INTERNATIONAL STANDARD

ISO 23936-2

First edition
2011-12-15

Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production —

Part 2: Elastomers

Industries du pétrole, de la pétrochimie et du gaz naturel — Matériaux non métalliques en contact avec les fluides relatifs à la production de pétrole et de gaz —

Partie 2: Élastomères

Reference number
ISO 23936-2:2011(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

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

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

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

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

ISO 23936-2 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

ISO 23936 consists of the following parts, under the general title *Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production*:

— *Part 1: Thermoplastics*

— *Part 2: Elastomers*

The following parts are planned:

— *Part 3: Thermosets*

— *Part 4: Fibre-reinforced composite*

— *Part 5: Other non-metallic materials*

Introduction

ISO 23936 is intended to be of benefit to a broad industry group, ranging from operators and suppliers to engineering companies and authorities. ISO 23936 covers relevant generic types of non-metallic material (thermoplastics, elastomers, thermosetting plastics, fibre-reinforced plastics, etc.) and draws upon a wide range of existing technical experience, which has never before been summarized in a technical standard.

ISO 23936 does not cover polymeric coatings such as thermal insulation and paint that are applied to the outside of components but that are not in contact with oilfield fluids.

The evaluation and qualification process described in this part of ISO 23936 is intended to ensure that the user of non-metallic materials has sufficient understanding and knowledge of the applicable materials to obtain acceptable performance in the specified environment, and that the user can rely on stable quality to meet given specifications. A quality system is useful to ensure compliance with the requirements of this part of ISO 23936.

Successful qualification of a manufacturer and a specific material is intended to be valid for other projects and different operators. The consideration of qualification of a manufacturer is at the discretion and determination of the purchaser, normally on the basis of documentation provided by the manufacturer, as required in this part of ISO 23936 or any specific additional documentation.

The purchaser is responsible for ensuring (if necessary, with external competence) that the manufacturers selected are qualified.

This part of ISO 23936 is based on NORSOK standard M-710.

Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production —

Part 2: Elastomers

1 Scope

ISO 23936 describes general principles and gives requirements and recommendations for the selection and qualification of non-metallic materials for service in equipment used in oil and gas production environments, where the failure of such equipment could pose a risk to the health and safety of the public and personnel, or to the environment. It can be applied to help avoid failures of the equipment itself. It supplements, but does not replace, the material requirements given in the appropriate design codes, standards or regulations.

This part of ISO 23936 describes the requirements and procedures for qualification of elastomeric material used in equipment for oil and gas production.

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 34-1:2010, *Rubber, vulcanized or thermoplastic — Determination of tear strength — Part 1: Trouser, angle and crescent test pieces*

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

ISO 2921, *Rubber, vulcanized — Determination of low-temperature retraction (TR test)*

ISO 3601-3:2005, *Fluid power systems — O-rings — Part 3: Quality acceptance criteria*

ISO 7619-1, *Rubber, vulcanized or thermoplastic — Determination of indentation hardness — Part 1: Durometer method (Shore hardness)*

ISO 13628-10:2005, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 10: Specification for bonded flexible pipe*

ASTM D297, *Standard Test Methods for Rubber Products — Chemical Analysis*

ASTM D395, *Standard Test Methods for Rubber Property — Compression Set*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers — Tension*

ASTM D624, *Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers*

ASTM D1414, *Standard Test Methods for Rubber O-Rings*

ASTM D1415, *Standard Test Method for Rubber Property — International Hardness*

ASTM D2240, *Standard Test Method for Rubber Property — Durometer Hardness*

API 17K, *Specification for Bonded Flexible Pipe*

3 Terms, definitions and abbreviated terms

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

3.1 Terms and definitions

3.1.1
accelerated test
test undertaken under conditions designed to speed material deterioration

NOTE This is usually accomplished by increasing temperature, in order to raise chemical reaction rates, but fluid concentration and stress are variables which can also be manipulated.

3.1.2
asset operator
person who operates an asset, who has knowledge of well parameters and who transmits this information to the **user** (3.1.15)

NOTE 1 An asset can be a well, a production train, a plant, etc.

NOTE 2 Well parameters can be fluid exposure, temperatures, pressures, duration, etc.

3.1.3
compression set
difference between the original sample height and the post-test height, divided by the interference, expressed as a percentage

3.1.4
elastomer
rubber
amorphous material mechanically mixed with other constituents to form a rubber compound, which is then shaped by flow into articles by means of the manufacturing processes of moulding or extrusion, and then (invariably) chemically cured at elevated temperature to form an elastic insoluble material

3.1.5
fluid
medium such as a gas, liquid, supercritical gas, or a mixture of these

3.1.6
interference
difference between the original sample height and the height of spacer bar, each measured in the same direction as the direction of compression

3.1.7
compound manufacturer
manufacturer
producer of the elastomer material or of semi-finished products made from elastomer materials

3.1.8
modulus
tensile stress at a given elongation

NOTE In the rubber industry, the modulus at 50 % elongation is often chosen.

3.1.9
polymer
high molecular weight molecule, natural or synthetic, whose chemical structure can be represented by repeated small units which collectively form molecular chains

NOTE This material class has three main sub-groups: elastomers, thermoplastics and thermosets.

3.1.10
rapid gas decompression
RGD
depressurization
explosive decompression
rapid pressure-drop in a high pressure gas-containing system which disrupts the equilibrium between external gas pressure and the concentration of gas dissolved inside any polymer, with the result that excess gas tries to escape from the solution at points throughout the material, causing expansion

NOTE If large enough, and if the pressure-drop rate is faster than the natural gas diffusion rate, blistering or rupturing can occur.

3.1.11
room temperature
temperature of (23 ± 2) °C

3.1.12
seal cross-section
cross-section diameter
CSD
free height of a seal at room temperature, measured normal to seal diameter in the direction of compression in the test

NOTE The measurement is taken at three circumferentially equidistributed positions.

3.1.13
seal type
seal design of specified geometry, size and orientation

EXAMPLE An O-ring.

3.1.14
thermoplastic
material capable of being repeatedly softened by heating and hardened by cooling through a temperature range characteristic of the plastic and, in the softened state, of being repeatedly shaped by flow into articles by moulding, extrusion or forming

3.1.15
user
person responsible for the selection of suitable materials for a service operation based on information received from the **asset operator** (3.1.2)

3.1.16
purchaser
party responsible for procuring the elastomer material or component

3.2 Abbreviated terms

BOP	blow-out preventer
BRE	base resistant elastomers
COC	certificate of conformance
CSD	cross-section diameter
DMA	dynamic mechanical analysis
DMTA	dynamic mechanical thermal analysis
DSC	differential scanning calorimetry
GMPHOM	Guide to Manufacturing and Purchasing Hoses for Offshore Moorings
HNBR	hydrogenated nitrile butadiene rubber
HP	high pressure
LNG	liquefied natural gas
NBR	nitrile butadiene rubber
OCIMF	Oil Companies International Marine Forum
PBR	polished bore receptacle
RGD	rapid gas decompression (rapid gas depressurization)
SPS	solubility parameter spectroscopy
TMA	thermo mechanical analysis

4 Technical requirements

Technical requirements depend on material property characteristics and specific functional tests for an application.

Elastomer selection shall be based on evaluation of compatibility with service environment, functionality under service and the design lifetime. This part of ISO 23936 covers materials tests and not functional tests. The following should be considered as appropriate to the component requirements and evaluated when selecting the material:

a) adequate physical and mechanical properties (density, hardness, tensile strength, elongation at break, modulus of elasticity, compression set, tear strength, etc.); standard properties from which design specifications are selected and for quality assurance and control aspects;

b) resistance against RGD events; a property of importance in high pressure gas sealing applications, covered in depth in this part of ISO 23936;

c) long-term behaviour; resistance to chemical/physical change of the material; an important characteristic regarding sealing generally in the oil and gas sector, covered in this part of ISO 23936;

d) low temperature flexibility; a property highly relevant to low temperature sealing applications;

e) for large components exposed to gaseous production fluid, high pressure gas permeation; a property highly relevant to possible gas pressure build-up within the component structure, e.g. for hoses;

f) resistance to high pressure extrusion or creep (functional tests not covered by this part of ISO 23936);

g) resistance to thermal cycling and dynamic movement (functional tests not covered by this part of ISO 23936).

Clause 2 gives references to relevant standards for elastomeric materials. The standards describe the test methodology for performing particular materials tests. The test conditions and durations shall be as described in this part of ISO 23936 and shall take precedence in those cases where this part of ISO 23936 deviates from the referenced standards.

Long term (ageing) test objectives are described in Clause 7; procedural details are given in Annex A. RGD test objectives and procedures for elastomer O-ring seals are described in Clause 7 and Annex B.

It is the responsibility of the asset operator to provide all necessary information about service conditions and environment.

Information on elastomer characteristics is provided in Annex C.

5 Documentation requirements

NOTE The required documentation of material properties of thermoplastic materials is described in ISO 23936-1.

Required documentation of material properties is given in Table 1. Requirements pertaining both to documentation of properties and quality control are given. Each elastomer material used shall be traceable to the compound manufacturer and their quality control documentation as required in Table 1. Each batch of material shall be supplied with, as a minimum, a certificate of conformance (COC) and traceability information.

Table 1 also defines the minimum amount of production and quality control testing required during manufacturing of the elastomer materials. The final procedures, with respect to key parameters and tolerances, shall be defined based on results from testing performed according to this part of ISO 23936.

The user shall define the necessary requirements with tolerances in the purchase specification.

Guidelines on selection of standards are given in parentheses. Characteristics, which are not relevant for expected service conditions and/or material type, may be omitted.

Table 1 — Required documentation for elastomer material properties

Properties	Documentation	Quality control tests
Density (ISO 2781 or ASTM D297)	D[a]	B[c]
Hardness (IRHD/Shore A) (ISO 48/ISO 7619-1, ASTM D2240/ ASTM D1415)	D	B
Tensile and elongation properties (ISO 37, ASTM D1414, ASTM D412)	D	B
Compression set (ISO 815-1, ASTM D395/ASTM D1414)	D	
Low temperature characteristics by DSC, DMA or TMA	D	
Tear strength (ISO 34-1:2010, Method A, ASTM D624)	D	
Temperature of retraction (ISO 2921)	D	
Ageing/RGD characteristics (Annexes A/B)	D	
High pressure gas permeation	DH[b]	

[a] D: Properties to be documented for each supplier for each type of material. Nominal values with tolerances shall be given (Data Sheet).

[b] DH: As for D, but specifically when using all large components exposed to high pressure gas.

[c] B: Properties to be documented on a batch-wise basis, minimum 5 samples per test per batch with all results presented. The acceptance criteria shall be established prior to the test and based on qualification test results.

Material property tests may also be omitted if users have documented performance-based functional tests that they use to approve rubber materials.

6 Requirements for manufacturers

6.1 General requirements

It is the requirement of the manufacturer to provide documents attesting that the material has been manufactured and tested appropriately and that the material has met the relevant quality control requirements in this part of ISO 23936.

The testing shall be performed on specimens produced from specific rubber formulations and, where possible, production procedures. The COC should include as a minimum density, batch hardness, tensile properties (moduli, strength, elongation at break), date of manufacture and (where referenced) the sample curing process. The COC should be signed by a quality representative. For large rubber components, tests on small components shall be suitable for the properties of the large component unless otherwise agreed between the interested parties.

This part of ISO 23936 specifies the required types of tests that shall be performed in order to document the material suitability and compatibility with test fluids specified in this part of ISO 23936 which are applicable to the intended application.

The testing shall apply for the elastomer materials and the results shall be valid as long as the requirements stated in 6.2 are satisfied. For later supplies of identical material from the same manufacturer, a quality control of each batch of material shall be sufficient. Table 2 lists typical quality assurance and quality control document templates showing imaginary data.

Table 2 — Typical quality assurance and quality control information

Material			
Manufacturer		Acme Seals, Inc.	
Compound grade		FabFluoro	
Elastomer type	ASTM D1418-05	FKM Type 3	
Lot/batch no.		FF2344rw4r/07	
Cure date		Q4 2010	
Typical Properties	**Applicable standard**	**Unit**	**Value**
Density	ISO 2781	g/cm^3	1,8
Hardness	ISO 48	IRHD	85
Tensile strength	ISO 37	MPa	21
Modulus at 50% elongation	ISO 37	MPa	10,1
Modulus at 100% elongation	ISO 37	MPa	18,5
Elongation at break	ISO 37	%	125

It may not be necessary to perform qualification testing for a particular material, if relevant successful well-documented in-service experience with traceable production records and quality control documentation is available to all relevant parties. This shall be agreed between interested parties.

Such documentation shall contain detailed information about service conditions such as time, temperature, pressure, fluid composition and chemicals added. An asset operator can, for example, provide the documentation of flawless service. The existing service temperature recorded therein shall be in the same range as for the new application (it shall be a maximum of 10 °C below), the existing service pressure shall not be more than 10 % below that for the new application, and the existing service life shall be a minimum of 50 % of design life.

The manufacturer who has tested and qualified his compound(s) can make a statement making this known. Such a statement shall define which parts of ISO 23936 are complied with. Further, the statement shall include whether the testing was done according to Annex A and/or Annex B, and define the fluid composition, conditions and overall duration for the testing.

6.2 Validation of compliance

The elastomer properties shall apply to each specific elastomer compound produced by each specific manufacturer. The existing elastomer data used by one purchaser may also be accepted by subsequent purchasers, provided the requirements in this part of ISO 23936 are still complied with.

A compound shall be re-tested if changes are made to the compound or the process. If compound mixing and/or moulding is carried out at different plants/locations, a separate qualification shall be performed for each plant.

NOTE All materials previously approved in accordance with NORSOK M-710 are approved in accordance with this part of ISO 23936.

7 Qualification of elastomer materials (ageing and RGD)

7.1 General

The technical necessities for the testing of elastomeric materials are divided into two parts:

— 7.2 defines the chemical ageing test requirements (see Annex A);

— 7.3 defines the requirements for RGD testing (see Annex B).

The test regimes shall be selected based on an analysis of the service conditions applying to the material in question, if these are known. Such an assessment shall include the nature and type of all fluids which contact the elastomer. The service life of the seal material in the relevant service environment shall be evaluated using appropriate techniques.

7.2 Requirements for ageing tests

7.2.1 General

This part of ISO 23936 defines test procedures for the prediction of the progressive degradation of elastomeric materials exposed to fluids at elevated temperatures over extended periods of time. It is applicable where it is necessary to forecast material life in a specific application and for directly comparing the performance of candidate elastomer materials. Other standards, such as API TR6J1, also provide methods to assess life of elastomer materials.

The objective is to assess the physical effects of the fluid on the elastomer and to thermally accelerate chemical reaction (if this occurs) between the fluid and the elastomer, causing tensile and related property levels to shift systematically towards a pre-defined limit of acceptability. The material is considered to have "failed" (i.e. reached the end of its useful life) when this limit is attained. These data are then used to quantify service life and suitability for service.

By running exposure tests with test fluids at three different elevated temperatures above the operating temperature, three different times to reach the acceptance boundary will result, with the highest test temperature producing the shortest "time to failure". Plotting the log of failure times against the reciprocal of the test temperature should result in a linear trend, enabling an estimate of service life at the operating temperature.

For accelerated testing, the upper test temperature should be limited to give some confidence that only service-relevant chemical and/or physical processes will occur.

The preferred test piece geometry is the tensile dumbbell; various standards apply (see Table 1). The ageing of moulded sheet, for subsequent stamping-out of tensile test pieces, is not allowed. The elastomer shall be tested in unconstrained mode; that is, free-standing, with fluid able to freely access all surfaces.

When extrapolating data from the present procedures, appropriate statistical techniques shall be applied. For example, if progressive degradation is apparently dependent on a single chemical ageing process, a method based on the Arrhenius relationship shall be used as described in Annex D. It is recommended that results always first be assessed on an Arrhenius basis. If an Arrhenius relationship does not exist or ageing does not occur, see Annex E for further guidance.

Test media, conditions, equipment, procedures and test report requirements are described in detail in Annex A.

7.2.2 Acceptance criteria for elastomers

The acceptance criteria shall be established prior to commencing the ageing test. The following criteria have been established as the maximum acceptable ranges for three particular properties; any relaxation of these

requirements shall be agreed upon by the user. A narrower acceptance range can be applied to any of these if required by circumstances.

— Hardness: +10/–20 units (+5/–20 units when initial nominal hardness is 90); applies to Shore A and IRHD scales

— Volume: +25 % /–5 %

— Tensile: ±50 % [modulus (at 50 % or 100 % elongation), tensile strength, elongation at break]

Tensile test results shall be used to extrapolate the service life according to Arrhenius equation (see Annexes A and E). Other properties may be used by agreement between all parties.

7.3 Requirements for rapid gas decompression testing

7.3.1 General

This part of ISO 23936 gives test procedures for measuring the effect on elastomeric O-ring seals of rapid depressurization after periods at elevated temperature and high pressure in gaseous environments. In addition, guidance notes for interpretation of the results are provided. The supplier shall discuss with the user those applications for which this failure mode is relevant.

The test fluids, conditions, procedure, equipment, inspection procedure and test reporting requirements are described in Annex B.

7.3.2 Acceptance criterion

No seal cross-section shall have a rating of more than 3 (see Clause B.4).

8 Qualification of elastomeric materials in bonded flexible hose

8.1 General

Bonded flexible hose is the general class of flexible hose constructed from layers of elastomer and wire, wire fabric or textile fabric reinforcement that are bonded together by vulcanization during manufacture. The hose section from the internal to external diameter generally consists of the following:

— liner: inner layer of elastomer providing resistance to the fluids being transported;

— body layers: layers of reinforcement typically including textile fabric or parallel cords impregnated with elastomer, parallel steel wire cords impregnated with elastomer, and embedded helical wire. Infill elastomer layers may also be present;

— cover: outer layer of elastomer providing resistance to the external environment;

— insulation or buoyancy: an additional outer layer for hoses where either insulation or buoyancy is required.

The hose structure is integrated into suitable end fittings according to the specific design, usually by bonding of the elastomer to the metal end fitting with a suitable curable adhesive system during the vulcanization of the hose.

Bonded flexible hose usage can be generally classified into:

a) lower pressure applications that are typically used for loading and discharge of liquids and LNG in offshore mooring situations;