# International Standard 4928

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

# 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)*

**Second edition — 1980-05-15**



**UDC 629.113-592.2 : 678.06** **Ref. No. ISO 4928-1980 (E)**

**Descriptors :** road vehicles, brake systems, hydraulic brakes, rubber products, seals (stoppers), specifications, tests, performance tests, marking, test equipment.



Price based on 12 pages

## FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4928 was developed by Technical Committee ISO/TC 22, *Road vehicles*.

This second edition was submitted directly to the ISO Council in accordance with clause 5.10.1 of part 1 of the Directives for the technical work of ISO. It cancels and replaces the first edition (i.e. ISO 4928-1978), which had been approved by the member bodies of the following countries :

| | | |
|---|---|---|
| Australia | Iran | Romania |
| Austria | Italy | South Africa, Rep. of |
| Belgium | Japan | Spain |
| Brazil | Korea, Rep. of | Sweden |
| Bulgaria | Mexico | Switzerland |
| Chile | Netherlands | United Kingdom |
| Czechoslovakia | New Zealand | USSR |
| Germany, F.R. | Philippines | Yugoslavia |
| Hungary | Poland | |

The member bodies of the following countries had expressed disapproval of the document on technical grounds :

France
USA





Printed in Switzerland

# 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.

## 2 FIELD OF APPLICATION

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

## 3 REFERENCES

ISO 48, *Vulcanized rubbers — Determination of hardness (Hardness between 30 and 85 IRHD).*

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

ISO 4925, *Road vehicles — Non-petroleum base hydraulic brake fluids.*

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

ASTM D 91, *Test for precipitation number of lubricating oils.*

ASTM E 145, *Specification for gravity-convection and forced-ventilation ovens.*

NOTE — The ASTM references will be replaced by ISO references when the latter become available.

## 4 DEFINITIONS

For the purpose of this International Standard the following definitions apply :

**4.1 sloughing :** The release of carbon black on the surface of the rubber.

**4.2 scoring :** The formation of grooves in the rubber parallel to the direction of travel of the piston or seal.

**4.3 scuffing :** Visible erosion of the outer surface of the rubber.

## 5 GENERAL REQUIREMENTS

### 5.1 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.

### 5.2 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".

### 5.3 Packaging

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

### 5.4 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.

## 6 TEST REQUIREMENTS

### 6.1 Resistance to fluid at elevated temperature

After being subjected to the test for resistance to compatibility fluid at elevated temperature as prescribed in 7.1, the seals shall conform to the requirements specified in table 1.

TABLE 1 — **Requirements for fluid resistance at elevated temperatures** (120 °C)

| Characteristic | Permitted change |
|---|---|
| Volume | + 5 to + 20 % |
| Outside diameter, lip | 0 to + 5,75 % |
| Outside diameter, base | 0 to + 5,75 % |
| Hardness | − 15 to 0 IRHD |

The seals shall show no excessive disintegration as evidenced by blisters or sloughing.

### 6.2 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 7.2.

### 6.3 Wheel cylinder seals heat pressure stroking

Wheel cylinder seals when tested by the procedure specified in 7.3 shall meet the following performance requirements :

#### 6.3.1 *Lip diameter change*

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

TABLE 2 — **Lip diameter change, wheel cylinder seals**

| Diameter<br>mm | Excess over bore<br>mm min. |
|---|---|
| Up to 25,4 | 0,51 |
| Over 25,4 up to 38,1 | 0,64 |
| Over 38,1 up to 60 | 0,76 |

#### 6.3.2 *Leakage*

Constant dampness past the seals or fluid discoloration of the filter paper on two or more inspections shall be cause for rejection.

#### 6.3.3 *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.

#### 6.3.4 *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 7.7.

#### 6.3.5 *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.

### 6.4 Master cylinder seals heat pressure stroking

Master cylinder seals when tested by the procedure specified in 7.4 shall meet the following performance requirements :

#### 6.4.1 *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, master cylinder seals**

| Diameter<br>mm | Excess over bore<br>mm min. |
|---|---|
| Up to 25,4 | 0,38 |
| Over 25,4 up to 38,1 | 0,51 |
| Over 38,1 up to 60 | 0,64 |

#### 6.4.2 *Leakage*

As for wheel cylinder seals (see 6.3.2).

#### 6.4.3 *Corrosion*

As for wheel cylinder seals (see 6.3.3).

#### 6.4.4 *Change in hardness*

As for wheel cylinder seals (see 6.3.4).

#### 6.4.5 *Condition of test seals*

As for wheel cylinder seals (see 6.3.5).

### 6.5 Low-temperature performance

#### 6.5.1 *Leakage*

No leakage of fluid shall occur when seals are tested according to the procedure specified in 7.5.1.

#### 6.5.2 *Bend test*

The seal shall not crack and shall return to its approximate original shape within 1 min when tested according to the procedure specified in 7.5.2.

### 6.6 Oven ageing

Seals when tested according to the procedure specified in 7.6 shall meet the following requirements :

#### 6.6.1 *Change in hardness*

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

#### 6.6.2 *Condition of test seals*

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

### 6.7 Corrosion

**6.7.1** Seals when tested by the procedure specified in 7.8 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 an extent discernible to the naked eye, but staining or discoloration is permitted.

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

TABLE 4 — **Permissible change in mass of corrosion test strips**

| **Test strips*** (see ISO 4925, annex B) | **Permissible change in mass max. 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 |

* Test strips may be obtained from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pa. 15096 U.S.A.

### 6.8 Storage corrosion test

After 12 cycles in the humidity cabinet when operated according to the procedure specified in 7.9, there shall be no evidence of corrosion adhering to or penetrating the wall of the cylinder bore which was in contact with the test seal.

Slight discoloration (staining) or any corrosion or spots away from the contact surface of the test seals shall not be cause for rejection.

## 7 TEST PROCEDURES

### 7.1 Resistance to fluid at elevated temperature — Dimensional test

#### 7.1.1 *Apparatus*

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

**7.1.1.2 Glass containers** of capacity approximately 250 ml and diameter 50 mm, which can be tightly sealed.[1)]

**7.1.1.3 Oven,** dry air type, uniformly heated, conforming to the requirements for type II A of ASTM E 145.

#### 7.1.2 *Test specimens*

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

#### 7.1.3 *Procedure*

Rinse the cups in isopropyl or ethyl alcohol 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 7.7 and figure 5.)

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 of compatibility reference fluid as defined in ISO 4926, in a suitable glass container (7.1.1.2) and seal the container to prevent vapour loss. Place the container in the oven (7.1.1.3) set at 120 ± 2 °C for a period of 70 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 ± 5 °C for 60 to 90 min. At the end of the cooling period, remove the seals from the container and rinse in isopropyl or ethyl 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.

1) Suitable glass containers and tinned steel lids can be obtained from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pa. 15096 U.S.A.

After removal from the alcohol and drying, place each seal in a separate, tared, stoppered weighing bottle 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 after rinsing in alcohol.

#### 7.1.4 *Expression of results*

**7.1.4.1** Volume change shall be reported as a percentage of the original volume. The change in volume is given by the formula :

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

where

$m_1$ is the initial mass, in grams, in air;

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

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

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

#### 7.1.4.2 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 a percentage of the original diameters.

#### 7.1.4.3 HARDNESS

Change in hardness shall be determined and recorded.

#### 7.1.4.4 DISINTEGRATION

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

### 7.2 Precipitation test

#### 7.2.1 *Apparatus*

**7.2.1.1 Glass containers** of capacity approximately 250 ml and diameter 50 mm which can be tightly sealed.[1)]

**7.2.1.2 Cone-shaped centrifuge tube** of capacity 100 ml.

**7.2.1.3 Oven,** uniformly heated dry air type, conforming to the requirements for type II A of ASTM E 145.

#### 7.2.2 *Test specimens*

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

#### 7.2.3 *Procedure*

To determine the precipitation compatibility characteristics of the test seals, place the sample (7.2.2) in one of the specified glass containers (7.2.1.1) containing 75 ml of compatibility fluid of ISO 4926. Seal the container to prevent vapour loss and place in an oven at 120 ± 2 °C for 70 h. (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 to a cone-shaped centrifuge tube of 100 ml capacity and determine the sediment as described in paragraphs 5 and 6 of ASTM D 91.

### 7.3 Wheel cylinder seals heat pressure stroking

#### 7.3.1 *Apparatus*

**7.3.1.1 Oven,** uniformly heated dry air type conforming to the requirements for type II B of ASTM E 145.

**7.3.1.2 Actuating stroking fixture** for wheel cylinder seals, designed to provide a 3,8 ± 1,7 mm movement of each piston. During the total movement of the piston the pressure shall increase to 7,0 ± 0,3 MPa. The rate of operation shall be held to a uniform reciprocating motion of 1 000 ± 100 strokes/hour. Figure 2 illustrates a recommended pressure (MPa) versus wheel cylinder piston movement curve for wheel cylinders having diameters of 12,7 to 60 mm.

NOTE — A new wheel cylinder assembly must be used for each test.

#### 7.3.2 *Test specimens*

Two wheel cylinder seals shall be used as test specimens.

#### 7.3.3 *Procedure*

Rinse the seals in isopropyl or ethyl alcohol 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.



1) Suitable glass containers and tinned steel lids can be obtained from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pa. 15096 U.S.A.

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.

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. 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 cylinder to catch and determine leakage.

Place the stroking fixture assembly in the oven (7.3.1.1) and actuate for 70 h at 120 ± 2 °C. Shut off the actuating means and the oven heater at the termination of the 70 h 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 ± 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 isopropyl or ethyl 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.

Measure the lip diameter of each seal within 30 to 60 min after 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 allowable lip diameter change).

### 7.4 Master cylinder seals heat pressure stroking

#### 7.4.1 *Apparatus*

**7.4.1.1 Oven,** uniformly heated, dry air type conforming to the requirements for type II A of ASTM E 145.

NOTE – 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.

**7.4.1.2 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.

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 1 illustrates a recommended master cylinder seal stroking apparatus. Figure 3 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 shown in figure 1 actuated by a 25 mm diameter master cylinder. The total stroke of such a master cylinder shall be 25 mm. The initial movement of approximately 14 to 15 mm shall be at a rate providing a gradual buildup 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 buildup of pressure to 7,0 ± 0,3 MPa during the last 1,6 to 3,2 mm of the stroke.

The master cylinder shall be located in the oven (7.4.1.1) and the fluid temperature in the master cylinder reservoir shall be maintained at 120 ± 2 °C.

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

#### 7.4.2 *Test specimens*

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

#### 7.4.3 *Procedure*

Rinse the seals in isopropyl or ethyl alcohol 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. 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.

Operate the master cylinder assembly after installation in the oven (7.4.1.1) for 70 h at the rate specified in 7.4.1 and at a temperature of 120 ± 2 °C. 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 70 h 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 ± 2 h at room temperature. Immediately after completion of the 22 h 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 isopropyl or ethyl alcohol and dry with compressed air. Rinse the secondary seal on the piston in isopropyl or ethyl alcohol, dry with compressed air and measure the lip diameter 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 to 60 min after 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.

### 7.5 Low-temperature performance

#### 7.5.1 *Leakage*

##### 7.5.1.1 Apparatus

**7.5.1.1.1 Cold chamber,** large enough to permit arrangement of the test apparatus within and to permit the operator to check and operate the apparatus without removal from the chamber.

**7.5.1.1.2 Master cylinder** and **wheel cylinder,** so connected that their operation closely approximates the brake system in actual service. The apparatus shown in figure 4 has been found to be satisfactory. The cylinder bore containing the test seals shall meet the dimensional limitations and bore finish requirements specified by the manufacturer.

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

##### 7.5.1.2 Test specimens

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

##### 7.5.1.3 Procedure

Rinse the test seals in isopropyl or ethyl 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. Assemble the test seals in the test cylinder. During the assembly of the cylinder, coat the cylinder walls with compatibility fluid of ISO 4926 as well as other parts intended to be immersed in the fluid.

Install the wheel and master cylinder assembly containing the test seals on the test apparatus in the cold chamber. Fill the system with test fluid and bleed all air from the system. Do not use boots.

Enclose the complete actuating system in the cold chamber and subject to a temperature of − 40 to − 43 °C for 120 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, 96, 120 h). The strokes shall be approximately 1 min apart, and the piston shall return to the stop after each stroke. No leakage shall occur during the 120 h test period.

#### 7.5.2 *Bend test*

##### 7.5.2.1 Test specimen

One seal shall be used.

##### 7.5.2.2 Procedure

Bend the test seal, after it has been maintained for 22 h at − 40 to − 43 °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.

### 7.6 Oven ageing

#### 7.6.1 *Apparatus*

**Oven,** conforming to the requirements of type II B of ASTM E 145.

#### 7.6.2 *Test specimens*

Two seals shall be used.

#### 7.6.3 *Procedure*

Rinse two test seals in isopropyl or ethyl alcohol 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.

Place the two test seals in the oven (7.6.1), and subject to hot air heating at 100 ± 2 °C for 70 h. At the termination of the 70 h heating period, remove the seals from the oven and allow to cool for 16 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.

### 7.7 Hardness determination

**7.7.1** As specified in ISO 48.

If ISO 48 cannot be used, another procedure may be selected, possibly using a rubber anvil (see figure 5).

### 7.8 Corrosion test

#### 7.8.1 *Test materials*

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

#### 7.8.2 *Test specimens*

Two seals shall be used.

#### 7.8.3 *Procedure*

Prepare two sets of test strips from each of the metals. Drill a hole between 4 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 (ISO 1250) 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 containing desiccant maintained at 23 ± 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 straight-sided round glass jars[1] having a capacity of approximately 475 ml and inner dimensions of approximately 100 mm in height and 75 mm in diameter.

Use only tinned steel lids vented with a hole 0,8 ± 0,1 mm in diameter. 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 maintained at 100 ± 2 °C for 120 ± 2 h. Allow the jars to cool at 23 ± 5 °C for 60 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 ± 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 and determine the percentage sediment as described in paragraphs 5 and 6 of ASTM D 91.

### 7.9 Storage corrosion test

#### 7.9.1 *Apparatus*

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

**7.9.1.2** Three **wheel cylinder assemblies** of correct size for the seals being tested.

#### 7.9.2 *Test specimens*

Six seals shall be used.

#### 7.9.3 *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 the storage corrosion test fluid specified in ISO 4926. Install the clean boots onto the cylinders to hold the pistons in position. Leave one inlet hole open and close the remaining holes with suitable rubber or metal plugs.

1) Suitable glass containers and tinned steel lids can be obtained from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pa. 15096 U.S.A.

Adjust the humidity cabinet (7.9.1.1) to 46 °C and 95 % humidity. Place the cylinders in the cabinet with the unplugged inlet holes facing down. Maintain the specified temperature and humidity conditions for 16 h. Readjust the cabinet controls to 21 °C and 95 % humidity and maintain these new conditions for 8 h to complete the first cycle.

Repeat the above 24 h cycle for 12 days. 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 at 95 % 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.

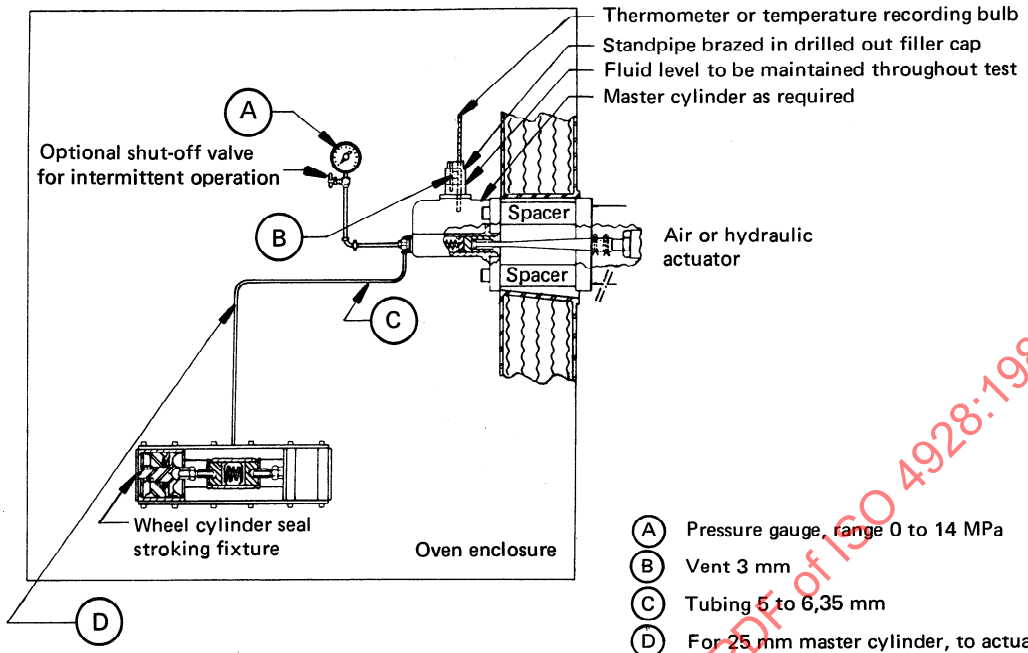
Inspect the cylinder assemblies in accordance with the following procedure :

— 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.

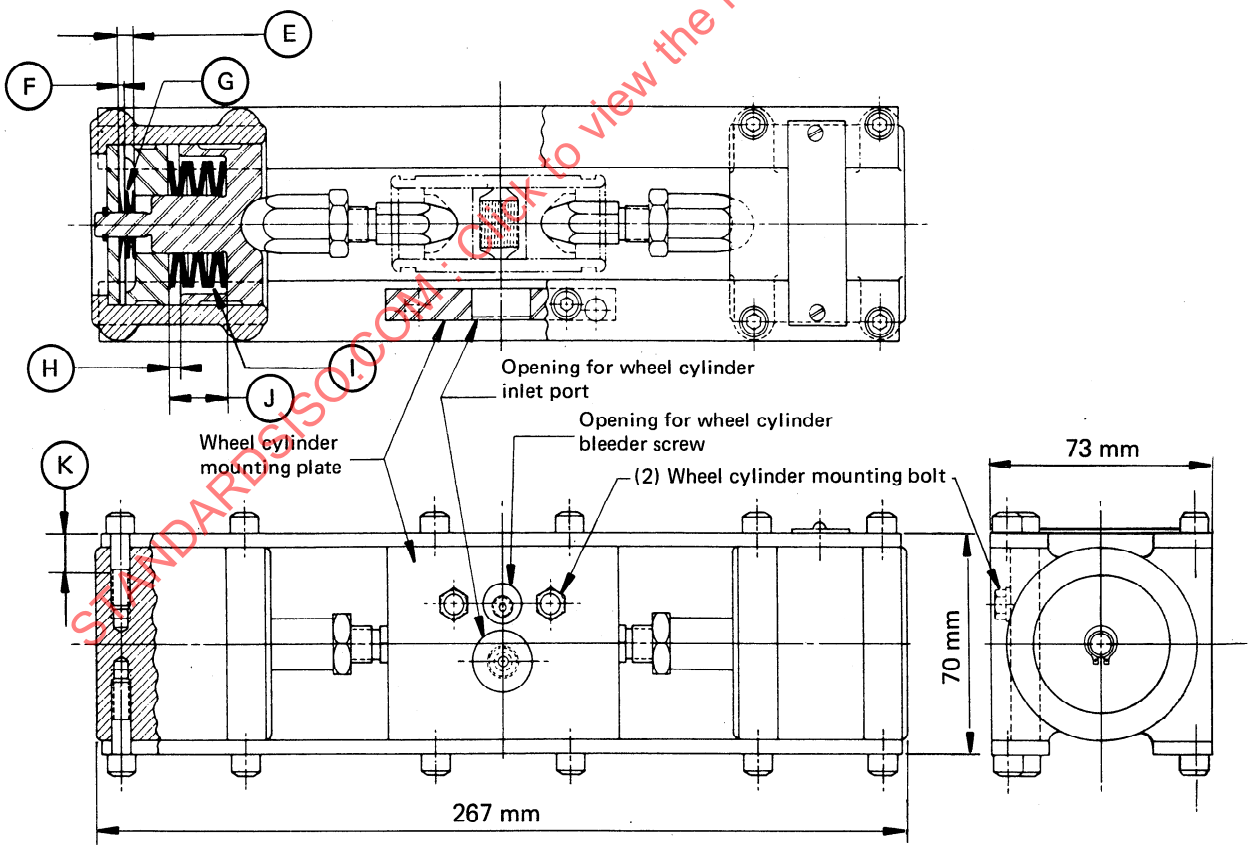



(A) Pressure gauge, range 0 to 14 MPa

(B) Vent 3 mm

(C) Tubing 5 to 6,35 mm

(D) For 25 mm master cylinder, to actuate 3 stroking fixtures equipped with 22 mm diameter wheel cylinders.




(E) 5,2 mm at zero pressure, and 3,05 at 440 N

(F) Stroke 2,13 mm calculated

(G) 4 schnorr discs 20 by 8,2 by 0,6 mm

(H) Stroke 3,35 mm calculated

(I) 6 schnorr discs 40 by 18,3 by 2,0 mm

(J) 18,90 mm at zero pressure, 18,57 mm at 440 N and 15,54 mm at 3960 N

(K) Ream at assembly 13 mm deep to top diameter for shear strength (16 places)

**Figure 1 — Recommended wheel and master cylinder stroking test apparatus**

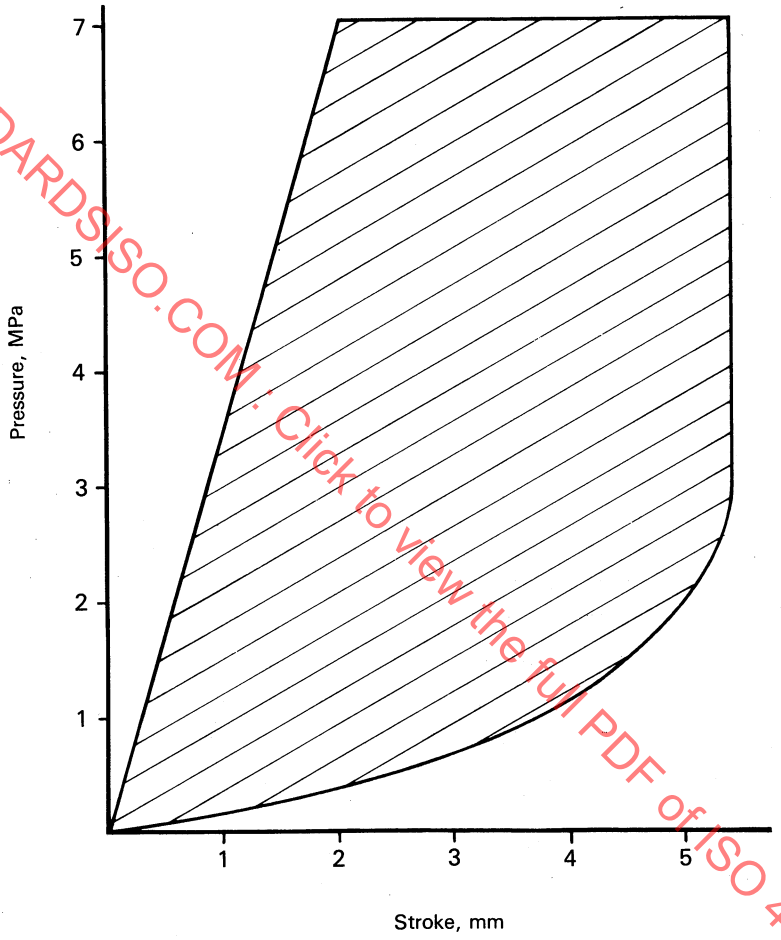





**Figure 2 — Pressure versus wheel cylinder piston movement for wheel cylinders having diameters of 12,7 to 60 mm**