JCMAS

Hydraulic Fluids for Construction Machinery -- Evaluation Method for Indicating Lubrication Property in High Pressure Piston Pump

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Forward

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Japan Construction Mechanization
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JCMAS
P 044 : 2004

Hydraulic Fluids for Construction Machinery -- Evaluation Method for Indicating Lubrication Property in High Pressure Piston Pump

1 Scope

This standard specifies a test method for evaluating lubrication property of hydraulic fluids for construction machinery with a piston pump.

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 B 0651, *Geometrical Product Specifications (GPS) -- Surface texture: Profile method -- Nominal characteristics of contact (stylus) instruments*

NOTE Corresponding International Standard: **ISO 3274** (Identical)

JIS B 7502, *Micrometer calipers*

NOTE Corresponding International Standard: **ISO 3611** (Not equivalent)

JIS B 7503, *Dial Gauges*

NOTE Corresponding International Standard: **ISO/TR 463** (Modified)

JIS B 7515, *Cylinder Gauges*

JIS B 7520, *Indicating Micrometers*

JIS B 9934, *Hydraulic fluid power -- Determination of particulate contamination by automatic counting using the light extinction principle*

NOTE Corresponding International Standard: **ISO 11500** (Identical)

JIS K 0116, *General rules for atomic emission spectrometry*

JIS K 2275, *Testing Methods for Water Content of Crude Oil and Petroleum Products*

NOTE Corresponding International Standard: **ISO 3733 and ISO 9029** (Modified)

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

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

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

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

ASTM D893:2002**,** *Standard Test Method for Insolubles In Used Lubricating Oils (Procedure B)*

National Aerospace Standard (NAS) 1538, *Cleanliness requirements of parts used in hydraulic systems*

3 Apparatus:

3.1 Components:

The test apparatus shall consist of the components listed in Table 1 below:

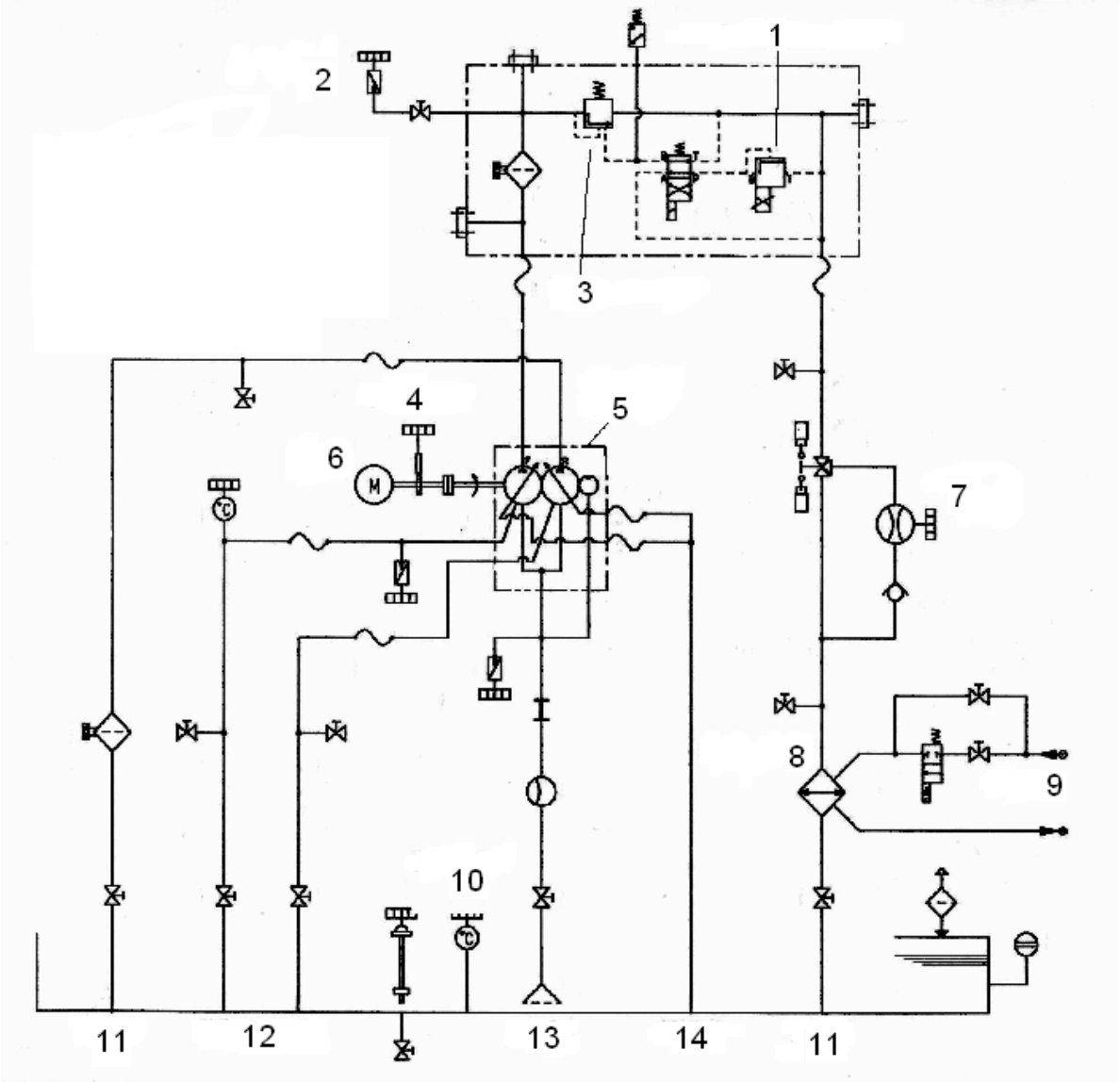
Table 1 Test Apparatus Components

No.	Components	Description
1	Motor	AC 200V, 37 kW
2	Pump	Tandem-type, bent-axis axial piston pump[1)]
3	Hydraulic fluid tank	60L, stainless steel-made, with an air-breather (ϕ 50 × 50mm)
4	Pressure regulator valve	Pilot-operated relief valve, Rated pressure: 34.3±1.0 MPa, Flow rate: 150L/min.
5	Temperature control unit	For range 40°C-120°C, Control precision: ±1°C
6	Temperature indicator	For liquid temperature measurement
7	Pressure indicator	For pump outlet and filter pressure differential measurements
8	Heat exchanger	Oil-side capacity: approx. 10L, Heat-transfer area: 4.0 m^2, Stainless steel-made
9	Filter unit	Rated pressure: 3.5MPa, Fineness: β_{10}=2.0 (Cellulose element)
10	Flow meter	Maximum flow rate: 12kL/hr, Precision: ± 0.1kL/hr, Max. operating pressure: 1.0 MPa, Max. operating temperature: 110°C.
11	Alarm unit	For low liquid level, and oil temperature increase
12	Recorders	Oscillograph, Dynamic strain gauge

NOTE [1)] Reference model: HPV35+35

3.2 Test hydraulic circuit:

The test stand consisting of the components in Table 1 shall be configured and placed as shown in Figure 1.



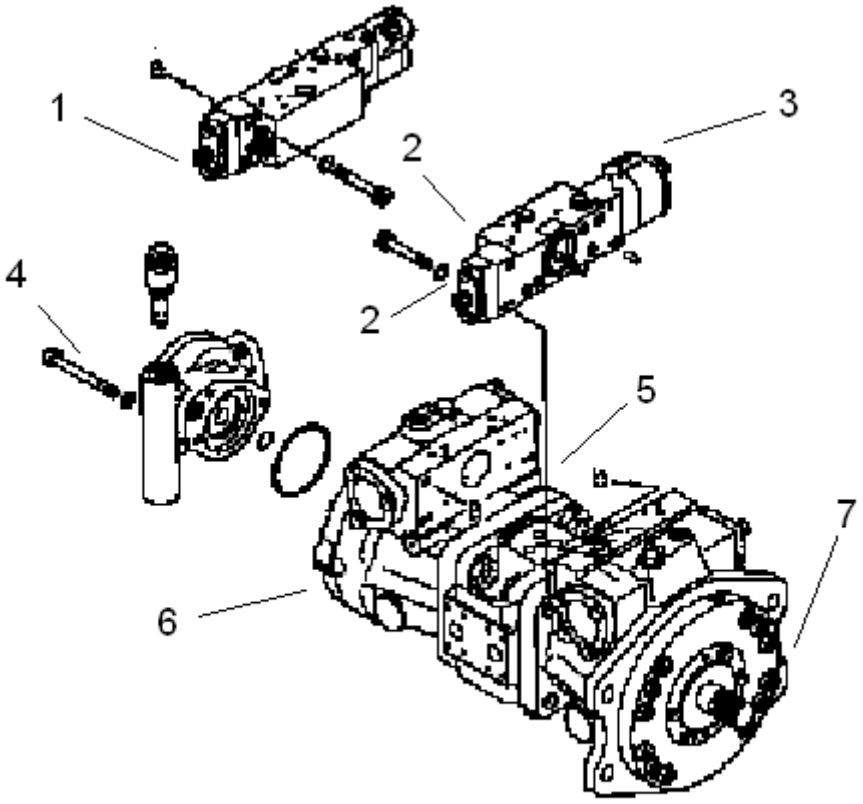
Key

1	Electromagnetic proportional relief valve
2	Pressure indicator
3	Relief valve
4	Tachometer
5	Test pump
6	Motor
7	Flow meter
8	Oil cooler
9	Cooling water
10	Temperature control unit
11	Return
12	Drain
13	Suction
14	Mode switch

Figure 1 Test Stand Hydraulic Circuit

3.3 Test pump:

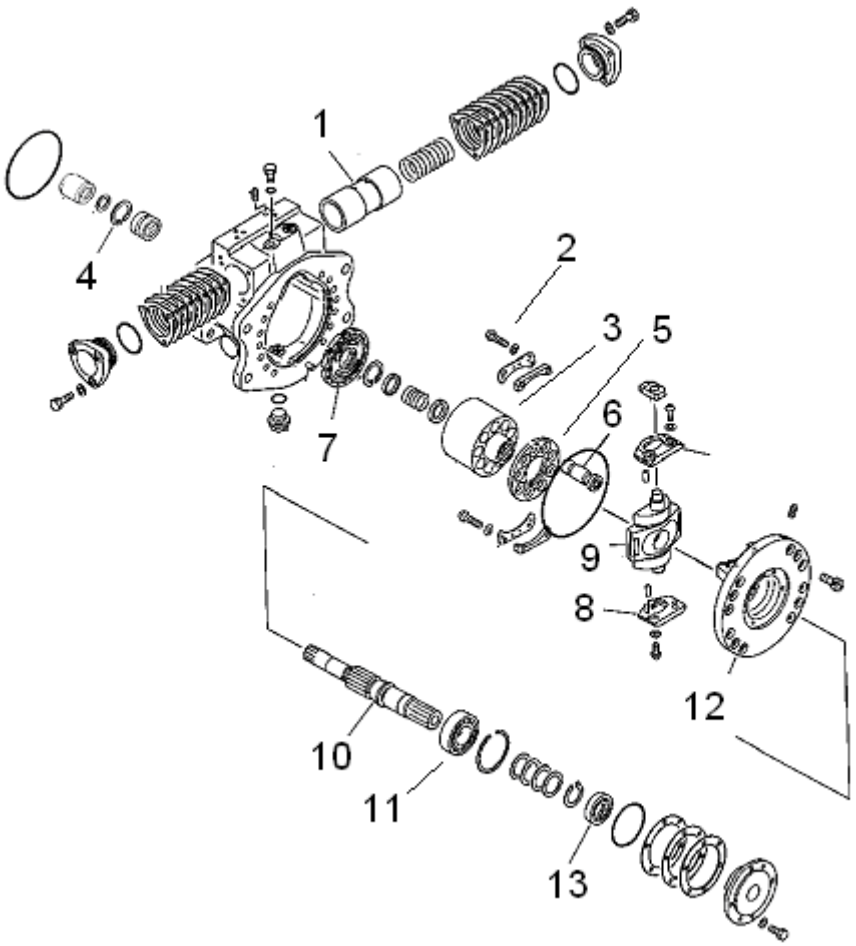
Figure 2 is a general assembly drawing of the test pump. Either the front section pump or the rear section pump shall be used for the testing purpose and renewed upon each test run. The pump at the other section that is not used for the testing and the gear pump shall be used continuously without overhaul. The servo valves at the front and rear sections shall be inspected only in the event of a decreased flow rate. Figure 3 is an exploded view showing the front section pump parts to be inspected in the test.



Keys

1	Rear section servo valve
2	Adjusting screws (A and B)
3	Front section servo valve
4	Gear pump
5	End cap
6	Rear section pump
7	Front section pump

Figure 2 Assembly drawing of a Model HPV35+35 Pump



Keys

1	Servo piston
2	Retainer bearing
3	Cylinder block
4	Needle bearing
5	Shoe retainer
6	Piston sub-assembly
7	Valve plate
8	Side plates
9	Locker cam
10	Shaft
11	Bearing
12	Cradle
13	Oil seal

Figure 3 Front section pump parts

4 Test procedures:

4.1 Flushing:

Drain any fluid remaining from a previous test from the hydraulic fluid tank, pipes and fittings. After draining the old test fluid, install the front section test pump, and replace the hydraulic fluid filter with a new unit. Charge the system with test fluid and ensure that any entrained air is expelled. Start the system and circulate the fluid for two

hours at 2.0 - 5.0 MPa and 1 200 - 1 500 min^{-1}. Upon completion of the above operation, drain the fluid and refill the system with fresh test fluid. Inspect the extracted fluid for viscosity, TAN, or metals content and, if contamination of the previous test fluid is suspected, repeat the above flushing procedure.

4.2 Preparation of the test pump:

Measure the dimensions of the test pump components and perform visual inspection on the same in accordance with the Appendix Tables 1 through 5. For valve plate and cylinder block, and locker cam and cradle, provide lapping to ensure fitting between them using lapping powder. Throughout the above procedures, examine the components for any manufacturing or material defects such as burrs or cracks. After the above inspection and lapping process, thoroughly clean each component with an appropriate cleaning solvent and assemble the test pump while wetting all parts with a film of test fluid.

4.3 Installing the test pump:

Install the assembled test pump on the test stand.

4.4 Break-in operation:

Perform a break-in operation following the pressure-time pattern given in Figure 4, whereby the pump is started at a speed of 1 000 min^{-1} at no load, and 5 minutes later stepped up to the test speed of 2 100 min^{-1}. Subsequently, increase the discharge pressure manually step-wise in increments of 6.9 MPa and with intervals of 5 minutes until the test pressure of 34.3 MPa is attained, while maintaining the fluid temperature at 50 +/- 5°C. Either the front section pump or the rear section pump shall be used for the testing purpose and renewed at each test run. The pump at the other section that is not used for the testing shall be operated at no load.

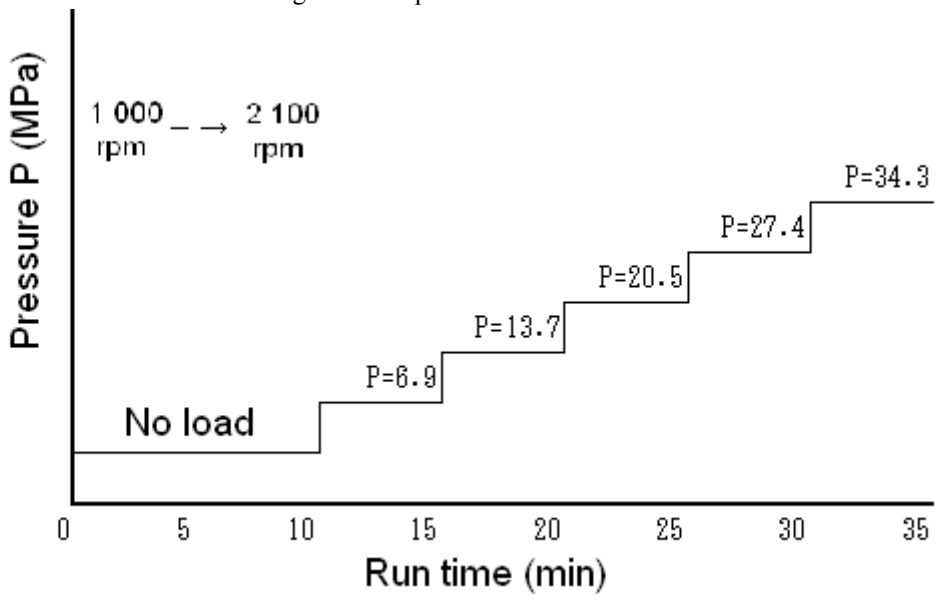


Figure 4 Break-in operation mode

4.5 Performance test:

Start the system with a speed of 2 100 min^{-1} at no load, and increase the discharge pressure manually in increments

of 4.9 MPa until the test pressure is attained, while recording the flow rate at each step. During the above procedure, control the flow rate by manipulating the adjusting screws A and B so that it falls within the range shown in Figure 5, while maintaining the fluid temperature at 50 +/- 5°C. Meanwhile, measure the inlet pressure by means such as Bourdon-tube pressure gauge and record.

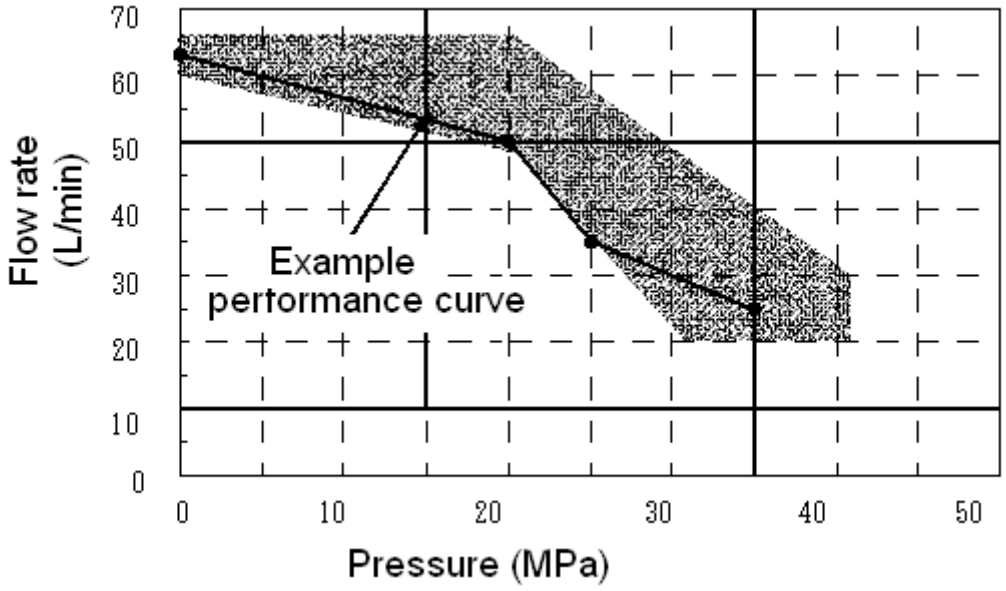


Figure 5 Pressure-flow rate characteristics

4.6 Endurance test:

Set the initial operating conditions for the endurance test as specified in Table 2 below, with a pressure-time cycle to be controlled by the electromagnetic proportional relief valve preset in accordance with the pattern as shown in Figure 6. Start the system under an automatic control. After completion of every 100 hours of operation, briefly interrupt the endurance test, check and collect data on items listed in Table 3, and at the same time take a 500 mL sample of test fluid which shall be analyzed for test items listed in Table 4. Restart the endurance test immediately after completing the above procedures.

The test should be terminated upon observation of any one of the following phenomena: a drop in hydraulic fluid flow rate or pressure in excess of 3 % from the specified limits, an occurrence of pump noise, or a fluid leakage.

Table 2 Endurance Test Conditions

Load pressure	34.3 MPa±0.5 MPa
Pump speed	2,100±50 min^{-1}
Flow rate	20 L/min (at max. pressure) to 60 L/min (at no load)
Test duration	500 hours
Fluid volume in system	62.5±2.5 L
Fluid temperature in tank	95±5°C
Drain temperature	120°C max.

Table 3 Inspection items (for every 100 hours of operation)

No.	Inspection items
1	Inlet pressure
2	Drain pressure
3	Pump speed
4	Fluid temperature in tank
5	Drain temperature
6	Flow rate: To be measured according to Paragraph 4.5 Performance test

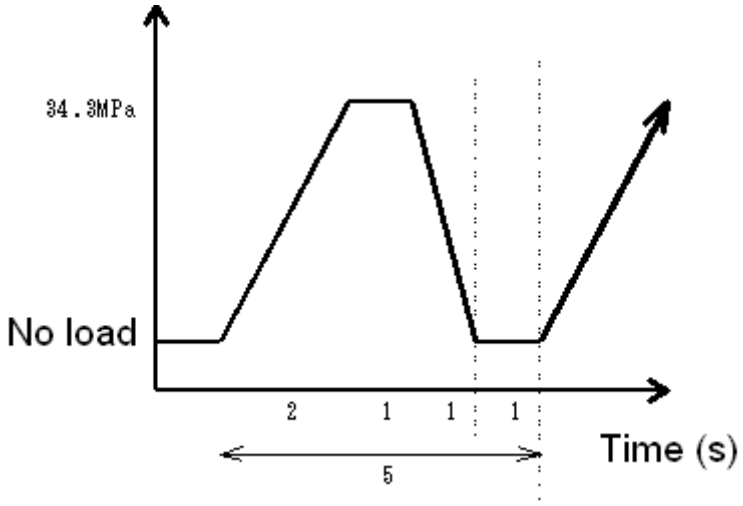


Figure 6 Pressure-time cycle

Table 4 Test Fluid Analysis (for every 100 Hours)

No.	Item	Units	Test method
1	Kinematic viscosity, 40 °C	mm^2/s	JIS K 2283
2	Total acid number	mgKOH/g	JIS K 2501
3	Water content	mg/kg	JIS K 2275
4	Coagulated pentane insolubles	%	ASTM D 893, Procedure B
5	Metal content in the fluid (Fe, Cu, Pb, Zn, Si, Al)	Mass ppm	JIS K 0116
6	Contaminants	Particle count NAS Cleanliness Class	JIS B 0034 NAS 1638

4.7 Final parts inspection:

After completion of the 500 hour endurance test, disassemble the test pump and measure the dimensions of the parts in accordance with the Appendix Tables 1 to 8. Record all irregularities observed on any part even if the part is not covered in the Appendix Tables.

Note that servo piston, servo valves, and needle bearing may be used continuously if it could be made certain that there is no identifiable irregularity in them.

4.8 Instruments for dimensional measurements:

For the dimensional measurements herein, the following instruments shall be used:

JIS B 0651 Geometrical Product Specifications (GPS) -- Surface texture: Profile method -- Nominal characteristics of contact (stylus) instruments

JISB 7502 Micrometer calipers

JIS B 7503 Dial Gauges

JIS B 7515 Cylinder Gauges

5 Reporting of test results:

The measurements and test results shall be summarized and reported in the format shown in Table 5:

Table 5 Summary of measurements and analysis

Test fluid:
Test conditions: °C, MPa×500hrs.

No.	Items	Before Test	After Test	Pass/Fail
1	Change in flow rate			
2	[Parts wear] Cylinder block, Bore diameter, mm			
	Cylinder block, Spherical portion, mm			
	Piston, Outer diameter, mm			
	Piston shoe, Thickness, mm			
	Piston shoe, Looseness, mm			
	Valve plate, Spherical portion, mm			
	Locker cam, Shoe sliding surface, mm			
	Locker cam, Cylindrical surface, mm			
	Cradle, Cylindrical surface, mm			
	Servo piston, mm			
	Oil seal, Wear width on the main lip, mm			
3	[Parts condition (Visual inspection)] Cylinder block, Spherical portion			
	Cylinder block, Bore surface			
	Valve plate, Spherical portion			
	Locker cam, Sliding surface with cradle			
	Cradle, Cylindrical surface			
	Piston			
	Piston, Oil hole plugging			
	Piston shoe			
	Piston shoe retainer			
	Side plate			
	Bearings			
	Oil seals			
	Servo piston			
	Needle bearings			
	Filter plugging			

Table 5 Summary of measurements and analysis (Continued)

No.	Items		Before Test			After Test			Pass/Fail
4	Change in fluid characteristics, hrs.		0	100	200	300	400	500	Pass/Fail
	Kinematic viscosity (40°C), mm^2/s								
	Total acid number (TAN), mgKOH/g								
	Water content, mg/kg								
	Pentane insolubles, %								
	Metals in fluid, Mass ppm (Report)	Fe							
		Cu							
		Pb							
		Zn							
		Si							
		Al							
	Contaminants (Report)	5 - 15 μm							
		15 - 25 μm							
		25 - 50 μm							
		50 - 100 μm							
		>100 μm							

6 Pass/fail criteria:

The criteria to make the pass/failure evaluation shall be as given in Table 6.

Table 6 Evaluation criteria

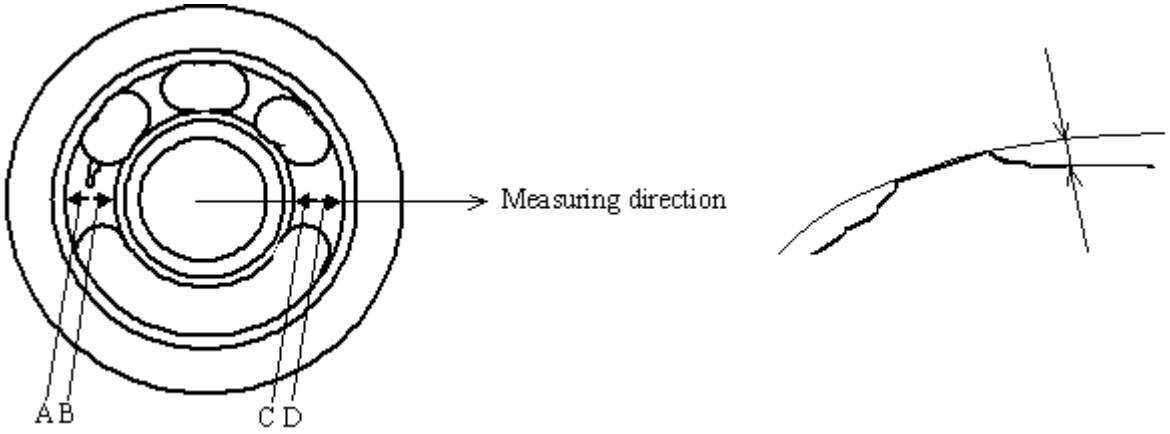
No.	Evaluation items	Pass/Fail Criteria (based on highest measurements)
1	Change in flow rate	Decrease in flow rate: 3% max. (at 19.6 MPa)
2	[Parts wear] Cylinder block, Bore diameter, mm	0.050 max.
	Piston, Outer diameter, mm	0.030 max.
	Piston shoe, Thickness, mm	0.050 max.
	Piston shoe, Looseness, mm	0.20 max.
	Cylinder block, Spherical portion, mm	0.015 max.
	Valve plate, Spherical portion, mm	0.015 max.
	Locker cam, Shoe sliding surface, mm	0.015 max.
	Locker cam, Cylindrical surface, mm	0.020 max.
	Cradle, Cylindrical surface, mm	0.010 max.
	Servo piston, mm	0.010 max.[1)]
	Oil seal, Wear width on the main lip, mm	0.80 max.
3	Parts condition, Visual inspection on all pump parts	Should be free from any signs of seizure, scoring, erosion, surface roughness, significant deposit, lacquer and precipitate. (See Appendix Figures 1 to7) Further, the area ratio of seizure, scoring, and/or adhesive wear damage between locker cam and cradle should be 10% or less of the cylindrical surface.
4	Filter	Should be free from abnormal plugging

NOTE [1)] Wear measurement with the profilometer may be omitted if no irregularity such as scoring or seizure is visually identifiable.

Table 6 Evaluation criteria (Continued)

No.	Evaluation items		Pass/Fail Criteria (based on highest measurements)
5	[Change in fluid characteristics] Kinematic viscosity (40°C), %		+/- 5
	TAN increase, mgKOH/g		0.8 max.
	Water content, mg/kg		1 000 max.
	Pentane insolubles, %		0.1 max.
	Metals in fluid, Mass ppm	Fe	Report
		Cu	Report
		Pb	Report
		Zn	Report
		Si	Report
		Al	Report
	Contaminants; (Particle count) (NAS Cleanliness Class)	For size 5 - 15 μm	Report
		15 - 25 μm	Report
		25 - 50 μm	Report
		50 - 100 μm	Report
		>100 μm	Report

Appendix Table 1 Valve Plate Inspection Sheet

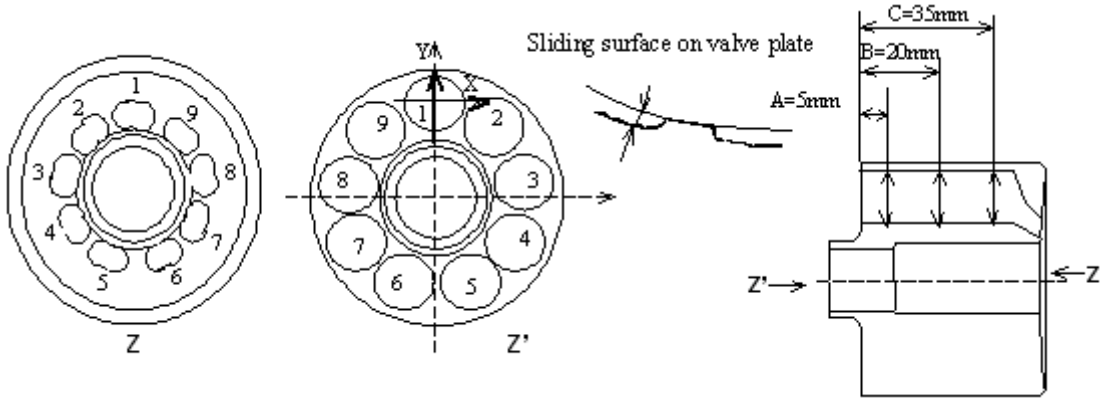


Positions and direction of wear measurements with a stylus profilometer

Test fluid ID			
Test duration, hrs.			
Test period		From:	To:
Measurement by			
Date			
Wear on the spherical portions (*), μm			
(*) Measurement with a stylus profilometer, using a vertical magnification at ×1,000 and a horizontal magnification at ×20.	A		
	B		
	C		
	D		

NOTE Signs of scoring, adhesive wear, cavitation, deposit, etc. if any, shall be recorded either with diagrammatic sketches or photographs.

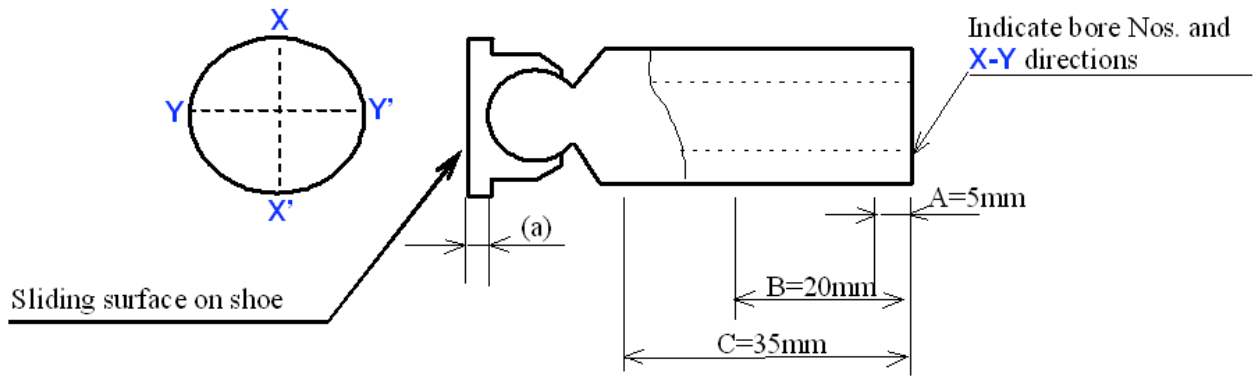
Appendix Table 2 Cylinder Block Inspection Sheet



Test fluid ID											
Test duration, hrs.											
Test period		From:			To:						
Measurement by											
Date											
Measured positions:											
Bore diameter (*), μm (*) Measurement with a cylinder gauge	Bore Nos.	1	2	3	4	5	6	7	8	9	Average changes
	Ax										
	Ay										
	Bx										
	By										
	Cx										
	Cy										
Wear on the spherical portions*, μm		Bore Nos.9-1			Bore Nos.3-4			Bore Nos.6-7			
(*) Measurement with a stylus profilometer, using a vertical magnification at ×1,000 and a horizontal magnification at ×20.	A										
	B										
	C										

NOTE Signs of scoring, adhesive wear, cavitation, deposit, etc. if any, shall be recorded either with diagrammatic sketches or photographs.

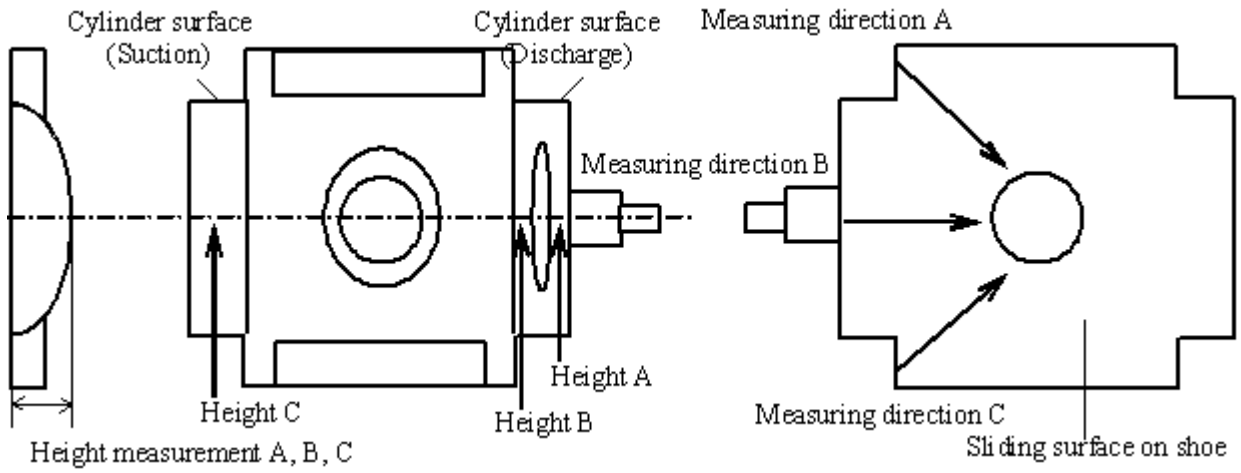
Appendix Table 3 Piston Subassembly Inspection Sheet



Test fluid ID											
Test duration, hrs.											
Test period		From:		To:							
Measurement by											
Date											
Measured positions:											
Piston outer diameter*, mm (*) Measurement with a micrometer	Bore Nos.	1	2	3	4	5	6	7	8	9	Average changes
	Piston Nos.										
	Ax										
	Ay										
	Bx										
	By										
	Cx										
	Cy										
Piston caulking looseness*, mm											
(*) Measurement with a dial gauge	Changes										
Piston shoe wear*, mm	X										
	Y										
(*) Measurement with a micrometer	X'										
	Y'										
	Average changes										

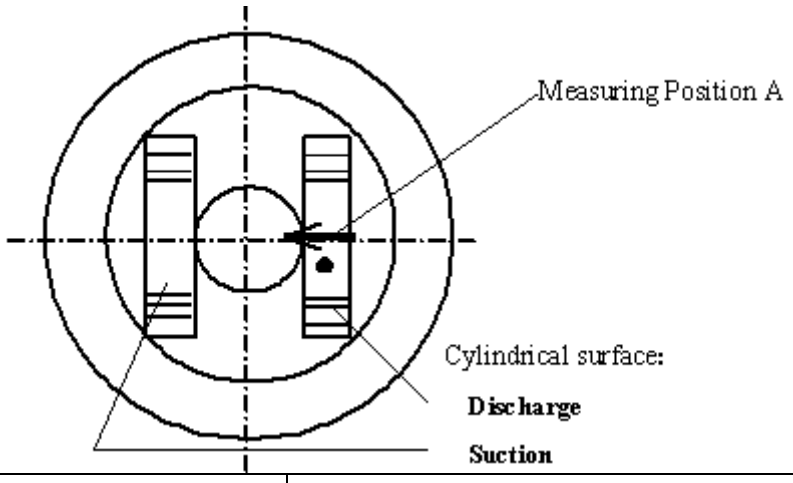
NOTE Scoring, adhesive wear, cavitation, deposit, clogging of oil hole etc. shall be recorded on the other paper by diagrammatic sketch or photograph.

Appendix Table 4 Locker Cam Inspection Sheet locker cam



Test fluid ID			
Test duration			
Test period		From:	To:
Measurement by			
Date			
Measured positions:			
Wear on shoe sliding surface*, μm (*) Measurement with a stylus profilometer, using a vertical magnification at ×1,000 and a horizontal magnification at ×4.	A		
	B		
	C		
Height loss on cylindrical surface, μm	A		
	B		
	C		
Area ratio of seizure/adhesive wear on suction side cylindrical surface, in %: Area ratio = (seizure area + adhesive wear area, in mm) / 1,600 mm×100			
NOTE Signs of scoring, adhesive wear, cavitation, deposit, etc. if any, shall be recorded either with diagrammatic sketches or photographs. The area ratio of seizure and/or adhesive wear on the cylindrical surface should not exceed 10%.			

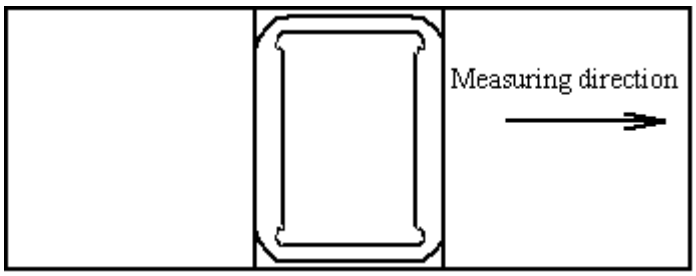
Appendix Table 5 Cradle Inspection Sheet



Test fluid ID			
Test duration			
Test period		From:	To:
Measurement by			
Date			
Measured portion			
Wear on cylindrical surface*, μm (*) Measurement with a stylus profilometer, using a vertical magnification at ×1,000 and a horizontal magnification at ×4.	A		
Area ratio of seizure/scoring on suction side cylindrical surface, in %: Area ratio = (seizure area + scoring area, in mm) / 1,445 mm×100			

NOTE Any signs of scoring, adhesive wear, cavitation, deposit, etc. observed on the above parts shall be recorded either with diagrammatic sketches or photographs. The area ratio of seizure and/or scoring on the cylindrical surface should not exceed 10%, except an adhesive wear mark on suction side cylindrical surface with a thickness below 1 μm is precluded from the area ratio calculation..

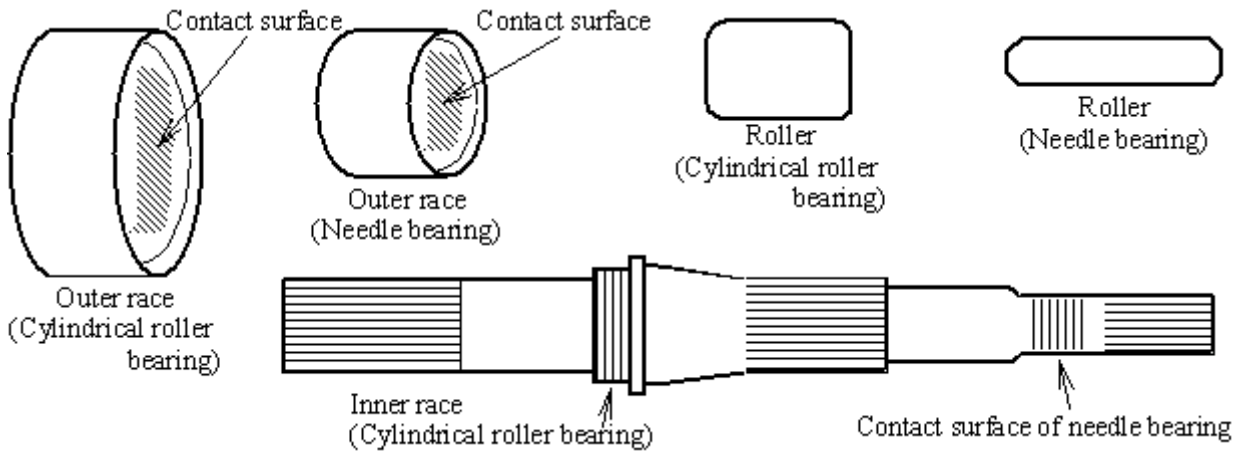
Appendix Table 6 Servo Piston Inspection Sheet



Test fluid ID		
Test duration		
Test period	From:	To:
Measurement by		
Date		
Existence of irregularity*: (*) Visual inspection	Yes ☐ No ☐	
Wear*, μm (*) Measurement with a stylus profilometer, using a vertical magnification at ×2,000 and a horizontal magnification at ×4.	(To be measured only when scoring is observed.)	

NOTE Signs of scoring, adhesive wear, lacquer, deposit, etc. if any, shall be recorded either with diagrammatic sketches or photographs.

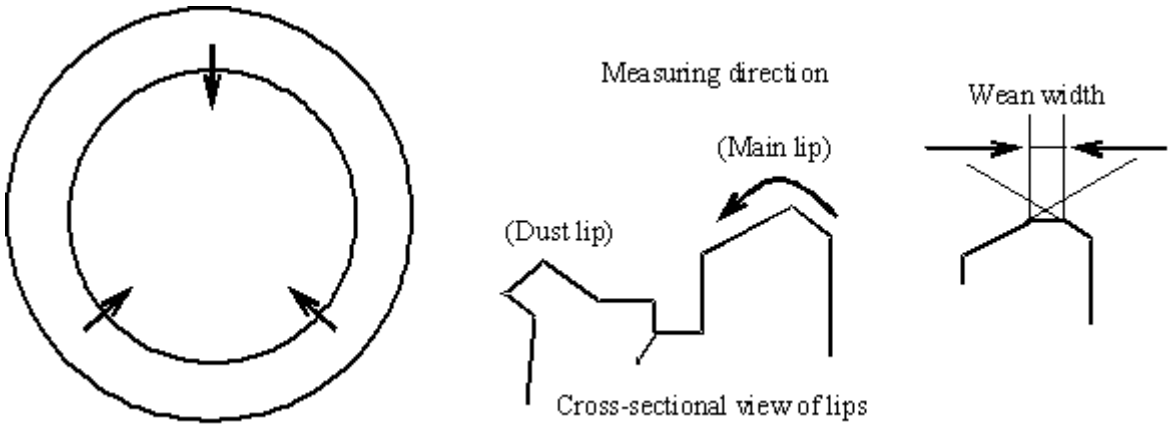
Appendix Table 7 Bearings/Needle bearings Inspection Sheet



Test fluid ID			
Test duration			
Test period		From:	To:
Measurement by			
Date			
Measurement positions		Roller bearing	Needle bearing
Existence of irregularity* (*)Visual check	Roller and needle		
	Outer race		
	Inner race (Shaft)		

NOTE Signs of pitching, fretting, smearing, deposit, etc. of inner and outer race, roller and needle bearings, etc. if any, shall be recorded either with diagrammatic sketches or photographs. Measure the amount of wear if necessary.

Appendix Table 8 Oil Seal Inspection Sheet



To be measured at the three points on the circumference direction

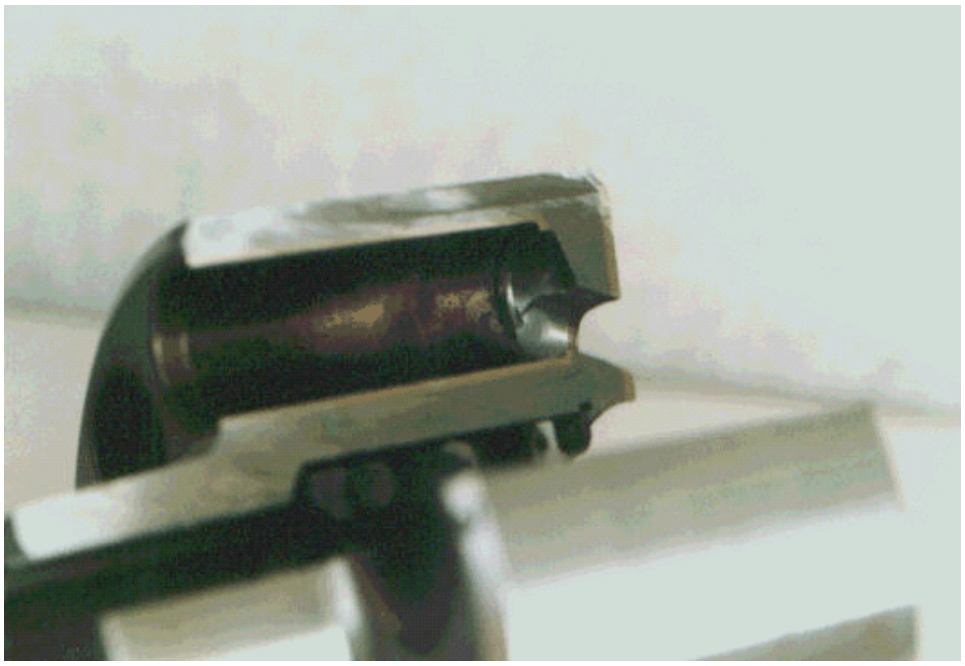
Test fluid ID		
Test duration		
Test period	From:	To:
Measurement by		
Date		
Main lip wear width*		
(*) Measurement with a stylus profilometer, using a vertical magnification at ×2,000 and a horizontal magnification at ×4.	1:	
	2:	
	3:	

NOTE Signs of lip rupture, deposit, blister, etc. if any, shall be recorded either with diagrammatic sketches or photographs..

a) An unacceptable example due to corrosion thickness exceeding 1 μm

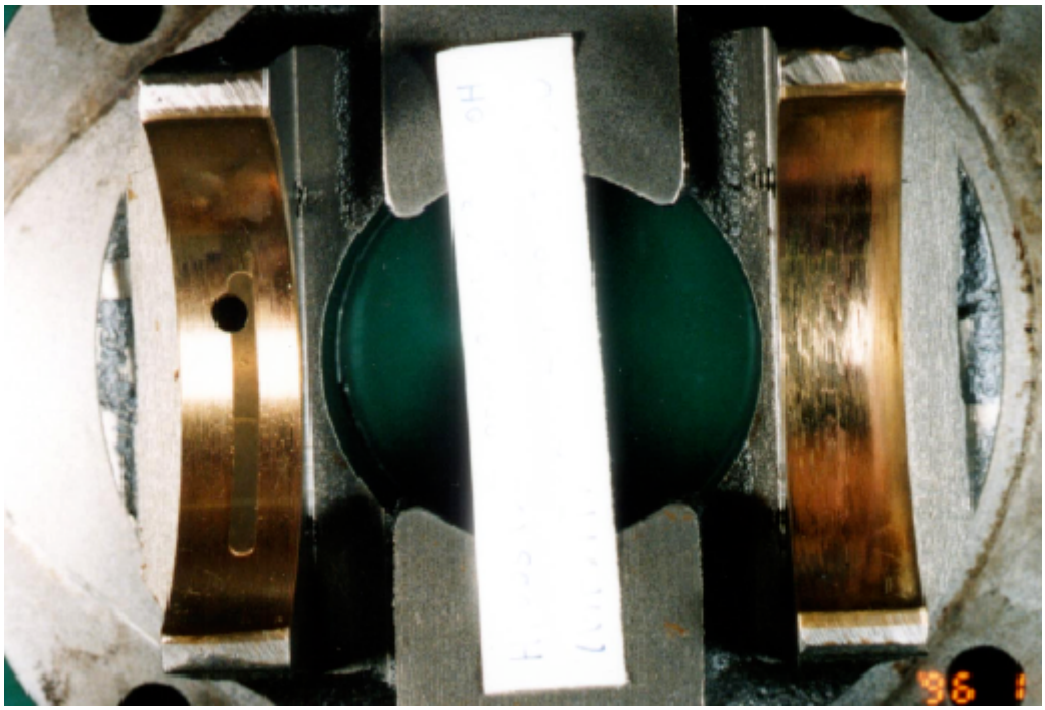
b) An acceptable example without any corrosion

Appendix Figure 1 Examples of corrosion on the spherical portion cylinder block



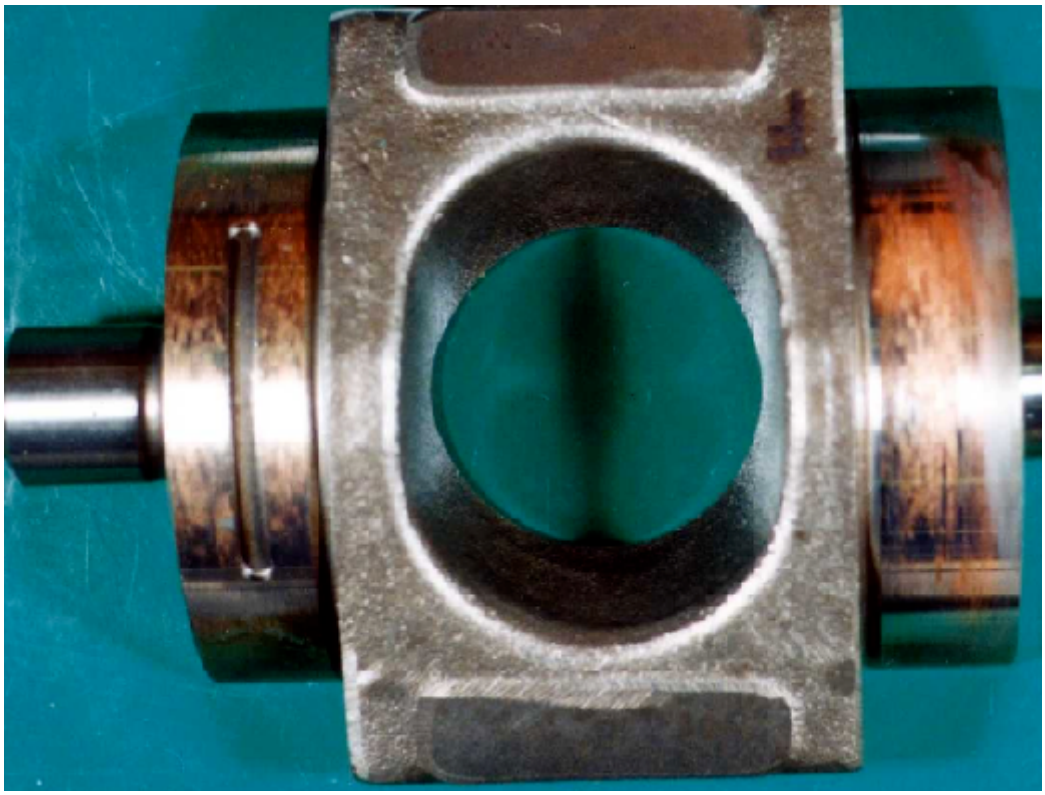
Appendix Figure 2 Unacceptable example with cavitation/erosion (arrow mark) inside cylinder

(Cavitation/erosion occurring in the cylinder center may be disregarded if its diameter is less than 0.1mm.)



a) Cradle side

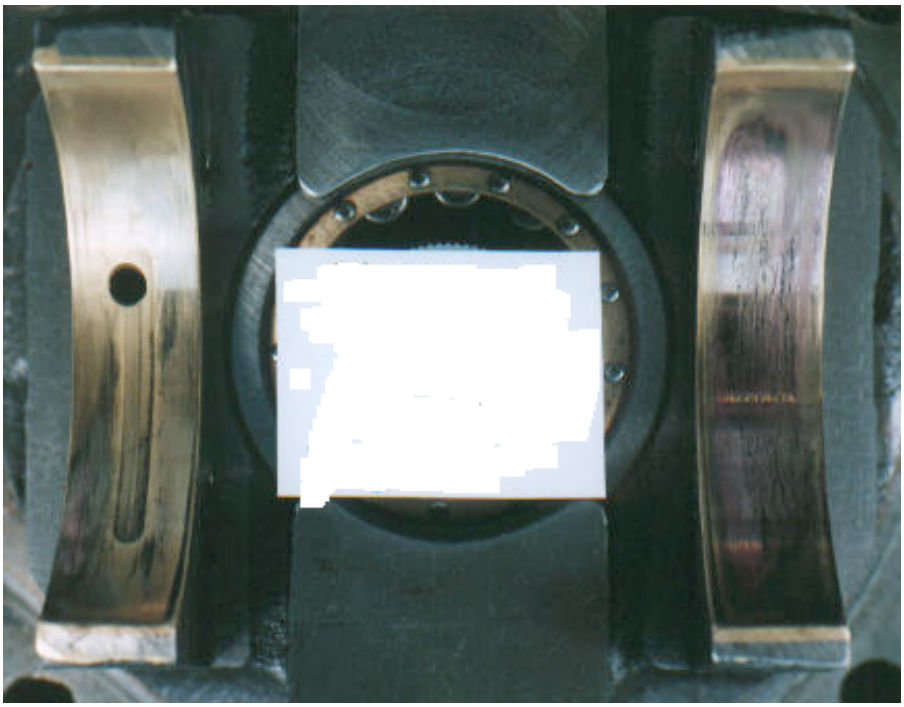
Appendix Figure 3 An unacceptable example with seizure between cradle and locker cam



b) Locker arm side

NOTE For the load side of the cradle [in the left, with oil groove], any seizure signs, even if minor, shall be evaluated as a failure, while on the load-free side in the right, a seizure area ratio of up to 10% is permissible

Appendix Figure 3 An unacceptable example with seizure between cradle and locker cam (Continued)

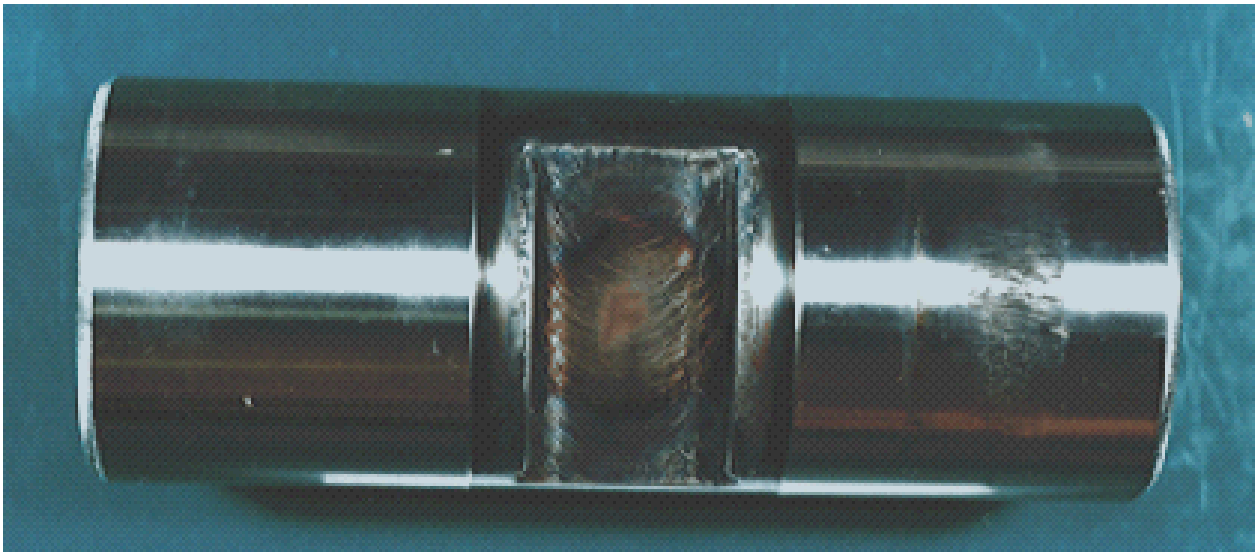


NOTE A minor occurrence without accompanying cracks, flaking, or seizure is permissible.

Appendix Figure 4 An example of dezincification

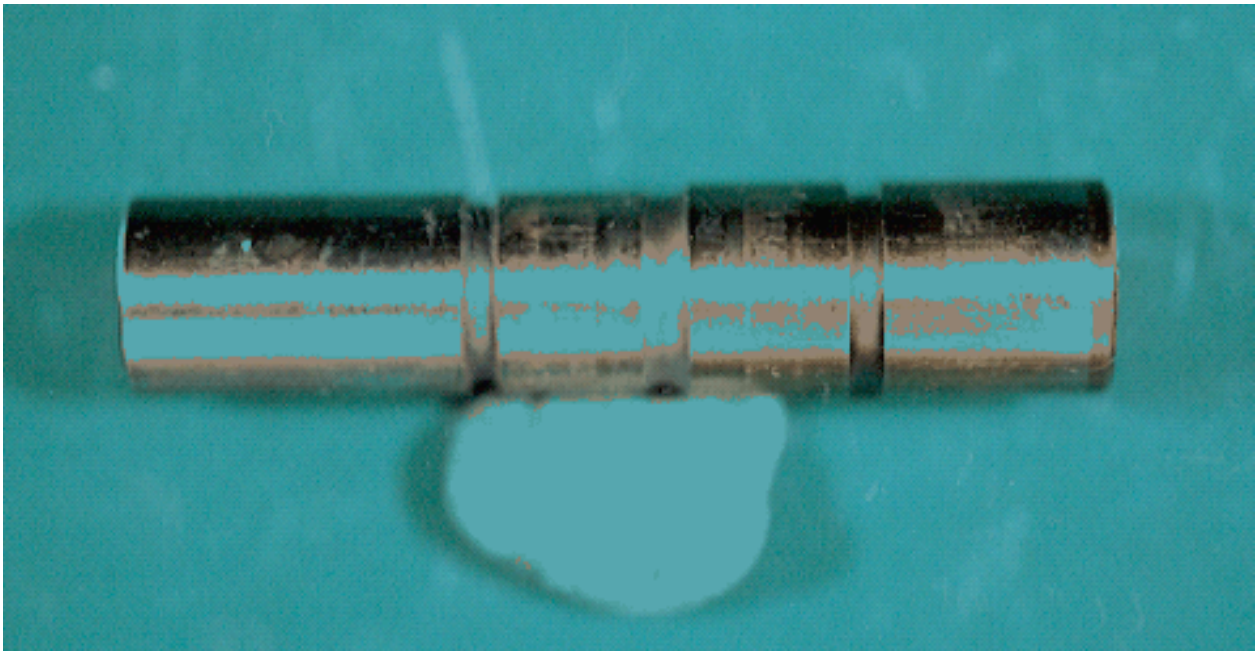
NOTE Table 6 provides the evaluation criteria.

Appendix Figure 5 An example of abnormal wear on piston shoe



NOTE Table 6 provides the evaluation criteria.

Appendix Figure 6 An example of scoring on servo piston



NOTE This component shall be disassembled and inspected if the drop in flow rate has exceeded the specified pass/failure criterion, and a lacquered area covering 20 % or more of the total surface shall be evaluated as a failure. The component can be reused after the lacquer film is thoroughly removed with a cleaning solvent.)

Appendix Figure 7 An example of lacquer on servo valve piston

Annex (informative)
Explanatory Note on JCMAS P044
Hydraulic Fluids for Construction Machinery -- Evaluation Method for Indicating Lubrication Property in High Pressure Piston Pump

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

In the process of developing a quality standard for hydraulic fluids for use in construction machinery, this Standard has been established as a method required for evaluating lubrication property of hydraulic fluids in piston pumps commonly employed in construction machinery.

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 comment according to WTO Agreement on Technical Barriers to Trade (TBT) “Code of good practice (CGP)” prior to publication as a JCMAS.

As a method for evaluating lubrication property of a hydraulic fluid based on a piston pump test, among various methods listed in ASTM D6813:2002 Standard Guide for Performance Evaluation of Hydraulic Fluid for Piston Pumps, a method based on the Model A4VSO pump and the method of this Standard were reviewed and compared, and the method described in this Standard has been adopted from the viewpoints of the test pump availability in Japan and the cost of testing. The draft for this Standard has been prepared through discussions at the forum of Fuels & Lubricants Subcommittee of JCMA, with the participation of hydraulic fluid suppliers, manufacturers of construction machinery, and lubricant additives suppliers. Additionally, a coordination meeting with Japan Fluid Power Association (JFPA) was held to consult with specialized hydraulic pump manufacturers and obtain their views on the matter.

3 Issues discussed during the deliberation

To examine the appropriateness of this Standard as a method for evaluating hydraulic fluids for construction machinery, the Fuels & Lubricants Subcommittee of the JCMA conducted evaluation tests on two commercial products commonly used in construction machinery in the market, in accordance with the method specified herein.

As a result of the jointly performed overhaul and inspections by the Subcommittee members, it became apparent that some of the items specified in the proposed evaluation criteria were too stringent and consequently revised.

4 Scope

This Standard applies to hydraulic fluids for construction machinery.

5 Supplementary notes on items specified in this Standard

Nothing to state in particular.

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 below are members who compose the Drafting Committee and the Reviewing Committee related to this Standard:

Reviewing Committee (Domestic Standard Subcommittee)

Responsibility	Name	Organization/Position
Chairman	Hideo Ohashi	Academic expert
Members	Shoichi Takahashi	Ministry of Health, Labor & Welfare
	Yuji Nagahama	Ministry of Economy, Trade & Industry
	Masashi Miyaishi	Ministry of Land, Infrastructure & Transport
	Masahito Takagi	Ministry of Economy, Trade & Industry
	Yoshimitu Tanaka	Ministry of Land, Infrastructure & Transport
	Kenichi Watanabe	Japanese Standards Association
	Hidehiko Higashi	Academic expert
	Yasuo Sugiyama	Academic expert
	Tadaaki Nishigaya	Construction Method & Machinery Research Institute
	Yoshihiro Tonomura	Nishio Rent All Co., Ltd.
	Suketaka Kuwahara	Nishimatsu Construction Co., Ltd.
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	Kaoru Tokunaga	Komatsu Ltd.
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	Satoshi Fujimoto	Kobelco Construction Machinery Co., Ltd.
	Haruhisa Nagata	Sumitomo Construction Machinery Co., Ltd.
	Akira Hatakoshi	Mitsubishi Heavy Industries, Ltd.
	Yukio Niki	Nihon Koki Co., Ltd.
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	Tetsuro Nishiwaki	Japan Construction Mechanization Association
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