# JCMAS

# Biodegradable hydraulic fluids for construction machinery

JCMAS P 042 : 2004

Published 2004-05-20

Japan Construction Mechanization Association

# Forward

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- The draft of this JCMAS was approved on 2004-01-29 at JCMA Domestic Standardization Committee
- Invitation for submission of comments on the draft JCMAS according to WTO/TBT agreement "Code of good practice" was made from 2004-03-15 to 2004-05-15.
- Then this JCMA has been published on 2004-05-20.

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Japan Construction Mechanization Association Standard

JCMAS P 042 : 2004

# Biodegradable hydraulic fluids for construction machinery

## 1 Scope

This standard specifies classification, quality and performance, and test methods for biodegradable hydraulic fluids for construction machinery (hereafter also **HKB**).

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies

**JIS K 2001,** *Industrial liquid lubricants -- ISO viscosity classification*

**NOTE** Relevant International Standard: **ISO 3448** (Modified)

**JIS K 2249,** *Crude petroleum and petroleum products -- Determination of density and petroleum measurement tables based on a reference temperature (15°C)*

**NOTE** Relevant International Standards: **ISO 91-1**, **ISO 649-1**, **ISO 3675** and **ISO 3838** (Modified)

**JIS K 2251,** *Crude Petroleum and Petroleum Products -- Sampling*

**NOTE** Relevant International Standard: **ISO 3170** (Modified)

**JIS K 2265,** *Crude oil and petroleum products -- Determination of flash point*

**JIS K 2269,** *Testing Methods for Pour Point and Cloud Point of Crude Oil and Petroleum Products*

**NOTE** Relevant International Standards: **ISO 3015**, **ISO 3016** (Modified)

**JIS K 2275,** *Crude oil and petroleum products -- Determination of water content*

**NOTE** Relevant International Standards: **ISO 3733**, **ISO 9029** (Modified)

**JIS K 2283,** *Crude petroleum and petroleum product -- Determination of kinematic viscosity and calculation of viscosity index from kinematic viscosity*

**NOTE** Relevant International Standards: **ISO 2909**, **ISO 3104** (Modified)

**JIS K 2501,** *Petroleum products and lubricants -- Determination of neutralization number*

**NOTE** Relevant International Standards: **ISO 3771**, **ISO 6618, ISO 6619**, **ISO 7537** (Modified)

**JIS K 2510,** *Lubricants -- Determination of rust-preventing characteristics*

**NOTE** Relevant International Standards: **ISO 7120** (Modified)

**JIS K 2513,** *Petroleum product -- Corrosiveness to coppe -- Copper strip test*

**NOTE** Relevant International Standards: **ISO 2160** (Modified)

**JIS K 2518,** *Petroleum products - Lubricating oils - Determination of foaming characteristics*

**NOTE** Relevant International Standards: **ISO 6247** (Modified)

**JIS K 2580,** *Petroleum product -- Determination of colour*

**NOTE** Relevant International Standards: **ISO 2049** (Modified)

**JIS K 6251,** *Rubber, vulcanized or thermoplastic -- Determination of tensile stress-strain propoerties*

**NOTE** Relevant International Standards: **ISO 37** (Modified)

**JIS K 6253,** *Rubber, vulcanized or thermoplastic -- Determination of hardness*

**NOTE** Relevant International Standards: **ISO 48, ISO 7619-1, ISO 7619-2** (Modified)

**JIS K 6258,** *Rubber, vulcanized or thermoplastic -- Determination of the effect of liquids*

**NOTE** Relevant International Standard: **ISO 1817** (Modified)

**ISO 4406:1999,** *Hydraulic fluid power – Fluids – Method for coding the level of contamination by solid particles*

**ISO 6743-4**:1999**,** *Lubricants, industrial oils and related products (class L) – Classification – Part 4: Family H (hydraulic systems)*

**ISO 13226**:1999**,** *Rubber – Standard reference elastomers (SREs) for characterizing the effect of liquids on vulcanized rubbers*

**ISO 15380**:2002**,** *Lubricants, industrial oils and related products (class L) – Classification – Part 4: Family H (hydraulic systems) specification for HETG, HEPG, HEES and HEPR*

**IP-281 (BSI 2000: Part 281)** Determination of anti-wear properties of hydraulic fluids – Vane pump method

Note: IP: The Institute of Petroleum

**ASTM D7043**:2005, *Standard test method for indicating wear characteristics of petroleum and non-petroleum hydraulic fluids in a constant volume vane pump*

**ASTM D2619**:1995**,** *Standard test method for hydrolytic stability of hydraulic fluids (Beverage bottle method)*

**ASTM D5182**:1997**,** *Standard test method for evaluating the scuffing load capacity of oils (FZG visual method)*

**DIN 51354-2:**1990**,** *Testing of lubricants; FZG gear test rig; method A/8,3/90 for lubricating oils*

**National Aerospace Standard (NAS) 1638**:2001, *Cleanliness requirements of parts used in hydraulic systems*

**JPI-5S-26-90,** *Testing Methods for Low-Temperature Viscosity of Gear Oils*

**JPI-5S-32,** *Testing Method for Anti-Wear Properties of Lubricating Fluid (Shell Four -Ball Method)*

**JPI-5S-40,** *Testing Method for Extreme-Pressure Properties of Lubricating Fluids (Shell Four-Ball Method)*

**JCMAS P045,** *Hydraulic fluids for construction machinery -- Test method for indicating oxidation stability in high pressure piston pump*

**JCMAS P047,** *Hydraulic fluids for construction machinery -- Test method for friction characteristics*

## 3 Classification

Biodegradable hydraulic fluids for construction machinery are classified into two types, i.e. a normal temperature use type and a low temperature use type, based on the self-priming properties under low temperature as determined by **JPI-5S-26-90**, each of which are further sub-classified into two viscosity grades of ISO VG32 and VG46 according to their viscosities as determined in accordance with **JIS K 2001**.

Table 1 Classification of biodegradable hydraulic fluids for construction machinery

| Type | Symbol | Application |
|---|---|---|
| Normal temperature use | VG32<br>VG46 | For use in construction machinery mainly operating under ambient temperatures of -5°C or higher |
| Low temperature use | VG32L<br>VG46L | For use in construction machinery mainly operating under ambient temperatures of -25°C or higher for VG32L, and -20°C or higher for VG46L |

## 4 Performance criteria

Biodegradable hydraulic fluid for construction machinery (**HKB**) is comprised of base stock oil that possesses biodegradability and of additives that do not give harmful effects to the environment. It shall meet the performance criteria in **Table 2** when tested in accordance with the testing methods as specified in **Clause 5**.

Table 2 Classification of biodegradable hydraulic fluids for construction machinery

| Test items | | Type | | | |
|---|---|---|---|---|---|
| | | Normal temperature use | | Low temperature use | |
| | | Viscosity Classification | | | |
| | | VG32 | VG46 | VG32L | VG46L |
| Density (15 °C), kg/m$^3$ | | Report[1)] | | | |
| Color, ASTM | | Report[1)] | | | |
| Flash Point, °C | | Report[1)] | | | |
| Kinematic Viscosity, mm$^2$/s | (40°C) | 28.8 min.<br>35.2 max. | 41.4 min.<br>50.6 max. | 28.8 min.<br>35.2 max. | 41.4 min.<br>50.6 max. |
| | (100°C) | 5.3 min. | 6.8 min. | 5.3 min. | 6.8 min. |
| Low Temperature Viscosity, mPas | (-10°C) | Report[1)] | | - | |
| | (-25°C) | - | | 5,000 max. | - |
| | (-20°C) | | | - | 5,000 max. |
| Pour Point, °C | | -17.5 max. | | -35 max. | -30 max. |
| AN, mgKOH/g | | Report[1)] | | | |
| Water Content, mg/kg | | 1,000 max. (before breaking the container seal) | | | |
| Copper Corrosion (100°C, 3 hrs) | | 1 max. | | | |
| Rust-preventing property (Distilled water) | | No rust to be identified | | | |
| Foaming, ml | (24°C) | 50 max./0 max. | | | |
| | (93.5°C) | 50 max./0 max. | | | |
| | (24°C after 93.5°C) | 50 max./0 max. | | | |
| Seal Compatibility Test (NBR[3)], 100°C, 240 hrs) | Hardness change[2)] | -40 - +10 | | | |
| | Change in Volume, % | -5 - +70. | | | |
| | Change in Elongation, % | -60 - +20 | | | |
| | Change in Tensile strength, % | -65 - +20 | | | |

1) Report the test results.
2) Use Type-A Durometer.
3) For the specimen NBR, use low-acrylonitrile SRE-NBR/L per ISO 13226.
4) For the specimen HNBR, use the material described in Table 3.
5) For the specimen AU, use the material described in Table 3.
6) Evaluation for the friction characteristics shall be conducted by either one of the Micro-clutch Test in accordance with JCMAS P047, or a test using the SAE No.2 Friction Test Machine (at 800 rpm).

Table 2 Classification of biodegradable hydraulic fluids for construction machinery (Continued)

| Test items | | | Normal temperature use | | Low temperature use | |
|---|---|---|---|---|---|---|
| | | | VG32 | VG46 | VG32L | VG46L |
| Elastomer Compatibility Test (HNBR[4], 100°C, 240 hrs) | | Hardness Change[2] | -8 - +8 | | | |
| | | Change in Volume, % | -5 - +15. | | | |
| | | Change in Elongation, % | -15 - +20 | | | |
| | | Change in Tensile strength, % | -15 - +20 | | | |
| Elastomer Compatibility Test (AU[5], 100°C, 240 hrs) | | Hardness Change[3] | Report[1] | | | |
| | | Change in Volume, % | Report[1] | | | |
| | | Change in Elongation, % | Report[1] | | | |
| | | Change in Tensile strength, % | Report[1] | | | |
| FZG Gear Test, Failure Load Stage | | | 8 min. | | | |
| Vane Pump Test (Model 104C, 250 hrs) | | Ring wear, mg | 120 max. | | | |
| | | Vane wear, mg | 30 max. | | | |
| Service Life Evaluation with Model A2F10 Pump (500 hrs) | | Viscosity change (40°C), % | 10 max. | | | |
| | | AN increase, mgKOH/g | 2.0 max. | | | |
| | | Contaminants (0.8μm), mg/100 ml | 10 max. | | | |
| | | Oil-layer Cu-content increase, mass ppm | Report[1] | | | |
| Hydrolytic Stability | | Copper weight loss, mg/cm$^2$ | Report[1] | | | |
| | | Copper Appearance | Report[1] | | | |
| | | AN increase in oil layer, mgKOH/g | Report[1] | | | |
| Load-carrying Capacity (Shell 4 Ball), Weld-load, N | | | 1 235 min. | | | |
| Anti-wear Test (Shell 4 Ball) (294 N, 1,200 min$^{-1}$, 60 min., 75°C), Wear Diameter, mm | | | 0.6 max. | | | |
| Friction Characteristics[6] | | Micro-clutch test, μ | 0.05 min. | | | |
| | | SAE No.2 Friction Test Machine, (1,000 cycles), μs | 0.07 min. | | | |
| Environmental Criteria | | Biodegradability (28 Days) | shall meet the criteria specified in **5.22** | | | |
| | | Acute Toxicity (96 hrs, $LC_{50}$ Value) | shall meet the criteria specified in **5.22** | | | |

1) Report the test results.
2) Use Type-A Durometer.
3) For the specimen NBR, use low-acrylonitrile SRE-NBR/L per ISO 13226.
4) For the specimen HNBR, use the material specified in Table 3.
5) For the specimen AU, use the material specified in Table 3.
6) Evaluation for the friction characteristics shall be conducted by either one of the Micro-clutch Test in accordance with JCMAS P047, or a test using the SAE No.2 Friction Test Machine (at 800 rpm).

Table 3 Elastomer Characteristics

| | Items | HNBR (G361) | AU (U801) |
|---|---|---|---|
| Requirements | Hardness rating, by Type-A Durometer | 75 - 85 | 88 - 98 |
| | Tensile strength, MPa | 28.3 min. | 29.4 min. |
| | Elongation, % | 260 min. | 300 min. |

**5. Testi methods:**

**5.1 Method of sampling**

Sampling of the fluid for inspection shall be performed in accordance with **JIS K 2251**.

**5.2 Viscosity classification:**

Viscosity classification and designation shall be established in accordance with **JIS K 2001**.

**5.3 Density:**

Density shall be determined in accordance with the method specified in **JIS K 2249**.

**5.4 Color:**

Color shall be determined in accordance with the method specified in **JIS K 2580**.

**5.5 Flash point:**

Flash point shall be determined in accordance with the method specified in **JIS K 2265**.

**5.6 Kinematic viscosity and viscosity index:**

Kinematic viscosity and viscosity index shall be determined in accordance with the method specified in **JIS K 2283**.

**5.7 Low temperature viscosity:**

Low temperature viscosity shall be determined in accordance with the method specified in **JPI-5S-26-90** (Brookfield Viscometer Method).

**5.8 Pour point:**

Pour point shall be determined in accordance with the method specified in **JIS K 2269**.

**5.9 Total Acid Number:**

The TAN AN shall be determined in accordance with the method specified in **JIS K 2501**.

**5.10 Moisture:**

Water content shall be determined in accordance with the method specified in **JIS K 2275** (Karl Fischer Method).

**5.11 Copper corrosion:**

Copper corrosion shall be determined in accordance with the method specified in **JIS K 2513**.

**5.12 Rust-preventing characteristics:**

The rust-preventing characteristics shall be determined in accordance with the method specified in **JIS K 2510**.

**5.13 Foaming:**

Foaming characteristics shall be determined in accordance with the method specified in **JIS K 2518**.

**5.14 Seal compatibility test:**

The seal compatibility test shall be conducted in accordance with **JIS K 6258** and the results shall be evaluated in accordance with **JIS K 6251** for tensile strength and **JIS K 6253** for hardness.

**5.15 FZG gear test:**

The FZG gear test shall be conducted in accordance with either **DIN 51354-2** or **ASTM D5182**.

**5.16 Vane pump test:**

The Model 104C vane pump test shall be conducted in accordance with either **IP-281** or **ASTM D7043**

**5.17 Service life evaluation:**

The service life evaluation shall be conducted in accordance with **JCMAS P045** high-pressure piton pump test

**5.18 Hydrolytic stability:**

Hydrolytic stability shall be tested in accordance with the method specified in **ASTM D2619**.

**5.19 Load carrying capacity test:**

The load carrying capacity test shall be conducted in accordance with **JPI-5S-40** (Shell 4-Ball Method).

**5.20 Anti-wear property test:**

The anti-wear property test shall be conducted in accordance with **JPI-5S-32** (Shell 4-Ball Method).

**5.21 Friction characteristics:**

Friction characteristics shall be determined in accordance with the method specified in **JCMAS P047**.

**5.22 Environmental criteria:**

The environmental criteria shall be examined in accordance with Section 4-1 of the Eco Mark Product Category No.110 “Biodegradable Lubricating Oil” (Version 2.0) as specified by the Japan Environment Association – Eco Mark Office.

# Annex (Informative)
# Explanatory note on JCMAS P042 Biodegradable hydraulic fluids for construction machinery

This explanatory note, which does not form a part of this JCMAS, elaborates on the main body of the Standard and matters specified or described therein, as well as items of reference and other matters related thereto.

**1. Purpose of establishing this standard:**

While presently a number of biodegradable hydraulic fluids have been developed and marketed in response to an increasing demand for hydraulic fluids that will present less environmental risks in the event of spillage into the nature, in line with heightened awareness for environmental protection, no standard so far has been developed to define and specify such products in an integrated manner.

When used in places where attention on environmental impact is required for reasons such as preservation of biodiversity, since biodegradable hydraulic fluids could be gradually decomposed by microorganisms existing naturally in the environment, they can help minimize the environmental burden due to oil contamination in the event of accidental leakage or spillage of hydraulic fluid into the environment during work involving construction machinery.

While various performance standards specifying hydraulic fluids for a general range of hydraulic equipment have been developed by international organizations such as ISO, and widely implemented as generic hydraulic fluids, it is well known that the hydraulic systems employed in construction machinery tend to expose hydraulic fluids to much more severe load than other, general type hydraulic equipment, as exemplified in hydraulic excavators where the frequent intermittent operations in addition to high operating pressures and temperatures are causing moisture in the air to condensate inside the reservoir and increasing the risk of water ingress into hydraulic fluids. This Standard has been developed in response to the strong needs arising from the above-mentioned circumstances that call for a performance standard defining and specifying biodegradable hydraulic fluids for construction machinery.

This Standard is developed based on the framework of ISO 15380 which has already been in place to govern biodegradable hydraulic fluids for industrial use, while paying attention to maintaining consistency with standards specifying mineral-based hydraulic fluids for construction machinery. Further, quality levels of commercially available biodegradable hydraulic fluids with proven performance in construction machinery have also been referenced.

Since the performance requirements for construction machinery vary widely by types and designs of the machinery, as well as by operating conditions, the application of this Standard to individual construction machinery should be discussed between the respective hydraulic fluid supplier and the machinery manufacturer or, if necessary, the supplier of the hydraulic equipment of interest.

**2. History of establishment of this standard:**

The draft for this Standard was prepared by the Equipment Engineering Committee - Fuels and Lubricants Subcommittee (Biodegradable Hydraulic Fluid Task Force) of the Japan Construction Mechanization Association

(JCMA), and after the review and approval by the Standard Committee - Domestic Standard Subcommittee, was posted for public comment under the WTO Agreement on Technical Barriers to Trade (TBT) prior to establishment as a JCMAS.

**3. Issues discussed during the deliberation:**

**3.1 Moisture specification:**

Although considerable discussions were held concerning pros and cons of incorporating the water content, which is considered a part of manufacturing process parameters, into this Standard specifying basically the finished product performance, it has been decided to adopt this item because it is empirically known that there is a correlation between water content and service life of hydraulic equipment or of hydraulic fluid itself, and also because the ISO standard mentioned above includes a similar specification in it. However, since some of the biodegradable hydraulic fluids are prone to absorbing moisture in the air owing to the characteristics of their components, and it is difficult to define quality at the time of manufacture and shipping only by the provisions of JIS K 2251, application of this item is restricted to a product before breaking the container seal for the purpose of accurate interpretation of the provision.

**3.2 Cleanliness:**

Cleanliness of a hydraulic fluid at the time of make-up should desirably be maintained at a contamination level of 17/14 or below according to ISO Cleanliness Code 4406, or a Cleanliness Class 8 or below for particle size of 15μm or larger according to NAS 1638.

While there has been an opinion suggesting that the above point be incorporated into the main body of the Standard, since this Standard is meant to specify the performance of a fresh hydraulic fluid and also it is difficult to incorporate the requirement as a specification when the effect of distribution and handling after manufacture of a fresh fluid is taken into consideration, it has been decided to just mention it in this explanatory note.

**4. Scope:**

This Standard applies to biodegradable hydraulic fluids for construction machinery.

**5. Supplementary notes on items specified in this Standard:**

Since the main part of this Standard has been developed drawing upon quality levels of biodegradable hydraulic fluids that are currently available in the Japanese market with proven performance, some of the provisions herein are not consistent with those specified in ISO 15380. In addition, periodic amendments are required to establish consistency between this Standard and the standards to be developed in the future to cover mineral-based hydraulic fluids for construction machinery. The following sections deal with such considerations and the differences between the provisions of this Standard and those in ISO 15380.

**5.1 The symbols in the Table 2 of the Standard (Viscosity classification):**

Hydraulic fluids formulated with mineral base oils manufactured through typical refining process have a viscosity index of around 100, which is insufficient to provide adequate viscosity characteristics for application with a wide temperature range. To make up for this deficit, base oils are made with higher degrees of refining such as hydro-treating and additives are used to improve viscosity index, and hydraulic fluids formulated with such materials are designated with a suffix “W” to indicate their wide-temperature application capability.

By contrast, a typical biodegradable hydraulic fluid has a high viscosity index by itself, which makes it possible to

qualify for the viscosity characteristics of a mineral-based hydraulic fluid designated with a suffix “W”. However, some biodegradable hydraulic fluids comprising vegetable oils which can offer cost advantages tend to have relatively high pour points. To regulate the physical properties at low temperatures at too stringent levels seemed to run a risk of excluding such vegetable oil based products and thereby obstructing diffusion and promotion of biodegradable hydraulic fluids into the market.

For the above reasons, it has been decided to use a suffix “L” indicating that the difference exists only in low temperature properties, and to avoid the use of the suffix “W” to be adopted in the standard for mineral-based hydraulic fluids.

**5.2 Table 2 of the Standard (Density, Color, TAN AN, Moisture, Hydrolytic stability):**

The five items mentioned above have been adopted from ISO 15380 as specified therein. Inclusion of these items was considered important to establish a standard for biodegradable hydraulic fluids that is consistent with the ISO standard, and to cover a wide variety of biodegradable base stocks having completely different characteristics than mineral base oils.

**5.3 Shear stability test:**

The above item has not been adopted in this Standard since the object of the test is to determine the performance of viscosity index improvers, which are used in a mineral-based hydraulic fluid but not in a typical biodegradable hydraulic fluid, and also the item is not included in the specifications of ISO 15380.

**5.4 Aniline point and filterability:**

The above items have not been adopted in this Standard since they are not included in the specifications of ISO 15380, and also it could be difficult to accurately measure these items depending on the characteristics of base materials.

**5.5 Oxidation stability (JIS K 2514):**

The above item has not been adopted in this Standard since it is not included in the specifications of ISO 15380, and also the required property can be determined with the test for indicating oxidation stability in high pressure piston pump (see JCMAS P045).

**5.6 Ash, Appearance, Low-temperature fluidity after 7-days, Air release, and Water separation:**

The above five items included in ISO 15380 have not been adopted in this Standard based on the drafting committee decision that these are not critical to hydraulic fluids for construction machinery.

**5.7 Oxidation stability, Baader test:**

The above two items included in ISO 15380 have not been adopted in this Standard because the required property can be determined with the test for indicating oxidation stability in high pressure piston pump (see JCMAS P045).

**6. Issues at hand:**

Nothing to state in particular.

**7. Issues concerning the normative references:**

Nothing to state in particular.

**8. Issues concerning patent and intellectual properties:**

Nothing to state in particular.

**9. Other issues:**

Nothing to state in particular.

**10. Composition of the Drafting Committees:**

Listed as follows are members who compose the Drafting Committee and the Reviewing Committee related to this Standard:

**Reviewing Committee (Domestic Standardization Committee)**

| Responsibility | Name | Organization/Position |
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| | Takashi Inagaki | Ministry of Land, Infrastructure & Transport |
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