INTERNATIONAL STANDARD

ISO 6118

Second 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 70 °C max.)

Véhicules routiers — Coupelles et joints en élastomère pour cylindres de systèmes de freinage hydrauliques utilisant un liquide de frein à base non pétrolière (température maximale d'utilisation: 70 °C)

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Contents

Page

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 6118 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 2, *Braking systems and equipment*.

This second edition cancels and replaces the first edition (ISO 6118:1980), 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 70 °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 rubber, for use in hydraulic actuating cylinders employing road vehicle non-petroleum base hydraulic brake fluid conforming to the requirements of ISO 4925.

NOTE The rubber used in these seals shall be suitable for operation in a temperature range of $-40\ ^{\circ}C$ to $+70\ ^{\circ}C$.

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 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 6118”.

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 (70 °C**)**

Characteristics	Permitted change
Volume	From 0,0 % to +16,0 %
Outside diameter, lip	From 0,0 % to +5,75 %
Outside diameter, base	
Hardness	From −10 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
$\leqslant$ 19,05	0,40
$>$ 19,05 $\leqslant$ 25,4	0,50
$>$ 25,4 $\leqslant$ 38,1	0,65
$>$ 38,1 $\leqslant$ 60	0,75

5.3.3 Leakage

No constant dampness past the seals and no 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 10 IRHD when tested in accoprdance with the procedure 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 wheel cylinder bore	Minimum excess over bore
$\leqslant$ 19,05	0,30
$>$ 19,05 $\leqslant$ 25,4	0,40
$>$ 25,4 $\leqslant$ 38,1	0,50
$>$ 38,1 $\leqslant$ 60	0,65

5.4.3 Leakage

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

5.4.4 Corrosion

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

5.4.5 Change in hardness

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

5.4.6 Condition of the test seals

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 its approximately original shape within 1 min when tested in accordance with 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 $\pm$5 IRHD.

5.6.3 Condition of the 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 in accordance with 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 gelling 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 12 cycles in the humidity cabinet when operated in accordance with 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

The following apparatus and material shall be used for the test.

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 70 °C.

6.1.3 Test 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 $\pm$ 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 70 °C $\pm$ 2 °C for a period of 120 h $\pm$ 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 $\pm$ 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 formula:

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

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 change

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

The following apparatus shall be used for the test.

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 $\pm$ 0,5 g. Since sizes of seals vary, small pieces may be cut from the seal to arrive at the mass. Use the minimum number of pieces to obtain a mass of 4,0 g $\pm$ 0,5 g.

6.2.3 Test 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 an oven (6.2.1.3) at 70 °C $\pm$ 2 °C for 120 h $\pm$ 2 h.

As an optional test, a blank test may be run on the brake fluid prior to the test and any sediment from the blank test may be subtracted from the sediment amount obtained from the 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 in 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 20 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 20 times, exactly as before. The success of this method depends to a large degree upon

having a thoroughly homogeneous mixture which 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

The following apparatus shall be used for the test.

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 $\pm$ 1,7 mm movement of each piston.

6.3.2 Test specimens

Two wheel cylinder seals shall be used as test specimens.

6.3.3 Test 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.

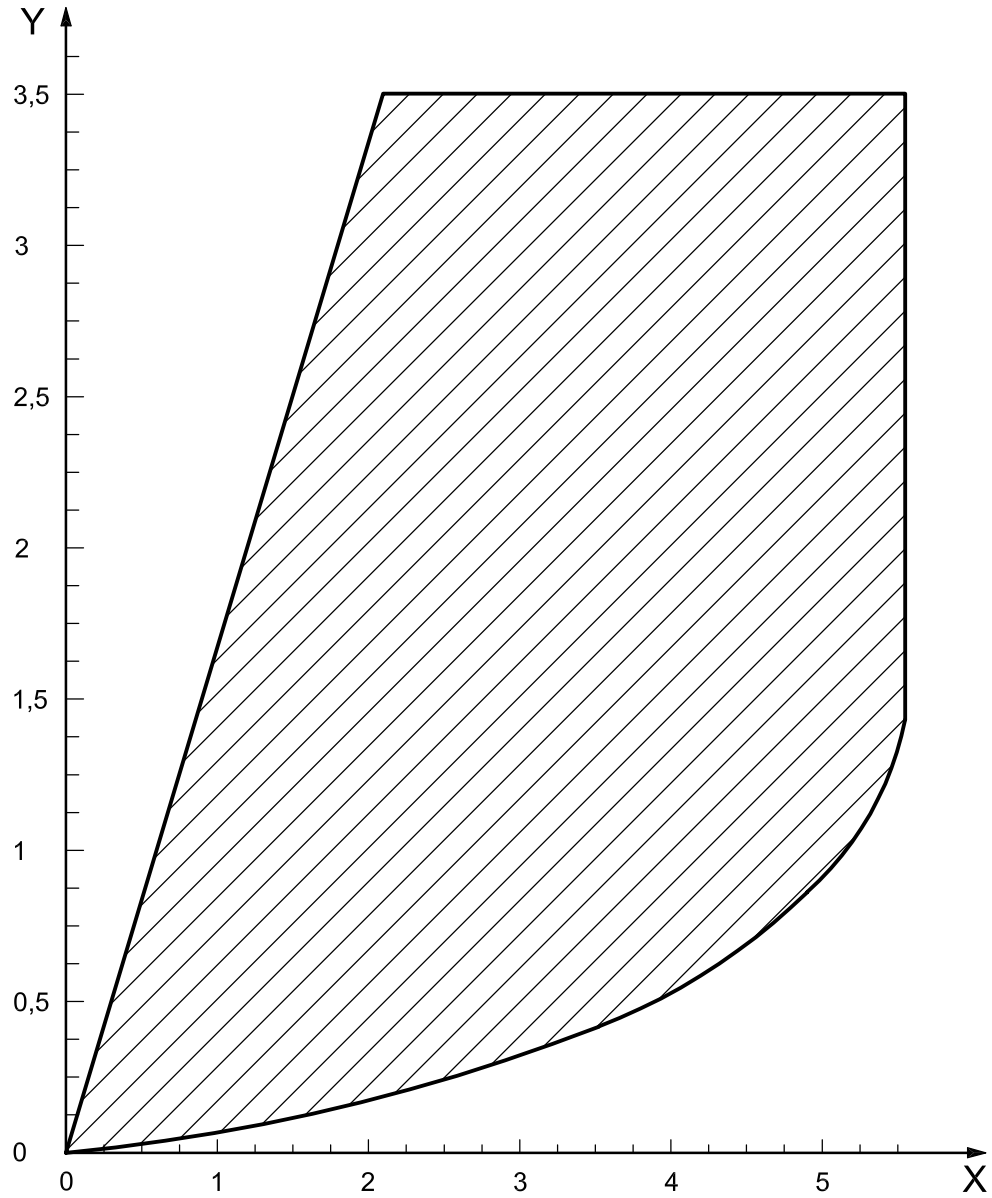
In the case of double-lip seals, take these measurements after the seal has been assembled on the piston. Determine and record the initial hardness of the test seals in IRHD in accordance with 6.7.

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 and actuate for 120 h $\pm$ 2 h at 70 °C $\pm$ 2 °h. During the total movement of the piston the pressure shall increase to 3,5 MPa $\pm$ 0,3 MPa. The rate of operation shall be held to a uniform reciprocating motion of 0,28 strokes/s $\pm$ 0,03 strokes/s (1 000 strokes/h $\pm$ 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 $\pm$ 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.



Key

X Stroke in mm

Y Pressure in MPa

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

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.

6.4 Master cylinder seals heat pressure stroking

6.4.1 Apparatus

The following apparatus shall be used for the test.

6.4.1.1 oven, uniformly heated dry air type, conforming to the requirements for method B of ISO 188;

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 strokes/s $\pm$ 0,03 strokes/s (1 000 strokes/h $\pm$ 100 strokes/h). The total piston movement shall be sufficient to cover approximately 90 % of the total available stroke.

6.4.2 Test specimens

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

6.4.3 Test 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.

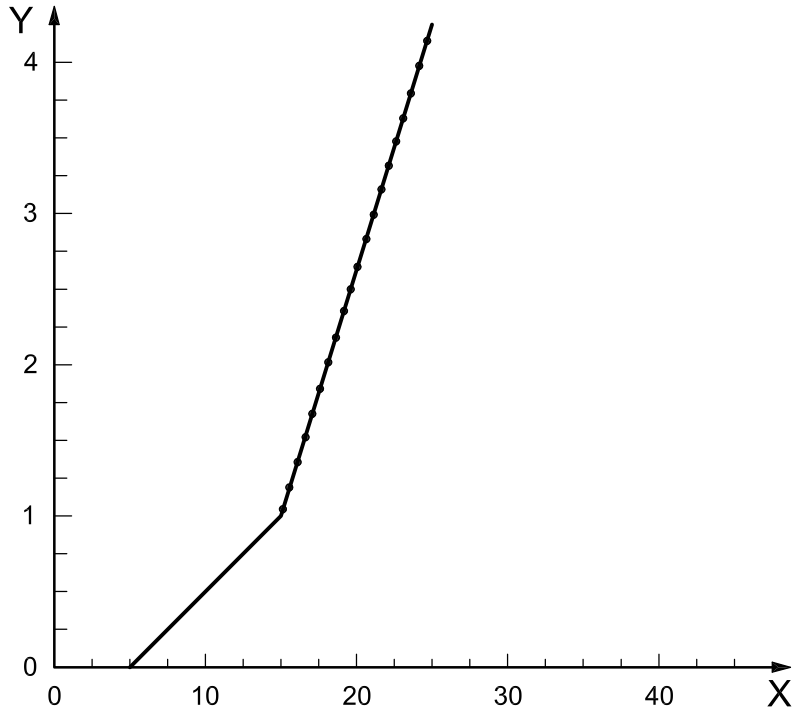
Determine and record the initial hardness of the test seals in IRHD in accordance with 6.7.

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 and the fluid temperature in the master cylinder reservoir shall be maintained at 70 °C $\pm$ 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 120 h $\pm$ 2 h at the rate of (0,28 $\pm$ 0,03) stroke/s [(1 000 $\pm$ 100) strokes/h] and at a temperature of 70 °C $\pm$ 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 $\pm$ 0,02) stroke/s [(800 $\pm$ 80) strokes/h]. Full pressure 3,5 MPa $\pm$ 0,3 MPa shall be attained. 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 25,0 mm $\pm$ 0,4 mm. The initial movement of approximately 14 mm to 15 mm shall be at a rate providing 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 3,5 MPa $\pm$ 0,3 MPa during the last 1,6 mm to 3,2 mm of the stroke.



Key

X Stroke in mm

Y Pressure in MPa

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

After allowing excess fluid to evaporate, 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 means 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 $\pm$ 2 h at room temperature. Immediately after completion of the cooling period, make a careful inspection to check fluid leakage past the master cylinder secondary seal.

Drain the fluid from the master cylinder. Remove the primary seal from the cylinder, rinse with 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 after 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.

6.5 Low temperature performance

6.5.1 Leakage

6.5.1.1 Apparatus

The following apparatus shall be used for the test.

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 Test 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 cylinder to catch and determine leakage.

Enclose the complete actuating system in the cold chamber and subject to a temperature of $-43\ ^{\circ}C$ to $-40\ ^{\circ}C$ for 120 h $\pm$ 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 Test procedure

Bend the seal, after it has been maintained for 22 h $\pm$ 1 h at $-43\ ^{\circ}C$ to $-40\ ^{\circ}C$, between the thumb and finger through an angle of approximately 90° and release immediately. (Bend the cold seal while in the cold chamber 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 form.

6.6 Oven ageing

6.6.1 Apparatus

The following apparatus shall be used for the test:

6.6.1.1 Oven, uniformity heated, dry air type conforming to the requirements for method B of ISO 188:1998.

6.6.2 Test specimens

Two seals shall be used.

6.6.3 Test 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 70 °C ± 2 °C for 120 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 original form. 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 determination 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.

a) Single lip seal **b) Secondary seal**

Figure 3 — Anvils for measuring hardness

NOTE Material for anvils: rubber having hardness in same range (±5 IRHD) as a seal being tested.

6.8 Corrosion test

6.8.1 Apparatus and material

The following apparatus and material shall be used for the test.

6.8.1.1 Oven, uniformity heated, dry air type conforming to the requirements for method B of ISO 188:1998.

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

6.8.1.3 Chemical balance, capable of weighing to 0,1 mg.

6.8.1.4 Glass jars, round with straight sides, having a capacity of approximately 475 ml and inner dimensions of approximately 100 mm in height and 75 ml in diameter. The jar lids shall be of tinned steel vented with a hole 0,8 mm $\pm$ 0,1 mm in diameter.

6.8.1.5 Desiccator, with desiccant.

6.8.1.6 Corrosion test strips, as listed in Table 4, each strip having a surface area of 25 cm^2 $\pm$ 5 cm^2 (i.e. approximately 8,0 cm long by 1,3 cm wide and not more than 0,6 cm thick).

6.8.2 Test specimens

Two seals shall be used.

6.8.3 Test procedure

Prepare two sets of test strips (6.8.1.6) from each of the metals listed in Table 4. Drill a hole between 4 mm and 5 mm in diameter and about 6 mm from one end of each strip. With the exception of the tinned iron strips, clean the strips by abrading them on all surface areas with 320 A waterproof silicon carbide paper and white spirit[1] solvent or ethanol until all surface scratches, cuts, and pits are removed from the strips, using a new piece of silicon carbide paper for each different type of metal. With the exception of the tinned iron strips, polish the strips with 00 grade (very fine) steel wool, using a new piece of steel wool for each strip. Wash the strips, including the tinned iron, with 95 % ethanol, dry them with a clean lint-free cloth and place them in a desiccator (6.8.1.5) containing desiccant maintained at 23 °C $\pm$ 5 °C for at least 1 h. Handle the strips with clean forceps after polishing to avoid fingerprint contamination.

Weigh each strip to the nearest 0,1 mg and assemble each set of strips on an uncoated steel cotter pin or bolt in the order tinned iron, steel, aluminium, cast iron, brass and copper so that the strips are in electrolytic contact. Bend the strips, other than cast iron, so that there is a separation of approximately 10 mm between adjacent strips at their free ends. Place one rubber seal with lip edges facing up, in each of two the test jars (6.8.1.4).

Place a metal strip assembly in each jar so that the pinned end is in contact with the rubber seal (i.e. resting on it) and the free end is extending upward in the jar. Mix 1 140 ml of compatibility fluid of ISO 4926 with 60 ml of distilled water.

Add a sufficient amount of the mixture to cover the metal strip assembly in each jar to a depth of approximately 10 mm above the tops of the strips listed in Table 4. Tighten the lids and place the jars in an oven (6.8.1.1) maintained at 70 °C $\pm$ 2 °C for 120 h $\pm$ 2 h. Allow the jars to cool at 23 °C $\pm$ 5 °C for 60 min to 90 min. Immediately following the cooling period, remove the metal strips from the jars by use of forceps, removing loose adhering sediment by agitation of the metal strip assembly in the fluid jar.

Examine test strips and test jars for adhering crystalline deposit, disassemble the metal strips, remove adhering fluid by flushing with water and clean individual strips by wiping with a cloth wetted with 95 % ethanol. Examine the strips for evidence of corrosion and pitting. Place strips in a desiccator containing a desiccant maintained at 23 °C $\pm$ 5 °C for at least 1 h. Weigh each strip to the nearest 0,1 mg.

Determine the difference in mass of each metal strip and divide the difference by the total surface area of the metal strip measured in square centimetres. Average the results for the strips of each type of metal.

Examine the fluid-water mixture in the jars. Agitate the fluid to suspend and uniformly disperse sediment, transfer a 100 ml portion of this fluid to a cone-shaped centrifuge tube (6.8.1.2) and determine the percentage sediment as described in 6.2.3.

6.9 Storage corrosion test

6.9.1 Apparatus

The following apparatus shall be used for the test.

6.9.1.1 Humidity cabinet, capable of maintaining temperatures of 21 °C ± 2 °C and 46 °C ± 2 °C at 95 % ± 2 % humidity.

6.9.1.2 Three-wheel cylinder assemblies, of correct size for the seals being tested.

6.9.2 Test specimens

Six seals shall be used.

6.9.3 Test procedure

Disassemble the three cylinder assemblies and using a clean, lint-free cloth, wipe all fluids from the cylinders, pistons, boots and springs.

Discard cylinders or parts showing light stains or corrosion.

Assemble the six test seals into the wheel cylinders after completely coating the cylinder walls, seals, springs and pistons with a light film of ISO fluid for corrosion storage test (see ISO 4926) or the storage corrosion test fluid agreed by parties concerned. Install the clean boots on to the cylinders to hold the pistons in position. Leave one inlet hole open and close the remaining holes with suitable rubber or metal plugs.

Adjust the humidity cabinet to 46 °C ± 2 °C and 95 % ± 2 % humidity. Place the cylinders in the cabinet with the unplugged inlet holes facing down. Maintain the specified temperature and humidity conditions for 16 h ± 1 h;. Readjust the cabinet controls to 21 °C ± 2 °C and 95 % ± 2 % humidity and maintain these new conditions for 8 h ± 1 h to complete the first cycle.

Repeat the above 24 h cycle for 12 d. When interrupted due to incidence of one or more non-working days, keep the cylinder assemblies in the humidity cabinet with the cabinet controls set to maintain 21 °C ± 2 °C at 95 % ± 2 % humidity until cycling can be resumed.

At the conclusion of 12 complete cycles, remove the cylinder assemblies from the humidity cabinet for inspection. In case of a non-working day, make the inspection on the following working day.

Inspect the cylinder assemblies in accordance with the following procedure:

— During the removal from the humidity cabinet and subsequent disassembly, maintain the cylinders in the same position as they were in the cabinet to avoid fluid contamination of the inside of the cylinder.

— Remove the pistons and seals from the cylinders, after removal of the boots, by pulling them out from their respective ends. Slight air (dry) pressure may be applied internally in the cylinder, if necessary, to aid in the removal of seals and pistons.

— Wipe the cylinder bore free of fluid with a clean, lint-free cloth. Inspect the condition of the cylinder bore under or adjacent to the seal lip under a strong light for corrosion, discoloration or spots, noting particularly the area of the ring left by the lip of the seal during its exposure in the humidity cabinet.

Disregard any corrosion or spots away from the contact surface of the seals.

Bibliography

[1] ISO 1250:1972[1)], *Mineral solvents for paints — White spirits and related hydrocarbon solvents*

1) International Standard withdrawn.

ICS 43.040.40; 83.140.50

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