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Standard Classification of Hydraulic Fluids for Environmental Impact[1]

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1. Scope*

1.1 This classification covers all unused fully formulated hydraulic fluids in their original form.

1.2 This classification establishes categories for the impact of hydraulic fluids on different environmental compartments as shown in Table 1. Fluids are assigned designations within these categories; for example PwL, Pwe, and so forth, based on performance in specified tests.

1.3 This classification includes environmental persistence and acute ecotoxicity as aspects of environmental impact. Although environmental persistence is discussed first, this classification does not imply that considerations of environmental persistence should take precedence over concerns for ecotoxicity.

1.3.1 Environmental persistence describes long term impact of hydraulic fluids to the environment. Environmental persistence is preferably measured by ultimate biodegradation but can also be measured by other means.

1.3.2 Acute toxicity describes the immediate toxic impact of hydraulic fluids to the environment. Acute toxicity is preferably measured by the three trophic levels of aquatic organisms (Algae, Crustacea, and Fish).

1.4 Another important aspect of environmental impact is bioaccumulation. This aspect is not addressed in the present classification because adequate test methods do not yet exist to measure bioaccumulation of hydraulic fluids.

1.5 The present classification 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 have no significant impact on the atmosphere; therefore that compartment is not addressed.

1.6 This classification addresses releases to the environment which are incidental to the use of a hydraulic fluid. The classification is not intended to address environmental impact in situations of major, accidental release. Nothing in this classification should be taken to relieve the user of the responsibility to properly use and dispose of hydraulic fluids.

1.7 This classification does not cover any performance properties of a hydraulic fluid which relate to its performance in a hydraulic system.

1.8 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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

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*A Summary of Changes section appears at the end of this standard

TABLE 1 Overview of Extended Classification

Environmental Compartment	Categories of Environmental Impact		
	Environmental Persistence	Ecotoxicity	Bioaccumulation
Fresh Water	Pw	Tw	Bw
Marine	Pm	Tm	Bm
Soil	Ps	Ts	Bs
Anaerobic	Pa	Ta	Ba

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D5291 Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants

D5864 Test Method for Determining Aerobic Aquatic Biodegradation of Lubricants or Their Components

D6006 Guide for Assessing Biodegradability of Hydraulic Fluids

D6081 Practice for Aquatic Toxicity Testing of Lubricants: Sample Preparation and Results Interpretation

E943 Terminology Relating to Biological Effects and Environmental Fate

E1440 Guide for Acute Toxicity Test with the Rotifer Brachionus

2.2 *ISO Standards:*[3]

International Standard ISO Test 9439:1990 Technical Corrigendum 1, Water Quality—Evaluation in An Aqueous Medium of the "Ultimate" Biodegradability of Organic Compounds—Method by Analysis of Released Carbon Dioxide

2.3 *OECD Standards:*[4]

OECD 301B CO_2 Evolution Test (the Modified Sturm Test)

OECD 301C Modified MITI Test (I)

OECD 301F Manometric Respirometry Test

OECD 201 Alga, Growth Inhibition Test

OECD 202 Daphnia sp., Acute Immobilisation Test and Reproduction Test

OECD 203 Fish, Acute Toxicity Test

OECD 207 Earthworm Acute Toxicity Test

OECD 208 Terrestrial Plants Growth Test

2.4 *US EPA Tests:*[5]

Aerobic Aquatic Biodegradation Test, 40 CFR 796.3100 (Also available as EPA publication 560/6-82-003, number CG-2000)

Toxic Substances Control Act (TSCA), 40 CFR Parts 796 and 797—Environmental Effects Testing Guidelines, Federal Register, Vol 50, No. 188, September 27, 1985, p. 39321

2.5 *Environmental Canada Test Methods:*[6]

Biological Test Method: Acute Lethality Test Using Rainbow Trout, Report EPS 1/9, Environment Canada, July 1990

Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout, Reference Method EPS 1/RM/13, Environment Canada, July 1990

Biological Test Method: Growth Inhibition Test Using the Freshwater Alga *Selenastrum capricornutum*, Report EPS 1/RM/25, Environment Canada, November 1992

Biological Test Method: Acute Lethality Test Using *Daphnia* spp., Report EPS 1/RM/11, Environment Canada, July 1990

Biodegradability of Two-Stroke Cycle Outboard Engine Oils in Water, CEC L-33-A-93, Co-Ordinating European Council, 1994 (Formerly L-33-T-82)

Toxic Substances Control Act (TSCA), Good Laboratory Practice Standards, Final Rule, U.S. Federal Register, 40 CFR Part 792, August 17, 1989

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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] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org. All standards referenced are from the OECD Guidelines for Testing of Chemicals.

[4] Available from Organization for Economic Cooperation and Development (OECD), 2, Rue Andre Pascal, S-75775, Paris CEDEX 16, France. May also be found in U.S. Federal Register, Vol 50, No. 188, September 27, 1965, paragraph 796.3260.

[5] Available from U.S. Government Printing Office, Washington, DC.

[6] Available from CEC, Madou Plaza, Place Madou 1, B-1030 Brussels, Belgium.

2.6 *Other Standards:*
MENVIQ 92.03/800—D.mag. 1.1, March 1992[7]
29 CFR 1910 OSHA Regulated Carcinogens and Potential Carcinogens[5]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this classification not given below, refer to Terminology D4175.

3.1.2 *acute ecotoxicity, n*—the propensity of a material to produce adverse behavioral, biochemical, or physiological effects in non-human organisms or populations in a short period of time, usually not constituting a substantial portion of the life span of the organism.

3.1.3 *aerobic, adj*—(*1*) taking place in the presence of oxygen, (*2*) living or active in the presence of oxygen.

3.1.4 *anaerobic, adj*—(*1*) taking place in the absence of oxygen, (*2*) living or active in the absence of oxygen.

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

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

3.1.6 *ecotoxicity, n*—the propensity of a material to produce adverse behavioral, biochemical, or physiological effects in non-human organisms or populations.

3.1.7 *effect load XX (ELXX), n*—a statistically or graphically estimated loading rate of test material that is expected to cause one or more specified effects in XX % of a group of organisms under specified conditions for a specified time.

3.1.7.1 *Discussion*—
This terminology should be used for hydraulic fluids instead of the standard effect concentration (ECXX) when the hydraulic fluid is not completely soluble under test conditions.

3.1.8 *environmental compartment, n*—a subdivision of the environment based on physical or chemical properties, or both.

3.1.8.1 *Discussion*—
Examples of environmental compartments are aerobic fresh water, aerobic marine, aerobic soil, and anaerobic media. The results of test procedures may be applied to environmental compartments, but the test systems do not constitute an environmental compartment.

3.1.9 *fresh water environment, n*—the aerobic, fresh water environmental compartment.

3.1.10 *good laboratory practices (GLP), n*—guidelines for the management of laboratory experiments which are published by regulatory agencies or other recognized groups and are concerned with the organizational process and the conditions under which laboratory studies are planned, performed, monitored, recorded, and reported.

3.1.10.1 *Discussion*—
The major GLPs used are USEPA–TSCA, USFDA, OECD, and to some extent the MITI version from Japan for submissions in Japan.

3.1.11 *inhibition load XX (ILXX), n*—a statistically or graphically estimated loading rate of test material that is expected to cause a XX % inhibition of a biological process (such as growth or reproduction) which has an analog as opposed to a digital measure.

3.1.11.1 *Discussion*—
An example of a digital measure would be alive or dead. This terminology should be used for hydraulic fluids instead of the standard inhibition concentration (ICXX) when the hydraulic fluid is not completely soluble under test conditions.

3.1.12 *inoculum, n*—spores, bacteria, single-celled organisms, or other live materials that are introduced into a test medium.

[7] Available from Ministere de l'Environment, Gouvernment du Quebec.

3.1.13 *lethal load XX (LLXX), n*—a statistically or graphically estimated loading rate of test material that is expected to be lethal to XX % of a group of organisms under specified conditions for a specified time.

3.1.13.1 *Discussion*—
This terminology should be used for hydraulic fluids instead of the standard lethal concentration (LCXX) when the hydraulic fluid is not completely soluble under test conditions.

3.1.14 *loading rate, n*—the ratio of test material to aqueous medium used in the preparation of a water accommodated fraction (WAF) and in interpretation of the results of a toxicity study with a poorly water soluble lubricant or lubricant component.

3.1.15 *mechanical dispersion, n*—a mixture produced by the application of mechanical shearing forces to a multi-phase system, one component of which is water, so as to distribute one or more of the materials uniformly throughout the mass of the water with the water existing as a continuous phase.

3.1.16 *pre-adaptation, n*—the pre-incubation of an inoculum in the presence of the test material and under conditions similar to the test conditions.

3.1.16.1 *Discussion*—
The aim of pre-adaptation is to improve the precision of the test method by decreasing variability in the rate of biodegradation produced by the inoculum. Pre-adaptation may mimic the natural processes which cause changes in the microbial population of the inoculum leading to more rapid biodegradation of the test material but not to a change in the final extent of biodegradation.

3.1.17 *primary biodegradation, n*—degradation of the test material by microorganisms resulting in a change in its physical or chemical properties, or both.

3.1.17.1 *Discussion*—
The extent to which the results of a primary biodegradation test correspond to the biological conversion of the test material will depend on the attribute which is being measured.

3.1.18 *primary biodegradation test, n*—a test which follows the disappearance of a test material by measuring some attribute of the material.

3.1.18.1 *Discussion*—
The extent to which the results of a primary biodegradation test correspond to the biological conversion of the test material will depend on the attribute which is being measured.

3.1.19 *terrestrial (or soil) environment, n*—the aerobic environmental compartment which is found in and on natural soils.

3.1.20 *theoretical CO_2, n*—the amount of CO_2 which could in theory be produced from the complete oxidation of all the carbon in a material.

3.1.21 *theoretical O_2, n*—the amount of oxygen which would theoretically be required to completely oxidize a material.

3.1.22 *ultimate biodegradation, n*—degradation achieved when a material is totally utilized by microorganisms resulting in the production of carbon dioxide (and possibly methane in the case of anaerobic biodegradation), water, inorganic compounds, and new microbial cellular constituents (biomass or secretions or both).

3.1.23 *ultimate biodegradation test, n*—a test which estimates the extent to which the carbon in a material is converted to CO_2 or methane, either directly by measuring the production of CO_2 or methane, or, for aerobic biodegradation, indirectly by measuring the consumption of O_2.

3.1.23.1 *Discussion*—
The measurement of new biomass is usually not attempted.

3.1.24 *water accommodated fraction (WAF), n*—the predominately aqueous portion of a mixture of water and a poorly water-soluble material which separates in a specified period of time after the mixture has undergone a specified degree of mixing and includes water, dissolved components, and dispersed droplets of the poorly water soluble material.

3.1.24.1 *Discussion—*
The chemical composition of the WAF depends on the ratio of poorly soluble material to water in the original mixture as well as the details of the mixing procedure.

3.1.25 *wppm*—an abbreviation for part per million by weight.

~~3.1.25 Definitions and terms not given in this classification may be found in the Compilation of ASTM Standard Definitions, 1990 or Terminology E943.~~

4. Significance and Use

4.1 This classification establishes categories of hydraulic fluids which are distinguished by their response to certain standardized laboratory procedures. These procedures indicate the possible response of some environmental compartments to the introduction of the hydraulic fluid. One set of procedures measures the aerobic aquatic biodegradability (environmental persistence) of the fluids and another set of procedures estimates the acute ecotoxicity effects of the fluids.

4.1.1 Although this classification includes categories for both persistence and ecotoxicity, there is no relationship between the two categories. They may be used independently of each other, that is, a hydraulic fluid can be categorized with respect to both sets of laboratory procedures, or to persistence but not ecotoxicity, or to ecotoxicity but not persistence.

4.1.2 There is no relationship between the categories achieved by a hydraulic fluid for persistence and for ecotoxicity. The placing of a hydraulic fluid with regard to one set of categories has no predictive value as to its placement with regard to the other set of categories.

4.2 The test procedures used to establish the categories of hydraulic fluids are laboratory standard tests and are not intended to simulate the natural environment. Definitive field studies capable of correlating test results with the actual environmental impact of hydraulic fluids are usually site specific and so are not directly applicable to this classification. Therefore, the categories established by this classification can serve only as guidance to estimate the actual impact that the hydraulic fluids might have on any particular environment.

4.3 This classification can be used by producers and users of hydraulic fluids to establish a common set of references that describe some aspects of the anticipated environmental impact of hydraulic fluids which are incidental to their use.

4.4 Inclusion of a hydraulic fluid in any category of this classification does not imply that the hydraulic fluid is suitable for use in any particular hydraulic system application.

4.5 The composition of hydraulic fluids may change with use and any change could influence the environmental impact of a used hydraulic fluid. Therefore, the classification of a hydraulic fluid may change upon use depending on the type and extent of the use.

5. Basis of Classification

5.1 This classification consists of two groups of tests, one group addressing the environmental persistence of hydraulic fluids (Category P) and one group addressing acute ecotoxicity of hydraulic fluids (Category T). The ecotoxicity categories are further divided into two environmental compartments, aerobic soil (Ts) and aerobic fresh water (Tw). At this time categories for environmental persistence are limited to aerobic fresh water (Pw).

5.2 All testing shall use as its starting point the unused fully formulated hydraulic fluid.

5.3 The classification of hydraulic fluids for environmental persistence is defined by the hydraulic fluid's biodegradability as measured in tests for ultimate biodegradation. Primary biodegradation measures the degradation of the hydraulic fluid only, without any precise measurement of the remaining materials. Therefore it is not suitable to address long term environmental persistence. Pre-adaptation of inoculum for a period of up to two weeks is allowed for all categories. The classification system is given in Table 2.

5.3.1 Table 2 is divided into three parts. Part A, for hydraulic fluids with elemental analyses indicating a contents of less than ~~10 wt %~~ 10 % by weight oxygen, has separate requirements for tests which measure % theoretical CO_2 and % theoretical O_2. For these

TABLE 2 Environmental Persistence Classification—Aerobic Fresh Water

NOTE 1—Test methods are given in Table 4.

Persistence Designation	Ultimate Biodegradation Test Results	
	% Theoretical CO_2	% Theoretical O_2
	~~*For Hydraulic Fluids Containing Less Than 10 Wt % O_2*~~ *For Hydraulic Fluids Containing Less Than 10 % by weight O_2*	
Pw1	greater than or equal to 60 % in 28 days	greater than or equal to 67 % in 28 days
Pw2	greater than or equal to 60 % in 84 days (12 weeks)	greater than or equal to 67 % in 84 days (12 weeks)
Pw3	greater than or equal to 40 % in 84 days (12 weeks)	greater than or equal to 45 % in 84 days
Pw4	less than 40 % in 84 days (12 weeks)	less than 45 % in 84 days (12 weeks)
Persistence Designation	Ultimate Biodegradation Test Results % Theoretical CO_2 or % Theoretical O_2	
	~~*For Hydraulic Fluids Containing 10 Wt % or More O_2*~~ *For Hydraulic Fluids Containing 10 % by weight or More* O_2	
Pw1	greater than or equal to 60 % in 28 days	
Pw2	greater than or equal to 60 % in 84 days (12 weeks)	
Pw3	greater than or equal to 40 % in 84 days (12 weeks)	
Pw4	less than 40 % in 84 days (12 weeks)	
Persistence Designation	Primary Biodegradation, Test Results % Loss of Starting Material	
	For All Hydraulic Fluids	
Pw-C	greater than or equal to 80 % in 21 days	
Pw4	less than 80 % in 21 days	

hydraulic fluids the different numerical results for the two different types of ultimate biodegradability tests are technically equivalent. Part B for hydraulic fluids with elemental analyses indicating a contents of ~~10 wt %~~ 10 % by weight or more oxygen has the same numerical result for both types of ultimate biodegradation test and these numerical results are also technically equivalent. The difference between hydraulic fluids containing little oxygen and fluids containing relatively abundant oxygen is related to the use of the oxygen present in the base stocks by the microorganisms. Further information is given in Appendix X1.

5.3.1.1 Oxygen content of hydraulic fluids is most commonly determined by difference, that is, by determining the other elemental components of the hydraulic fluid and subtracting that percentage from 100. For purposes of this classification determination of carbon, hydrogen, and nitrogen by Test Methods D5291 and subtraction of that total from 100 is acceptable. Direct determination of elemental oxygen by neutron activation is also acceptable.

5.3.1.2 Table 2 has been constructed assuming that 60 % of the carbon in the hydraulic fluid goes directly to CO_2 during biodegradation and that the remaining carbon is converted to biomass.

5.3.2 Class Pw1 includes hydraulic fluids which would be expected to be the least persistent in the environment. It may be assumed that such a fluid would rapidly and extensively biodegrade in an aerobic aquatic environment which contains microbial life and the conditions necessary for it.

5.3.2.1 Although a minimum production of 60 % theoretical CO_2 or greater up to but not including 100 % theoretical CO_2 or consumption of the technically equivalent fraction of theoretical O_2 leads to a strong implication that the hydraulic fluid will rapidly and extensively biodegrade, such a finding does not unequivocally rule out the possibility that the biodegradation produces recalcitrant metabolites not normally found in nature. Recalcitrant metabolites could constitute a persistent residue of the hydraulic fluid that may remain in the environment. It is also possible that a very small fraction of the original hydraulic fluid, perhaps an additive, could not be biodegraded and could persist in the environment.

5.3.3 Class Pw2 includes hydraulic fluids which would not be expected to persist in the environment in the long term. It may be assumed that these fluids would most likely be biodegraded eventually in an aerobic aquatic environment which contains microbial life and the conditions necessary for it.