BS ISO 6072:2011

BSI Standards Publication

Rubber — Compatibility between hydraulic fluids and standard elastomeric materials

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National foreword

This British Standard is the UK implementation of ISO 6072:2011. It supersedes BS ISO 6072:2002, which is withdrawn.

The UK committee would like to highlight that Annex C 'Guidelines on elastomer compatibility' in BS ISO 6072:2002 has been removed in BS ISO 6072:2011. They considered that this annex provides useful guidance and have retained it as National Annex NA (informative).

The UK participation in its preparation was entrusted to Technical Committee PRI/54, Vulcanised rubber compounds.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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INTERNATIONAL STANDARD

ISO 6072

Third edition
2011-12-01

Rubber — Compatibility between hydraulic fluids and standard elastomeric materials

Caoutchouc — Compatibilité des fluides hydrauliques avec les matériaux élastomères de référence

Reference number
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Foreword

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

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

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

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

ISO 6072 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 4, *Products (other than hoses)*.

This third edition cancels and replaces the second edition (ISO 6072:2002), which has been technically revised.

Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit. Elastomers are used as seals in fluid power systems. Elastomeric materials are any substances having the ability to return to their original size and shape after deformation. Hydraulic fluids are water, oil or other fluids which are forced through an orifice or round a closed circuit. Elastomeric materials and hydraulic fluids are defined as compatible if they are not significantly altered by chemical reaction or physical swelling.

From the changes in volume, hardness, tensile strength and elongation at break, which standard test specimens of a test elastomer undergo when immersed in a certain fluid under specified test conditions (see Table 11), an elastomer compatibility index (ECI) can be established for this fluid and can be expressed in the format given in Clause 5. The ECI (which should be quoted by oil suppliers) allows selection of suitable combinations of fluids and elastomeric materials without prolonged testing and might provide enough information to eliminate totally unsuitable elastomer/fluid combinations without having to resort to extensive screening tests.

Representative standard compositions of various types of elastomer permit evaluation of the effect of hydraulic fluids on such compositions and comparison with commercial elastomeric materials for actual service. They could also assist producers of additives and hydraulic fluids in the development of hydraulic fluids compatible with different elastomer types.

INTERNATIONAL STANDARD ISO 6072:2011(E)

Rubber — Compatibility between hydraulic fluids and standard elastomeric materials

1 Scope

This International Standard specifies test methods for evaluating the effect of hydraulic fluids on standard elastomeric materials that have been manufactured in accordance with specified processes. It allows baseline comparisons of fluids with standard elastomers.

This International Standard provides formulations, mixing procedures and vulcanization procedures for five types of elastomeric composition:

a) acrylonitrile-butadiene rubbers (NBR 1 and NBR 2);

b) fluorocarbon rubber (FKM 2);

c) ethylene propylene diene rubber (EPDM 1);

d) hydrogenated acrylonitrile-butadiene rubber (HNBR 1).

These procedures evaluate the effect of mineral-based, fire-resistant and biodegradable hydraulic fluids on such compositions by measurement, under controlled conditions, of physical properties of standard test pieces of the elastomer before and after immersion in the fluids.

This International Standard does not provide formulations of elastomeric materials for actual service, although service elastomers may be tested using these compatibility procedures if required.

NOTE The elastomeric materials used in these formulations are sensitive to fluid variations and have comparatively high swelling characteristics. Stable cure systems can be used to give adequate storage life.

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 37, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*

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

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

ISO 1629, *Rubber and latices — Nomenclature*

ISO 1817:2011, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

ISO 2393, *Rubber test mixes — Preparation, mixing and vulcanization — Equipment and procedures*

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

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

ISO 6743-4, *Lubricants, industrial oils and related products (class L) — Classification — Part 4: Family H (Hydraulic systems)*

3 Terms and definitions

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

3.1
elastomer
macromolecular material which returns rapidly to approximately its initial dimensions and shape after substantial deformation by a weak stress and release of the stress

[ISO 1382:2008[1]]

3.2
test elastomer
rubber vulcanizate with a known composition, used for evaluating the effect of media on elastomers

NOTE In order to minimize error, a test elastomer contains only the most essential ingredients for a vulcanizate.

3.3
commercial rubber
elastomeric material for actual service, the composition of which is not given by the manufacturer and which contains many more ingredients than the standard rubbers in order to fulfil processing and service requirements

NOTE It is not advisable to use commercial rubbers for quality control of media as they are generally subject to larger quality tolerances than test elastomers.

3.4
elastomer compatibility index
ECI
simple one-line designation incorporating the details of the changes in volume, hardness, tensile strength and elongation at break which standard test specimens of a test elastomer undergo when immersed in a particular fluid under specified test conditions

NOTE An elastomer compatibility index can be established for each combination of fluid and test elastomer specified in Table 11.

4 Test elastomers

4.1 General

The mixing and vulcanization procedures given in ISO 2393 shall be followed for the test elastomers.

A single source for each of the ingredients of the test elastomers shall be used and the quality of each batch produced shall be checked.

4.2 Standard acrylonitrile-butadiene rubber with 28 % acrylonitrile content (NBR 1)

4.2.1 Composition by mass

The composition by mass is given in Table 1.

Table 1 — Composition by mass of NBR 1

Material	Parts by mass
NBR [a]	100,0
Zinc oxide (rubber grade)	5,0
Polymerized 2,2,4-trimethyl-1,2-dihydroquinoline (melting point 75 °C to 100 °C)	0,5
FEF carbon black (ASTM designation: N550)	70,0
Dicumyl peroxide (grade with 40 % peroxide content on inert filler)	3,0
Total	178,5

[a] Acrylonitrile content (28 ± 1) %, cold-polymerized, Mooney viscosity (45 ± 5) ML (1 + 4) 100 °C (Perbunan NT2845 from Lanxess or Nipol DN2850 from Zeon Corporation, or equivalent).

Perbunan® NT2845 and Nipol® DN2850 are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

4.2.2 Mixing procedure

Follow the procedure a) to m), maintaining the surface temperature of the rolls at (50 ± 5) °C.

a) Band crude rubber with the mill opening set at 1,4 mm and break down.

b) Add the zinc oxide, then the polymerized 2,2,4-trimethyl-1,2-dihydroquinoline evenly across the rolls at a constant rate.

c) Make 3/4 cuts on the rolls from one end diagonally to the other end.

d) Add approximately half the carbon black evenly across the rolls at a constant rate.

e) Open the mill at intervals to maintain a constant bank.

f) Make three 3/4 cuts from each side.

g) Add the rest of the carbon black, plus any ingredients that have dropped through to the pan.

h) Add the dicumyl peroxide evenly across the rolls.

i) Make six 3/4 cuts from each side.

j) Cut the batch from the mill and set the opening to 0,2 mm.

k) Pass the rolled stock endwise through the mill six times.

l) Sheet off samples at 2,2 mm and allow to cool on a flat metal surface.

m) Prepare samples for curing.

4.2.3 Preparation of standard vulcanized sheets

Prepare standard vulcanized sheets by curing sheets (2,0 ± 0,2) mm thick for 20 min at 170 °C.

4.2.4 Control tests

Carry out all the tests specified in Table 2 on the sheets prepared in 4.2.3.

Table 2 — Control tests for NBR 1

Control test	Property requirement	Unit	Document specifying test method
Hardness	80 ± 3	IRHD	ISO 48
Tensile strength, type 2 dumb-bell test piece	≥ 20	MPa	ISO 37
Elongation at break, type 2 dumb-bell test piece	≥ 150	%	ISO 37
Compression set after 22 h at 100 °C, using a type B test piece obtained by plying three discs	≤ 20	%	ISO 815-1
Density	1,23 ± 0,02	Mg/m^3	ISO 2781
Percentage change in mass after 22 h immersion at (23 ± 2) °C in ISO liquid B [70 % (by volume) pure 2,2,4-trimethylpentane and 30 % (by volume) pure toluene]	27 [a]	%	ISO 1817

[a] Typical value (recommended range 27 ± 5).

4.3 Standard acrylonitrile-butadiene rubber with 34 % acrylonitrile content (NBR 2)

4.3.1 Composition by mass

The composition by mass is given in Table 3.

Table 3 — Composition by mass of NBR 2

Material	Parts by mass
NBR [a]	100,0
Zinc oxide (rubber grade)	5,0
Stearic acid	1,0
Polymerized 2,2,4-trimethyl-1,2-dihydroquinoline (melting point 75 °C to 100 °C)	0,5
FEF carbon black (ASTM designation: N550)	50,0
Tetrabenzylthiuram disulfide	3,0
N-Cyclohexyl-2-benzothiazylsulfenamide	2,0
Sulfur (rubber grade)	0,5
Total	162,0

[a] Acrylonitrile content (34 ± 1) %, Mooney viscosity (56 ± 5) ML (1 + 4) 100 °C (N237 from JSR Corp. or Nipol DN3350 from Zeon Corporation, or equivalent).

N237 and Nipol® DN3350 are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

4.3.2 Mixing procedure

Follow the procedure a) to m), maintaining the surface temperature of the rolls at (50 ± 5) °C.

a) Band crude rubber with the mill opening set at 1,4 mm and break down.

b) Add the zinc oxide and the stearic acid, then the polymerized 2,2,4-trimethyl-1,2-dihydroquinoline evenly across the rolls at a constant rate.

c) Make 3/4 cuts on the rolls from one end diagonally to the other end.

d) Add approximately half the carbon black evenly across the rolls at a constant rate.

e) Open the mill at intervals to maintain a constant bank.

f) Make three 3/4 cuts from each side.

g) Add the rest of the carbon black, including any ingredients that have dropped through to the pan.

h) Add the tetrabenzylthiuram disulfide, the *N*-cyclohexyl-2-benzothiazylsulfenamide and the sulfur evenly across the rolls.

i) Make six 3/4 cuts from each side.

j) Cut the batch from the mill and set the opening to 0,2 mm.

k) Pass the rolled stock endwise through the mill six times.

l) Sheet off samples at 2,2 mm and allow to cool on a flat metal surface.

m) Prepare samples for curing.

4.3.3 Preparation of standard vulcanized sheets

Prepare standard vulcanized sheets by curing sheets (2,0 ± 0,2) mm thick for 20 min at 170 °C.

4.3.4 Control tests

Carry out all the tests specified in Table 4 on the sheets prepared in 4.3.3.

Table 4 — Control tests for NBR 2

Control tests	Property requirement	Unit	Document specifying test method
Hardness	70 ± 3	IRHD	ISO 48
Tensile strength, type 2 dumb-bell test piece	≥ 15	MPa	ISO 37
Elongation at break, type 2 dumb-bell test piece	≥ 300	%	ISO 37
Compression set after 22 h at 100 °C, using a type B test piece obtained by plying three discs	≤ 20	%	ISO 815-1
Density	1,18 ± 0,02	Mg/m^3	ISO 2781
Percentage change in mass after 22 h immersion at (23 ± 2) °C in ISO liquid B [70 % (by volume) pure 2,2,4-trimethylpentane and 30 % (by volume) pure toluene]	23 [a]	%	ISO 1817

[a] Typical value (recommended range 23 ± 5).

4.4 Standard fluorocarbon rubber (FKM 2)

4.4.1 Composition by mass

The composition by mass is given in Table 5.

Table 5 — Composition by mass of FKM 2

Material	Parts by mass
Vinylidene fluoride hexafluoropropylene copolymer [a]	100,0
Magnesium oxide [b]	3,0
Calcium hydroxide	2,0
MT carbon black (ASTM designation: N990)	25,0
Accelerator: organic phosphonium salt [c]	0,44
Crosslinking agent: bisphenol AF [d]	1,35
Total	131,79
The test elastomer FKM2 has the same composition as SRE-FKM/2X given in ISO 13226:2011[4], and both have quite similar manufacturing processes. SRE-FKM/2X can be used as the test elastomer if measurement values obtained by the control tests (see Table 6) satisfy the relevant requirements.	
[a] Fluorine content (66 ± 1) %, such as Viton A-500 from Dupont Dow Elastomers, Tecnoflon N935 from Solvay Solexis or Fluorel FC-2230 from Dyneon.	
[b] High activity.	
[c] Accelerator batch: Viton Curative No. 20 from Dupont Dow Elastomers, or equivalent. The phosphonium salt content of this batch is 33 %, so take 1,33 phr and reduce the amount of rubber by 0,9 phr.	
[d] Curative batch: Viton Curative No. 30 from Dupont Dow Elastomers, or equivalent. The bisphenol content of this batch is 50 %, so take 2,7 phr and reduce the amount of rubber by 1,4 phr.	
Viton® A-500, Tecnoflon® N935, Fluorel® FC-2230, Viton® Curative No. 20 and Viton® Curative No. 30 are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.	

4.4.2 Mixing procedure

Follow the procedure a) to k), maintaining the surface temperature of the rolls at (50 ± 5) °C.

a) Band the crude rubber with the mill opening set at 1,4 mm.

b) Blend all the ingredients together and add evenly across the rolls at a constant rate.

c) Open the mill at intervals to maintain a constant bank.

d) When all the ingredients have been added, including any that have dropped through to the pan, make one 3/4 cut from each side.

e) Make three 3/4 cuts from each side.

f) Cut the batch from the mill and set the opening to 0,2 mm.

g) Pass the rolled stock endwise through the mill six times.

h) Sheet off samples at 2,2 mm and allow to cool on a flat metal surface for 24 h.

i) After ageing for 24 h, refine the mixed stock by passing it six times through a tightly set mill (opening set at 0,8 mm) with the surface temperature of the rolls at (50 ± 5) °C.

j) Sheet off at 2,2 mm and allow to cool on a flat metal surface.

k) Prepare samples for curing.

4.4.3 Preparation of standard vulcanized sheets

Prepare standard vulcanized sheets by mould-curing sheets (2,0 ± 0,2) mm thick for 20 min at 180 °C and post-curing them for 24 h at 230 °C in a circulating-air oven.

4.4.4 Control tests

Carry out all the tests specified in Table 6 on the sheets prepared in 4.4.3.

Table 6 — Control tests for FKM 2

Control tests	Property requirement	Unit	Document specifying test method
Hardness	70 ± 3	IRHD	ISO 48
Tensile strength, type 2 dumb-bell test piece	≥ 12	MPa	ISO 37
Elongation at break, type 2 dumb-bell test piece	≥ 250	%	ISO 37
Compression set after 22 h at 150 °C, using a type B test piece obtained by plying three discs	≤ 15	%	ISO 815-1
Density	1,85 ± 0,03	Mg/m^3	ISO 2781
Percentage change in mass after 22 h immersion at (23 ± 2) °C in ISO liquid E (toluene)	3 [a]	%	ISO 1817

[a] Typical value (recommended range 3 ± 2).

4.5 Standard peroxide-vulcanized ethylene propylene diene rubber (EPDM 1)

4.5.1 Composition by mass

The composition by mass is given in Table 7.

Table 7 — Composition by mass of EPDM 1

Material	Parts by mass
Ethylene propylene diene terpolymer [a]	100,0
FEF carbon black (ASTM designation: N550)	50,0
Zinc oxide (rubber grade)	5,0
Polymerized 2,2,4-trimethyl-1,2-dihydroquinoline (melting point 75 °C to 100 °C)	0,5
Dicumyl peroxide (grade with 40 % peroxide content on inert filler)	5,0
Total	160,5

[a] Mooney viscosity (42 ± 5) ML (1 + 4) 100 °C, ethylene content (54 ± 5) % (by mass), diene (ENB) content (5 ± 2) % (by mass) (EPT 3045 from Mitsui Chemicals, Buna EP G 3440 from Lanxess or ESPRENE 501A from Sumitomo Chemical, or equivalent).

EPT 3045, Buna® EP G 3440 and ESPRENE® 501A are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

4.5.2 Mixing procedure

Follow the procedure a) to j), maintaining the surface temperature of the rolls at (50 ± 5) °C.

a) Band the crude rubber with the mill opening set at 1,4 mm and break down.

b) Blend the carbon black, the zinc oxide and the polymerized 2,2,4-trimethyl-1,2-dihydroquinoline together and add them evenly across the rolls at a constant rate.

c) Open the mill at intervals to maintain a constant bank.

d) When all the ingredients have been added, including any that have dropped through to the pan, make one 3/4 cut from each side.

e) Add the dicumyl peroxide evenly across the rolls.

f) When the dicumyl peroxide has been mixed in, make three 3/4 cuts from each side.

g) Cut the batch from the mill and set the opening to 0,8 mm.

h) Pass the rolled stock endwise through the mill six times.

i) Sheet off samples at 2,2 mm and allow to cool on a flat metal surface.

j) Prepare samples for curing.

4.5.3 Preparation of standard vulcanized sheets

Prepare standard vulcanized sheets by curing sheets (2,0 ± 0,2) mm thick for 20 min at 170 °C.

4.5.4 Control tests

Carry out all the tests specified in Table 8 on the sheets prepared in 4.5.3.

Table 8 — Control tests for EPDM 1

Control tests	Property requirement	Unit	Document specifying test method
Hardness	68 ± 3	IRHD	ISO 48
Tensile strength, type 2 dumb-bell test piece	≥ 15	MPa	ISO 37
Elongation at break, type 2 dumb-bell test piece	≥ 200	%	ISO 37
Compression set after 22 h at 150 °C, using a type B test piece obtained by plying three discs	≤ 25	%	ISO 815-1
Density	1,09 ± 0,02	Mg/m^3	ISO 2781
Percentage change in mass after 22 h immersion at (23 ± 2) °C in methyl ethyl ketone	8 [a]	%	ISO 1817

[a] Typical value (recommended range 8 ± 3).

4.6 Standard hydrogenated acrylonitrile-butadiene rubber with 35 % acrylonitrile content (HNBR 1)

4.6.1 Composition by mass

The composition by mass is given in Table 9.

Table 9 — Composition by mass of HNBR 1

Material	Parts by mass
HNBR [a]	100,0
4,4′-(α,α-Dimethylbenzyl)diphenylamine	1,0
Zinc salt of 2-mercaptobenzoimidazole	1,0
FEF carbon black (ASTM designation: N550)	50,0
1,3-bis-(*t*-Butylperoxyisopropyl)benzene (grade with 40 % peroxide content on inert filler)	8,0
Total	160,0

[a] Acrylonitrile content (35 ± 2) %, Mooney viscosity (75 ± 15) ML (1 + 4) 100 °C, residual double bonds < 2 %, such as Zetpol 2000 from Zeon Corporation or Therban A 3407 from Lanxess.

Zetpol® 2000 and Therban® A 3407 are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

4.6.2 Mixing procedure

Follow the procedure a) to m), maintaining the surface temperature of the rolls at (50 ± 5) °C.

a) Band the crude rubber with the mill opening set at 1,4 mm and break down.

b) Add the 4,4′-(α,α-dimethylbenzyl)diphenylamine and the zinc salt of 2-mercaptobenzoimidazole evenly across the rolls at a constant rate.

c) Make 3/4 cuts on the rolls from one end diagonally to the other end.

d) Add approximately half the carbon black evenly across the rolls at a constant rate.

e) Open the mill at intervals to maintain a constant bank.

f) Make three 3/4 cuts from each side.

g) Add the rest of the carbon black, plus any ingredients that have dropped through to the pan.

h) Add the 1,3-bis-(*t*-butylperoxyisopropyl)benzene evenly across the rolls.

i) Make six 3/4 cuts from each side.

j) Cut the batch from the mill and set the opening to 0,2 mm.

k) Pass the rolled stock endwise through the mill six times.

l) Sheet off samples at 2,2 mm and allow to cool on a flat metal surface.

m) Prepare samples for curing.

4.6.3 Preparation of standard vulcanized sheets

Prepare standard vulcanized sheets by curing sheets (2,0 ± 0,2) mm thick for 20 min at 170 °C.

4.6.4 Control tests

Carry out all the tests specified in Table 10 on the sheets prepared in 4.6.3.

Table 10 — Control tests for HNBR 1

Control tests	Property requirement	Unit	Document specifying test method
Hardness	68 ± 3	IHRD	ISO 48
Tensile strength, type 2 dumb-bell test piece	≥ 20	MPa	ISO 37
Elongation at break, type 2 dumb-bell test piece	≥ 250	%	ISO 37
Compression set after 22 h at 150 °C, using a type B test piece obtained by plying three discs	≤ 40	%	ISO 815-1
Density	1,15 ± 0,02	Mg/m^3	ISO 2781
Percentage change in mass after 22 h immersion at (23 ± 2) °C in ISO liquid B [70 % (by volume) pure 2,2,4-trimethylpentane and 30 % (by volume) pure toluene]	26 [a]	%	ISO 1817

[a] Typical value (recommended range 26 ± 5).

5 Designation system for the elastomer compatibility index (ECI)

For the purposes of this document, the ECI shall be expressed as a simple one-line designation incorporating the following details:

a) the test elastomer used;

b) the percentage change in volume (see 6.2.2);

c) the change in hardness, expressed in IRHD (microtest) (see 6.2.3);

d) the percentage change in tensile strength (see 6.2.4);

e) the percentage change in elongation at break (see 6.2.4).

See Annex B for examples.

6 Determination of the ECI

6.1 Test conditions

Unless otherwise specified, refer to Table 11 for the test temperature and duration.

Table 11 — Test conditions for the determination of the ECI

Fluid	Symbol [a]	Suitable test elastomer [b]	Temperature [c] °C ±1	Duration of test [d] h ±2
Mineral-oil-based	HH, HL, HM, HR, HV	NBR 1, 2	100	1 000 and 168
		HNBR 1		
		FKM 2		
Water/glycol mixtures	HFC	NBR 1, 2	60	1 000 and 168
		HNBR 1		
		EPDM 1		
Oil-in-water emulsions	HFAE, HFAS	NBR 1, 2	60	1 000 and 168
		HNBR 1		
		FKM 2		
Water-in-oil emulsions	HFB	NBR 1, 2	60	1 000 and 168
		HNBR 1		
		FKM 2		
Alkyl phosphate esters	HFDR	EPDM 1	100	1 000 and 168
Aryl phosphate esters		FKM 2	100	
		EPDM 1		
Polyol esters	HFDU	NBR 1, 2	60	1 000 and 168
		HNBR 1	80	
		FKM 2		
Biodegradable synthetic esters	HEES	NBR 1,2	60	1 000 and 168
		HNBR 1	80	
		FKM 2		
Triglycerides (vegetable-oil-based)	HETG	NBR 1, 2	60	1 000 and 168
		HNBR 1		
		FKM 2		
Poly(alkylene glycol) compounds	HEPG	HNBR 1	100	1 000 and 168
		FKM 2		
Poly(α-olefin) compounds and related hydrocarbons	HEPR	NBR 1, 2	100	1 000 and 168
		HNBR 1		
		FKM 2		

[a] See ISO 6743-4.

[b] See ISO 1629.

[c] The choice of test temperature is dependent upon (1) the stability of the elastomeric material and/or (2) the stability of the fluid. Where possible, the test temperatures have been selected to reflect the maximum continuous service temperature found in normal operation, as recommended in ISO 11158[2], ISO 12922[3] and ISO 15380[5]. Higher temperatures are only experienced in very localized situations for short periods of time, such as in a dynamic seal contact or across a relief valve, and are not appropriate to testing with bulk fluid.

[d] The standard test duration is 1 000 h, but a shorter test duration can provide additional compatibility information.

6.2 Determination of change in volume, change in hardness and change in tensile strength and elongation at break

6.2.1 General

The general procedure shall be as specified in ISO 1817:2011, Subclause 8.1, except that the fluid used, the temperature and the duration of the test shall, unless otherwise specified, be selected from Table 11.

6.2.2 Change in volume

Determine the change in volume in accordance with ISO 1817:2011, Subclause 8.3.

6.2.3 Change in hardness

Determine the change in hardness in accordance with ISO 1817:2011, Subclause 8.6.

6.2.4 Change in tensile strength and elongation at break

Determine the change in tensile strength and elongation at break in accordance with ISO 1817:2011, Subclause 8.7.

7 Test report

For each test method (6.2.2 to 6.2.4), the test report shall include the following:

a) all information necessary for the complete identification of the sample;

b) a reference to this International Standard;

c) the test elastomer used;

d) the test method(s) carried out;

e) the type of fluid used (e.g. HM, HFC);

f) a description of the test pieces used;

g) the test temperature and the duration of each test, if different from the values given in Table 11;

h) the test result(s) obtained;

i) the appearance of the test pieces after immersion (e.g. the presence of cracks or stickiness);

j) details of any operations not specified in this International Standard;

k) details of any incidents which might have influenced the result(s);

l) any unusual features (anomalies) observed during the test(s);

m) any discolouration of the immersion liquid or formation of sediment;

n) the date of each test.

The elastomer compatibility index (ECI) for the fluid concerned shall also be stated in the test report.

8 Identification statement (reference to this International Standard)

Use the following statement in test reports, catalogues and sales literature when electing to comply with this International Standard:

"Elastomeric material compatibility with fluids determined in accordance with ISO 6072:2011, *Rubber — Compatibility between hydraulic fluids and standard elastomeric materials*."

Annex A
(informative)

Further information on hydraulic fluids and the types of elastomer used with them

A.1 Types of hydraulic fluid

Hydraulic fluids include mineral-based oils, fire-resistant fluids, biodegradable fluids and synthetic hydrocarbons. Fire-resistant fluids fall into two main groups.

a) Aqueous-based fluids:

   — oil-in-water emulsions;

   — water-in-oil emulsions;

   — water/glycol mixtures.

b) Non-aqueous-based fluids:

   — phosphate esters;

   — polyol esters.

A.2 Types of elastomer

A.2.1 General

A wide variety of elastomer types are used in hydraulic equipment, for example:

— acrylonitrile-butadiene rubbers (NBR);

— fluorocarbon rubbers (FKM);

— ethylene propylene diene rubbers (EPDM);

— hydrogenated NBR (HNBR);

— butyl rubbers (IIR);

— polyacrylic rubbers (ACM);

— silicone rubbers (VMQ);

— chloroprene rubbers (CR);

— polyurethanes (EU and AU).

The nomenclature and abbreviations used for elastomers are in accordance with ISO 1629. The names of the elastomeric materials are generic, i.e. a whole variety of compounds might exist under that name, all of which will have certain properties, but specific properties will differ with the degree of compounding.

NOTE The methods used for processing polyurethane are different from those used for other types of elastomeric material.

A.2.2 Acrylonitrile-butadiene rubbers

Acrylonitrile-butadiene rubbers are the most important class of elastomers used in hydraulic equipment. They are resistant to petroleum oils, to fire-resistant oil-in-water and water-in-oil emulsions, and to biodegradable fluids. However, they are not suitable for use with phosphate ester fluids.

Chemically, acrylonitrile-butadiene rubber is a copolymer of butadiene and acrylonitrile, the acrylonitrile content varying between approximately 18 % and 48 %. Nominal designations are low, medium and high nitrile. Resistance to petroleum-based oils increases with increasing nitrile content but, at the same time, low-temperature flexibility decreases with increasing nitrile content. In order to obtain good low-temperature performance with acrylonitrile-butadiene rubbers, it is usually necessary to sacrifice some high-temperature oil resistance.

A.2.3 Fluoroelastomers

Fluoroelastomers are based on copolymerization of vinylidene fluoride and hexafluoropropylene, offering a range of rubbers with outstanding resistance to chemical attack and a maximum continuous service temperature of 200 °C, although the low-temperature performance is only comparable with that of high nitrile.

Fluoroelastomers are resistant to mineral-based oils and aryl phosphate ester fluids, but not resistant to alkyl phosphate esters.

A.2.4 Ethylene propylene diene rubbers

Ethylene propylene diene rubbers are not resistant to mineral-based oils. They are mainly used in hydraulic systems based on fire-resistant phosphate ester fluids. They are also excellent for steam and hot-water service.

A.2.5 Hydrogenated NBR

Hydrogenated NBR (HNBR) is made by hydrogenating the double-bond part of NBR and by saturating it. Its characteristics and use are similar to those of NBR, although HNBR is superior to NBR in high-temperature performance and chemical resistance.

A.3 Action of hydraulic fluids on elastomers

Elastomers in contact with hydraulic fluids are subject to two simultaneous actions:

— absorption of the liquid by the rubber;

— extraction of soluble constituents (especially plasticizers) from the rubber.

The result is a change in volume, i.e. swelling if absorption is greater than extraction, or shrinkage if extraction is greater than absorption.

Swelling increases with time of immersion up to the point when no more fluid can be absorbed and the volumetric expansion remains constant. Swelling also depends on temperature: as a general rule, the higher the temperature, the greater will be the equilibrium expansion. The time required for equilibrium swelling is proportional to the square of the thickness of the test piece.

The change in volume can alter the physical properties of the elastomer, such as hardness, tensile strength and extensibility. Furthermore, some additives in hydraulic fluids can react chemically with the elastomer, particularly at elevated temperatures, leading to major changes in the chemical and physical properties of the elastomeric material, such as embrittlement. These changes can considerably affect the performance of elastomers used in hydraulic systems.

Annex B
(informative)

Example of test report — Fluid-elastomer compatibility index (ECI)

B.1 Test conditions

Immersion fluid		Temperature °C	Duration h
Commercial name	**Type according to Table 11 of ISO 6072:2011**		

B.2 Test results

B.2.1 ECI

Test elastomer	Δ volume %	Δ hardness IRHD	Δ tensile strength %	Δ elongation at break %

EXAMPLE 1 NBR 1 +20 % −4 points IRHD −8 % −10 %

NBR 1 +20 −04 −08 −10

EXAMPLE 2 FKM 2 +6 % −4 points IRHD −6 % −10 %

FKM 2 +06 −04 −06 −10

B.2.2 Name of polymer used as test elastomer

.....

B.3 Conformity statement

The tests have been carried out in conformity with ISO 6072:2011.

☐ **Yes** ☐ **No** (give details of the differences)

Annex C
(informative)

Rapid method for indicating, by measuring the volume change index (VCI), the change in volume of commercial rubbers when treated with mineral-based oils

C.1 General

This annex specifies a method for predicting the percentage change in volume of commercial rubbers in mineral-based oils. The percentage change in volume of a standard elastomer, NBR 1, after immersion in various mineral-based oils under the test conditions given in Table 11, establishes a quick method for predicting percentage changes in volume of commercial rubbers in such oils without having to carry out tests on each combination.

C.2 Terms and definitions

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

C.2.1
swelling behaviour
SB
<commercial rubbers> correlation of percentage changes in volume in a range of mineral oils with those of a standard elastomer, NBR 1

NOTE See Figure C.1.

C.2.2
volume change index
VCI
swelling behaviour of standard elastomer NBR 1 in mineral-based oil under the test conditions given in Table 11 of this International Standard

C.3 Procedure

To quote the swelling behaviour of a commercial elastomer, the rubber manufacturer has to evaluate the relationship between the percentage change in volume of the commercial rubber and that of the standard rubber, NBR 1 (see Figure C.1). To ensure that the chemical conditions are always the same, it is recommended that international reference fluids be used.

After plotting a minimum of two points with the percentage change in volume of the standard elastomer, NBR 1, as the abscissa and the percentage change in volume of the commercial rubber in the same oil as the ordinate, a best-fit line is calculated:

$$\text{SB} = \text{VCI} \times s + i$$

where

s is the slope of the line;

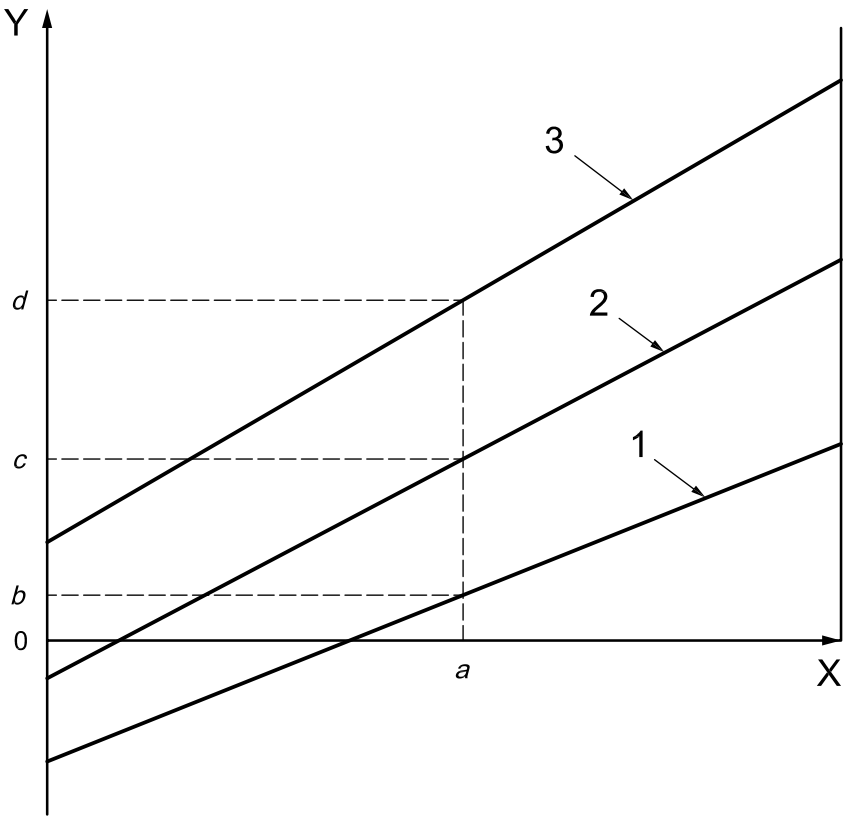
i is the intercept on the Y-axis.

For every commercial rubber, there is an individual straight line like that shown in Figure C.1. Knowing the VCI of a mineral-based oil, the swelling behaviour of another commercial rubber can be easily calculated.

EXAMPLE If the percentage change in volume of standard elastomer NBR 1 after immersion in a mineral-based oil is equal to a (see Figure C.1), it would be possible to predict the percentage change in volume of commercial rubber No. 1 to be equal to b, that of commercial rubber No. 2 to be equal to c and that of commercial rubber No. 3 to be equal to d, without having to carry out immersion tests with these other rubbers in the oil.

C.4 Comments

The formulation of standard elastomer NBR 1 is designed so that usually no shrinkage takes place. Commercial elastomers can shrink, however, the extent of shrinkage depending on the amounts of extractable ingredients like plasticizers that they contain. Therefore the percentage change in volume of standard elastomer NBR 1 is for information only. The real behaviour of the commercial elastomer always has to be calculated using the linear relationship correlating the two.



Key

X percentage change in volume of standard rubber NBR 1

Y percentage change in volume of commercial rubber

1 swelling behaviour of commercial rubber No. 1

2 swelling behaviour of commercial rubber No. 2

3 swelling behaviour of commercial rubber No. 3

Figure C.1 — Relationship between percentage change in volume of commercial rubber and standard rubber NBR 1 in mineral oils

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National Annex NA
(informative)

Guidelines on elastomer compatibility

These guidelines show acceptable change of properties of elastomers or elastomer compatibility index (ECI) for each of the specified immersion times.

WARNING The values shown here are for reference purposes and they should not be taken as the direct basis on which elastomer compatibility is to be determined, because this also depends on the purpose and conditions of actual use.

Table NA.1 Guidelines on acceptable change of properties (ECI)

Immersion time	Maximum volume swell %	Maximum volume shrinkage %	Hardness change IRHD	Maximum tensile strength change %	Maximum elongation change %
168	15	—4	±8	—20	—20
1 000	20	—5	±10	—50	—50

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