INTERNATIONAL STANDARD

ISO 4928

Third edition
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Road vehicles — Elastomeric cups and seals for cylinders for hydraulic braking systems using a non-petroleum base hydraulic brake fluid (Service temperature 120 °C max.)

Véhicules routiers — Coupelles et joints en caoutchouc pour cylindres de dispositifs de freinage hydrauliques utilisant un liquide de frein à base non pétrolière (Température maximale d'utilisation 120 °C)

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 40421 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 2, *Braking and systems equipment*.

This third edition cancels and replaces the second edition (ISO 4928:1980), which has been technically revised.

Road vehicles — Elastomeric cups and seals for cylinders for hydraulic braking systems using a non-petroleum base hydraulic brake fluid (Service temperature 120 °C max.)

1 Scope

This International Standard specifies performance tests of brake cups and seals for hydraulic braking systems for road vehicles; it does not include requirements relating to chemical composition, tensile strength and elongation of the rubber compound. Disc brake seals are not covered by this International Standard.

This International Standard is applicable to moulded seals (cups or double-lipped type gland seals), 60 mm in diameter and smaller, compounded from high temperature-resistant rubber, for use in hydraulic actuating cylinders using road vehicle non-petroleum base hydraulic brake fluid conforming to the requirements of ISO 4925.

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 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 188:1998, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 1250, *Mineral solvents for paints — White spirits and related hydrocarbon solvents*

ISO 4925, *Road vehicles — Specification of non-petroleum-base brake fluids for hydraulic systems*

ISO 4926, *Road vehicles — Hydraulic braking systems — Non-petroleum base reference fluids*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
sloughing
release of carbon black on the surface of the rubber

3.2
scoring
formation of grooves in the rubber parallel to the direction of travel of the piston or seal

3.3
scuffing
visible erosion of the outer surface of the rubber

4 General requirements

4.1 Workmanship and finish

Seals shall be free from blisters, pin-holes, cracks, protuberances, embedded foreign material or other physical defects which can be detected by thorough inspection, and shall conform to the dimensions specified on the drawings.

4.2 Marking

The identification mark of the manufacturer and other details as specified on drawings shall be moulded into each seal. Each seal in conformity with this International Standard may also have the following mark: “ISO 4928”.

4.3 Packaging

Seals shall be packaged to meet requirements specified by the purchaser.

4.4 Sampling

The minimum lot on which complete specification tests shall be conducted for quality control testing, or the frequency of any specific type test used to control production, shall be agreed upon by the manufacturer and the purchaser.

5 Test requirements

5.1 Resistance to fluid at elevated temperature

After being subjected to the test for resistance to compatibility fluid at elevated temperature as prescribed in 6.1, the seals shall conform to the requirements specified in Table 1, and shall show no excessive disintegration as evidenced by blisters or sloughing.

Table 1 — Requirements for fluid resistance at elevated temperature (120 °C)

Characteristics	Permitted change
Volume	From 0,0 % to + 20,0 %
Outside diameter, lip	From 0,0 % to + 5,75 %
Outside diameter, base	From 0,0 % to + 5,75 %
Hardness	From − 15 IRHD to 0 IRHD

5.2 Precipitation

Not more than 0,3 % sediment by volume shall be formed in the centrifuge tube after the seals have been tested as specified in 6.2.

5.3 Wheel cylinder seals heat pressure stroking

5.3.1 General

Wheel cylinder seals, when tested by the procedure specified in 6.3, shall meet the performance requirements specified in 5.3.2 to 5.3.6.

5.3.2 Lip diameter change

The minimum lip diameter of wheel cylinder seals after the stroking test shall be greater than the wheel cylinder bore by the minimum dimensions specified in Table 2.

Table 2 — Lip diameter change of wheel cylinder seals

Dimensions in millimetres

Diameter of wheel cylinder bore	Minimum excess over bore
⩽ 19,05	0,40
> 19,05; ⩽ 25,4	0,50
> 25,4; ⩽ 38,1	0,65
> 38,1; ⩽ 60	0,75

5.3.3 Leakage

No constant dampness past the seals or fluid discoloration of the filter paper on two or more inspections shall occur.

5.3.4 Corrosion

Pistons and cylinder bore shall not show corrosion as evidenced by pitting to an extent discernible to the naked eye, but staining or discoloration shall be permitted.

5.3.5 Change in hardness

Rubber seals shall not decrease in hardness by more than 15 IRHD when tested in accordance with the procedure as specified in 6.7.

5.3.6 Condition of test seals

Wheel cylinder seals shall not show excessive deterioration such as scoring, scuffing, blistering, cracking, chipping (heel abrasion) or change in shape from original appearance.

5.4 Master cylinder seals heat pressure stroking

5.4.1 General

Master cylinder seals, when tested by the procedure specified in 6.4, shall meet the performance requirements specified in 5.4.2 to 5.4.6.

5.4.2 Lip diameter change

The minimum lip diameter of master cylinder seals after the stroking test shall be greater than the master cylinder bore by the minimum dimensions specified in Table 3.

Table 3 — Lip diameter change of master cylinder seals

Dimensions in millimetres

Diameter of master cylinder bore	Minimum excess over bore
⩽ 19,05	0,30
> 19,05; ⩽ 25,4	0,40
> 25,4; ⩽ 38,1	0,50
> 38,1; ⩽ 60	0,65

5.4.3 Leakage

The same requirement as specified for wheel cylinder seals shall be applied (see 5.3.3).

5.4.4 Corrosion

The same requirement as specified for wheel cylinder seals shall be applied (see 5.3.4).

5.4.5 Change in hardness

The same requirement as specified for wheel cylinder seals shall be applied (see 5.3.5).

5.4.6 Condition of test seals

The same requirement as specified for wheel cylinder seals shall be applied (see 5.3.6).

5.5 Low-temperature performance

5.5.1 Leakage

No leakage of fluid shall occur when seals are tested according to the procedure specified in 6.5.1.

5.5.2 Bend test

The seal shall not crack and shall return to approximately its original shape within 1 min when tested according to the procedure specified in 6.5.2.

5.6 Oven ageing

5.6.1 General

Seals, when tested according to the procedure specified in 6.6, shall meet the requirements specified in 5.6.2 and 5.6.3.

5.6.2 Change in hardness

The change in hardness shall be within the limits of ± 5 IRHD.

5.6.3 Condition of test seals

The seal shall show no evidence of deterioration, or change in shape from original appearance.

5.7 Corrosion

5.7.1 General

Seals, when tested according to the procedure specified in 6.8, shall meet the requirements specified in 5.7.2 and 5.7.3.

5.7.2 Corrosion of metal strips

The seals shall not cause corrosion exceeding the limits shown in Table 4. The metal strips outside of the area where the strips are in contact shall be neither pitted nor roughened to the extent discernible to the naked eye, but staining or discoloration is permitted.

Table 4 — Permissible change in mass of corrosion test strips

Test strips	Permissible change in mass mg/cm^2 of surface
Tinned iron	± 0,2
Steel	± 0,2
Aluminium	± 0,1
Cast iron	± 0,2
Brass	± 0,4
Copper	± 0,4
Zinc	± 0,4

5.7.3 Fluid-water mixture characteristics

The fluid-water mixture at the end of the test shall show no jellying at 23 °C ± 5 °C. No crystalline type deposits shall form and adhere to either the glass wall or the surface of metal strips. The fluid-water mixture shall contain no more than 0,2 % sediment by volume.

5.8 Storage corrosion test

After twelve cycles in the humidity cabinet when operated according to the procedure specified 6.9, there shall be no evidence of corrosion adhering to or penetrating the wall of the cylinder bore that was in contact with the test seal.

Slight discoloration (staining) or any corrosion or spots away from the contact surface of the test seals may be permissible.

6 Test procedures

6.1 Resistance to fluid at elevated temperature — Dimensional test

6.1.1 Apparatus and material

6.1.1.1 **Micrometer, shadowgraph or other suitable apparatus**, to measure accurately to 0,02 mm.

6.1.1.2 **Glass container**, of capacity approximately 250 ml and diameter 50 mm, which can be tightly sealed.

6.1.1.3 **Chemical balance**, capable of weighing to 1 mg.

6.1.1.4 **Oven**, uniformly heated dry air type, conforming to the requirements for Method B of ISO 188:1998.

6.1.1.5 **Two glass-stoppered weighing bottles**, of adequate mouth size to hold the seals under test.

6.1.1.6 **Isopropyl or ethyl alcohol**, of 95 % (by volume) reagent grade for washing purpose.

6.1.2 Test specimens

Two seals shall be used for testing at 120 °C.

6.1.3 Procedure

Rinse the cups in the alcohol (6.1.1.6) and wipe dry with a clean, lint-free cloth to remove dirt and packing debris. Do not leave the seals in the alcohol for more than 30 s.

Measure the lip and base diameters to the nearest 0,02 mm, taking the average of two readings at right angles to one another. Take care when measuring the diameters before and after ageing that the measurements are made in the same manner and at the same locations.

Determine and record the initial hardness of the test seals. (See 6.7 and Figure 3.)

Determine the volume of each seal in the following manner: weigh the seals in air (m_1) to the nearest 0,001 g and then weigh the seals immersed in distilled water at room temperature (m_2). Quickly dip each specimen in alcohol and then blot dry with filter paper free of lint and foreign material.

Immerse two seals completely in 75 ml ± 1 ml of compatibility reference fluid as defined in ISO 4926, in the glass container (6.1.1.2) and seal the container to prevent vapour loss. Place the container in the oven (6.1.1.4) set at 120 °C ± 2 °C for a period of 70 h ± 2 h. At the end of the heating period, remove the container from the oven and allow the seals to cool in the container at 23 °C ± 5 °C for 60 min to 90 min. At the end of the cooling period, remove the seals from the container and rinse in the alcohol and wipe dry with a clean, lint-free cloth. Do not allow the seals to remain in the alcohol for more than 30 s.

After removal from the alcohol and drying, place each seal in a separate, tarred, stoppered weighing bottle (6.1.1.5) and weigh (m_3). Remove each seal from its weighing bottle and weigh immersed in distilled water (m_4) to determine water displacement after hot fluid immersion. Make all weighings to the nearest 0,001 g.

Determine the final volume, dimensions and hardness of each seal within 60 min of rinsing in the alcohol.

6.1.4 Expression of results

6.1.4.1 Volume change

Volume change ΔV shall be reported as a percentage of the original volume. The change in volume is given by the equation:

$$\Delta V = \frac{(m_3 - m_4) - (m_1 - m_2)}{(m_1 - m_2)} \times 100$$

where

m_1 is the initial mass in air, in grams;

m_2 is the initial apparent mass in water, in grams;

m_3 is the mass in air after immersion in test fluid, in grams;

m_4 is the apparent mass in water after immersion test fluid, in grams.

6.1.4.2 Dimensional changes

The original measurements of the lip and base diameters shall be subtracted from measurements taken after the test and the difference reported in millimetres and as percentages of the original diameters.

6.1.4.3 Hardness

Change in hardness shall be determined and recorded.

6.1.4.4 Disintegration

The seals shall be examined for disintegration as evidenced by blisters or sloughing.

6.2 Precipitation test

6.2.1 Apparatus

6.2.1.1 Glass containers, of capacity approximately 250 ml and diameter 50 mm, which can be tightly sealed.

6.2.1.2 Cone-shaped centrifuge tube, of capacity 100 ml.

6.2.1.3 Oven, uniformly heated dry air type, conforming to the requirements for Method B of ISO 188:1998.

6.2.2 Test specimen

From two or more seals to be tested, obtain a sample of mass 4,0 g ± 0,5 g. Since sizes of seals vary, small pieces may be cut from the seal to reach the specified mass. Use the minimum number of pieces to obtain a mass of 4,0 g ± 0,5 g.

6.2.3 Procedure

To determine the precipitation compatibility characteristics of the test seals, place the sample (6.2.2) in one of the specified glass containers (6.2.1.1) containing 75 ml of compatibility fluid of ISO 4926. Seal the container to prevent vapour loss and place in the oven (6.2.1.3) at 120 °C ± 2 °C for 70 h ± 2 h.

As an optional test, a blank test may be run on the brake fluid prior to the real test and any sediment from the blank test may be subtracted from the sediment amount obtained from the real test.

At the end of the heating period, remove the container from the oven and allow to cool at room temperature for 24 h, after which remove the seals.

Agitate thoroughly the contents of the jar and transfer the fluid and suspended particles to a cone-shaped centrifuge tube (6.2.1.2) of 100 ml capacity and determine the sediment as follows.

a) Measure a 10 ml sample of the fluid and suspended particles to be tested, into each of two clean, dry centrifuge tubes at room temperature. Fill each tube to the 100 ml mark with the naphtha (see caution below) and close tightly with a softened cork (not a rubber stopper). Then invert each tube at least twenty times, allowing the liquid to drain thoroughly from the tapered tip of the tube each time. Place the tubes in a water bath at 32 °C to 35 °C for 5 min. Momentarily remove the corks to relieve any pressure, and invert each tube again at least twenty times, exactly as before. The success of this method depends to a large degree upon having a thoroughly homogeneous mixture that will drain quickly and completely from the tapered tip when the tube is inverted.

CAUTION — Naphtha is an inflammable liquid. Handle in a well-ventilated area, away from naked flames or other sources of ignition. The use of protective gloves and suitable eye protection is recommended.

b) Balance the two centrifuge tubes or pairs of tubes with their respective trunnion cups and place them on opposite sides of the centrifuge head. Then whirl them for 10 min at a rate sufficient to produce a relative centrifugal force (rcf) of between 600 and 700 at the tips of the whirling tubes. Repeat this operation until the volume of sediment in each tube remains constant for three consecutive readings. In general, not more than four whirlings will be required.

c) Read the volume of the solid sediment at the bottom of each centrifuge tube, estimating to 0,1 ml or closer if possible. If the two readings differ by not more than 0,1 ml, report the mean of the two as the

"precipitation number". If the two readings differ by more than 0,1 ml, make two more determinations and report the average of the four determinations.

6.3 Wheel cylinder seals heat pressure stroking

6.3.1 Apparatus

6.3.1.1 **Oven**, uniformly heated dry air type, conforming to the requirements for Method B of ISO 188:1998;

6.3.1.2 **Actuating stroking fixture for wheel cylinder seals**, designed to provide a 3,8 mm ± 1,7 mm movement of each piston.

6.3.2 Test specimen

Two wheel cylinder seals shall be used as test specimens.

6.3.3 Procedure

Rinse the seals in the alcohol (6.1.1.6) and wipe dry with a clean, lint-free cloth to remove dirt and packing debris. Do not allow the seals to remain in the alcohol for more than 30 s.

Determine the lip diameter to the nearest 0,02 mm, taking the average of two readings at right angles to one another.

In the case of double-lip seals, take these measurements after the cup has been assembled on the piston. Determine and record the initial hardness of the test seals in IRHD in accordance with 6.7.

Install the internal parts, which may include among other things seals, piston springs, expanders, etc., in a wheel cylinder of known diameter using compatibility fluid of ISO 4926 as a lubricant. (Boots shall not be used.)

Mount the wheel cylinder assembly on the stroking fixture (6.3.1.2). Fill the system with compatibility fluid conforming to ISO 4926. Bleed all air from the system. Place a sheet of filter paper under each end of the wheel cylinders to catch and determine leakage.

Place the stroking fixture assembly in the oven (6.3.1.1) and actuate for 70 h ± 2h at 120 °C ± 2 °C. During the total movement of the piston the pressure shall increase to 7,0 MPa ± 0,3 MPa. The rate of operation shall be held to a uniform reciprocating motion of (0,28 ± 0,03) strokes/s [(1 000 ± 100) strokes/h]. Figure 1 illustrates a recommended pressure (MPa) versus wheel cylinder piston movement curve for wheel cylinders having diameters of 12,7 mm to 60 mm. Shut off the actuating means and the oven heater at the termination of the stroking period with the master cylinder piston in the "off" position to relieve retained pressure in the system.

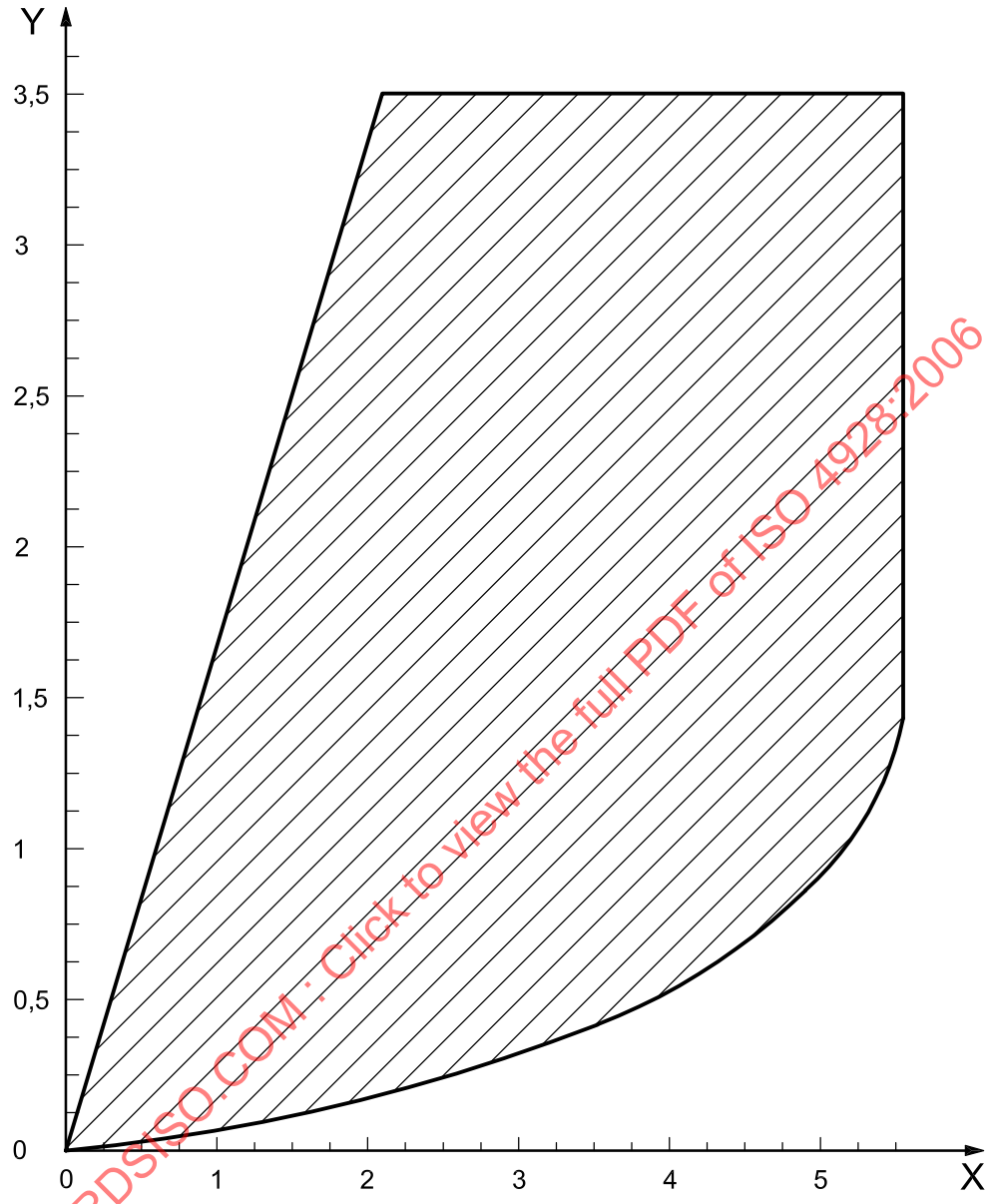
After a cooling period of 1 h with the oven door open and a ventilating fan on, disconnect the fluid line at the wheel cylinder inlet. Remove the entire stroking test fixture containing the test wheel cylinder from the oven and allow to cool for 22 h ± 2 h at room temperature. Immediately after completion of the cooling period, make a careful inspection to check for fluid leaks past the seals and record the results.

Drain the fluid from the system, and remove the seals from the wheel cylinder. Measure double-lip seals before removal from the pistons. Rinse the seals in the alcohol and dry with compressed air. Do not allow the seals to remain in the alcohol for more than 30 s.

Inspect seals for scoring, scuffing, blistering, cracking, chipping (heel abrasion), and change in shape from original appearance. Inspect cylinder parts, recording any pitting on pistons and cylinder walls. Determine and record the change in hardness in IRHD in accordance with 6.7.

Measure the lip diameter of each seal within 30 min to 60 min of removal from the wheel cylinder and report the difference between the actual cylinder bore and the lip diameter after the test (see Table 2 for permissible lip diameter change).

A new wheel cylinder assembly shall be used for each test.



Key

X stroke, in mm

Y pressure, in MPa

Figure 1 — Typical wheel cylinder seal stroke versus pressure, diameter 12,7 to 60 mm

6.4 Master cylinder seals heat pressure stroking

6.4.1 Apparatus

6.4.1.1 **Oven**, uniformly heated dry air type, conforming to the requirements for Method B of ISO 188:1998.

6.4.1.2 **Actuating stroking machine for master cylinder seals**, consisting of a suitable means for actuating the master cylinder containing the test specimens at the rate of (0,28 ± 0,03) stroke/s [(1 000 ± 100 strokes/h)]. The total piston movement shall be sufficient to cover approximately 90 % of the total available stroke.

6.4.2 Test specimen

One primary and one secondary seal shall be used for test specimens.

6.4.3 Procedure

Rinse the seals in the alcohol (6.1.1.6) and wipe dry with a clean, lint-free cloth to remove dirt and packing debris. Do not allow the seals to remain in the alcohol for more than 30 s.

Determine and record the initial hardness of the test seals in IRHD in accordance with 6.7.

Measure the lip diameter of the primary and secondary seals and record to the nearest 0,02 mm, taking the average of two readings at right angles to one another. Measure the lip diameter of the secondary seal after the seal has been assembled on the piston.

Dip the seals and master cylinder internal parts in compatibility fluid of ISO 4926 and coat the cylinder walls with the same fluid before assembly. Fill the system with compatibility fluid conforming to ISO 4926. Bleed all air from the system.

The master cylinder shall be located in the oven (6.4.1.1) and the fluid temperature in the master cylinder reservoir shall be maintained at 120 °C ± 2 °C. When strip heaters are used, they shall be placed not less than 150 mm from the cylinder on test, but shall be shielded to prevent direct radiation to any cylinder.

Operate the master cylinder assembly after installation in the oven for 70 h ± 2 h at the rate of (0,28 ± 0,03) stroke/s [(1 000 ± 100) strokes/h] and at a temperature of 120 °C ± 2 °C. All master cylinders having a total stroke of 63 mm or more shall be heat pressure stroke tested at 90 % of the 63 mm stroke, or 57 mm. The rate of stroking shall be (0,22 ± 0,02) stroke/s [(800 ± 80) strokes/h]. Full pressure (7 MPa) shall be attained and maintained for 3 mm of the stroke or 1 s maximum. Figure 2 illustrates a recommended pressure (MPa) versus master cylinder piston movement curve obtained with three wheel cylinders of approximately 22 mm diameter mounted in the stroking fixtures actuated by a 25 mm diameter master cylinder. The total stroke of such a master cylinder shall be 25 mm ± 0,4 mm. The initial movement of approximately 14 mm to 15 mm shall be at a rate that provides a gradual build-up of pressure, not exceeding 1 MPa. This shall permit the primary seal to pass over the compensating port at a low pressure. The balance of the stroke shall provide a gradual build-up of pressure to 7,0 MPa ± 0,3 MPa during the last 1,6 mm to 3,2 mm of the stroke.

After allowing excess fluid to evacuate, place a sheet of filter paper under the secondary seal of the master cylinder to catch and determine leakage past the secondary seal. Shut off the heat and actuating apparatus at the termination of the stroking period with the master cylinder in the “off” position to relieve retained pressure in the master cylinder.

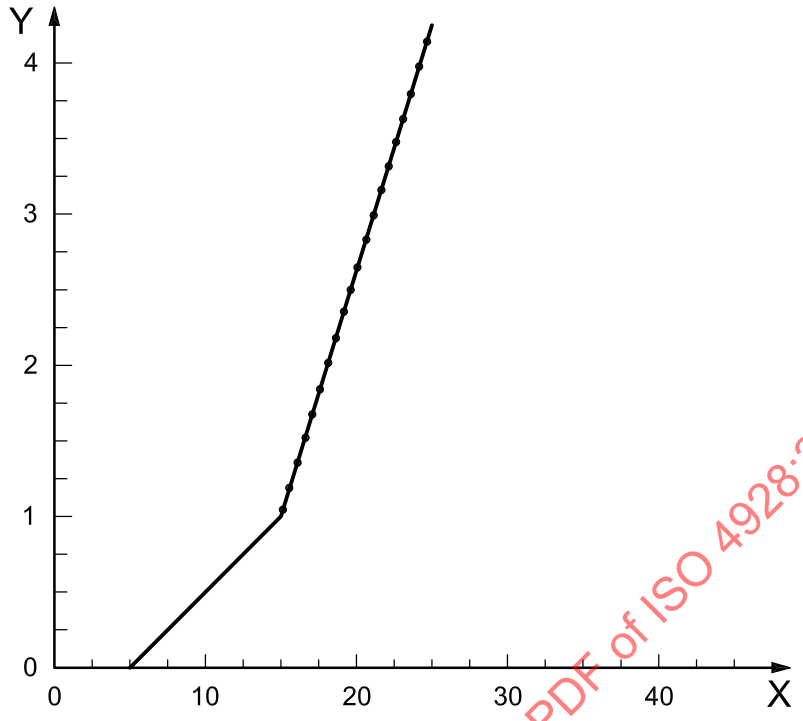
After a cooling period of 1 h with the oven door open and the ventilating fan on, disconnect the fluid line at the master cylinder outlet. Remove the master cylinder from the oven and allow to cool for 22 h ± 2 h at room temperature. Immediately after completion of the cooling period, make a careful inspection to check for fluid leakage on the filter paper past the master cylinder secondary seal.

Drain the fluid from the master cylinder. Remove the primary seal from the cylinder, rinse the alcohol (6.1.1.6) and dry with compressed air. Rinse the secondary seal on the piston in the alcohol (6.1.1.6), dry with compressed air and measure the lip diameter within 30 min to 60 min of removal from the cylinder and before removal from the piston. Do not allow seals to remain in the alcohol for more than 30 s.

Inspect seals for deterioration such as scoring, scuffing, blistering, cracking, chipping (heel abrasion) and change in shape from original appearance. Inspect cylinder parts, recording any pitting on piston or cylinder walls. Measure the lip diameter of the primary seal within 30 min to 60 min of removal from the cylinder and determine the difference between the actual cylinder bore and the lip diameter after the test and record the difference for both primary and secondary seals.

Determine and record the change in hardness in IRHD in accordance with 6.7.

A new master cylinder shall be used for each test. It is recommended that at least 0,05 mm to 0,13 mm clearance be allowed between the master cylinder piston and the master cylinder bore when conducting a master cylinder stroking test.



Key

X stroke, in mm

Y pressure, in MPa

Figure 2 — Typical master cylinder cup stroke versus pressure curve (diameter 25 mm)

6.5 Low-temperature performance

6.5.1 Leakage

6.5.1.1 Apparatus

6.5.1.1.1 Cold chamber, large enough to accomodate the test apparatus and to permit the operator to check and operate the apparatus without removal from the chamber.

6.5.1.1.2 Master cylinder and wheel cylinder, so connected that their operation closely approximates the brake system in actual service. The cylinder bore containing the test seals shall meet the dimensional limitations and bore finish requirements specified by the manufacturer.

6.5.1.1.3 Retractor spring, such as to require a line pressure of not more than 0,35 MPa to make a complete stroke at room temperature.

6.5.1.2 Test specimens

Two wheel cylinder seals and one primary and one secondary master cylinder seal shall be used for test seals.

6.5.1.3 Procedure

Rinse the test seals in the alcohol (6.1.1.6) and wipe dry with a clean, lint-free cloth. Do not allow the seals to remain in the alcohol for more than 30 s. Assemble the test seals in the test cylinder. During the assembly of the cylinder, coat the cylinder walls with compatibility fluid of ISO 4926. Dip the seals and internal parts of the cylinders in the same compatibility fluid.

Install the wheel and master cylinder assembly (6.5.1.1.2) containing the test seals on the test apparatus in the cold chamber (6.5.1.1.1). Fill the system with test fluid and bleed all air from the system. Do not use boots. Place a sheet of filter paper under the wheel and master cylinders to catch and determine leakage.

Enclose the complete actuating system in the cold chamber and subject to a temperature of − 43 °C to − 40 °C for 120 h ± 2 h. Maintain the piston and seals in a static position during the first 72 h of the test and thereafter actuate the cylinders for 6 strokes at 0,7 MPa and 6 strokes at 3,5 MPa each 24 h (after 72 h, 96 h, 120 h). The strokes shall be approximately 1 min apart, and the piston shall return to the stop after each stroke.

6.5.2 Bend test

6.5.2.1 Test specimens

One seal shall be used.

6.5.2.2 Procedure

Bend the seal, after it has been maintained for 22 h ± 1 h at − 43 °C to − 40 °C, between the thumb and finger through an angle of approximately 90° and release immediately. (Bend the cold seal while in the cold chamber (6.5.1.1.1) and handle it with gloved hands to prevent warming from body heat.) Within 1 min, examine the test seal for cracking and change in shape from the original.

6.6 Oven ageing

6.6.1 Apparatus

6.6.1.1 **Oven**, conforming to the requirements for Method B of ISO 188:1998.

6.6.2 Test specimens

Two seals shall be used.

6.6.3 Procedure

Rinse two test seals in the alcohol (6.1.1.6) and wipe dry with a clean, lint-free cloth to remove dirt and packing debris. Do not allow the seals to remain in the alcohol for more than 30 s.

Determine and record the hardness of the seals in IRHD in accordance with 6.7.

Place the two test seals in the oven (6.6.1.1), and subject to hot air heating at 120 °C ± 2 °C for 70 h ± 2 h. At the termination of the heating period, remove the seals from the oven and allow to cool for 16 h to 96 h at room temperature.

Inspect the seals for blistering, or change in shape from the original. Determine and record the hardness after ageing.

6.7 Hardness determination

Hardness shall be determined as specified in ISO 48, using an anvil such as illustrated in Figure 3. The hardness tester shall be applied to the seal in such a way as to ensure full contact between the seal and the face of the supporting anvil. The same operator shall make all hardness determinations for any one test.

If ISO 48 cannot be used, use a rubber anvil or cylinder having a hardness within 5 IRHD of the hardness of the seals being tested. See Figure 3 for two possible types of anvil. Others may be needed for other shapes of seal. The anvil thickness shall be sufficient to meet the requirements of the ISO 48 test.