

JCMAS

Hydraulic Fluids for Construction Machinery —Test Method for Friction Characteristics

**JCMAS P 047: 2025
(Second Revised Edition)**

(English version of JCMAS P047:2025 second revised edition)

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Japan Construction Machinery and Construction Association

Forward

This Japan Construction Machinery and Construction Association Standard (hereafter “JCMAS”) was prepared by Drafting Committee (Oil Technical Subcommittee) and Domestic Standards Committee of Japan Construction Machinery and Construction Association (hereafter “JCMA”) and has been published by Chairman of JCMA.

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The first edition:

- The draft was approved on 2004-02-20 by JCMA Domestic Standards Committee
- Invitation for submission of comments on the draft JCMAS according to WTO/TBT agreement "Code of good practice" was made from 2004-07-15 to 2004-09-15.
- The established date of the first edition: 2004-09-30

Correction: Issued on 2010-11-30

Correction: Issued in October, 2016

The second revision:

- The draft was approved on 2025-04-18 by JCMA Domestic Standards Committee
- Invitation for submission of comments on the draft JCMAS according to WTO/TBT agreement "Code of good practice" was made from 2025-05-01 to 2025-0629..
- The established date of the second revision : 2025-07-10

NOTE: This English version is the translation of the second revision(2025-07-10).

Hydraulic Fluids for Construction Machinery — Test Method for Friction Characteristics

1 Scope

This standard specifies test methods for evaluating friction property of hydraulic fluids for construction machinery.

2 Normative references

The following referenced documents are indispensable for the application of this document. The latest edition of the referenced document (including any amendments) applies

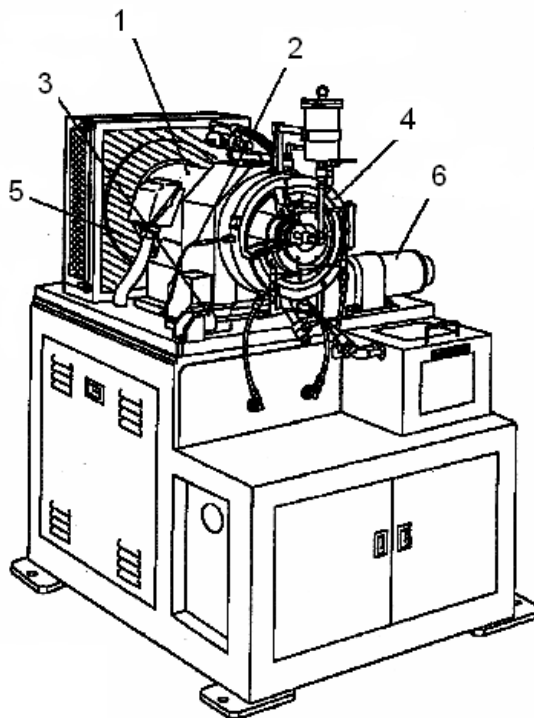
JASO M 348 *Friction characteristics test method for automatic transmission fluids*

SAE J286 *SAE No.2 Clutch friction test machine guidelines*

3 Friction test method using SAE No.2 friction test machine:

3.1 Test machine:

An SAE No.2 friction test machine shall be used in accordance with SAE J286 (see Figures 1 and 2).

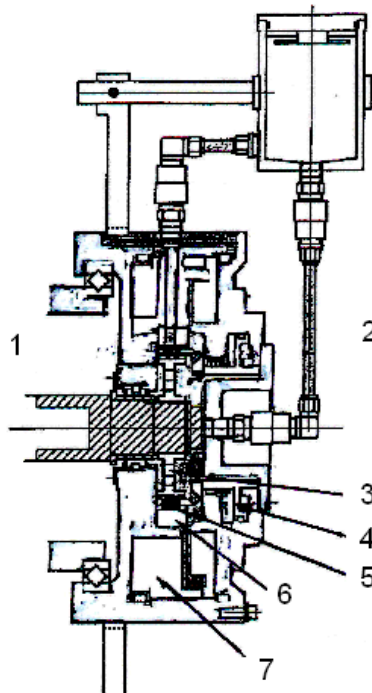


Key

- 1 Motor for dynamic friction tests
- 2 Thermocouple for oil temperature measurement
- 3 Load cell for friction force measurement
- 4 Test oil sump
- 5 Inertia disc (Flywheel)
- 6 Motor for static friction tests

Figure 1

SAE No.2 Friction test machine (Example)



Key

- 1 Spacer side
- 2 Piston side
- 3 Plate holder (Shaft side)
- 4 Pressure applying piston
- 5 Test plate
- 6 Plate holder (Casing side)
- 7 Test oil sump

Figure 2

Sectional view of friction head assembly (Example)

3.2 Friction components for the test:

Friction plates and steel clutch plates for this test shall be prepared in accordance with Table 1 as follows:

Table 1 Friction components for SAE No.2 Friction test machine

Friction Plate	Dimensions	Thickness: 2.05 mm, OD: 126.7 mm, ID: 102 mm
	Item No.	FZ127-24-Y12 per JASO M 348
	Number of pieces used	3

Steel Plate	Dimensions	Thickness: 1.8 mm, OD: 127.3 mm, ID: 102.2 mm
	Item No.	FZ132-8-Y2 per JASO M 348
	Number of pieces used	4

3.3 Test conditions

The testing shall be conducted in accordance with JASO M 348 except for the conditions specified in Tables 2 and 3.

Table 2 Dynamic friction test conditions

No.	Items		Conditions
1	Flywheel moment of inertia	kg·m ²	0.343
2	Test speed	min ⁻¹	800 +/- 50
	Time to attain target speed	s	8 +/- 2
3	Oil temperature	°C	100 +/- 5
4	Friction plate pressure	kPa	785
5	Test cycle time	s/cycle	30 (Motor ON/OFF time = 15/15)
6	Time to attain piston apply pressure	s	0.10 ~ 0.15
7	Piston apply pressure holding time	s	2
8	Test duration	cycles	1000

Table 3 Static friction test conditions

No.	Items		Conditions
1	Test speed	min ⁻¹	0.7
	Time to attain required speed	s	0.4 +/- 0.1
2	Oil temperature	°C	100 +/- 5
3	Friction plate pressure	kPa	785
4	Timing of test commencement		Clutch engagement to be commenced after completion of the dynamic traction test for prescribed cycles and upon the stabilization of oil temperature (approx. 60 s).
5	Test cycles for measurements		At 1, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 cycles, and every 100 cycles thereafter until 1000 cycles

3.4 Testing procedure

Testing shall be conducted in accordance with JASO M 348.

3.5 Calculation of friction coefficients

3.5.1 Friction coefficients

Friction coefficients are calculated from results of dynamic and static friction tests using the following equation, with the results being rounded off in accordance with JIS Z 8401:

$$\mu = \frac{T}{2 \times 3^{(1)} \times 57.4^{(2)} \times 785^{(3)} \times 4434^{(4)}} \quad (1)$$

Where,

μ : Friction coefficient

T : Torque

NOTE	1)	Number of friction plates
	2)	Mean effective friction radius, in mm
	3)	Pressure applied by piston to the surface of the friction plate, in kPa
	4)	Friction area of the friction plate, in mm ²

3.5.2 Dynamic friction coefficient, μ_d

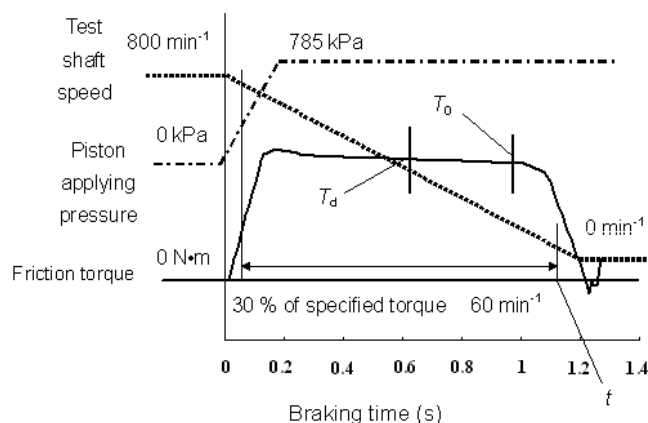
In the dynamic friction test, a dynamic friction coefficient μ_d is derived from frictional torque T_d as shown in Figure 3 and Eq. (1), whereas a dynamic friction coefficient μ_0 is calculated from the maximum frictional torque T_0 under a speed of less than 200 min⁻¹ as shown in Figure 3 and Eq. (1).

3.5.3 Static friction coefficient, μ_s

In the static friction test, a static friction coefficient μ_s is derived from the stable torque T_s obtained 2 seconds after the engagement as shown in Figure 4 and Eq. (1), whereas a static friction coefficient μ_s is calculated from the peak torque T_s after the engagement as shown in Figure 4 and Eq. (1).

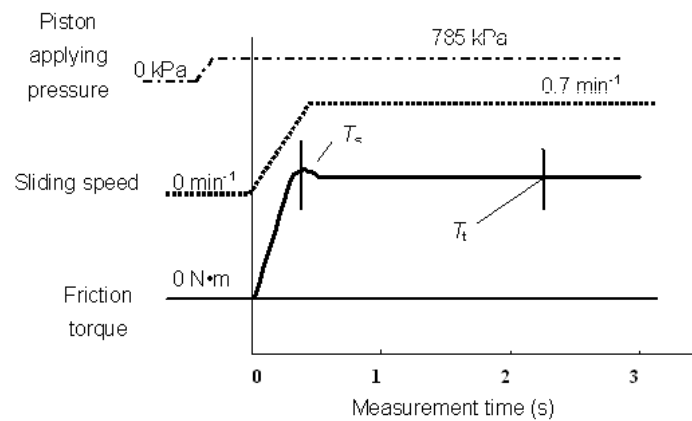
3.5.4 Braking time, t

Braking time t is defined as the time elapsed from the point at which 30% of the specified piston apply pressure (785 kPa) is attained to the point when the shaft speed decelerates to 60 min⁻¹ as shown in Figure 3.



T_0	Maximum torque under a speed of less than 200 min ⁻¹ immediately before the stoppage of the friction plate
T_d	Dynamic friction torque 500 min ⁻¹
t	Braking time at the test

Figure 3 Dynamic friction test (An example of measurement)



T_s Maximum torque immediately after the engagement

T_t Torque at 2 seconds after the engagement)

Figure 4 Static friction test (An example of measurement)

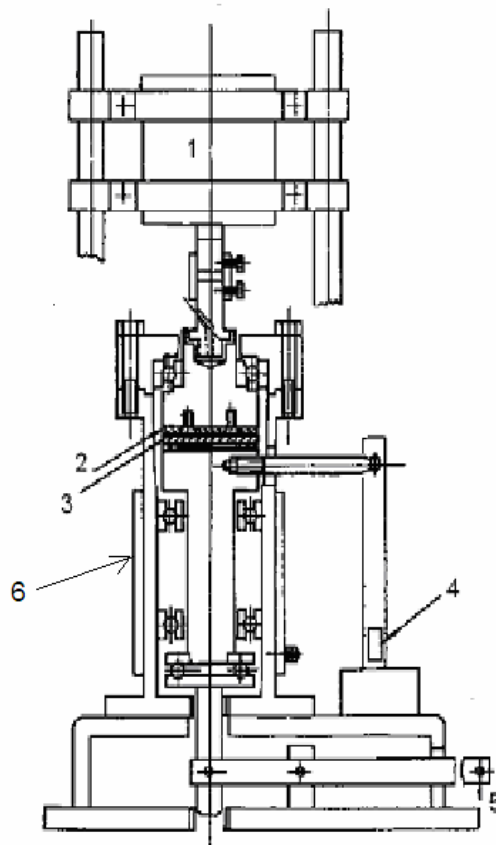
3.6 Reporting:

Report the test results in accordance with JASO M 348 based on the test result report form described therein.

4 Friction test procedure using a micro clutch test rig

4.1 Apparatus

A schematic of a micro clutch test rig for this friction test is shown in Figure 5.



Key

- 1 DC motor
- 2 Clutch disc
- 3 Plate
- 4 Strain gauge
- 5 Load
- 6 Heater

Figure 5 Micro clutch test rig

4.2 Friction components for the test

Friction plates and clutch discs for this test shall be prepared in accordance with Table 4 below:

Table 4 Friction components for SAE No.2 Friction test machine

Clutch disc	Dimensions	As per Figure 6 (a)	As per Figure 6 (b)
	Facing material	SD1795-S	NW-461E
	Back-plate material	SS400	
Friction Plate	Dimensions	As per Figure 7	
	Material	SS400	
Test fluid quantity		20 ml	

Unit mm

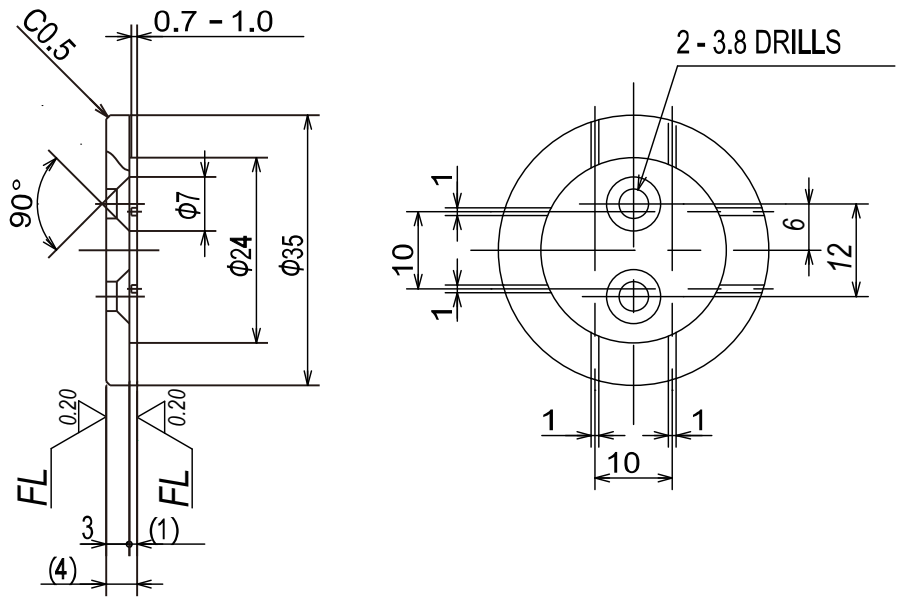


Figure 6 (a) Clutch disc (SD1795-S)

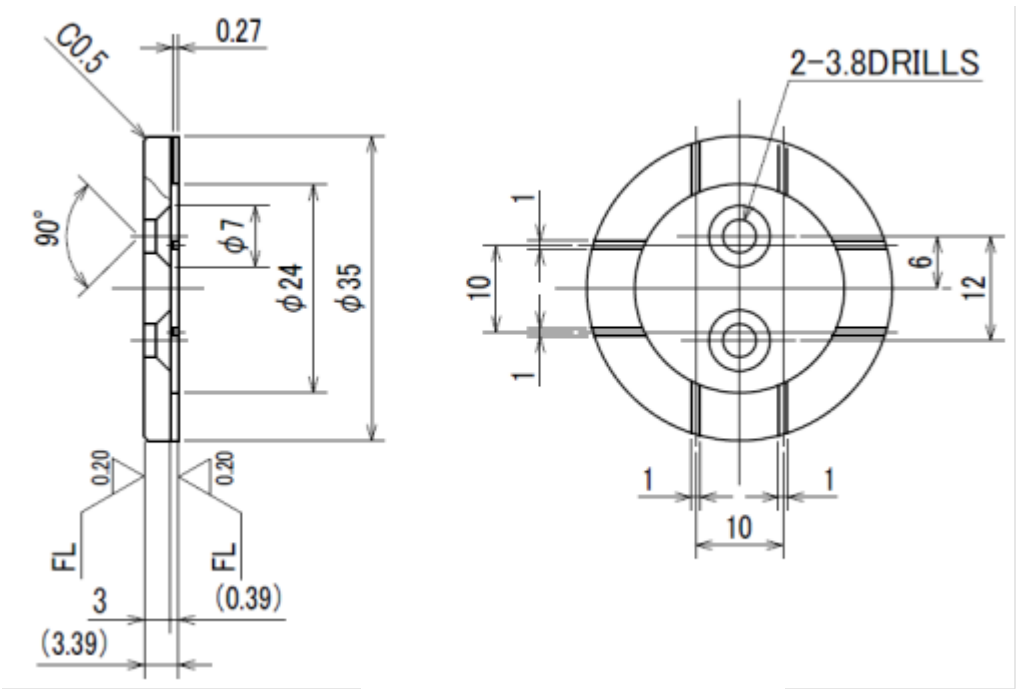


Figure 6 (b) Clutch disc (NW-461E)

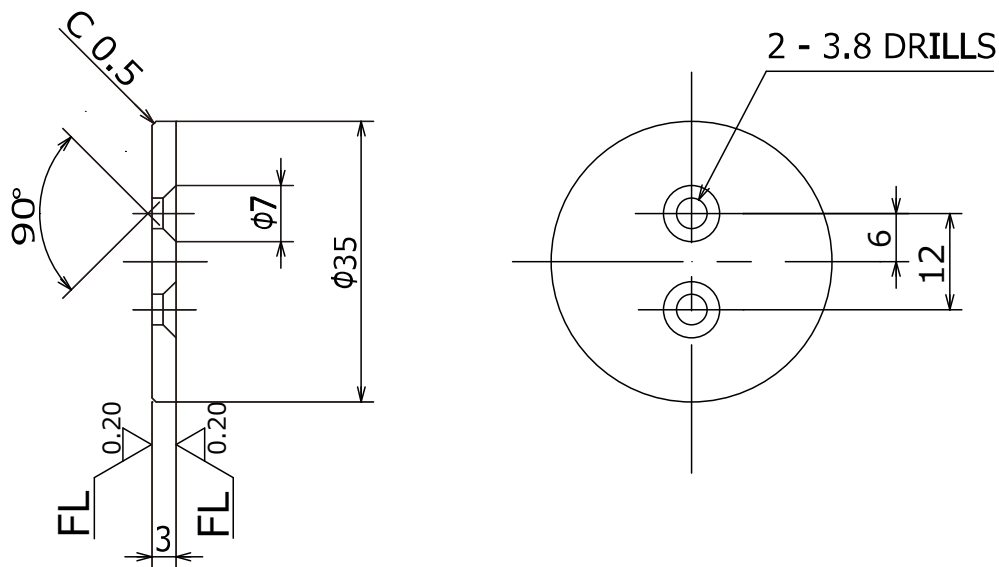


Figure 7 Friction plate

4.3 Test conditions

The testing shall be conditions specified in Table 5.

Table 5 Micro clutch friction test conditions

No.	Items	Conditions
1	Temperatures	40, 60, 80, 100, 120, 140°C
2	Surface pressure (apparent)	392 kPa
3	Peripheral speed	3.0×10^{-2} m/s (20 min ⁻¹)
4	Friction time	5 minutes (at each temperature)

4.4 Testing procedure:

4.4.1 Impregnation and coating of components with test fluid:

If a test disc is new, place the disc in a 50 ml beaker filled with 20 ml of a test fluid, heat them to 100°C for 10 minutes and allow them to cool so that the test disc is impregnated with the test fluid.

For a used test disc, immerse the test disc, the friction plate, and the bolts in a 50 ml beaker filled with 50% n-hexane and 50% acetone, cleanse the components with an ultrasonic cleaning device for 10 minutes. Repeat the ultrasonic cleaning step after renewing the hexane/acetone solvent. After drying, impregnate the disc with the test fluid in the same manner described above for a new disc.

For the friction plate as well as the bearing unit of the test apparatus, apply test fluid after cleaning the components with n-hexane

4.4.2 Breaking-in:

For a new test disc, provide a break-in operation in accordance with Table 6 as follows but without taking measurement. For a used test disc, no break-in operation is required.

Table 6 Break-in operating conditions

No.	Items	Conditions
1	Temperature	Room temperature
2	Surface pressure (apparent)	392 kPa
3	Peripheral speed	3.0×10^{-2} m/s (20 min ⁻¹)
4	Friction time	60 minutes or more

4.4.3 Measurement of friction coefficient

- Operate the test apparatus at room temperature for 5 minutes with conditions given in Table 5, while measuring friction coefficients and temperature.
- Operate the test apparatus at the surface pressure and peripheral speed given in Table 5 until reaching a next test temperature controlled by electric heater of the Micro clutch test rig.
- Measure temperatures and friction coefficients while maintaining the test temperature for 5 minutes.

4.5 Recording the test results:

Plot the average temperature and friction coefficient data for the 5-minute measurements on the recording format as shown in Figure 8 and obtain a temperature - friction coefficient curve by connecting the points.

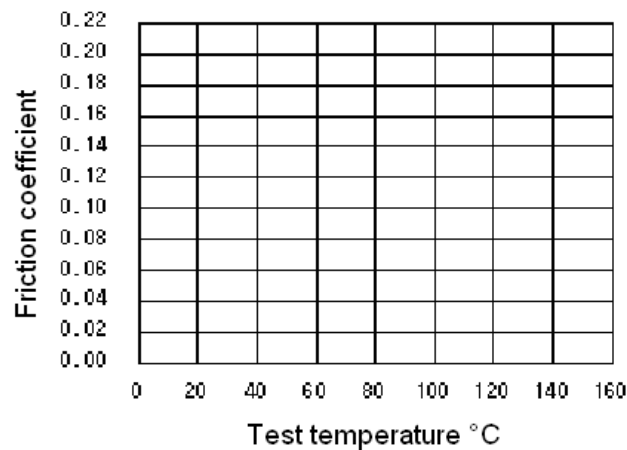


Figure 8 Recording format

Explanatory Notes on JCMAS P 047

Hydraulic Fluids for Construction Machinery — Test Method for Friction Characteristics

These explanatory notes are provided to explain the provisions of this Standard and related matters. They do not form part of the Standard.

1 Purpose of the establishment and revision

1.1 Purpose of the establishment (the first edition)

This Standard has been established in the process of developing a quality standard for hydraulic fluids for use in construction machinery, as a method required for evaluating friction property which is an inherent requirement of hydraulic fluids for construction machinery.

1.2 Purpose of the revision (the second edition)

Twenty years have passed since the first edition was established, and changes have occurred in the friction materials (clutch discs) specified in the standard, including the addition of new materials, so it was decided to revise the standard.

2 History of establishment and revision

The draft of the first and the second edition were prepared by the Oil Technical Subcommittee of JCMA, then were deliberated and approved by the Domestic Standards Committee of JCMA, and these documents were subsequently published after the WTO/TBT public comment notice for a period of 60 days.

As the method of evaluating friction property of hydraulic fluids, a micro clutch test method, which has already been publicized as an in-house test method of a construction machinery manufacturer, and the SAE No.2 friction machine test, which is standardized as JASO M 348 by the Society of Automotive Engineers of Japan (JSAE) emerged as the candidates. Of these, the micro clutch test method was first adopted as a standard method for the intended purpose since the correlation between the test results and hydraulic fluids with proven field performance had already been established. It was further decided to adopt a modified version of the SAE No.2 friction machine test, which is widely referenced as a method of evaluating automatic transmission fluids both domestically as well as overseas, so that the method of evaluating friction property of hydraulic fluids can be defined with the above two methods.

3 Issues discussed during the deliberation:

In the study on the evaluation method using the SAE No.2 friction test machine, six brands of commercial biodegradable hydraulic fluids with proven field performance in the market have been evaluated based on the JASO M 348 precisely as specified. However, the excessive severity of the test conditions in the specification made it difficult to differentiate between the samples and also to correlate the results with those based on the micro clutch tests. Since it was subsequently established that an approximate correlation with the micro clutch test could be obtained by modifying the test speed from 3600 min^{-1} in the JASO M 348 to 800 min^{-1} , it has been decided to adopt the method with the modification.

4 Scope:

This Standard applies to hydraulic fluids for construction machinery.

5 Supplementary notes on items specified in this Standard:**5.1 Clause 3 of the main text (Friction test method using SAE No.2 friction test machine)**

With exception of items specified in this Standard, the test shall be conducted in accordance with the standards referenced.

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 and the Deliberation Committee

The membership lists of the Drafting Committee and the Deliberative Committee are shown below.

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