

Rotary shaft lip-type seals incorporating elastomeric sealing elements

Part 4: Performance test procedures

ICS 23.100.60; 83.140.50

National foreword

This British Standard is the UK implementation of ISO 6194-4:2009. It supersedes BS ISO 6194-4:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/11, Fluid seals and their housings.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Rotary shaft lip-type seals incorporating elastomeric sealing elements —

Part 4: Performance test procedures

*Bagues d'étanchéité à lèvres pour arbres tournants incorporant des
éléments d'étanchéité en élastomère —*

Partie 4: Méthodes d'essai de performance



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Contents

Page

Foreword.....	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms, definitions and symbols	2
3.1 Terms and definitions.....	2
3.2 Symbols	2
4 Pre-test procedure	2
5 Dynamic normal-temperature test	2
5.1 Test apparatus	2
5.2 Installation	5
5.3 Test conditions	5
5.4 Test procedure	5
5.5 Post-test measurements	5
5.6 Recording	5
5.7 Acceptance criteria.....	5
6 Dynamic low-temperature test	5
6.1 General.....	5
6.2 Test apparatus	6
6.3 Installation	7
6.4 Test procedure	7
6.5 Post-test measurements	7
6.6 Recording	7
6.7 Acceptance criteria.....	7
7 Material testing of elastomeric components	7
7.1 Elastomeric material requirements.....	7
7.2 Density	8
7.3 Hardness.....	8
7.4 Compression set.....	8
7.5 Fluid immersion	8
7.6 Dry-heat ageing in air	8
7.7 Stiffness at low temperature.....	9
7.8 Recording	9
8 Identification statement (Reference to this part of ISO 6194)	9
Annex A (informative) Typical example of a seal test report for the dynamic test.....	10
Annex B (informative) Typical example of a seal test report for the dynamic low-temperature test	13
Annex C (informative) Typical example of an elastomeric material test report.....	15
Bibliography	17

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.

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

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 6194-4 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 7, *Sealing devices*.

This third edition cancels and replaces the second edition (ISO 6194-4:1999), which has been technically revised.

ISO 6194 consists of the following parts, under the general title *Rotary shaft lip-type seals incorporating elastomeric sealing elements*:

- *Part 1: Nominal dimensions and tolerances*
- *Part 2: Vocabulary*
- *Part 3: Storage, handling and installation*
- *Part 4: Performance test procedures*
- *Part 5: Identification of visual imperfections*

Introduction

Rotary shaft lip-type seals are used to retain fluid, e.g. lubricant, in equipment where the differential pressure is relatively low. Typically, the shaft rotates, and the housing is stationary, although in some applications the shaft is stationary, and the housing rotates.

Dynamic sealing is normally the result of a designed interference fit between the shaft and a flexible element incorporated in the seal.

Similarly, a designed interference fit between the outside diameter of the seal, and the diameter of the housing bore, retains the seal and prevents static leakage.

Careful storage, handling and proper installation of all seals are necessary to avoid hazards, both prior to and during installation, which would adversely affect service life.

Rotary shaft lip-type seals incorporating elastomeric sealing elements —

Part 4: Performance test procedures

WARNING — Persons using this part of ISO 6194 should be familiar with normal laboratory practice. Whilst this part of ISO 6194 does not purport to address all the safety problems, if any, associated with its application, attention is drawn to the need to employ sensible precautions while handling hot and cold fluids and equipment. It is the responsibility of the user of this part of ISO 6194 to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

1 Scope

ISO 6194 describes seals utilizing elastomeric sealing elements. They are considered suitable for use under low-pressure conditions (see ISO 6194-1:2007, 6.1).

This part of ISO 6194 specifies general test requirements for rotary shaft lip-type seals. The tests may be used for qualification purposes.

NOTE ISO 6194 is complementary to ISO 16589 which covers seals incorporating thermoplastic sealing elements.

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, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 812, *Rubber, vulcanized or thermoplastic — Determination of low-temperature brittleness*

ISO 815-1, *Rubber, vulcanized or thermoplastic — Determination of compression set — Part 1: At ambient or elevated temperatures*

ISO 815-2, *Rubber, vulcanized or thermoplastic — Determination of compression set — Part 2: At low temperatures*

ISO 1817, *Rubber, vulcanized — Determination of the effect of liquids*

ISO 2781, *Rubber, vulcanized or thermoplastic — Determination of density*

ISO 5598, *Fluid power systems and components — Vocabulary*

ISO 6194-1:2007, *Rotary shaft lip-type seals incorporating elastomeric sealing elements — Part 1: Nominal dimensions and tolerances*

ISO 6194-2, *Rotary-shaft lip-type seals incorporating elastomeric sealing elements — Part 2: Vocabulary*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6194-2 and ISO 5598 and the following apply.

3.1.1

batch

identifiable and traceable consignment of rubber compound of definite composition and manufactured in a single production operation

3.2 Symbols

For the purposes of this document, the symbols given in ISO 6194-1 apply.

4 Pre-test procedure

4.1 Inspect all seals submitted for testing for conformity to a relevant drawing or detailed specification declared by the seal manufacturer.

4.2 For seals with an elastomeric component, ensure that the seal manufacturer has stated the material designation batch number from which the seals have been made, together with the nominal density, nominal hardness, maximum compression set value and maximum volume change after immersion in the test fluid.

Where the seal is required for the low-temperature stiffness test, ensure that the seal manufacturer has also stated the maximum modulus after test at the selected test temperature.

Ensure that the batch of elastomer has been tested in accordance with Clause 7.

4.3 To facilitate accurate analysis of the test results, determine the following data concerning the physical characteristics of the seal and test apparatus before testing:

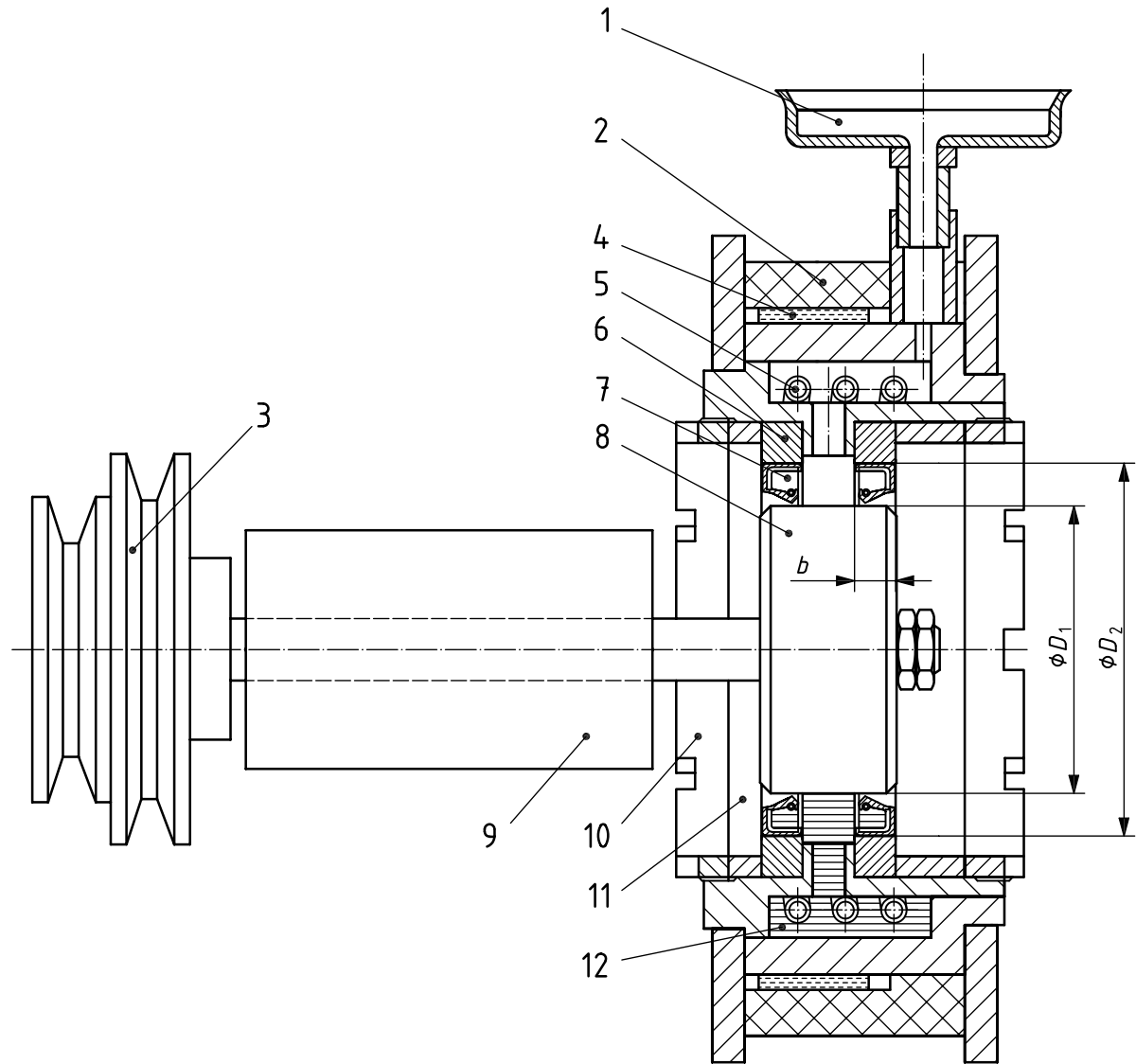
- a) lip diameter (with spring);
- b) lip diameter (without spring, measured not less than 24 h after removal of spring);
- c) outer case mean diameter and out-of-roundness;
- d) shaft diameter, material hardness and surface roughness;
- e) housing diameter, material and surface roughness;
- f) protection lip diameter, where applicable (with and without sealing lip spring fitted).

4.4 Ensure that the specified shaft eccentricity and housing off-set of the test apparatus have been incorporated.

5 Dynamic normal-temperature test

5.1 Test apparatus

The test apparatus shall be similar to the typical example shown in Figure 1 and shall consist of a suitable housing for retaining the test fluid and for positioning the test seals, as well as a rotating member having a spindle mounted horizontally on suitable bearings. The design of the housing for the seal shall be in accordance with the dimensions specified in ISO 6194-1. The housing and the rotating member shall be capable of reproducing the eccentricity and off-set specified in 4.4.



Key

- 1 filler tray
- 2 insulation
- 3 drive from prime mover
- 4 heater band
- 5 cooling coil
- 6 seal housing
- 7 test seal
- 8 test shaft
- 9 test head support
- 10 locking ring
- 11 spacer ring
- 12 test fluid

b nominal seal width

D_1 nominal diameter of the shaft to be used with the seal

D_2 nominal diameter of the housing bore or outer diameter of the seal

Figure 1 — Typical example of dynamic normal-temperature test apparatus

Where it is not practicable to provide a test apparatus with the particular shaft and housing size relevant to the application, the test apparatus shall be selected from the standard sizes listed in Table 1. The size selected shall be that nearest to the application size.

Table 1 — Standard shaft and housing dimensions

Dimensions in millimetres

Shaft diameter <i>D</i> ₁	Housing diameter <i>D</i> ₂	Seal width <i>b</i>
20	35	7
40	55	8
60	80	8
90	120	12
200	230	15

The test apparatus shall also conform to the following additional requirements.

- a) The shaft shall be capable of cycling and/or maintaining the shaft speeds to within $\pm 3\%$.
- b) The shaft shall be capable of maintaining the specified test eccentricity under dynamic conditions to within $\pm 0,03$ mm throughout each test.
- c) The test head shall be designed and constructed so as to maintain the housing bore alignment relative to the test shaft axis within 0,03 mm throughout the operating temperature range.
- d) The design of the test head support shall ensure minimum deformation and vibration.
- e) The test head and heat transfer system shall be capable of maintaining the temperature of the test fluid within ± 3 °C, and shall be vented to atmosphere.
- f) Heat shall be applied in a manner that does not subject the test fluid to high localized temperatures that could cause fluid decomposition.
- g) The test shaft shall have a surface that is free of helical machine marks and shall comply with the requirements for shafts specified in ISO 6194-1.
- h) The test housing bore shall comply with the requirements specified in ISO 6194-1.
- i) The materials, surface finish and dimensions of the test shaft and test housing bore shall conform as closely as possible to the shaft and housing bore to be used in service.
- j) A minimum quantity of 750 cm³ of test fluid shall be used.
- k) The level of the test fluid in the test head shall be $0,3D_1$ to $0,5D_1$ above the lowest point of the shaft diameter *D*₁.
- l) For seal housings with inboard bearings, the test housing shall be suitably relieved at the bearing supports to prevent excessive fluid pressure between the bearing and seals.
- m) Means shall be provided for collecting and measuring the mass of any fluid leakage from the seals during the test.
- n) The test head shall have a device capable of pressurizing the seal housing to the working pressure.
- o) A liquid level measuring device shall be provided on the test head.

5.2 Installation

5.2.1 Thoroughly clean the test head of contaminants and extraneous matter.

5.2.2 Install the seal into the test head so that the cumulative eccentricities of the seal and the test head are known.

5.2.3 Ensure that the plane of the seal lip is perpendicular to the shaft axis, unless otherwise specified.

5.2.4 Locate the test shaft in such a position that a clean unused area of its surface is in contact with the sealing element of the test seal.

5.3 Test conditions

Apply test conditions that simulate the seal application operating conditions, as agreed between purchaser and supplier, i.e. normal operating temperature, normal operating shaft speed, maximum envisaged operating temperature and maximum envisaged shaft speed.

5.4 Test procedure

Submit six seals to 10 cycles, each of 24 h duration, consisting of 14 h at normal operating temperature and speed, according to service conditions, and 6 h at the maximum envisaged operating temperature and speed, followed by a 4 h shutdown when the test machine is allowed to return to room temperature. For lifetime performance testing, duration will be extended in agreement between purchaser and supplier.

5.5 Post-test measurements

After completion of the test, determine the seal lip diameters, the minor lip diameters where applicable, and the contact bandwidth. Inspect the seal lip, noting any cracks, tears, splits or any imperfections that may have appeared as a result of the test.

5.6 Recording

Record all test data on a seal test report. An example of a seal test report for a dynamic test is shown in Annex A.

5.7 Acceptance criteria

Unless otherwise agreed between manufacturer and purchaser, there shall be no visible leakage (i.e. any wetness on the outside of the seal) from all six seals.

NOTE Seal performance can be influenced by operating and environmental conditions beyond the scope of this test. Therefore, the fact that seals pass, is no guarantee of zero leakage in service.

6 Dynamic low-temperature test

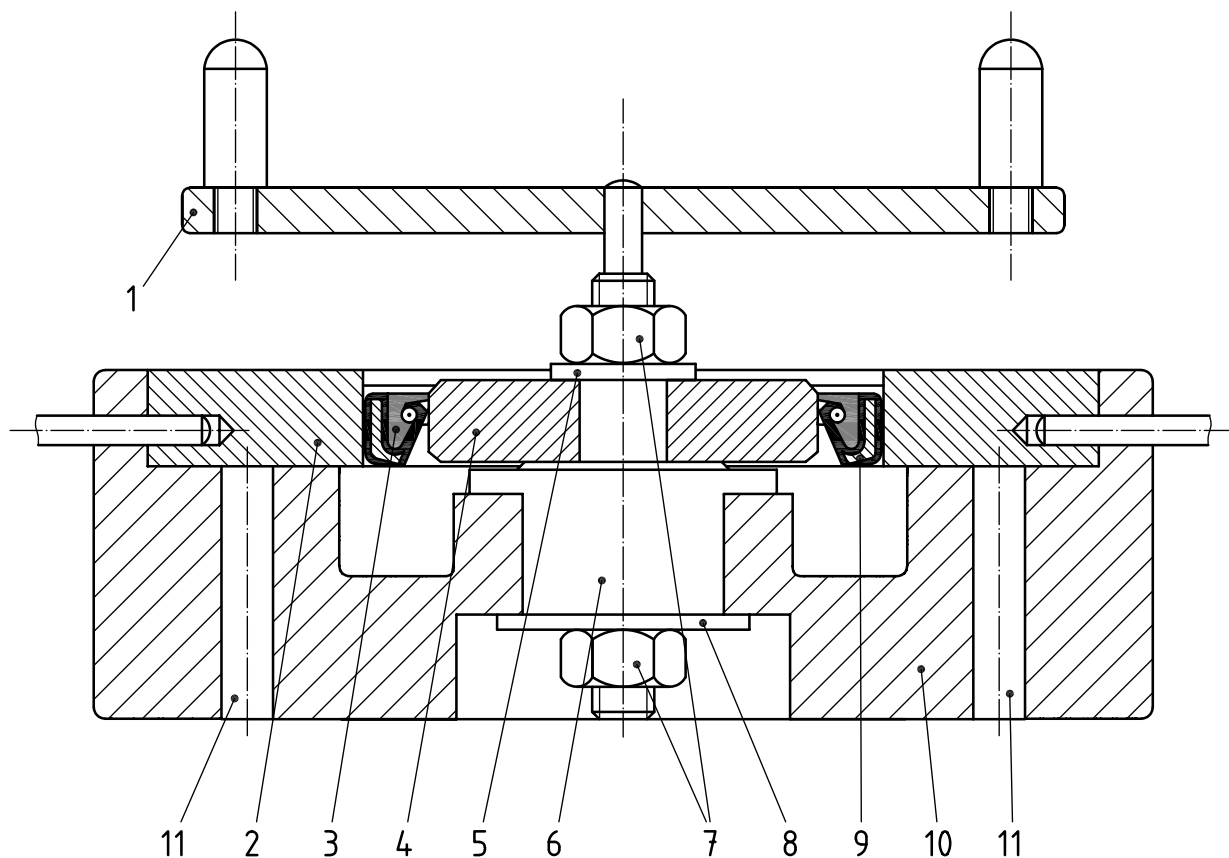
6.1 General

This test is applicable to all rotary shaft lip-type seals for which the minimum specified operating temperature is stated to be $-10\text{ }^{\circ}\text{C}$ or lower.

6.2 Test apparatus

The test apparatus shall be similar to the typical example shown in Figure 2.

The test shaft and seal housing shall simulate the envisaged maximum eccentricities specified by the customer. The test shaft diameter, the test shaft surface roughness and seal housing dimensions shall also be those specified by the customer or as specified in ISO 6194-1.



Key

- 1 handle
- 2 seal housing
- 3 test fluid
- 4 test shaft
- 5 washer
- 6 spigot
- 7 plain hexagonal nut
- 8 washer
- 9 test seal
- 10 base
- 11 holes to locate with pins in base plate of refrigeration unit

Figure 2 — Typical example of dynamic low-temperature test fixture

6.3 Installation

The requirements of 5.2.1, 5.2.2 and 5.2.3 shall be followed.

6.4 Test procedure

Submit two seals to the following procedure.

- 6.4.1** Soak the seal in test fluid for 70 h at normal operating temperature (see Annex B).
- 6.4.2** Remove the seal from the test fluid and shake off the excess. Do not blot dry.
- 6.4.3** Lubricate the test shaft with a small quantity of the test fluid.
- 6.4.4** Correctly locate the seal in the test fixture.
- 6.4.5** Fill the test fixture with the test fluid to submerge the fluid side of the seal lip.
- 6.4.6** Place the test fixture in a cold box and soak for 16 h at the minimum temperature specified by the customer (see Annex B).
- 6.4.7** With the test fixture still in the cold box, rotate the shaft 10 revolutions by hand in one direction at an approximate speed of 1 Hz, pausing once every 180°.
- 6.4.8** Remove the test fixture from the cold box and allow it to stand at room temperature for a minimum period of 6 h.
- 6.4.9** Remove the seal from the test fixture.

6.5 Post-test measurements

Inspect for leakage that may have occurred during the test and visually inspect the seal lip, noting any cracks, tears, splits or imperfections that may have appeared as a result of the test.

6.6 Recording

Record all test data on a seal test report. An example of a seal test report for the dynamic low-temperature test is shown in Annex B.

6.7 Acceptance criteria

There shall be no visible damage to the lip and there shall be no leakage greater than that specified by the customer.

7 Material testing of elastomeric components

7.1 Elastomeric material requirements

Each batch of material from which the test seals are manufactured shall be tested for the purpose of quality control. In order to ensure that the material used for production seals does not vary significantly from that of the dynamic-test seals, subsequent production batches shall also be tested on a random sample basis. The materials used for tests shall be in an unused condition.

Unless otherwise agreed between the supplier and purchaser, tests shall be in accordance with 7.2 to 7.7.

7.2 Density

Each batch of material shall be tested in accordance with ISO 2781.

The result shall be the specified nominal density (see 4.2) within a tolerance of $\pm 0,03 \text{ g/cm}^3$ for all materials.

7.3 Hardness

Each batch of material shall be tested in accordance with ISO 48.

If the dimension of the test piece is greater than 4 mm, then the normal test procedure shall be used. If it is less than 4 mm, then the micro test procedure shall be used.

The result shall be the specified nominal hardness (see 4.2) within a tolerance of ± 7 IRHD.

7.4 Compression set

Each batch of material shall be tested in accordance with ISO 815-1 or ISO 815-2.

The duration of the test shall be $24 \begin{smallmatrix} 0 \\ -2 \end{smallmatrix}$ h, and the temperature of the test for different elastomers shall be as given in Table 2.

The result shall be not greater than the specified maximum value (see 4.2).

Table 2 — Recommended test temperatures

Elastomer	Temperature °C
Nitrile	100
Hydrogenated nitrile	150
Polyacrylate	150
Fluorocarbon	200
Silicone	200

7.5 Fluid immersion

Each batch of material shall be tested in accordance with ISO 1817.

The duration of the test shall be $24 \begin{smallmatrix} 0 \\ -2 \end{smallmatrix}$ h, and the temperature of immersion for each material shall be as listed in Table 2. The test fluid shall be ASTM No. 1 oil (see ISO 1817).

The change in volume shall be within ± 2 % of the nominal change in volume.

7.6 Dry-heat ageing in air

Each batch of material shall be tested in accordance with ISO 188, using an air-oven method.

The duration of the test shall be (168 ± 2) h, and the temperature of the test for different elastomers shall be as given in Table 2.

The test specimens shall be similar to those used for the hardness test (see 7.3).

The apparent hardness after test shall be within ± 10 IRHD of the hardness recorded prior to test.

7.7 Stiffness at low temperature

Where the minimum operating temperature is stated to be $-10\text{ }^{\circ}\text{C}$ or lower, each batch shall be tested in accordance with ISO 812, or as agreed between manufacturer and purchaser, at the lower specified test temperature (see 4.2), i.e. $-10\text{ }^{\circ}\text{C}$, $-20\text{ }^{\circ}\text{C}$ or $-40\text{ }^{\circ}\text{C}$.

7.8 Recording

Record all test data on a material test report, an example of which is given in Annex C.

8 Identification statement (Reference to this part of ISO 6194)

Manufacturers are strongly recommended to use the following statement in test reports, catalogues and sales literature when electing to comply with this part of ISO 6194.

“The performance test procedures described in this document are in accordance with ISO 6194-4, Rotary shaft lip-type seals incorporating elastomeric sealing elements — Part 4: Performance test procedures.”

Annex A
(informative)

Typical example of a seal test report for the dynamic test

A.1 General data

Test report reference:

Seal drawing reference or specification:

Seal type:

Elastomer	Compound:	Batch No.:
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A.2 Pre-test measurements

Test seal No.:							
Seal lip diameter	without spring: mm						
	with spring: mm						
Seal outer case	mean diameter: mm						
	out of round: mm						
Protection lip diameter (where applicable)	without spring: mm						
	with spring: mm						

A.3 Test conditions

Test fluid:	Description:	
	Normal operating temperature: °C	ISO viscosity grade:
	Maximum operating temperature: °C	ISO classification:

Shaft:	Diameter: mm	Material:
	Hardness:	Surface roughness, <i>Ra</i> : μm and <i>Rz</i> : μm
	Eccentricity (TIR ^a): mm	Normal operating speed: min ⁻¹ (r/min)
		Maximum operating speed: min ⁻¹ (r/min)
	^a Total indicator reading.	

Housing:	Diameter: mm	Material:
	Off-set: mm	Surface roughness, <i>Ra</i> : μm and <i>Rz</i> : μm

Test cycle (if different from 5.4):	
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A.4 Post-test measurements

Test seal No.:							
Seal lip diameter	without spring: mm						
	with spring: mm						
Protection lip diameter (where applicable)	without spring: mm						
	with spring: mm						

A.5 Test results

Test seal No.:							All seals:
Leakage: cm ³							Total: cm ³

A.6 Comments

Comments on seal condition before and after test:

Annex B
(informative)

**Typical example of a seal test report
for the dynamic low-temperature test**

B.1 General data

Test report reference:

Seal drawing reference or specification:

Seal type:

Elastomer	Compound:	Batch No.:
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B.2 Pre-test measurements

Test seal No.:								
Seal lip diameter	without spring:	mm						
	with spring:	mm						
Seal outer case	mean diameter:	mm						
	out of round:	mm						
Protection lip diameter (where applicable)	without spring:	mm						
	with spring:	mm						

B.3 Test conditions

Test fluid:	Description:	
	Normal operating temperature: °C	ISO viscosity grade:
	Maximum operating temperature: °C	ISO classification:
	Minimum operating temperature: °C	

Shaft:	Diameter: mm	Material:
	Hardness:	Surface roughness, R_a : μm and R_z : μm
	Eccentricity (TIR ^a): mm	Normal operating speed: min^{-1} (r/min)
		Maximum operating speed: min^{-1} (r/min)
	^a Total indicator reading	

Housing:	Diameter: mm	Material:
	Off-set: mm	Surface roughness, R_a : μm and R_z : μm

Test cycle (if different from 6.4):	
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B.4 Test results

Test seal No.:		
Leakage: cm^3		

B.5 Comments

Comments on seal condition before and after test:

Annex C
(informative)

Typical example of an elastomeric material test report

C.1 General data

Test report reference:

Seal drawing reference or specification:

Seal type:

Elastomer	Compound:	Batch No:
	Type:	

C.2 Test conditions

Compression set

Time:

Temperature:

Fluid immersion

Test fluid:

Dry-heat ageing in air

Time:

Temperature:

Stiffness at low temperature

Temperature:

C.3 Test results

	Required:	Results:
Density:		
Hardness:		
Compression set:		
Fluid immersion:		
Dry-heat ageing:		
Stiffness at low temperature:		

C.4 Comments

Comments on seal condition before and after test:

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