H Schedule of Required Data for Hydraulic Fluids

CETOP R 48 H Procedure for Determining Corrosion Resistant Characteristics of Water Base Fire Resistant Fluids

CETOP RP 110H Hydraulic Fluids for Hydraulic Transmission - Fire Resistant Fluids - Group HFA – Specifications

CETOP RP 112 H Fluids for Hydraulic Transmission - Mineral Oils Category HV - Method for Determination of Shear Stability

2.1.6 Denison Publication

Available from Dennison Hydraulics, 14 Route du bois blanc – B.P. 539, 18105 Vierzon Cedex, France. http://pagesperso-orange.fr/fluidsinfo/Sommaire.htm.

Denison H30585 Denison Hydraulic Fluid Specification.

2.1.7 DIN Publications

Available from Deutsches Institut für Normung e.V., Burggrafenstrasse 6, 10787 Berlin, Germany, www.din.de.

DIN 38 404/5 German Standard Methods for Examination of Water, Waste Water and Sludge; Physical and Physico-Chemical Characteristics (Group C); Determination of PH Value (C5)

DIN 38 405/1 German Standard Methods for the Examination of Water, Waste Water and Sludge; Anions (Group D); Determination of Chloride Ions (D 1)

DIN 38 405/5 German Standard Methods for the Examination of Water, Waste Water and Sludge; Anions (Group D); Determination of Sulfate Ions (D 5)

DIN 38 405/9 German Standard Methods for the Examination of Water, Sewage and Sludge; Anions (Group D), Determination of Nitrate Ions (D9)

DIN 38 406/1 German Standard Methods for the Examination of Water, Waste Water and Sludge; Cations (Group E); Determination of Iron (E1)

DIN 38 406/3 German Standard Methods for the Examination of Water, Sewage and Sludge; Cations (Group E), Determination of Calcium and Magnesium (E3)

DIN 38 409/7 German Standard Methods for the Examination of Water, Sewage and Sludge; Summary of Indices of Actions and Substances (Group H), Determination of Acid and Base Capacity (H7)

DIN 51 345 Testing the Compatibility of Fire Resistant Hydraulic Fluids with Metals

DIN 51 346 Testing the Stability of Fire Resistant Hydraulic Fluids

DIN 51 348 Test of Fire Resistant Governor Fluid - Determination of Hydrolytic Stability

DIN 51 354/2 Mechanical Testing of Lubricants by the FZG Gear Rig Test Method; Method A/8, 3/90 for Testing Lubricating Oils

DIN 51 369 Testing of Cooling Lubricants; Determination of the PH Value of Water-Mixed Cooling Lubricants

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 Testing of Lubricating Oils, Governor Oils & Hydraulic Fluids; Determination of Air Release Properties

DIN 51 382 Determination of Shear Stability of Polymer-Containing Lubricating Oils by the Diesel Injector Nozzle Method

DIN 51 389/2 Determination of Lubricants; Mechanical Testing of Hydraulic Fluids in the Vane-Cell-Pump; Method A for Anhydrous Hydraulic Fluids

DIN 51 519 Lubricants; ISO Viscosity Classification for Industrial Liquid Lubricants

DIN 51 558/1 Testing of Mineral Oils; Determination of the Neutralization Number, Colour 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-Deg C (CANCELLED)

DIN 51 562/1 Viscometry - Determination o Kinematic Viscosity Using The Ubbelohde Viscometer - Part 1: Apparatus And Measurement Procedure

DIN 51 566 Testing of Lubricants; Determination of Foaming Characteristics (CANCELLED)

DIN 51 569 Determination of Viscosity of Mineral Oils, Liquid Fuels and Related Liquids at Temperatures from -55°C to Approximately 10°C Using the Vogel-Ossag Viscometer

DIN 51 585 Testing of Lubricants; Testing of Corrosion Protection Properties of Steam Turbine Oils and Hydraulic Oils Containing Additives

DIN 51 592 Testing of Lubricants; Determination of the Content of Undissolved Matter in Lubricating Oils; Membrane Filter Method

DIN 51 599 Determination of Demulsification Capacity of Lubricating Oils Using the Stirring Method

DIN 51 757 Testing of Mineral Oils and Related Materials; Determination of Density

DIN 51 759/1 Testing of Liquid Mineral Oil Products; Method of Test for Copper Corrosion; Copper Strip Test (SUPERSEDED BY ISO 2160)

DIN 51 794 Testing of Mineral Oil Hydrocarbons; Determination of Ignition Temperature

DIN 53 505 Testing of Rubber, Elastomers, and Plastics; Shore Hardness Testing A and D

DIN 53 521 Determination of the Behaviour of Rubber and Elastomers when Exposed to Fluids and Vapours

DIN 53 538/1 Standard Reference Elastomers; Acrylonitrile-Butadiene Rubber (NBR); Peroxide-Cured, for Characterizing Service Fluids with Respect to their Action on NBR

DIN 53 538/2 Standard Reference Elastomers; Acrylonitrile Butadiene Rubber (NBR) with Low Acrylonitrile Content for Characterizing Test Liquids and Greases Bases on Mineral Oil

2.1.8 EPA Publications

Standard test methods of the U. S. Environmental Protection Agency. SW-846 Methods are available on-line (Website: http://www.epa.gov/epaoswer/hazwaste/test/8xxx.htm). Method 24 available in the Code of Federal Regulations in 40 CFR, Part 60, Appendix A).

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 8270C Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry

2.1.9 Federal Test Method Publications

Standard test methods of the U.S. Department of Defense. FTM methods are available on-line (Website: http://stinet.dtic.mil/). Department of Defense Index of Specifications and Standards (DODISS) fielded search. Enter FED-STD-791C in “DODISS ID NUMBER” search field. Available in PDF format (Acrobat Reader Software required).

FTM 6930 High-Temperature - High Pressure Spray Flammability; Lubricants, Liquid Fuels and Related Products

2.1.10 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 15 Petroleum Products - Determination of Pour Point

IP 36 Determination of Open Flash and Fire Point - Cleveland Method

IP 71(Sect. 1) Petroleum Products - Transparent and Opaque Liquids - Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity

IP 74 Determination of Water Content of Petroleum Products - Distillation Method

IP 125 Determination of Cast Iron Corrosion Characteristics of Petroleum Products

IP 135 Determination of Rust-Preventing Characteristics of Steam Turbine Oil in the Presence of Water

IP 139 Petroleum Products and Lubricants - Determination of Acid or Base Number - Colour-Indicator Titration Method

IP 146 Determination of Foaming Characteristics of Lubricating Oils

IP 154 Petroleum Products - Corrosiveness to Copper - Copper Strip Test

IP 157 Determination of the Oxidation Stability of Inhibited Mineral Oils (The TOST Test)

IP 160 Determination of Density - Hydrometer Method

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

IP 177 Test Method for Acid 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 294 Determination of Shear Stability of Polymer-containing Oils - Diesel Injection Rig Method

IP 313 Determination of Air Release Value of Hydraulic, Turbine and Lubricating Oils

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

2.1.11 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; Calculation 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 4263 Petroleum products—Inhibited mineral oils—Determination of oxidation characteristics

ISO 4404 Petroleum and related products—Determination of the corrosion resistance of water containing fire-resistant fluids for hydraulic systems

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

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

ISO 6245 Petroleum products—Determination of ash

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

ISO 6614 Petroleum products—Determination of water separability of petroleum oils and synthetic fluids

ISO 6618 Petroleum products and lubricants—Determination of acid or base number—Colour-indicator titration method

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

ISO 12922 Lubricants, industrial oils and related products (Class L)—Family H (hydraulic systems)—Specifications for categories HFAE, HFAS, HFB, HFC, HFDR and HFDU

2.1.12 7th Luxembourg

Available from http://www.hse.gov.uk/mining/frfluid.pdf

7th Luxembourg HSE Approved specifications for fire resistance and hygiene of hydraulic fluids for use in machinery and equipment in mines

3. CONCEPT

This specification defines characteristics and requirements for type HFAE and HFB Serviceable Emulsions, type HFC Water Polymer (Glycol) solutions, type HFDR Phosphate Ester, type HFDU Synthetic (Other Compositions) and HETG Environmentally Acceptable.

Types HFAS, HFDS, and HFDT fluids are not addressed in this document.

4. REQUIREMENTS AND TESTING

See Table 2.

Type HFAE, HFB, and HFC fire resistant fluids are to be tested with the reagent water as specified in Appendix A. In addition, suggestions are given for manufacturing, using, monitoring and maintaining the emulsions in Appendix B. Water quality should conform to the process water specified in Table A1.

TABLE 2 - TYPE HF (FIRE-RESISTANT HYDRAULIC FLUIDS)

NOTE: Category for HFB (Water in Oil) Fluids was dropped as there is no longer appreciable use of these fluids.

Property	Requirements HFAE Oil in Water	Requirements HFC Water-Polymer	Requirements HFDR Phosphate Ester	Requirements HFDU Synthetic Polyol Ester Type	Requirements HFDU Synthetic Poly Alkylene Glycol Type Water Insoluble /Water Soluble	Requirements HETG Environmentally Acceptable (e.g., Vegetable Oils or Esters)	Testing as Specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards CETOP IP/BS	Comments
Base Oil Specification	For mineral oil components										
Paraffinic, Naphthenic, Aromatic Content	Report	NA	NA	NA	NA	NA			D 3238 D 2140		
Total PNA, ppm	100 Max.	NA	NA	NA	NA	NA				EPA SW-846 TN 8270C	
Total PCB, ppm	<1 ppm	NA	NA	NA	NA	NA				EPA SW-846 TN 8082	
Total Organic Halogens, ppm	5 Max.	NA	NA	NA	NA	NA				EPA SW-846 TN 8121	
Ames Mutagenicity: Fold Increase Mutagenicity Index Mutagen. Potency Index	Report 1 Max. Report	NA	NA	NA	NA	NA			E 1687		
Corrosive effect on steel[(1)]	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	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	4404	51 585	D 665-06 A	IP 135-2006	
Corrosive effect on Copper, 3 hours	Run at 50 °C, Not exceeding degree of corrosion 1B	Run at 50 °C, Not exceeding degree of corrosion 1B	Run at 100 °C, Not exceeding degree of corrosion 1B	Run at 100 °C, Not exceeding degree of corrosion 1B	Run at 100 °C, Not exceeding degree of corrosion 1B	Run at 100 °C, Not exceeding degree of corrosion 1B	2160-1998	51 759	D 130-04e1	IP 154-2000	
Mechanical testing by the vane pump method	Not recommended for vane pumps	Denison HF-4 Approval	Denison HF-5 Approval	Denison HF-0 Approval	Denison HF-0 Approval	Denison HF-6 or Eaton Vickers V20?				Denison H3058A Denison CM?	Vickers M104C
Piston Pump Test	Denison HF-3 Approval	Denison HF-4 Approval	Denison HF-5 Approval	Denison HF-0 Approval	Denison HF-0 Approval	Denison HF-6				Denison H3058A	
Oxidative Stability, D943 run w/out water, maximum increase in TAN.	NA	NA	≤2.0 In 500 hours	≤2.0 In 300 h	≤2.0 In 500 h	≤2.0 In 250 h	4263 Pt 1-2003 Pt 2-2003 Pt 3-2006	51 373 51 587	D 943-04A ASTM D2271?		Release draft showing D 943 w/out water unless ASTM procedure is approved
Oxidative Stability Index (OSI) by Rancimat or Instrument						100 h minimum				Rancimat	

1. Water containing fluids should be run without additional water.

TABLE 2 - TYPE HF (FIRE-RESISTANT HYDRAULIC FLUIDS) (CONTINUED)

Property	Requirements HFAE Oil in Water	Requirements HFC Water-Polymer	Requirements HFDR Phosphate Ester	Requirements HFDU Synthetic Polyol Ester Type	Requirements HFDU Synthetic Poly Alkylene Glycol Type Water Insoluble /Water Soluble	Requirements HETG Vegetable Oils or Esters	Testing as Specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards CETOP IP/BS	Comments
Behavior towards the appropriate seal material Relative change % in volume 70 and 168 h at 60C Change in Shore A hardness	See Annex A	See Annex A	See Annex A	See Annex A	See Annex A	See Annex A	1817 6072 868 7619 Pt 1,2-2004 12922	53 521 53 521 in conjunction with 53 505	D 471 D4289 D 471 D 4289	Denison H30585A section 5 IP 278	
Air release properties, in min. At 50 °C	VG 32 ≤20	VG 15 <-->32 ≤20 VG 46 <--> 100 ≤30	VG 32 ≤ 5 VG 46 ≤ 10 VG 68 ≤ 15 VG 100 ≤ 20	VG 32 ≤ 5 VG 46 ≤ 10 VG 68 ≤ 15 VG 100 ≤ 20	VG 32 ≤ 5 VG 46 ≤ 10 VG 68 ≤ 15 VG 100 ≤ 20	VG 32 ≤ 5 VG 46 ≤ 10 VG 68 ≤ 15 VG 100 ≤ 20	9120	51 381	D 3427	IP 313	
Foam Volume, in ml at 25 °C at 50 °C at 25 °C after heating to 50C (volume after 10 min settling)	≤50/0 ≤50/0 ≤50/0	≤50/0 ≤50/0 ≤50/0	≤50/0 ≤50/0 ≤50//0	≤50/0 ≤50/0 ≤50/0	≤50/0 ≤50/0 ≤50/0	≤50/0 ≤50/0 ≤50/0	6247	51 566	D 892	IP 146	
Gear rig test by the FZG method; minimum passing stage	NA	NA	12 minimum	12 minimum	12 minimum	12 minimum		51 354 Part 2	D 5182	IP 166 IP 334	
Hydrolytic Stability Copper weight loss, mg/cm^2 Acidity of water layer, mg KOH max	NA	NA	0.20 28	0.20 28	0.20 28	0.20 28		51 348	D 2619		
Spray Flammability Parameter	FM or 7th Luxembourg Approved (may vary by location)	FM or 7th Luxembourg Approved (may vary by location)	FM or 7th Luxembourg Approved (may vary by location)	FM or 7th Luxembourg Approved (may vary by location)	FM or 7th Luxembourg Approved (may vary by location)	FM or 7th Luxembourg Approved (may vary by location)				FTM 6930	
ISO VG viscosity Classification	NA	VG 32<------>46	VG32 <------> VG100	VG32 <-----> VG68	VG46<-------> VG100	VG46<-------> VG68	3448	51 519	D 2422	BS 4231	
Kinematic viscosity In mm²/s at 40 °C (also useful for quality control)	ISO Grade ± 10 %	ISO Grade ± 10 %	ISO Grade ± 10 %	ISO Grade ± 10 %	ISO Grade ± 10 %	ISO Grade ± 10 %	3104	51 561, 51 562 Part 1 or 51 569	D 445	IP 71 BS 188	
Viscosity index	NA	NA	Report	≥ 140	≥ 180	≥ 180	2909	DIN ISO 2909	D 2270	IP 226 BS2000: PTA226	
Pour Point °C (for shipping and storage)	≤ 0	≤ –40	VG 15,22,32 ≤ –10 VG 46,68 ≤ –5 VG 100 ≤ 0	VG 15,22,32 ≤ –10 VG 46,68 ≤ –5 VG 100 ≤ 0	VG 15,22,32 ≤ –40 VG 46,68 ≤ –40 VG 100 ≤ –30	VG 15,22,32 ≤ –10 VG 46,68 ≤ –5 VG 100 ≤ 0	3016	DIN ISO 3016	D 97	IP 15	
Flash Point °C	NA	NA	≥ 230	≥ 230	≥ 250	≥ 250	2592		D 92 D 7236	IP 36	
Fire point °C	NA	NA	≥ 280	≥ 280	≥ 300	≥ 270	2592		D 92	IP 36	

TABLE 2 - TYPE HF (FIRE-RESISTANT HYDRAULIC FLUIDS) (CONTINUED)

Property	Requirements HFAE Oil in Water	Requirements HFC Water-Polymer	Requirements HFDR Phosphate Ester	Requirements HFDU Synthetic Polyol Ester Type	Requirements HFDU Synthetic Poly Alkylene Glycol Type Water insoluble /water soluble	Requirements HETG Vegetable Oils or Esters	Testing as Specified in ISO	Technical Equivalent Standards DIN	Technical Equivalent Standards ASTM	Technical Equivalent Standards CETOP IP/BS	
Relative viscosity loss due to shear (250 cycles at 40 °C as a percentage)	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier	To be specified by the supplier		51 382	D 5621 D 6278	CETOP RP112H IP294	
Level of contamination by solid particles, max. (upon receipt, useful for quality control)	19/16/13 or better, as required	19/16/13 or better, as required	19/16/13 or better, as required	19/16/13 or better, as required	19/16/13 or better, as required	19/16/13 or better, as required	4406				
Water content, expressed as a proportion by mass, in % (also useful for quality control)	35 – 45	≥ 35	≤ 0.1	≤ 0.10	≤ 0.10	≤ 0.10	3733		D 9505e1 D6304e1	IP 74	
Density at 15 °C in g/ml	Report	Report	Report	Report	Report	Report	3675	51 757	D 4052 D 1298	IP 160	
Acid Number, in mg KOH/g Base Number, in mg KOH/g (also useful for quality control)	NA	NA	Report	Report	Report	Report	6618	51 558 Part 1	D 664 D 974 D 2896	IP 139 IP 177	
Metals content by ICP, ppm (also useful for quality control)	Report	Report	Report	Report	Report	Report			D 5185 D 4951		
Sulfur (also useful for quality control)	Report	Report	Report	Report	Report	Report			D 4294		
pH value at 20 °C	8.0 -9.5	6.7-11	NA	NA	NA	NA		51 369	E 70		
Emulsion stability after 25 days at 50 °C Assessment level[4]	Report	NA	NA	NA	NA	NA	6614	51 346	D 3707 (water in oil)		
Biostability	Report	NA	NA	NA	NA	Report			D 6046		

ANNEX A - RECOMMENDED SEAL TEST PROTOCOL FOR FIRE-RESISTANT HYDRAULIC FLUIDS

This procedure will provide some general guidance on seal testing as a basis for comparing different fluid types. It is by no means comprehensive enough to predict results with all seal types in all operating conditions.

Parameter	Parameter Value	Comments
Test Conditions and Length	Immersion in fluid for 70 and 168 h at 60 °C	Other temperatures and test lengths may be used as agreed upon by user and supplier
Measurements	Change in volume and hardness	Tensile strength and elongation may also be reported
Seal Materials*	Standard elastomers: SRE-NBR1, HNBR, Viton, EPDM, urethane, polyacrylate, silicone, VMAC, nitrile, neoprene – Seal materials to be selected based on SAE-AMS3217/2B test slab	Or others as identified by end users
Passing Limits	Change in volume: 0 to 18 Change in shore A hardness: 0 to -10	Change in elongation: report Change in tensile strength: report

- The fluid supplier will run standard elastomers (see partial list of recommended sources) at standard conditions. This will help to ensure that the fluid is being tested, not the elastomers. It may be desirable to compare these results with that of the current fluid in use.
- Fluids meeting the limits above with a given elastomer will be considered to be compatible with the given elastomer. The limits may be more or less difficult to meet from one fluid type to the next, but absolute limits should be based on what changes in seal properties are allowable without compromising the performance of the fluid system.
- The fluid supplier should consult with the end user regarding specific applications, type of seal (e.g., O-ring) to be tested, expected temperatures, etc., in order to generate the most meaningful results. The end user may require a specific dynamic seal test, for instance, as opposed to a static immersion test.
- The supplier will provide available results, whether passing or failing, so that the end user knows with which elastomers the fluid is compatible.
- Suggested Test Elastomers (Available from Test Engineering Inc. in San Antonio, TX)
- A-727 Polyacrylate
- T-599 Nitrile
- F-975 Fluorlelastomer
- CES14603-TEST KIT Complete Cummins Elastomers
- EPDM-6PACK EPDM EB153-75 TEST SLABS
- FLOURO-6 PACK FLOUROCARBON KFKM V8
- HNBR-6 PACK HNBR D65 TEST SLABS