Designation: D7044 – 04a

Standard Specification for Biodegradable Fire Resistant Hydraulic Fluids[1]

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1. Scope

1.1 This specification covers performance classifications for biodegradable fire-resistant hydraulic fluids that are used in the industrial/mobile and mining industries.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration
D892 Test Method for Foaming Characteristics of Lubricating Oils
D943 Test Method for Oxidation Characteristics of Inhibited Mineral Oils
D974 Test Method for Acid and Base Number by Color-Indicator Titration
D1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
D1401 Test Method for Water Separability of Petroleum Oils and Synthetic Fluids
D2422 Classification of Industrial Fluid Lubricants by Viscosity System
D2532 Test Method for Viscosity and Viscosity Change After Standing at Low Temperature of Aircraft Turbine Lubricants
D2783 Test Method for Measurement of Extreme-Pressure Properties of Lubricating Fluids (Four-Ball Method) [3]
D2882 Test Method for Indicating Wear Characteristics of Petroleum and Non-Petroleum Hydraulic Fluids in Constant Volume Vane Pump[4]
D3427 Test Method for Air Release Properties of Petroleum Oils
D4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter
D5182 Test Method for Evaluating the Scuffing Load Capacity of Oils (FZG Visual Method)
D6046 Classification of Hydraulic Fluids for Environmental Impact
D6304 Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
D6546 Test Methods for and Suggested Limits for Determining Compatibility of Elastomer Seals for Industrial Hydraulic Fluid Applications
E70 Test Method for pH of Aqueous Solutions With the Glass Electrode

2.2 *DIN Standards:*[5]

DIN 51348 Testing of fire resistant governor fluids; determination of hydrolytic stability
DIN 51354-2 Testing of Lubricants; FZG Gear Test Rig – Part 1: Method A/8,3/90 for Lubricating Oils
DIN 51373 Testing of Fire Resistant Heat Transfer Fluids; Determination of Resistance to Oxidation Including an Assessment of the Catalyst Plates
DIN 51389-2 Determination of lubricants; mechanical testing of hydraulic fluids in the vane-cell-pump; method A for anhydrous hydraulic fluids
DIN 51777-2 Testing of Mineral Oil Hydrocarbons and Solvents; Determination of Water Content according to Karl Fischer; Indirect Method

2.3 *ISO Standards:*[6]

ISO 2049 Petroleum Products - Determination of Color (ASTM Scale)
ISO 2160 Petroleum Products - Corrosiveness to Copper – Copper Strip Test

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.N0 on Hydraulic Fluids.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Withdrawn.

[4] Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

[5] Available from Deutsches Institut für Normung e. V. (DIN), 10772, Berlin, Germany.

[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

ISO 2592 Determination of Flash and Fire Points – Cleveland Open Cup Method
ISO 3104 Petroleum Products - Transparent and Opaque Liquids - Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity
ISO 3105 Glass Capillary Kinematic Viscometers—Specifications and Operating Instructions
ISO 3448 Industrial Liquid Lubricants - ISO Viscosity Classification
ISO 3675 Crude Petroleum and Liquid Petroleum Products - Laboratory Determination of Density - Hydrometer Method
ISO 3733 Petroleum Products and Bituminous Materials – Determination of Water - Distillation Method
ISO 4263-1 Petroleum and Related Products - Determination of the Aging Behavior of Inhibited Oils and Fluids – TOST Test – Part 1: Procedure for Mineral Oils
ISO 4404-1 Petroleum and Related Products - Determination of the Corrosion Resistance of Fire-Resistant Fluids – Part 1: Water-Containing Fluids
ISO 4406 Hydraulic Fluid Power—Fluids—Method for Coding the Level of Contamination by Solid Particles
ISO 5884 Aerospace—Fluid Systems and Components—Methods for System Sampling and Measuring the Solid Particle Contamination of Hydraulic Fluids
ISO 6072 Compatibility between Fluids and Standard Elastomeric Materials
ISO 6245 Petroleum Products - Determination of Ash
ISO 6247 Petroleum Products - Determination of Foaming Characteristics of Lubricating Oils
ISO 6296 Petroleum Products - Determination of Water – Potentiometric Karl Fischer Titration Method
ISO 6618 Petroleum Products and Lubricants - Determination of Acid or Base Number – Color Indicator Titration Method
ISO 6619 Petroleum Products and Lubricants—Neutralization Number—Potentiometric 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 7745 Hydraulic Fluid Power—Fire-resistant (FR) Fluids—Guidelines for Use
ISO 9120 Petroleum and Related Products - Determination of Air Release Properties of Steam Turbine and Other Oils – Impinger Method
ISO 12185 Crude Petroleum and Petroleum Products – Determination of Density - Oscillating U-Tube 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
ISO 12937 Petroleum Products - Determination of Water – Coulometric Karl Fischer Titration Method
ISO 14935 Petroleum and Related Products – Determination of Wick Flame Persistence of Fire Resistant Fluids
ISO 15029-1 Petroleum and Related Products – Determination of Spray Ignition Characteristics of Fire Resistant Fluids – Part 1: Spray Flame Persistence – Hollow-Cone Nozzle Method
ISO 15380 Lubricants, Industrial Oils and Related Products (Class L)—Family H (Hydraulic Systems)—Specifications for Categories HETG, HEPG, HEES, and HEPR

2.4 *Lux Standards:*[7]

Lux 3.1.3 Stabilized Flame Heat Release – Spray Test
Lux 5.2.3 Determination of the Emulsion Stability of HFB Fluids at Medium Temperature
Lux 5.2.4 Determination of the Emulsion Stability of HFB…LT Fluids at Low Temperature
Lux 5.3.1 Determination of aging Properties of HFC Fluids
Lux 5.8 Determination of the Shear Stability of Hydraulic Fluids
Lux 5.9.1 Determination of the Corrosion Inhibiting Properties of HFA, HFC, and HFD Fluids

2.5 *Other Standards:*

CETOP RP 65H Manifold Ignition Test[8]
CETOP RP 67H Antiwear Vane Pump Test for Hydraulic Fluids[8]
IP 281 [9]

3. Terminology

3.1 *Definitions:*

3.1.1 *bioaccumulation*, *n*—the net accumulation of a substance by an organism as a result of uptake from all environmental sources.

3.1.2 *biodegradable*, *n*—any substance containing <10 % wt. O_2 content which undergoes ≥60 % biodegradation as theoretical CO_2 in 28 days and ≥67 % biodegradation as theoretical O_2 uptake in 28 days, or any hydraulic fluid containing ≥10 % wt. O_2 content which undergoes ≥60 % biodegradation as theoretical CO_2 or as theoretical O_2 uptake in 28 days.

3.1.3 *biodegradation*, *n*—the process of chemical breakdown or transformation of a material caused by organisms or their enzymes.

3.1.3.1 *Discussion*—Biodegradation is only one mechanism by which materials are transformed in the environment.

3.1.4 *fire-resistant fluid*, *n*—any liquid that is able to withstand fire or give protection from fire.

3.1.5 *hydraulic fluid*, *n*—a liquid used in hydraulic systems for lubrication and transmission of power.

4. Classification

4.1 The following classifications of fire-resistant hydraulic fluids, except for HEPG, were taken from ISO 6743-4.

[7] European Commission, Safety and Health Commission for the Mining and Other Extractive Industries, "Requirements and Tests Applicable to Fire-Resistant Hydraulic Fluids Used for Power Transmission and Control (Hydrostatic and Hydrokinetic)," Seventh Edition, Doc. N4746/10/91 EN, Luxembourg, April 1994.

[8] Available from the Comité Européen des Transmissions Oléohydrauliques et Pneumatiques (CETOP), Lyoner Straße 18, 60528, Frankfurt am Main, Germany.

[9] Available from Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K.

TABLE 1 Specifications for Categories HFAE and HFAS Fluids According to ISO 12922

Composition	Type HFAE: These are oil-in-water emulsions, typically with more than 80 % water content (+5°C to + 50°C, ISO 7745) Type HFAS: These are chemical solutions in water, typically more than 80 % water content (+5°C to +50°C, ISO 7745)

Characteristic or Test	Unit	Specification		Standard or Test Method
		Finished Emulsion Category HFAE[A]	Finished Solution Category HFAS[A]	
Appearance		[B]	[C]	
Water content, min.	% (V/V)	80	80	D95, D6304
Foam at: +25°C max.[D]	ml/ml	300/10	300/10	D892
+50°C max.	ml/ml	300/10	300/10	
+25°C max.	ml/ml	300/10	300/10	
pH at 20°C		6.7 to 11.0	6.7 to 11.0	E70
Emulsion stability (50°C/600 h), max.	Rating	2A-2R	[B]	D1401
—free oil	% (v/V)	Trace	[B]	
cream, max.% (v/V)	% (v/V)	0.5	[B]	
Corrosion protection	Rating	[E]	[E]	(ISO 4404)
Elastomer compatibility NBR1, EPDM1 and FPM1 elastomer, 60°C/168 h		[E]	[E]	D6546
relative volume change, max.	%	7	7	
relative hardness change: min.	IRHD	–7	–7	
max.	IRHD	+2	+2	
change in tensile strength	%	[E]	[E]	
elongation at break		[E]	[E]	

[A] These products are normally supplied as concentrates, and should be used with the correct water quantity as specified by the supplier (viscosity of concentrate to be 350 mm^2/s maximum at 20°C).
[B] The requirement is not relevant to this fluid type.
[C] The appearance of the delivered fluid shall be clear and bright and free of any visible particulate matter, under normal visible light at ambient temperature, using a clear container of approximately 10 cm diameter.
[D] For fluids with a viscosity greater than 10 mm^2/s at 20°C.
[E] Report only on request.

4.1.1 *HFA*—Fire resistant hydraulic fluids that may be further classified as:

4.1.1.1 *HFAE*—Oil-in-water emulsions containing more than 80 % by weight water and typically in the range 95 to 99 % by weight water.

4.1.1.2 *HFAS*—Chemical solutions. Not containing emulsions and typically contains more than 80 % by weight water.

4.1.2 *HFB*—Water-in-oil emulsions containing approximately 60 % by weight oil.

4.1.3 *HFC*—Aqueous monomer and polymer polyglycol solutions. Water content not less than 35 % by weight.

4.1.4 *HFD*—Phosphate ester or polyolester-based, water-insoluble fire-resistant fluids.

4.1.5 *HFDR*—Phosphate ester-based fluids.

4.1.6 *HFDU*—Water-free fluids based on chemical compounds other than phosphate esters and chlorinated hydrocarbons.

4.1.7 *HEPG*—Anhydrous "environmentally friendly" polyalkylene glycol-derived hydraulic fluids that may be water soluble or insoluble.

5. Classification Requirements

5.1 *Type HFA Hydraulic Fluids*—The requirements for this type of fluid are presented in Table 1.

5.2 *Type HFB Hydraulic Fluids*—The requirements for this type of fluid are presented in Table 2 and include ISO viscosity grades from 46 to 100, in accordance with Classification D2422 (ISO 3448).

5.3 *Type HFC Hydraulic Fluids*—The requirements for this type of fluid are presented in Table 2 and include ISO viscosity grades from 22 to 68, in accordance with Classification D2422 (ISO 3448).

5.4 *Type HFD Hydraulic Fluids*—The requirements for this type of fluid are presented in Table 2 and include ISO viscosity grades from 15 to 100, in accordance with Classification D2422 (ISO 3448).

5.5 *Type HEPG Hydraulic Fluids*—The requirements for this type of fluid are presented in Table 3 and include ISO viscosity grades from 22 to 68, in accordance with Classification D2422 (ISO 3448).

6. Inspection

6.1 Inspection of the material shall be agreed upon between the purchaser and the supplier.

7. Packaging and Package Marking

7.1 The fluid shall be suitably packaged to permit acceptance by the carrier and to afford adequate protection from normal hazards of handling and shipping. Packaging shall conform to applicable carrier rules and regulations.

7.2 Packaging and labeling shall comply with state and federal regulations.

7.3 Each container shall be plainly marked with the manufacturer's name and brand, production code or lot number, or both, type of material, volume content, and any other information required by state and federal law.

TABLE 2 Specifications for Categories HFB, HFC and HFD Fluids According to ISO 12922

Composition	Type HFB: These are water-in-oil emulsions (+5°C to +50°C, ISO 7745) Type HFC: These are water polymer solutions, typically with more than 35 % water content (−20°C to +50°C, ISO 7745) Type HFDR: These are synthetic fluids free of water consisting of phosphate esters (−20°C to +70°C/150°C[A], ISO 7745) Type HFDU: These are synthetic fluids free of water but of other compositions than HFDR (−20°C to +70°C/150°C[A], ISO 7745)

Characteristic or Test	Unit	Specifications			Standard or Test Method
		Finished Emulsion Category HFB[B]	Finished Solution Category HFC[B]	Category HFD[B] (R-U classes)	
Viscosity grade, ISO VG		46 - 68 - 100	22 - 32 - 46 - 68	15 - 22 - 32 - 46 - 68 - 100	ISO 3448[C]
Appearance		[D]	[E]	[E]	
Water content	% *(m/m)*	[D]	≥35	≤0,1	D95, D6304
	% *(V/V)*	≥ 40	[D]	[D]	(ISO 3733)
Foam at: 25°C max.	ml/ml	[D]	300/10	300/10	D892
50°C max.	ml/ml	[D]	300/10	[D]	
100°C max.	ml/ml	[D]	[D]	300/10	
25°C max.	ml/ml	[D]	300/10	300/10	
Air release at 25°C	min	[F]	[D]	[D]	
Air release at 50°C max.	min	[D]	20; 20; 25; 25	8; 10; 12; 15; 25; 30	D3427
pH at 20°C		[D]	6,7,11,0	[D]	E70
Emulsion stability, 1 000 h at 20°C, max:					D1401
change in water content at 425 ml	%	5	[D]	[D]	
change in water content at 125 ml	%	5	[D]	[D]	
surface oil	ml	10	[D]	[D]	
accumulated free water	ml	2	[D]	[D]	
Emulsion stability, 48 h at 70°C, maximum					(VII LUX 5.2.3)
surface oil	ml	3	[D]	[D]	
accumulated free water	ml	1	[D]	[D]	
Emulsion stability, 336 h at 10°C/168 h at +20°C, max.					(VII LUX 5.2.4)
surface oil	ml	2	[D]	[D]	
accumulated free water	ml	1	[D]	[D]	
max change in water content at 5 ml	%	15	[D]	[D]	
mean change in water content at 5 ml	%	10	[D]	[D]	
Acid number	mg KOH/g	[F]	[D]	[F]	D664, D974
Corrosion protection	Rating	Pass	Pass	[D]	(ISO 4404)
		[D]	[D]	Pass	(VII LUX 5.9.1)
Shear stability, 100 bar/250 cycles[G]					(VII LUX 5.8)
viscosity change at 20°C, max.	%	±15	[F]	±10	
viscosity change at 40°C, max.	%	±15	[F]	±5	
viscosity change at 100°C, max.	%	[D]	[D]	±7	
pH change, max.		[D]	±1.0	[D]	
water content change, max.	%	5	8	[D]	
acid number change, max.	mg KOH/g	±0.50	[D]	±0.50	
Density at 15°C	kg/m^3	[F]	[F]	[F]	D1298, D4052
Elastomer compatibility: 68°C/168 h NBR 1[H] elastomers					D6546
• relative volume change, max.	%	7	7	[D]	
• relative hardness change mini/maxi	IRHD	−7/+2	−7/+2	[D]	
• change in tensile strength	%	[F]	[F]	[D]	
• elongation at break	%	[F]	[F]	[D]	
Elastomer compatibility: 100°C/168 h FPM 1[H], EPDM 1[H], NBR 1[H] elastomers					D6546
• relative volume change, max.	%	[D]	[D]	7	
• relative hardness change, mini/maxi	IRHD	[D]	[D]	−7/+2	
• change in tensile strength	%	[D]	[D]	[F]	
• elongation at break	%	[D]	[D]	[F]	
Spray ignition characteristics	Rating	[I]	[I]	[I]	(ISO 15029-1, VII LUX 3.1.3, NT FIRE 031)
Wick flame persistence	Rating	Pass	Pass	Pass	(ISO 14935)
Manifold ignition test	Rating	Pass	Pass	Pass	(CETOP RP 65 H)
Oxidation stability					(DIN 51373)
Acid number increase, max.	mg KOH/g	[D]	[D]	1,5	
Mass losses, max.	mg	[D]	[D]	1 (iron), 2 (copper)	
Ageing properties					(VII LUX 5.3.1)
pH value increase		[D]	4	[D]	
Insolubles	%	[D]	<4	[D]	

TABLE 2 *Continued*

Characteristic or Test	Unit	Specifications			Standard or Test Method
Composition	Type HFB: These are water-in-oil emulsions (+5°C to +50°C, ISO 7745) Type HFC: These are water polymer solutions, typically with more than 35 % water content (–20°C to +50°C, ISO 7745) Type HFDR: These are synthetic fluids free of water consisting of phosphate esters (–20°C to +70°C/150°C[A], ISO 7745) Type HFDU: These are synthetic fluids free of water but of other compositions than HFDR (–20°C to +70°C/150°C[A], ISO 7745)				
		Finished Emulsion Category HFB[B]	Finished Solution Category HFC[B]	Category HFD[B] (R-U classes)	
Viscosity grade, ISO VG		46 - 68 - 100	22 - 32 - 46 - 68	15 - 22 - 32 - 46 - 68 - 100	ISO 3448[C]
Cleanliness		[D]	[D]	<18/16[J]	(ISO 4406)
Hydrolytic stability					
Acid number increase, max.	mg KOH/g	[D]	[D]	[F]	(DIN 51348)
Vane pump	mg	[D]	[D]	[K]	D2882
4-Ball machine	mm	[K]	[K]	[K]	D2783
FZG gear test	Fail stage	[K]	[K]	[K]	D5182[L,M]

[A] The higher temperature indicates the approximate upper temperature limit for short-term operation. This will depend on whether the application is hydrostatic or hydrodynamic and, for HFDU fluids, on the chemical composition of the fluid. Where doubt exists, clarification should be sought from the equipment manufacturer or fluid supplier, or both.
[B] These fluids are normally supplied as the finished product.
[C] These viscosity grades are determined by measuring the viscosity as described in ISO 3104:1994 and ISO 3105:1994.
[D] The test method or requirement is either not applicable or is not relevant to this fluid type.
[E] The appearance of the delivered fluid shall be clear and bright and free of any visible particulate matter, under normal visible light at ambient temperature, using a clear glass container of approximately 10 cm diameter.
[F] It may be interesting to know the value corresponding to this characteristic and this should be provided by the supplier. Otherwise no limit value is required.
[G] For fluids with a viscosity greater than 10 mm^2/s at 20°C.
[H] EPDM 1 and FPM1 are elastomers normally suitable for HFDR fluids, with the exception of the combination of FPM 1 and alkyl phosphate esters. However, the degree of compatibility is highly dependent on the composition of the base polymer. NBR 1 elastomers are not suitable for use with HFDR fluids.
[I] The methods to be published in the three parts of ISO 15029 (see B.1 in Annex B) measure different fluid characteristics under conditions that are not necessarily comparable. However, performance under one test condition only would normally be required. The method and the limits are, therefore, to be agreed between the end user and the fluid supplier, in accordance with national or other requirements. Where data are reported, reference should be made to the method used.
[J] Apply the sampling technique prescribed in ISO 5884.
[K] Test methods and rating scales or limits are to be negotiated between the supplier and the user.
[L] DIN 51777-2 is applied to instances where interference by certain chemicals is to be avoided.
[M] For dyed fluids, ISO 6619 should be used.

8. Scope

8.1 Not all fire-resistant fluids are biodegradable, nor do all biodegradable fluids possess the same degree of fire resistance. The purpose of this test method is to define a classification, which distinguishes fire-resistant hydraulic fluids that are also biodegradable. Fire resistance can not be assessed on the basis of one test alone, but as a result of adequate performance in several tests representing the relevant hazards of the application. Fire resistance of a hydraulic fluid is determined by its ability to pass various tests that are specified by the appropriate agency responsible for specifying fire-safety regulations for the industry in which the fluid is being used. Examples of authorities who determine fire-safety testing and regulations include the national government, the industrial insurance industry, and various companies themselves. In this test method various standardized test procedures, although not all, that may be selected to determine fire resistance will be described.

9. Environmental Impact

9.1 Biodegradability and ecotoxicity requirements of a hydraulic fluid are set by national regulations using various standardized test procedures including those cited here.

9.2 *Biodegradability*—Classification D6046 lists test methodologies for evaluation of the biodegradability of hydraulic fluids. This classification covers all unused fully formulated hydraulic fluids in their original form.

9.2.1 In the current version of Classification D6046, the aspects of environmental impact included are environmental persistence, of which biodegradability is one component, and acute ecotoxicity. Although only environmental persistence will be addressed here, this classification does not imply that considerations of environmental persistence should take precedence over concerns for ecotoxicity.

9.2.2 Another important aspect of environmental impact is bioaccumulation. This aspect is not addressed in Classification D6046 because adequate test methods do not yet exist to measure bioaccumulation of hydraulic fluids.

9.2.3 Classification D6046 addresses the fresh water and soil environmental compartments. At this time, marine and anaerobic environmental compartments are not included, although they are pertinent for many uses of hydraulic fluids. Hydraulic fluids are expected to exhibit no significant impact on the atmosphere; therefore that compartment is not addressed. Classification D6046 also addresses releases to the environment that are incidental to the use of a hydraulic fluid. However, this classification is not intended to address environmental impact in situations of major accidental release.

9.3 *Basis of Biodegradable Classification*—Classification D6046 consists of two groups of tests, one group addressing

TABLE 3 Specifications for HEPG Fluids According to ISO/FDIS 15380

Characteristics of test	Units	Requirements				Test Method or Standard
Viscosity grade		22	32	46	68	ISO 3448
Density 15°C	kg/m^3	—[A]	—[A]	—[A]	—[A]	ISO 12185 ISO 3675
Colour[B]		—[A]	—[A]	—[A]	—[A]	ISO 2049
Appearance at 25°C[C]		Clbr	Clbr	Clbr	Clbr	
Ash content, max.	% (m/m)	—[C]	—[D]	—[D]	—[C]	ISO 6245
Flash point						
Cleveland open cup, min.	°C	165	175	185	195	ISO 2592
Kinematic viscosity						
at –20°C, max.	mm^2/s	—[C]	—[D]	—[D]	—[C]	
at 0°C, max.	mm^2/s	300	420	780	1 400	ISO 3104
at 40°C, min. to max.	mm^2/s	19.8 to 24.2	28.8 to 35.2	41.4 to 50.6	61.2 to 74.8	
at 100°C, min.	mm^2/s	4.1	5.0	6.1	7.8	
Pour point, max.	°C	–21	–18	–15	–12	ISO 3104
Low temperature fluidity after 7 days	°C	—[D]	—[D]	—[D]	—[D]	ASTM D2532
Acid number[E], max	mg KOH/g	—[C]	—[D]	—[D]	—[C]	ISO 6618
Water content, max.	mg/kg	5 000	5 000	5 000	5 000	ISO 12937 ISO 6296
Copper corrosion, 100°C, 3 h, max.	rating	2	2	2	2	ISO 2160
Rust prevention, procedure A		Pass	Pass	Pass	Pass	ISO 7120
Foam at 24°C, max.	ml	150/0	150/0	150/0	150/0	
at 93°C, max.		75/0	75/0	75/0	75/0	ISO 6247
at 24°C, max.		150/0	150/0	150/0	150/0	
Air release, 50°C, max.	min	7	7	10	10	ISO 9120
Elastomer compatibility[F] after 1 000 h at given test temperature						ISO 6072
NBR 1	°C	60	80	—	—	
HNBR	°C	60	80	100	100	
FPM AC 6	°C	60	80	100	100	
Change in Shore-A-Hardness, max.	grade	±10	±10	±10	±10	
Change in volume, max.	%	–3 to +10	–3 to +10	–3 to +10	–3 to +10	
Change in elongation, max.	%	30	30	30	30	
Change in tensile strength, max.	%	30	30	30	30	
Oxidation stability:						
TOST test time to reach						ASTM D943
ΔTAN = 2 mg KOH/g, min.	h	1 000	1 000	1 000	1 000	ISO 4263-1
Load carrying properties, FZG A/8, 3/90, min.	stage	—[G]	10	10	10	DIN 51354–2
Vane pump						
Ring, max.	mg	120	120	120	120	IP 281
Vane, max	mg	30	30	30	30	CETOP RP 67H DIN 51389-2

[A] Report.
[B] For purposes of identification, dye may be used by agreement between supplier and end user.
[C] Clear and bright is abbreviated as Clbr.
[D] Criteria of performance or values of characteristics to be negotiated between supplier and end user.
[E] Initial acid number is given by the base fluids and the additives.
[F] Other materials or test conditions may be agreed between supplier and end user. Limits are given for the standard reference elastomers.
[G] Not applicable to viscosity grade ISO 22.

the environmental persistence of hydraulic fluids (Category P) and one group addressing acute ecotoxicity of hydraulic fluids, which will not be addressed here. Table 4 shows the Category P classifications for aerobic fresh water persistence.

10. Biodegradable and Fire-Resistant Hydraulic Fluid Classification

10.1 This classification proposes that all fire-resistant hydraulic fluids (that is, type HF and HEPG) that meet the minimum criteria for biodegradability according to Classification D6046 (Pw1), and fire resistance, according to either FM Approvals (Factory Mutual Research Corp.) or ISO 12922, shall be designated with the prefix B- and the suffix -0, 1, or 2 according to the FM Approval rating (that is, B-*Fluid Type*-0, 1 or 2).

10.1.1 Tables 1 and 2 summarize the physical property requirements for type HF type hydraulic fluids according to ISO 12922. Table 3 summarizes the physical property requirements for category HEPG hydraulic fluids according to ISO 15380.

11. Industry Requirements for Fire Resistance

11.1 *Industrial/Mobile Equipment*—For a hydraulic fluid to be classified as both biodegradable and fire resistant, the fluid must meet the requirements of 10.1.

11.2 *Mining Equipment*—For a hydraulic fluid to be classified as both biodegradable and fire resistant, the fluid must meet the requirements of 10.1.

12. Keywords

12.1 biodegradable; ecotoxicity; fire resistance; fluids; FM approvals; hydraulics

TABLE 4 Aerobic Fresh Water Environmental Persistence Classification

Persistence Designation	Ultimate Biodegradation Test Results	
	% Theoretical CO_2	% Theoretical O_2
Hydraulic Fluids Containing <10 % O_2		
Pw1	≥60% in 28 days	≥67 % in 28 days
Pw2	≥60 % in 84 days	≥67 % in 84 days
Pw3	≥40 % in 84 days	≥45 % in 84 days
Pw4	<40 % in 84 days	<45 % in 84 days
Hydraulic Fluids Containing ≥10 % O_2		
Pw1	≥60 % CO_2 or O_2 in 28 days	
Pw2	≥60 % CO_2 or O_2 in 84 days	
Pw3	≥40 % CO_2 or O_2 in 84 days	
Pw4	<40 % CO_2 or O_2 in 84 days	
All Hydraulic Fluids		
Persistence Designation	Primary Biodegradation Test Results % Loss of Starting Material	
Pw-C	≥80 % in 21 days	
Pw4	<80% in 21 days	