INTERNATIONAL STANDARD

ISO 23936-1

First edition
2009-04-15

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

Part 1: Thermoplastics

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

Partie 1: Matières thermoplastiques

Reference number
ISO 23936-1:2009(E)

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Published in Switzerland

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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 23936-1 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*

Elastomers, thermosets, fibre-reinforced composites, and other non-metallic materials are to form the subjects of future parts 2, 3, 4 and 5.

Introduction

Non-metallic materials are used in the petroleum and natural gas industries for pipelines, piping, liners, seals, gaskets and washers, among others. Specifically, the use of piping and liners will considerably increase in the future. The purpose of ISO 23936 is to establish requirements and guidelines for systematic and effective planning, for the reliable use of non-metallic materials to achieve cost effective technical solutions, taking into account possible constraints due to safety and/or environmental issues.

ISO 23936 will be of benefit to a broad industry group ranging from operators and suppliers to engineers and authorities. It covers relevant generic types of non-metallic material (thermoplastics, elastomers, thermosetting plastics) and includes the widest range of existing technical experience. This is particularly important because the subject has not been summarized before in a technical standard. Coatings are excluded from the scope of ISO 23936.

ISO 23936 was initiated during work on ISO 15156-1, ISO 15156-2 and ISO 15156-3, which give the requirements and recommendations for the selection and qualification of low-alloy steels, corrosion-resistant alloys and other alloys for service in equipment used in environments containing H_2S in oil and natural gas production and natural gas treatment plants, where failure of such materials could pose a risk to the health and safety of the public and personnel or to the environment. A fourth part of ISO 15156 was originally envisaged to cover, likewise, the selection and qualification of non-metallic materials in the same environment. However, at a later stage it was decided that due to the differences in the corrosion mechanisms of metallic and non-metallic materials it would be too limiting to solely consider hydrogen sulfide as the corrosive component for non-metallic materials, because in oil and gas production services other systems parameters must also be considered as being corrosive and deteriorating for non-metallic materials.

It was therefore decided to produce a stand-alone International Standard, covering all systems parameters that are considered relevant in the petroleum and natural gas industries to the avoidance of corrosion damages to non-metallic equipment. ISO 23936 supplements, but does not replace, the materials requirements of the appropriate design codes, standards or regulations.

ISO 23936 applies to the qualification and selection of materials for equipment designed and constructed using conventional design criteria for technical application of non-metallic materials. Designs utilizing other criteria are excluded from its scope. ISO 23936 is not necessarily suitable for application to equipment used in refining or downstream processes and equipment.

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

Part 1: Thermoplastics

CAUTION — Non-metallic materials selected using the parts of ISO 23936 are resistant to the given environments in the petroleum and natural gas industries, but not necessarily immune under all service conditions. ISO 23936 allocates responsibility for suitability for the intended service in all cases to the equipment user.

1 Scope

ISO 23936 as a whole presents general principles and gives requirements and recommendations for the selection and qualification, and gives guidance for the quality assurance, 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 to avoid costly corrosion 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 addresses the resistance of thermoplastics to the deterioration in properties that can be caused by physical or chemical interaction with produced and injected oil and gas-field media, and with production and chemical treatment. Interaction with sunlight is included; however, ionizing radiation is excluded from the scope of this part of ISO 23936.

Furthermore, this part of ISO 23936 is not necessarily suitable for application to equipment used in refining or downstream processes and equipment.

The equipment considered includes, but is not limited to, non-metallic pipelines, piping, liners, seals, gaskets and washers.

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 178, *Plastics — Determination of flexural properties*

ISO 179-1, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

ISO 306, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST)*

ISO 527-1, *Plastics — Determination of tensile properties — Part 1: General principles*

ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 1183-2, *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method*

ISO 2578, *Plastics — Determination of time-temperature limits after prolonged exposure to heat*

ISO 11357-6, *Plastics — Differential scanning calorimetry (DSC) — Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)*

ISO 15156–1, *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production — Part 1: General principles for selection of cracking-resistant materials*

ISO 15156–2, *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low-alloy steels, and the use of cast irons*

ISO 15156–3, *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys*

ASTM D638, *Standard Test Method for Tensile Properties of Plastics*

ASTM D746, *Standard Test Method for Brittleness Temperature of Plastics and Elastomers By Impact*

ASTM D792, *Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement*

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
batch
discontinuously manufactured amount of thermoplastic material

3.1.2
certificate of compliance
〈inspection〉 document to be issued by the manufacturer in accordance with requirements stated in this standard or in the purchase order

3.1.3
end user
oil and/or gas operating company

3.1.4
fluid
liquid or gas

3.1.5
gasket
sealing component compressed in a joint

3.1.6
liner
thermoplastic material for protection of medium-contacted surfaces of pipes, piping, pipelines or equipment

3.1.7
lot
part of a batch or part of a continuously manufactured thermoplastic material

3.1.8
lot certificate
certificate of analysis issued by the manufacturer

3.1.9
manufacturer
producer of the thermoplastic material or semi-finished products made from thermoplastic materials

3.1.10
material specification
description of characteristics and test requirements for thermoplastic materials

3.1.11
operating temperature
temperature to which a component is subjected during normal operation

3.1.12
maximum operating temperature
maximum temperature to which a component is subjected, including deviations from normal operations, such as start-up/shutdown

3.1.13
minimum operating temperature
minimum temperature to which a component is subjected, including deviations from normal operations, such as start-up/shutdown

3.1.14
pipeline
those facilities through which fluids or gases are transported, including pipes, pig traps, components and equipment, including valves

NOTE Adapted from ISO 13623:2000, definition 3.12.

3.1.15
piping
pipe or system of pipes for the transport of fluids and gases

NOTE 1 A piping system can be regarded as one single system provided it conveys substances having the same properties and as a whole is designed for the same allowable pressure.

NOTE 2 Interruption by different components such as pumps, machines, vessels, etc. does not preclude integration into one single piping system.

3.1.16
seal
deformable polymeric device designed to separate different environments

3.1.17
swelling
increase in volume due to absorption of fluids

3.1.18
thermoplastics
plastics that are capable of being repeatedly softened by heating and hardened by cooling through a temperature range characteristic of the plastics and, in the softened state, of being repeatedly shaped by flow into articles by moulding, extrusion or forming

[ISO 15750-3:2002]

3.1.19
washer
flat plate of a material with a centralized hole used to seat bolt heads and nuts, among others

3.2 Abbreviated terms

COC	Certificate of compliance
COA	Certificate of analysis
DSC	Differential scanning calorimetry
DTMA/TMA	Dynamic thermo-mechanical analysis/Thermo-mechanical analysis
ECTFE	Polyethylene-chlorotrifluoroethylene
ETFE	Polyethylene-tetrafluoroethylene
HDPE	High density polyethylene
LDPE	Low density polyethylene
MDPE	Medium density polyethylene
PA	Polyamide
PAI	Polyamide-imides
PCTFE	Polychlorotrifluoro-ethylene
PE	Polyethylene
PEI	Polyether-imides
PEEK	Polyether-etherketones
PEX	Cross-linked polyethylene
PFA	Perfluoralkoxides
POM	Polyoximethylene
PP	Polypropylene
PP-B	Polypropylene heterophasic copolymers
PP-H	Polypropylene homopolymers
PP-R	Polypropylene random copolymers
PPS	Polyphenylene sulfide
PTFE	Polytetrafluoro-ethylene
PVDF	Polyvinylidene fluoride
QC	Quality control
RGD	Rapid gas decompression

4 Functional requirements

4.1 General

Materials selection shall be based on evaluation of compatibility with service environment, functionality under service and the design lifetime. The following shall be considered as appropriate to the requirements and evaluated when selecting a material for a specific application:

a) adequate physical and mechanical properties at maximum and minimum temperature (hardness, tensile strength, elongation at break, modulus of elasticity, etc.);

b) resistance to high pressure extrusion or creep at maximum temperature;

c) resistance against rapid gas decompression at maximum temperature;

d) resistance to thermal cycling and dynamic movement;

e) low temperature flexibility, as defined in ASTM D746 and ISO 178;

f) long-term behaviour;

g) gas permeation behaviour;

h) chemical resistance to service environment.

For load-carrying applications, special attention shall be paid on creep and cyclic mechanical loads.

Typical chemical resistances of the most commonly used thermoplastics are listed in Annex A.

4.2 Pipelines, piping and liners

4.2.1 General

The relevant thermoplastic materials in the field of pipelines, piping and liners for use in oil and gas production include Polyethylene (PE), Polypropylene (PP), Polyvinylidene fluoride (PVDF) and Polyamide (PA). Thermoplastic materials based on other monomers may also be used.

4.2.2 Polyethylene (PE)

Polyethylene (PE) is a semi-crystalline thermoplastic polymer. There are different types of PE used in the field of oil and gas production:

— LDPE (low density polyethylene);

— MDPE (medium density polyethylene);

— HDPE (high density polyethylene).

PEX is the abbreviation for cross-linked PE. Cross-linking is usually performed by peroxides (PEXa), silanes (PEXb) or irradiation (PEXc).

Table 1 gives the characteristic properties of the different types of PE and those of PEX, together with the related standards.

Table 1 — Characteristic properties of PE/PEX

Type	Property					
	Density g/cm³	Melting point (DSC) °C	Vicat A softening temperature °C	Maximum operating temperature[d] °C	Brittleness temperature °C	Impact strength at –30 °C (Charpy) MPa
	Standard					
	ISO 1183-2	ISO 11357-1 to ISO 11357-6	ISO 306	—	ASTM D746	ISO 179-1
LDPE	0,910 to 0,925 > 0,932[a]	90 to 120	80 to 105	40	< –50	No break
MDPE	0,926 to 0,940	125 to 130	110 to 120	50	< –60	No break
HDPE	⩾ 0,941	130 to 135	125 to 130	60	< –60	No break
PEX	[b]	[b]	[b]	[c]	< –60	No break

NOTE Table A.1 (see Annex A) gives more details on service limitations in media encountered in oil and gas production.

[a] Density of LDPE copolymers.

[b] Similar to basic material (LDPE, MDPE or HDPE) used, depending on the cross-linking technique.

[c] Generally higher than the basic material (LDPE, MDPE or HDPE); however, depending on the cross-linking technique.

[d] Related to a long-term service life in benign environments.

Increasing the density of PE will increase the temperature limits and enhance the chemical resistance. Cross-linking will also improve the overall properties of the PE material.

NOTE Chemicals like methanol and aromatic hydrocarbons can extract additives from PE materials and thus accelerate the ageing behaviour. Contact the manufacturer in respect to the chemical resistance of the PE material.

The long-term maximum temperature for PE is related to the Vicat A softening temperature (ISO 306).

The low temperature limits of PE are in the order of –40 °C and relate to the brittleness of the material characterized by impact measurements as described in Table 1.

PE is generally accepted in aqueous environments. In the presence of aliphatic and aromatic hydrocarbons the use of PE can be limited due to permeation (specifically aliphatic hydrocarbons) and swelling (loss of mechanical properties and dimensional stability). The resistance to hydrocarbons can be improved by cross-linking (PEXa,b,c materials). The degree of cross-linking may be determined in accordance with EN 579.

UV light will degrade the PE material unless efficient stabilizers are added to the polymer.

PE may be sensitive to environmental cracking if contacted with surface-active compounds, such as detergents, surfactants, emulsifiers, demulsifiers and corrosion inhibitors. Testing for susceptibility to environmental stress cracking can be performed in accordance with ISO 16770, ASTM D1693 or ISO 22088. The choice of the testing method should be agreed between end user and manufacturer.