JCMAS

Hydraulic fluids for construction machinery

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Forward

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Japan Construction Mechanization Association Standard

JCMAS P 041 : 2004

Hydraulic fluids for construction machinery

1 Scope

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

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

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

JIS K 2256, *Petroleum products – Determination of aniline point and mixed aniline point*

NOTE Relevant International Standard: **ISO 2977** (Modified)

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

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 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 2514, *Testing Methods for Oxidation Stability of Lubricating Oils*

NOTE Relevant International Standards: **ISO 4263** (Modified)

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

NOTE Relevant International Standards: **ISO 6247** (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 11158:1997, *Lubricants, industrial oils and related products (class L) – Family H (hydraulic systems) – Specifications for categories HH, HL, HM, HR, HV and HG*

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

ISO 20763:2004, *Petroleum and related products – Determination of anti-wear properties of hydraulic fluids – Vane pump method*

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

JPI-5S-29, *Test Methods for Shear Stability of Polymer-Containing 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)*

ASTM D6973:2003**,** *Standard test method for indicating wear characteristics of petroleum hydraulic fluids in a high pressure constant volume vane pump*

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

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

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

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

JCMAS P043, *Hydraulic fluid for construction machinery -- Test method for filterability*

JCMAS P044, *Hydraulic fluid for construction machinery -- Evaluation method for indicating lubrication property in high pressure piston pump*

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

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

Table 1 Classification of hydraulic fluids for construction machinery

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

4 Performance criteria

Hydraulic fluids for construction machinery shall meet the performance criteria established in Table 2 when tested in accordance with the testing methods specified in **Clause 5**. In addition, no toxic substance that may give adverse effects to the environment shall be used in the manufacture of such products.

Table 2 Classification of hydraulic fluids for construction machinery

Test items		Type			
		Normal temperature use		Low temperature use	
		Viscosity Classification			
		VG32	VG46	VG32L	VG46L
Kinematic Viscosity, mm^2/s		(40°C)	28.8 min. 35.2 max.	41.4 min. 50.6 max.	28.8 min. 35.2 max.
Flash Point, °C		Report[1)]			
Kinematic Viscosity, mm^2/s	(40°C)	28.8 min. 35.2 max.	41.4 min. 50.6 max.	28.8 min. 35.2 max.	41.4 min. 50.6 max.
	(100°C)	5.0 min.	6.1 min.	5.3 min.	6.8 min.
Viscosity Index		90 min.	90 min.	120 min.	120 min.
Pour Point, °C		-17.5 max.	-15 max.	-40 max.	-30 max.
Low Temperature Viscosity, mPas	(-20°C)	-	-	-	5,000 max.
	(-25°C)			5,000 max.	-
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.			
Shear Stability, Viscosity Loss (100°C), %		-		10 max.	
Oxidation Stability (95°C, 1,000 hrs), TAN Increase, mgKOH/g		1.0 max.			
Rust-preventing characteristics (synthetic sea water, 24 hrs)		No rust to be identified			
Seal Compatibility (NBR[4)], 100°C, 240 hrs)	Hardness change[3)]	-25 max.			
	Change in Tensile strength, %	-50 max.			
	Change in Elongation, %	-50 max.			
	Change in Volume, %	0 - +30			
Seal Compatibility (AU[5)], 120°C, 240 hrs)	Hardness change[3)]	-5 - +5			
	Change in Tensile strength, %	-30 max.			
	Change in Elongation, %	-30 max.			
	Change in Volume, %	-5 - +5			

1) Report the test results.
2) A value expressed in mm^2/s is numerically equal to that in cSt.
3) Use Type-A Durometer.
4) Use low-acrylonitrile elastomer SRE-NBR/L per ISO 13226 for specimen.
5) For the specimen polyester urethane, use the AU described in Table 3 or equivalent.

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

Test items			Normal temperature use		Low temperature use	
			VG32	VG46	VG32L	VG46L
Aniline Point, °C			90 min.			
Filterability Test, min.		1st run	25 max.			
		2nd run	30 max.			
Copper Corrosion (100°C, 3 hrs)			1 max.			
Load-carrying Capacity (Shell FourBall), Weld load, N			1,235 min.			
Anti-wear Test (Shell Four-Ball), (294 N, 1,200 min^{-1}, 60 min., 75°C), Wear Scar Diameter, mm			0.6 max.			
FZG Gear Test, Failure Load Stage			8 min.			
High-pressure Piston Pump Test[6)]	Lubricity Evaluation with Model HPV35+35 Pump (34.3 MPa, 2,100 min^{-1}, 95°C, 500 hrs)		For all changes to evaluation items)the discharge flow rates, components wear, and changes in the hydraulic fluid characteristics,) the test results shall be within the specified criteria.			
	Service Life Evaluation with Model A2F Pump (34.3 MPa, 2,100 min^{-1}, 80°C, 500 hrs)	Viscosity Change (40 °C), %				10 max.
		TAN Increase, mgKOH/g				2.0 max.
		Contaminants (0.8μm), mg/100 ml				10 max.
Vane Pump Test[7)]	Lubricity Evaluation with Model 35VQ25 Pump (20.79 MPa, 2,400 min^{-1}, 93°C, 150 hrs), wear, mg		Ring: 75 max. Vane: 15 max			
	Lubricity Evaluation with Model 104C Pump (13.7 MPa, 1,200 min^{-1}, 66°C, 100 hrs), wear, mg		Ring and vane total: 50 max.			
Friction Characteristics[8)]	Micro-clutch Test, μ		0.08 min.			
	SAE No.2 Friction Test Machine, (1,000 cycles), μs		0.07 min.			

1) Report the test results.
2) A value expressed in mm^2/s is numerically equal to that in cSt.
3) Use Type-A Durometer.
4) Use low-acrylonitrile elastomer SRE-NBR/L per ISO 13226 for specimen.
5) For the specimen polyester urethane, use the AU described in Table 3 or equivalent.

Table 3 Elastomer Characteristics

Requirements	Items	AU (U801)
	Hardness rating, Type-A Durometer	88 - 98
	Tensile strength, MPa	29.4 min.
	Elongation, %	300 min.

6) Evaluation with a high-pressure piston pump shall be conducted by either one of the Model HPV35+35 Pump Test according to JCMAS P044, or the Model A2F Pump Test in accordance with JCMAS P045.
7) Evaluation with a vane pump shall be conducted by either one of the Model 104C Pump Test in accordance with ASTM D7043 (or ISO 20763), or the Model 35VQ25 Pump Test in accordance with ASTM D6973.
8) Evaluation of 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). In addition, the test fluid is required to exhibit adequate anti-squeak function for the hydraulic cylinder operation regardless of the provisions for frictional characteristics.

5. Test methods:

5.1 Method of sampling:

Sampling shall be performed in accordance with the method specified in JIS K 2251.

5.2 Viscosity classification:

Viscosity classification and designation shall be established in accordance with JIS K 2001. Note, however, that the viscosity designation with a suffix "W" for low temperature application is established as a proprietary system unique to this Standard.

5.3 Flash point:

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

5.4 Kinematic viscosity and viscosity index:

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

5.5 Pour point:

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

5.6 Low temperature viscosity:

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

5.7 Foaming:

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

5.8 Shear stability:

Shear stability shall be determined in accordance with the method specified in JPI-5S-29.

5.9 Oxidation stability:

Oxidation stability shall be determined in accordance with the method specified in JIS K 2514, Section 5.

5.10 Rust-preventing characteristics:

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

5.11 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.

5.12 Aniline point:

Aniline point shall be determined in accordance with the method specified in JIS K 2256.

5.13 Filterability:

Filterability shall be determined in accordance with the method specified in JCMAS P043.

5.14 Copper corrosion:

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

5.15 Load carrying capacity test:

Load carrying capacity test shall be conducted in accordance with JPI-5S-40 (Shell Four-Ball Method).

5.16 Anti-wear property test:

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

5.17 FZG Gear test:

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

5.18 High-pressure piston pump test for lubricity evaluation:

The high-pressure piston pump test for lubricity evaluation shall be conducted in accordance with JCMAS P044.

5.19 High-pressure piston pump test for service life evaluation:

The high-pressure piston pump test for service life evaluation shall be conducted in accordance with JCMAS P045.

5.20 Model 35VQ25 vane pump test:

The Model 35VQ25 vane pump test shall be conducted in accordance with ASTM D6973.

5.21 Model 104C vane pump test:

The Model 104C vane pump test shall be conducted in accordance with either ASTM D7043 or ISO 20763.

5.22 Friction characteristics:

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

Annex (Informative)
Explanatory note on JCMAS P041 Hydraulic fluids for construction machinery

This explanatory note, which does not form a part of this Standard, 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 the Standard:

The operating pressure for hydraulic systems employed in construction machinery is becoming higher and higher in recent years, frequently exceeding 34.3 MPa in today's construction machinery. Upon establishing this Standard, , adoption of ISO 11158 had been considered, which already is in force.It transpired that the said standard specified a vane pump test evaluated at a pressure of only 13.7 MPa, and that hydraulic fluids specified in the standard would not possess sufficient performance for use in today's construction machinery. As a result, this Standard has been established to define hydraulic fluids that satisfy the minimum required performance to withstand operating conditions of a hydraulic pressure of 34.3 MPa and an operating temperature of 100°C. The hydraulic fluids specified in this Standard consist of four grades, i.e. two viscosity grades for each of normal-temperature use and low-temperature use categories as classified according to their low-temperature characteristics. Hydraulic fluids conforming to this Standard shall possess general properties, oxidation stability, rust-preventing characteristics, and seal compatibility, which are all considered necessary for hydraulic fluids for construction machinery, and are further approved (or: tested) for performance by high-pressure piston pump tests and vane pump tests for service life and lubricity, as well as by means of friction characteristics tests.

However, since the operational requirements for construction machinery vary widely by type, design, and the machinery make, this Standard can by no means satisfy all of the specifications for hydraulic fluids for factory fill use and after-market service use as required by the member companies of the Japan Construction Mechanization Association (JCMA). Accordingly, it is necessary for the users to enquire and confirm these with the individual manufacturer of the machinery of interest upon employment of this Standard.

2. History of establishment of the Standard:

The draft for this Standard was prepared by the Equipment Engineering Committee - Fuels and Lubricants Subcommittee of the 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 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, it has been decided to just mention it in this explanatory note. 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.

3.2 Fatigue damage tests for rolling bearings:

As a testing method for determining the performance of a hydraulic fluid in preventing fatigue damage of rolling-element bearings used in hydraulic pumps, a Unisteel Rolling Bearing Test has been proposed. However, since a concern was raised as to the reliability of the test, making it difficult to qualify the test to be included in this Standard, it has been decided to describe an outline of the proposed test and discuss the test results in this explanatory note as given below:

3.2.1 Unisteel Rolling Bearing Test:

This test method is designed to evaluate the effect of lubricating oil on rolling fatigue by using a thrust bearing. While it had been established as IP-305/79 by the Institute of Petroleum (reorganized in 2003 into the Energy Institute), the standard was later discontinued.

As illustrated in the Explanatory Figure 1, the test rig is configured on a ball thrust bearing unit from which one of the raceway rings is removed and replaced with a flat test piece. The test is conducted at a constant rotating speed under a constant axial load applied from the top, and the time for the balls and the test piece to develop fatigue damage is measured. The particulars of the rig and the test conditions are as given in the Explanatory Table 1.

Explanatory Table 2 Results of Unisteel Rolling Bearing Test

Sample Type	Test No.	Time-to-fatigue damage, hrs	Test Piece Damages	Ball Damage
Reference Fluid (A)	1	4.7	No	Yes
	2	36.2	No	Yes
	3	38.8	No	Yes
	4	53.1	Yes	No
	5	60.6	No	Yes
	6	83.5	Yes	No
	Median life	47.43	-	-
Inferior Fluid (B)	1	3.5	Yes	Yes
	2	15.5	No	Yes
	3	22.3	No	Yes
	4	64.7	No	Yes
	5	67.9	No	Yes
	6	69.0	No	Yes
	Median life	37.90	-	-
Test Fluid (C)	1	4.4	No	Yes
	2	33.1	No	Yes
	3	42.3	No	Yes
	4	51.6	Yes	No
	5	58.9	No	Yes
	6	81.3	Yes	No
	Median life	46.44	-	-

4. Scope:

This Standard applies to hydraulic fluids for construction machinery.

5. Supplementary notes on items specified in this Standard:

5.1 The symbols in the Table 1 of the Standard (Viscosity classification):

The viscosity grades in this Standard have been specified basically in accordance with the ISO viscosity classification system, while for the low temperature viscosity specifications, adoption of either ASTM D6080:2002 "Standard Practice for Defining the Viscosity Characteristics of Hydraulic Fluids", or ISO 11158:1997 "Lubricants, industrial oils and related products (class L) – Family H (hydraulic fluid) – Specifications for categories HH, HL, HM, HR, HV and HG" was considered. However, a survey conducted on 13 commercially marketed products that have a proven record of satisfactory performance as hydraulic fluids for construction machinery in the domestic market, has indicated that the establishment of original criteria is required for viscosity index and low temperature viscosities, resulting in the establishment of the proprietary viscosity grades with a suffix "W". The Explanatory Table 3 given below illustrates an example of a recommendation chart for proper application of viscosity grades according to ambient temperatures for hydraulic fluids for use in construction machinery including biodegradable hydraulic fluids. Note, however, that the temperature ranges shown in the example are slightly different from the ones specified in this Standard and, in any event, recommendations by the individual construction machinery makers must be followed for actual usage in the field.

Explanatory Table 3 Recommendation Chart for Usage of Hydraulic Fluids for Construction Machinery (Example)

Application
Type of Fluid and Symbols
Ambient Temperature
Hydraulic systems
Hydraulic fluid
Biodegradable hydraulic fluid

5.2 Load carrying capacity test, anti-wear property test, and FZG gear test in the Table 2 of the Standard:

In a meeting between the Japan Fluid Power Association (JFPA) and JCMA to exchange views concerning this Standard, it was suggested that the Standard adopt a load carrying property evaluation and an anti-wear property evaluation based on the Shell Four-Ball tests, as well as an anti-wear property evaluation based on the FZG gear test to guarantee satisfactory performance of the hydraulic fluids specified in this Standard against various pump designs. It has also been pointed out that, of the two methods specified for the high-pressure piston pump test, the A2F piston pump test has no evaluation requirement specified with regard to component wear (i.e. lubricity evaluation), and furthermore, of the two methods specified for the vane pump test, the 104C vane pump test may not be competent enough to evaluate lubricity since its operating pressure is considerably lower than the 35VQ25 vane pump test.

In consideration of the above suggestions, therefore, it has been decided to adopt a load carrying property test (Shell Four-Ball method), an anti-wear property test (Shell Four-Ball method), and FZG gear test as supplementary measures to guarantee performance of the hydraulic fluids specified in this Standard against various pump designs. With the above actions, it has been decided to allow the users to adopt either of the two tests specified for both the high-pressure piston pump test and the vane pump test.

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
Chairman	Hideo Ohashi	Academic expert
Members	Shoichi Takahashi	Ministry of Health, Labor & Welfare
	Yuji Nagahama	Ministry of Economy, Trade & Industry
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	Tadaaki Nishigaya	Construction Method & Machinery Research Institute
	Yoshihiro Tonomura	Nishio Rent All Co., Ltd.
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