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Petroleum and related products — Determination of anti-wear properties of hydraulic fluids — Vane pump method

Pétrole et produits connexes — Détermination des propriétés anti-usure des fluides hydrauliques — Méthode de la pompe à palettes

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 20763 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*.

Petroleum and related products — Determination of anti-wear properties of hydraulic fluids — Vane pump method

WARNING — The use of this International Standard may involve hazardous materials, operations and equipment. This International Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this International Standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1 Scope

This International Standard specifies procedures for the determination of steel-on-steel anti-wear properties of hydraulic fluids by means of performance in a vane-type hydraulic pump. It covers a range of hydraulic fluids, both anhydrous and aqueous, intended for applications where high-speed sliding contacts, such as those found in a vane pump, are encountered.

For mineral oils of categories HM and HV, and fire-resistant fluids of category HFD, the method is applicable to viscosity classes ISO VG 32, ISO VG 46 and ISO VG 68, as specified in ISO 3448[1]. Under different specified conditions, the method is applicable to aqueous fire-resistant hydraulic fluids in categories HFA, HFB and HFC, as specified in ISO 12922[3], within the same viscosity classes.

NOTE Viscosity classes below ISO VG 32 and above ISO VG 68 can be tested by this technique, but require different conditions of pump inlet viscosity, and have not been widely assessed. This International Standard is confined to the specified limiting values defined.

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.

ISO 3104:1994, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 3170:2004, *Petroleum liquids — Manual sampling*

ISO 3696:1987, *Water for analytical laboratory use — Specification and test methods*

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

3 Principle

Approximately 70 litres of the fluid under test is circulated for 250 h by a vane pump under conditions of output flow, operational pressure and fluid temperature related to the type and viscosity grade of the fluid. At the end of the test period, the mass loss of the 12 vanes and the ring on the test cartridge are determined. Measurement of decrease in output flow during the test run, and mass loss of the two side bushings and the rotor are also taken as control measures within the limiting test conditions, but the mass losses do not constitute a requirement of method conformance.

4 Reagents and materials

4.1 Water, conforming to the requirements of grade 3 of ISO 3696.

4.2 Cleaning solvents

4.2.1 General

The choice of solvent in some applications will be related to the fluid under test or being removed from previous tests, and the user shall select the most appropriate, related to his/her experience. Light hydrocarbon solvents are chosen for the removal of oily residues, and oxygenated solvents for the removal of water-containing residues. Acetone is specified as a high-volatility final rinse solvent, which also removes the last traces of water.

4.2.2 Light hydrocarbons, either heptane, 2,2,4-trimethylpentane or petroleum spirit having a boiling range essentially between 60 °C and 80 °C.

4.2.3 Oxygenated hydrocarbons, either methanol, ethanol or propan-2-ol (isopropyl alcohol).

4.2.4 Acetone, of commercial grade.

4.2.5 1,2-Propyleneglycol (propandiol), of 99 % minimum purity.

4.3 Abrasive stone, of fine grade for removing sharp edges and burrs from all steel cartridge parts.

4.4 Abrasive cloth or paper, including fine grade 2/0 (approximately 27 µm grit size [European grade P1 200]) and coarser grades including 37 µm and 53 µm grit size (grades P360 and P320) as required.

5 Apparatus

5.1 Test rig, consisting of a hydraulic circuit as illustrated in Figure 1. Pipes and fittings shall include facilities so that the rig can be bled free of air and the test fluid can be completely drained. The major components of the rig are given in 5.1.1 to 5.1.12. The rig shall be protected by means of automatic cut-off covering the electrical circuits to the motor and limiting values for temperature, pressure and fluid level.

WARNING — The test rig operates at high pressures and temperatures, and the automatic protection devices should be regularly tested for appropriate cut-off performance.

5.1.1 Fluid reservoir, constructed of corrosion-resistant material with a sealed lid and fitted pressure-relief valve, and capable of holding the test fluid volume of 70 litres with the fluid level approximately 500 mm above the pump inlet. An illustration of a suitable reservoir is given in Figure 2.

5.1.2 Vane pump, Vickers, of type V-104-C-10 or V-105-C-10[1]. The seals of the pump shall be compatible with the fluid type/test temperature conditions of the test. The main shaft, seals and ball bearings of the pump shall be replaced after five runs or when any signs of wear, as evidenced by test conditions, is apparent.

NOTE The life of the main shaft and ball bearings is decreased when testing aqueous fluids.

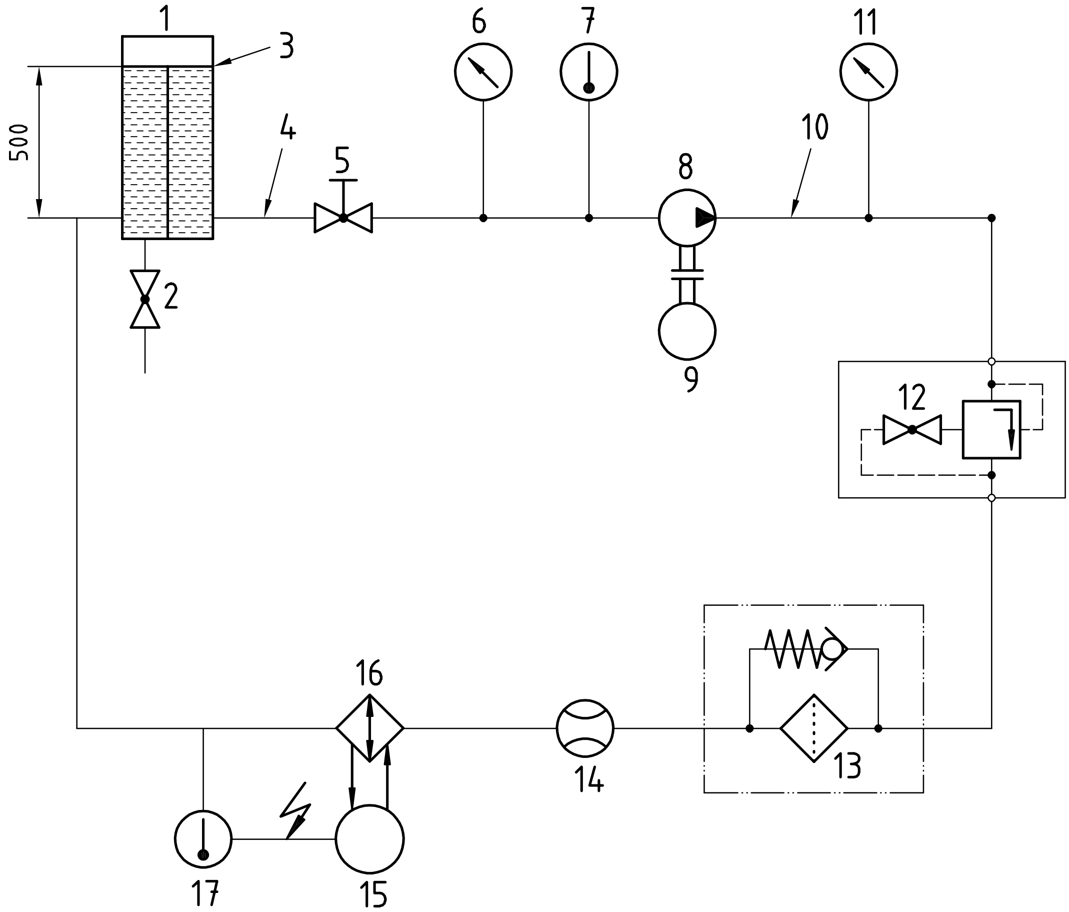
5.1.3 Test cartridge

The availability of test cartridges and components is under review following the decision of Eaton (formerly Vickers) to discontinue manufacturing these as separate items. See Annex B for the position at the time of publication of this International Standard.

5.1.4 Drive motor, with a rated power minimum of 11 kW, and a rated speed of 1 440 r/min ± 50 r/min.

1) This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

Dimensions in millimetres



Key

1 reservoir
2 drainage valve
3 level above pump inlet
4 pipe 28 × 2
5 ball valve
6 suction pressure gauge
7 temperature meter (test temperature)
8 vane pump
9 electric motor
10 pipe 25 × 5
11 test pressure gauge
12 relief valve
13 return filter
14 flow meter
15 cooling water regulator
16 fluid cooler
17 temperature controller

Figure 1 — Test rig layout

Dimensions in millimetres

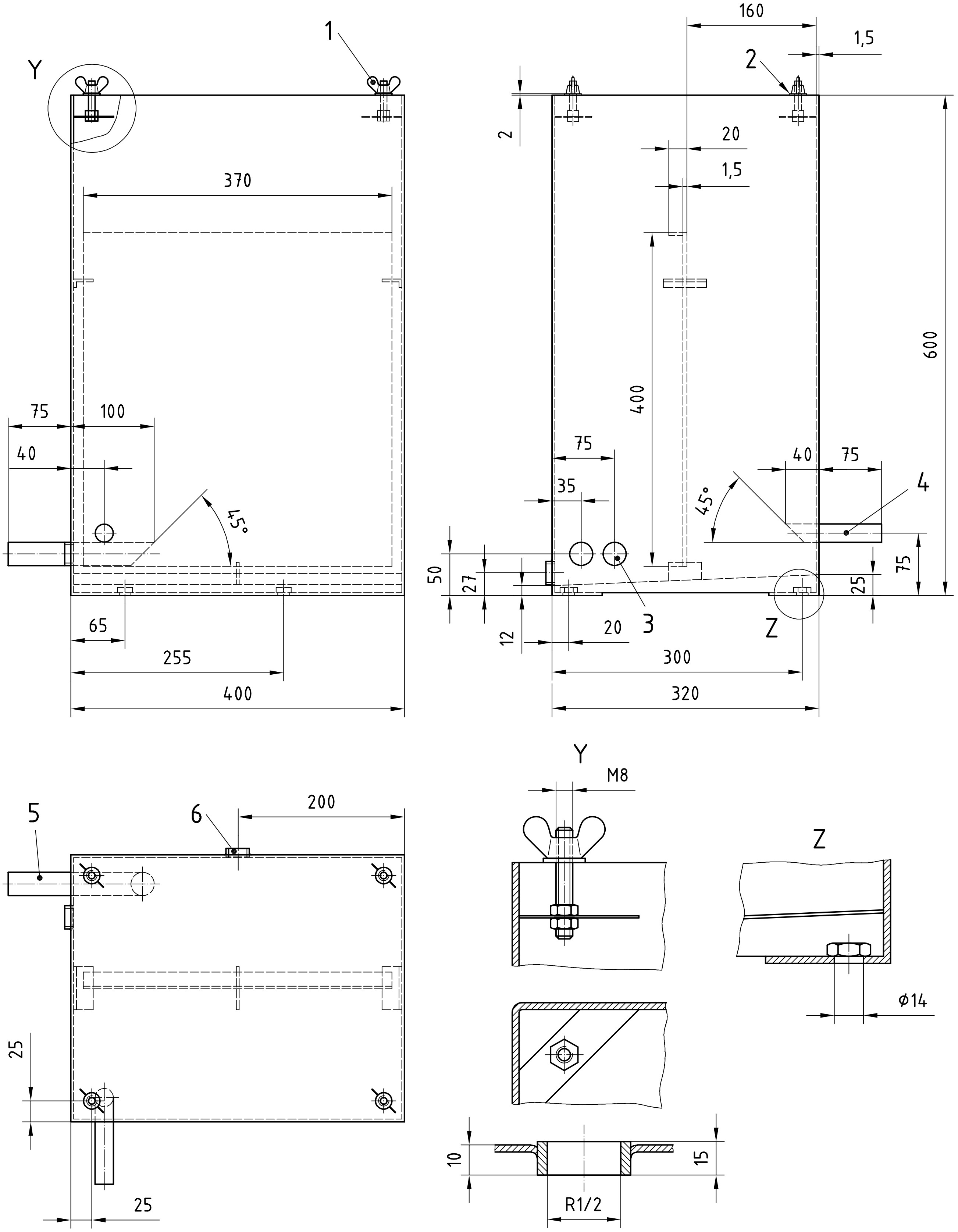


Figure 2 — Illustrative fluid reservoir

Key

1 butterfly nut M8
2 cover seal (rubber)
3 bore for liner (temperature sensor)
4 pipe 22 $\times$ 2
5 pipe 28 $\times$ 2
6 sleeve for oil drainage

Figure 2 — Illustrative fluid reservoir *(continued)*

5.1.5 Heat exchanger, fitted with control equipment to maintain the test fluid at the specified test temperature $\pm$ 2 °C before the pump.

NOTE A shell-and-tube-type heat exchanger is recommended with the connections in reverse (the fluid passed through the tubes) to facilitate effective cleaning between tests (see Clause 9).

5.1.6 Pipework

5.1.6.1 The pipe or hose compatible with the fluid under test, between the outlet of the reservoir and the pump, shall be of nominal 28 mm outside diameter with 2 mm wall thickness. It shall be fitted with a ball valve and connections to accommodate a suction pressure gauge (5.1.9) and a temperature sensor (5.1.10). Similar pipe or hose is suitable for the pipework from the outlet of the relief valve to the reservoir (5.1.1). This length shall be fitted with a filter (5.1.8) and a heat exchanger (5.1.5) and connections to accommodate instruments to measure fluid flow and temperature.

5.1.6.2 The pipe between the pump and the relief valve (5.1.7) shall be of 25 mm nominal outside diameter with 5 mm wall thickness. This length shall be fitted with a connection to accommodate a test pressure gauge (5.1.13).

5.1.7 Relief valve, with a rating of 17 MPa.

5.1.8 Filter, with an element of material compatible with the fluid under test. The filter shall be fitted with a contamination meter and bypass to give a solid contaminant code of 15/11 according to ISO 4406, or better.

NOTE This purity class makes as a condition a separation degree of $\beta_{10} = 75$ as described in ISO 16889[4].

5.1.9 Suction pressure gauge, with a range of 90 kPa to 105 kPa (absolute).

5.1.10 Temperature sensor, with a range of 0 °C to 100 °C and an accuracy of $\pm$ 0,1 °C.

5.1.11 Flowmeter, capable of measuring the flow of the test fluid within the range of 10 l/min to 45 l/min, with an accuracy of $\pm$ 1 l/min or better.

5.1.12 Test-conditions monitoring system, which may be an analogue or digital readout, but is normally an electronic logger or data printout.

The conditions of temperature, pressure and fluid level and fluid flow shall be monitored and recorded continuously throughout the test, and a suitable indicating system shall therefore be installed and linked to the automatic cut-off.

5.1.13 Test pressure gauge, with a range of 1 MPa to 16 MPa and a precision of 0,6 % of the measuring range value.

5.2 Timers, either electronic or manual, capable of measuring up to 60 min with an accuracy of $\pm$ 2 s, and a **timer**, or **time switch**, capable of measuring 250 h $\pm$ 0,5 h.

5.3 Analytical balance, of capacity 200 g minimum, capable of weighing to the nearest 1 mg.

5.4 Torque wrench, capable of measuring torque in the range 0 Nm to 20 Nm, with an analogue indicator and drag pointer.

5.5 Ultrasonic cleaning bath, of a capacity capable of accommodating the components of the test cartridge (5.1.3).

5.6 Finishing plate, clean and flat, of hardened steel, large enough to accommodate the cartridge liners for polishing.

6 Samples and sampling

6.1 Unless otherwise specified, samples shall be obtained by the procedures described in ISO 3170.

6.2 The laboratory sample size for this test is unusually large, with approximately 100 litres required for a single test run. Unless otherwise specified, or volume constrained, a sample of a full 205 litre drum shall be taken.

7 Preliminary test

7.1 Determine the kinematic viscosity of the test fluid at 40 °C, in accordance with ISO 3104, and at least one other temperature at a minimum of 20 °C above or below 40 °C. Select the temperatures to span the required operational viscosity.

7.2 Plot the viscosities on a standard viscosity-temperature sheet (log-log diagram) and determine the temperature required for the operational viscosity (13 mm^2/s for anhydrous fluids or 30 mm^2/s for aqueous fluids).

8 Preparation of apparatus

8.1 Drain off any fluid remaining from the previous test run and remove and responsibly dispose of the filter element. Check that all seals in the system are sound, and compatible with the type of fluid to be tested, and replace as necessary.

8.2 Clean all parts of the test rig that come into contact with test fluid with light hydrocarbon (4.2.2) for anhydrous fluids, or a mixture of equal volumes of 1,2-propyleneglycol (4.2.5) and water (4.1) for aqueous fluids. Carry out rigorous cleaning before and after the test. Where possible, use separate pump stands for testing anhydrous and aqueous fluids.

8.3 Carry out the flushing procedure appropriate to the fluid type described in Clause 9.

9 System flushing and cleaning

9.1 Procedure for anhydrous fluids

9.1.1 Select a good quality, previously used cartridge, dip it into the test fluid or flushing fluid, and fit it into the pump. Fit the cover plate to the pump and tighten the screws evenly in the order of 1, 5, 3, 7, 2, 6, 4, 8 with the torque wrench (5.4) to a maximum of 2 N·m. Check that the pump can be turned freely by hand. Fit a new filter element (5.1.8).

9.1.2 Charge the system with 8 litres to 10 litres of flushing fluid.

NOTE The flushing fluid can be a medium volatility hydrocarbon, such as kerosine or white spirit, or an anhydrous fluid similar in characteristics to that to be tested.

For the flushing procedure, the use of a replaceable reservoir of lower capacity can be used. If the standard reservoir is used, a displacer can be inserted to reach a fluid level that ensures proper operation and avoids the ingress of air. The displacer should be removed before test operation as it may introduce extra stresses on the fluid under test.

9.1.3 Open the relief valve (5.1.7) (or set it to the lowest setting) and switch on the pump. Increase the pressure to approximately 3 MPa and flush for a minimum of 15 min. Drain the fluid and ensure that remnants in areas difficult to expel are removed. Repeat the flush with a fresh portion of flushing fluid and drain.

9.2 Procedure for aqueous fluids

9.2.1 Disassemble the system, including the pump body, heat exchanger (5.1.5) and relief valve (5.1.7).

9.2.2 Do not clean pumps run with anhydrous fluids in the same bath used to clean pumps run with aqueous fluids. Do not use hoses which have previously been used with mineral oils, phosphate esters, polyol esters or PAO fluids with water glycols.

9.2.3 Rinse all hoses, other rubber parts and gaskets with water. Clean hoses by passing a bristle brush through the length several times and re-rinse. Dry all components with compressed air and inspect for wear, hardness, cracks and/or tackiness. Replace as necessary.

9.2.4 Clean metal parts by rinsing with water, scrubbing with a bristle brush, re-rinsing and drying with compressed air. Clean the heat exchanger tubes with a 6,4 mm, or other appropriate diameter, cleaning brush. Clean the metal tubing and holes in the castings with a test tube brush.

10 Preparation of cartridge for test

10.1 Clean the filter housing, fit a new filter element, and fill the reservoir with approximately 70 litres of test fluid, ensuring that the level of the fluid is 500 mm ± 50 mm above the pump inlet.

10.2 Select a new cartridge, disassemble it and clean the parts carefully with light hydrocarbon solvent (4.2.2). Examine the individual parts for manufacturing or material irregularities, and dimensional conformance, as detailed in Annex A. Follow the directions given in Annex A for the preparation and re-assembly of the test cartridge.

10.3 Remove the cartridge used for flushing and fit the test cartridge.

10.4 Fit the cover plate on the pump and tighten the screws as described in 9.1.1. Slacken off the screws and retighten until just below the binding torque. Ensure that the pump rotates freely, adjusting the torque carefully by hand as necessary.

11 Procedure

11.1 Preliminary operations

With the test fluid at ambient temperature (15 °C to 25 °C) and the relief valve open, switch on the pump and start both timers (5.2). Start the heat exchanger (5.1.5), set the determined temperature ± 2 °C to achieve a viscosity of 13 mm^2/s for anhydrous fluids or 30 mm^2/s for aqueous fluids (see 7.2).

Procedure A, given in 11.2, describes the procedure for anhydrous fluids, and Procedure B, given in 11.3, describes the procedure for aqueous fluids.

11.2 Procedure A

11.2.1 Set the relief valve within 60 s to a pressure of 2 MPa, and then in increments of 2 MPa at 10 min intervals until the final running pressure of 14 MPa ± 0,2 MPa is achieved (running-in).

11.2.2 Check the fluid temperature at the pump inlet and ensure that it is within ± 2 °C of that determined for a viscosity of 13 mm^2/s. On no account shall the temperature exceed the upper limit.

11.2.3 Check the fluid flow during each stage of the pressure increase. If, at any stage, the flow falls below 22 l/min, open the relief valve, switch off the pump, and then re-tighten the screws on the cover plate as described in 9.1.1. Complete this operation within 5 min of switching off the pump. Do not slacken off the cover screws, as this necessitates discontinuation of the test, and cartridge replacement.

11.2.4 At the end of the running-in period (approximately 1 h), the test pressure of 14 MPa ± 0,2 MPa, the test temperature ± 2 °C and the fluid flow of 25 l/min ± 3 l/min shall be constant, and the absolute pressure at the inlet to the pump shall be 95 kPa minimum. Ensure that all test-conditions monitoring equipment (5.1.12) is operating and recording.

NOTE The minimum absolute pressure at the pump inlet will normally be met if the level of fluid above the pump in the reservoir is maintained.

11.2.5 After 250 h ± 0,5 h of continuous operation, open the relief valve, switch off the pump, and extract the cartridge. Any interruption of the test within the running period leading to dismantling of the pump, invalidates the test.

11.2.6 Disassemble the cartridge, wash the parts in hydrocarbon solvent (4.2.2) and then with acetone (4.2.4) in the ultrasonic bath (5.5). Weigh the vanes, the ring, the rotor and the side bushings to the nearest 1 mg.

The loss in mass of the rotor and side bushings may be a cause of failure, but is not normally the symptom noted. Failure is normally noted by the inability of the pump to maintain pressure and/or flow, which could be the result of excessive wear, or other component failure. Users should establish a baseline of normal mass-loss level related to fluid type.

11.2.7 Visually inspect all components of the cartridge and record the condition.

11.3 Procedure B

11.3.1 Run the pump for 60 min ± 2 min with the relief valve open.

11.3.2 Set the relief valve slowly within 60 s to a pressure of 2 MPa, and then in three increments of 2 MPa followed by one increment of 2,5 MPa at 10 min intervals until the final pressure of 10,5 MPa ± 0,2 MPa is achieved.

11.3.3 Check the fluid temperature at the pump inlet and ensure that it is within ± 2 °C of that determined for a viscosity of 30 mm^2/s. On no account shall the temperature exceed the upper limit.

11.3.4 Check the fluid flow during each stage of the pressure increase. If, at any stage, the flow falls below 27 l/min, open the relief valve, switch off the pump, and then re-tighten the screws on the cover plate as described in 9.1.1. Complete this operation within 5 min of switching off the pump. Do not slacken off the cover screws, as this necessitates discontinuation of the test and cartridge replacement.

11.3.5 At the end of the running-in period (approximately 1 h 40 min), the test pressure of 10,5 MPa ± 0,2 MPa, the test temperature ± 2 °C and the fluid flow of 30 l/min ± 3 l/min shall be constant, and the absolute pressure at the inlet to the pump shall be 95 kPa minimum. Ensure that all test-condition monitoring equipment (5.1.12) is operating and recording.

11.3.6 After 250 h ± 0,5 h of continuous operation, open the relief valve, switch off the pump and extract the cartridge.

11.3.7 Disassemble the cartridge, wash the parts in water (4.1) followed by oxygenated hydrocarbon solvent (4.2.3) and then with acetone (4.2.4) in the ultrasonic bath (5.5). Weigh the vanes, the ring, the rotor and the side bushings, to the nearest 1 mg.

The loss in mass of the rotor and side bushings may be a cause of failure, but is not normally the symptom noted. Failure is normally noted by the inability of the pump to maintain pressure and/or flow, which could be the result of excessive wear, or other component failure. Users should establish a baseline of normal mass-loss level related to fluid type.

11.3.8 Visually inspect all components of the cartridge and record the condition.

12 Expression of results

a) Report the mass loss to the nearest 1 mg of the vanes and of the ring separately.

b) Report the actual running time if the test has been discontinued before 250 h.

c) Report any abnormalities in test conditions recorded during the test.

NOTE The continuous recording charts or printouts, if available, will normally be attached to the test report.

d) Report the condition of the cartridge parts.

NOTE In general, the descriptions "normal" or "abnormal" will be sufficient, with a further description of any abnormality optional.

13 Precision

13.1 General

The precision of this test method has only been estimated for anhydrous fluids and water/glycol, and is under evaluation for other aqueous fluids. The estimate of precision, obtained by statistical evaluation of interlaboratory test results, was not carried out in accordance with ISO 4259[2], and is not expressed in conventional terms of repeatability and reproducibility, but is given in 13.2 for guidance. See also Annex B.

13.2 Precision estimate

Mass-loss details over 30 mg for vanes and over 120 mg for the ring shall not be used for assessing differences between anhydrous fluids, and mass-loss details over 50 mg for vanes and 180 mg for the ring shall not be used for assessing differences between water/glycol mixtures.

14 Test report

The test report shall contain at least the following information:

a) a reference to this International Standard;

b) all information necessary for complete identification of the product tested;

c) the procedure used and the test result (see Clause 12);

d) any deviation, by agreement or otherwise, from the procedure specified;

e) the date of the test.

Annex A
(normative)

Test cartridge component selection, preparation and assembly

A.1 Component selection and preparation

A.1.1 General

The selection and preparation of the four components of the test cartridge is described in A.1.2 to A.1.5. The references to specific parts or dimensions given within each clause refer to the figure accompanying the clause. A commercial supply of preselected and prepared components may be available and suitable.

A.1.2 Rotor (see Figure A.1)

A.1.2.1 Visually inspect new rotors for deep longitudinal tool marks on the slot terminal hole, and for slots which are not fully overlapped by the terminal hole. Inspect new rotors for deep machining marks in the vane slots, for taper of the outer diameter, and for slots not cut parallel to the axis. Discard rotors with any of the above defects.

A.1.2.2 Remove sharp edges where the vane slots meet the faces and the outer diameter of the rotor (1), and where the faces meet the outer diameter (3) with the abrasive stone (4.3). Ensure that an even chamfer is obtained at the outer diameter (2) to act as a guide for the following face of the vane. Polish both faces of the rotor on the abrasive cloth (4.4) placed on the finishing plate (5.6). Protect the rotor shaft by masking tape during this operation. If necessary, to remove surface corrosion or burrs, polish the inside surfaces of the vane slots with abrasive cloth wrapped round a strip of steel or brass.

A.1.2.3 Wash the rotor thoroughly in light hydrocarbon solvent (4.2.2), and brush out the vane slots to remove grit and/or oil. Air dry and check that clean, deburred vanes will fall freely through the slots.

A.1.3 Vanes (see Figure A.2)

A.1.3.1 Visually inspect vanes for surface irregularities and correct chamfer (1, 2, 3). Measure each vane top to bottom (A, B) at each end to ensure that the edges are parallel. Discard vanes which have deep marks on the faces, are unevenly cut or have no apparent chamfer, or are more than 0,050 mm out of parallel.

A.1.3.2 Deburr all the vane edges, except the wear chamfer, to produce a chamfer of 0,05 mm to 0,10 mm $\times$ 45°, with the abrasive cloth, wetted with water or light oil, on the finishing plate. Ensure that the chamfered edge diagonally opposed to the wear chamfer (4) is even.

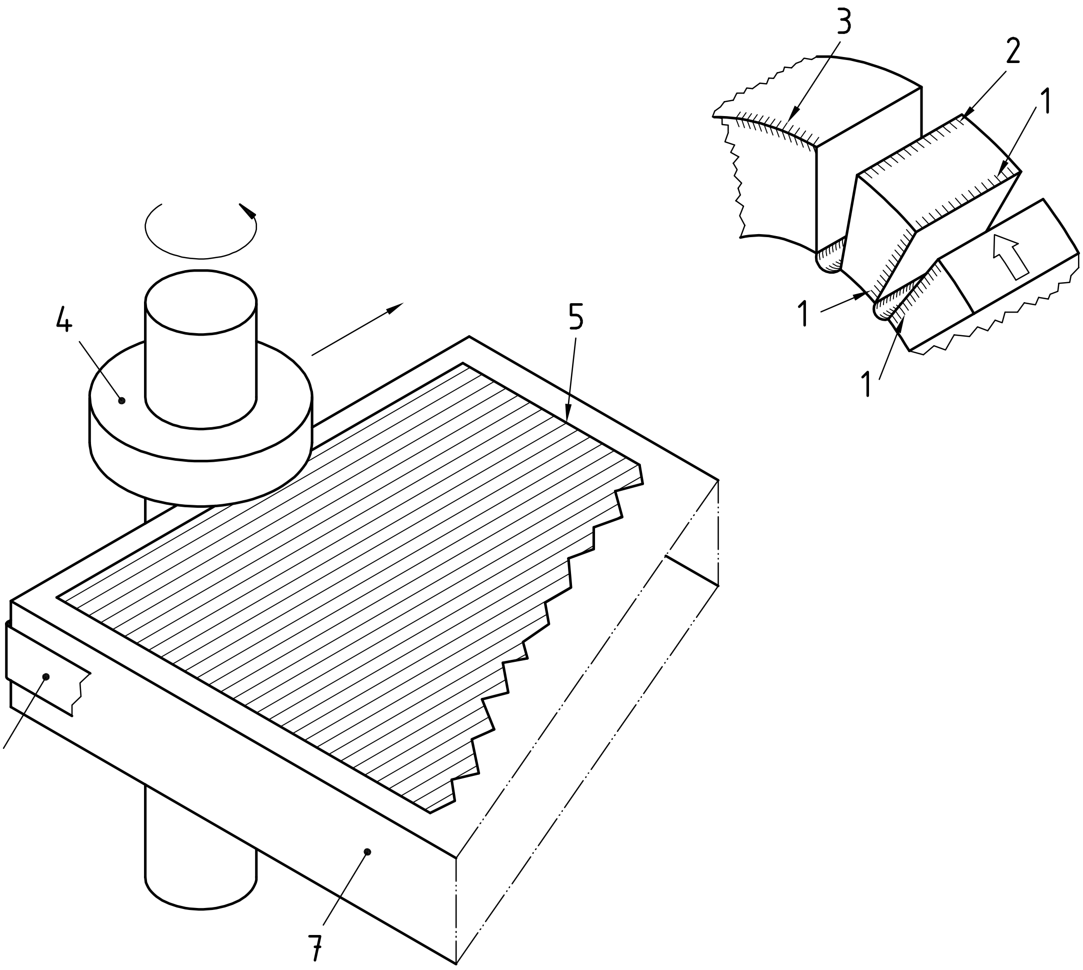
A.1.3.3 Measure the length of each vane at the top and bottom (C, D) and discard vanes which are more than 0,005 mm out of parallel. Segregate vanes into groups by length of 0,002 mm increments. Use a degausser to demagnetize the vanes before use.

NOTE It may be necessary to prepare a quantity of vanes in advance in order to have 12 suitable vanes of similar length available for one test.

A.1.4 Ring (see Figure A.3)

A.1.4.1 Visually inspect the ring for surface irregularities or poor finish on the cam wear surface. Discard rings with unusually coarse wear surfaces, surface pits or grinding chatter (1, 2).

NOTE Rings of less than 180 g mass have been associated with ring cracking and rotor failure.



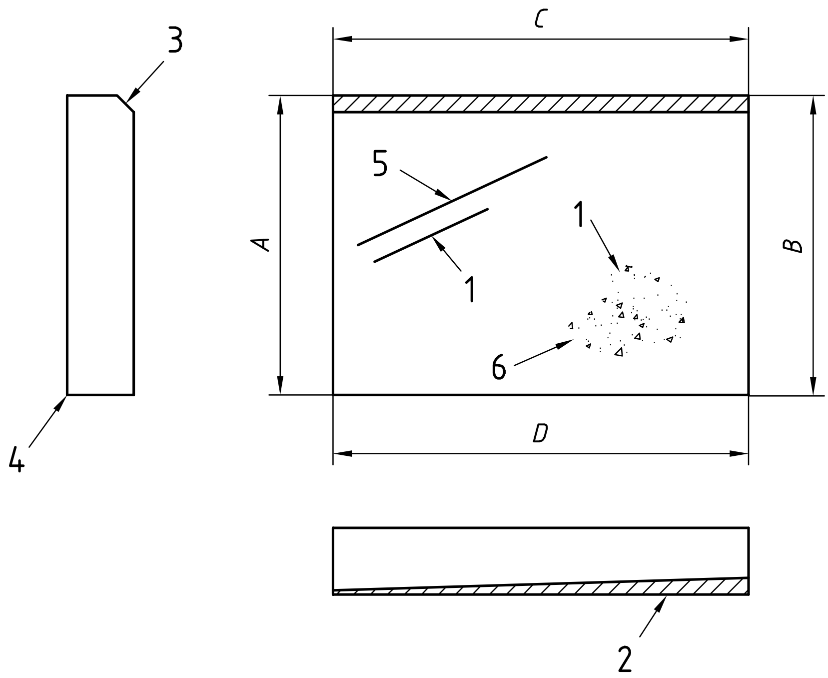
Key

1 edges where the vane slots meet the faces and the outer diameter of the rotor
2 outer diameter
3 edge where the face meets the outer diameter
4 face
5 paper
6 tape
7 finishing plate

Figure A.1 — Rotor preparation

A.1.4.2 Lightly deburr the edges where the cam surface and faces meet (3), using the abrasive stone (4.3) held at a 45° angle to the axis of the ring. Push the stone from the inside toward the outer diameter while following the periphery of the cam. Deburr the edges where the outer diameter and faces meet (4). Polish the flat faces of the ring (5) using a figure-of-eight motion on the abrasive cloth supported on the finishing plate.

A.1.4.3 Wash the ring in light hydrocarbon solvent to remove grit and/or oil. Air dry and use a degausser to demagnetize the ring before use.



Key

1 surface irregularities
2 uneven chamfer
3 wear chamfer
4 chamfered edge diagonally opposed to wear chamfer
5 deep scars
6 pits

Figure A.2 — Vane preparation

A.1.4.4 Measure the thickness of the ring (A) at 12 places equally spaced around the ring. If the thickness varies by more than 0,005 mm, discard the ring, or polish as described in A.1.4.2 until the condition is corrected.

To correct an out-of-parallel thickness condition, it is advisable to remove material from the thickest region of one face only. It may be advantageous to start the polishing with coarser abrasive cloth (37 µm or 53 µm grit size) before final polishing with the 27 µm grit size cloth. The polishing cloth should be kept wet, and the ring allowed to cool before taking intermediate measurements.

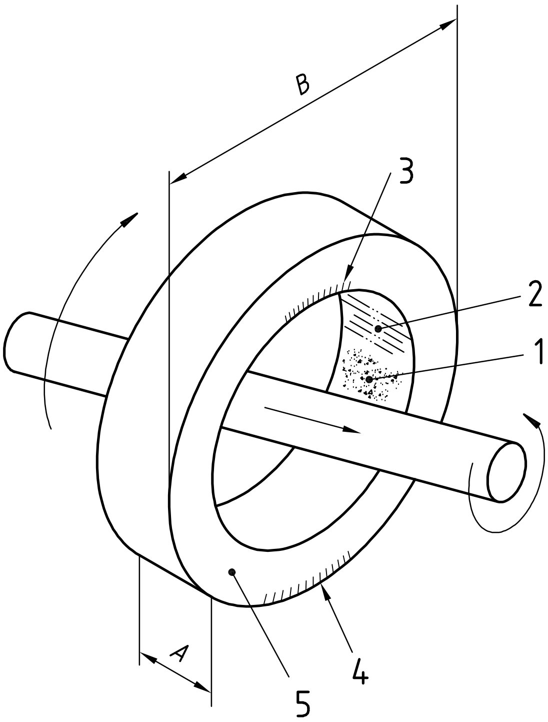
A.1.5 **Bushings** (see Figure A.4)

A.1.5.1 Visually inspect the bushings for surface defects, and check that the slots in the pressure ports are oriented properly (point against the direction of pump rotation), and that the oil grooves on the rear face of the bushings connect with the pressure ports. Check that the bushing has a concave face by resting the bushing on a precision plate and measuring the slope between the outer diameter (2) and the shank (1), and verifying a rise of 0,025 mm to 0,050 mm. Discard bushings that do not conform.

A.1.5.2 Check that the front and rear faces of the bushing are parallel by resting the bushing on a precision plate and measuring the thickness (C) at several places around its outer diameter. The thickness shall not vary by more than 0,010 mm.

NOTE It is permissible to lightly polish, in a figure-of-eight motion, the flat surface of the bushing to minimize internal pump leakage at elevated temperatures and pressures. The application of dye before polishing aids assessment.

A.1.5.3 Roll the alignment pin on a flat surface to verify that it is straight.



Key

1 surface pits

2 grinding chatter

3 edge where the cam surface and face meet

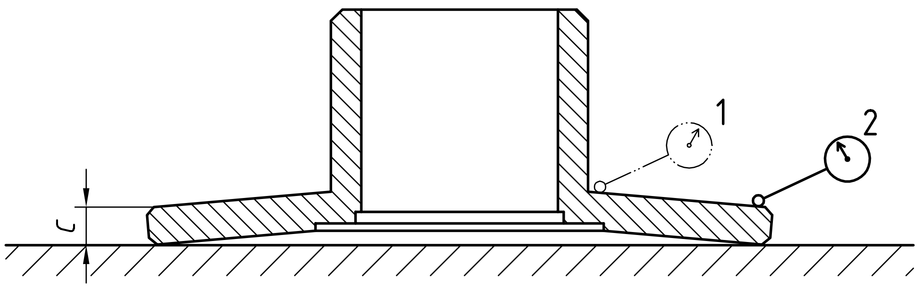
4 edge where the outer diameter and face meet

5 flat face of the ring

A Thickness of the ring.

B Outer diameter of the ring.

Figure A.3 — Ring preparation



Key

1 shank

2 outer diameter

C Thickness.

Figure A.4 — Bushing inspection

A.2 Cartridge assembly

A.2.1 Pre-assembly

A.2.1.1 Select components so that the average rotor thickness is 0,017 mm to 0,035 mm less than the average ring thickness [Figure A.3 (A)]. Select a set of vanes of equal length [Figure A.2 (D)] so that they are 0,002 mm to 0,015 mm less than the average rotor thickness.

A.2.1.2 Measure the outer diameter of the ring [Figure A.3 (B)] to ensure its suitability for the pump housing.

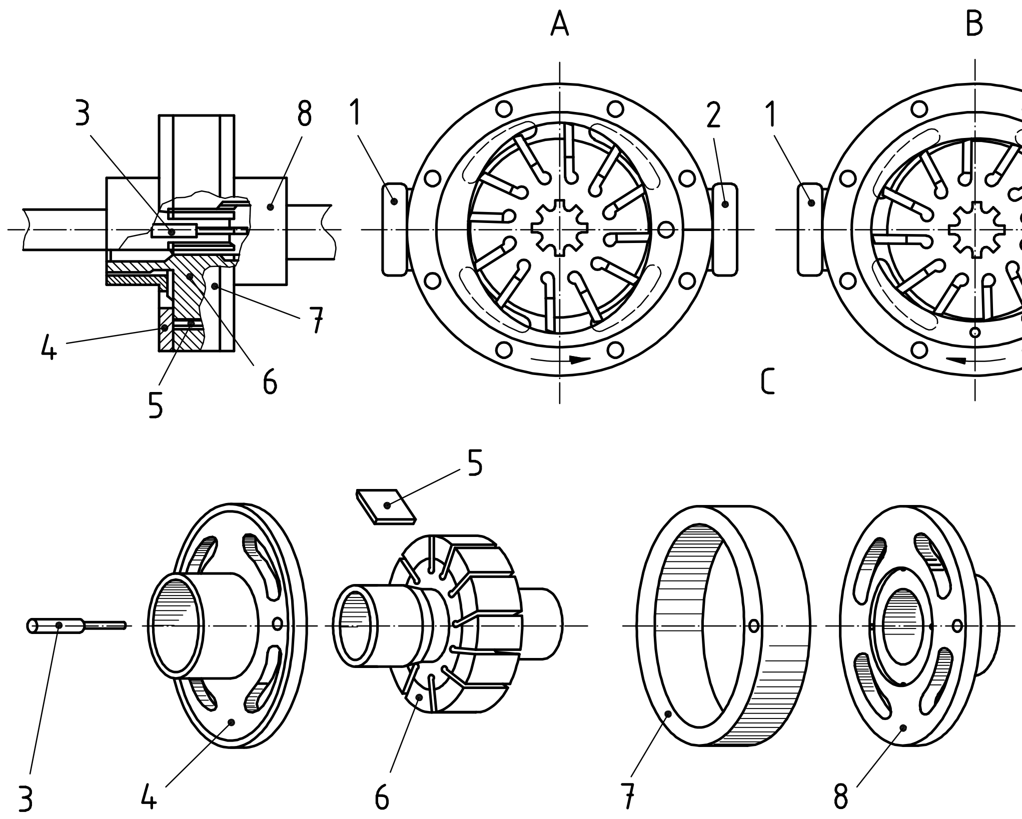
NOTE If the ring is undersized, a piece of 0,025 mm shim stock, trimmed to 20 mm $\times$ 235 mm, can be wrapped around the ring to pack out the excess clearance.

A.2.2 Assembly

A.2.2.1 Wash the selected components in oxygenated hydrocarbon (4.2.3) and then clean with acetone (4.2.4) in the ultrasonic bath (5.5). Dry in a stream of dry, clean air, or by wiping with a lint-free cloth.

A.2.2.2 Weigh all the vanes together, and weigh the ring separately, to the nearest 1 mg. Weigh the rotor and the two side bushings to the nearest 1 mg. Record the masses.

A.2.2.3 Re-assemble the cartridge, wetting the parts in test fluid before assembly. In assembling the vanes, ensure that the chamfered edges trail in the normal direction of rotation. Figure A.5 gives an expanded view of the test cartridge and its assembly.



Key

1 out
2 in
3 pin
4 bushing
5 vane
6 rotor
7 ring
8 bushing

A Assembled for right-hand rotation.
B Assembled for left-hand rotation.
C Assembled view facing head end.

Figure A.5 — Expanded view of the test cartridge

Annex B
(informative)

Test cartridge suppliers

The replaceable test cartridge consists of a cam ring, a rotor, two bushings, a set of 12 vanes and an alignment pin, set in a cartridge housing (see Figure A.5). As of mid-2001, the only supply of qualified cartridge parts is that manufactured by Eaton (formerly Vickers), but they ceased production in 2000. There is a significant, but rapidly diminishing, supply of "Vickers" parts at users and stockists, and urgent steps are under way to qualify alternatives.

Conestoga USA Inc. manufactures all parts of the test cartridge, including the housing, and testing was underway in late-2001/early 2002 on these parts alongside "Vickers" parts in four laboratories on three fluids of differing wear characteristics. Experience so far indicates that Conestoga parts perform similarly to Vickers parts, and are, of necessity, being increasingly used. They are normally supplied preselected and prepared.

Tokimec, in Japan, who were formerly a Vickers licensee, also continue to supply cartridge parts, and some tests have been carried out in Europe on the vanes manufactured by them. These may also prove to be compatible parts after further testing.

Some users have carried out satisfactory tests with locally manufactured bushings, but it is unlikely that this trend can be extended to the other cartridge parts.

The addresses of these suppliers[2)] are:

Conestoga USA Inc.
PO Box 3052
Pottstown
Pennsylvania, PA 19464
USA

Tokimec
2-16-46 Minami-Kamata
Ohta-ku
Tokyo 144-8551
Japan

2) This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

Bibliography

[1] ISO 3448:1992, *Industrial liquid lubricants — ISO viscosity classification*

[2] ISO 4259:1992, *Petroleum products — Determination and application of precision data in relation to methods of test*

[3] ISO 12922:1999, *Lubricants, industrial oils and related products (class L) — Family H (Hydraulic systems) — Specifications for categories HFAE, HFAS, HFB, HFC , HFDR and HFDU*

[4] ISO 16889:1999, *Hydraulic fluid power filters — Multi-pass method for evaluating filtration performance of a filter element*

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