ISO 23936

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
Part 3. Thermosets
Part 4: Fibre reinforced composites
Part 5: Other non-metallic materials

Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production — Part 1: Thermoplastics

Scope

The ISO 23936 series describes general principles and gives requirements and recommendations for the selection, qualification and guidance for quality assurance of non-metallic materials for service in equipment used in oil and gas production environments. It supplements, but does not replace, the material requirements given in the appropriate design codes, standards or regulations.

Scope (contnd.)

Part 1 of ISO 23936 addresses the resistance of thermoplastics to the deterioration in properties that may be caused by physical or chemical interaction with produced and injected oil and gas field media and with production and treatment chemical. Interaction with sunlight is included, however, ionising radiation is excluded from the scope of this part of ISO 23936

ContentsPart 1 (Thermoplastics)

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 the material for specific applications:

Selection criteria for specific applications

- adequate physical and mechanical properties at max. and min. temperature
- resistance to high pressure extrusion or creep at max. temperature;
- resistance against rapid gas decompression at max. temperature;
- resistance to thermal cycling and dynamic movement;
- low temperature flexibility
- long term behaviour;
- gas permeation behaviour;
- chemical resistance to service environment.

For load carrying applications special attention on creep and cyclic mechanical loads must be taken.

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

Pipelines, piping and liners

The relevant thermoplastic materials in the field of pipelines, piping and liners for use in oil and gas production include:

- **Polyethylene (PE),**
- **Polypropylene (PP),**
- **Polyvinylidenfluoride (PVDF),**
- **Polyamide (PA).**

Thermoplastic materials based on other monomers may also be used.

Table 1 — Characteristic properties of PE/PEX

	Properties					
	Density	**Melting point (DSC)**	**Vicat A softening temperature**	**Maximum operating temperatured**	**Brittleness temperature**	**Impact strength at – 30 °C (Charpy)**
	g/cm³	°C	°C	°C	°C	MPa
Standard	ISO 1183–2	ISO 11357 Part 1 to 6	ISO 306	–	ASTM D746	ISO 179–1
LDPE	0,916 to 0,932 > 0,932a	90 to 120	80 to 105	40	< – 50	no break
MDPE	0,935 to 0,945	125 to 130	110 to 120	50	< – 60	no break
HDPE	0,945 to 0,965	130 to 135	125 to 130	60	< – 60	no break
PEX	b	b	b	c	< – 60	no break

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.
NOTE Table A1 in Annex A gives more details on service limitations in media encountered in oil and gas production.

Seals, washers and gaskets

Thermoplastics used as seals and also for backup or support for seals include:

- **polyphenylenesulfide (PPS),**
- **polyether-etherketones (PEEK),**
- **polytetrafluoro-ethylene (PTFE),**
- **polyamid-imides (PAI),**
- **polyether-imides (PEI),**
- **polyoximethylene (POM),**
- **polychlorotrifluoro-ethylene (PCTFE)**

(Often reinforced by glass powder, glass fibres or carbon fibres: enhancement of the mechanical properties.
Table 5: Characteristic properties of the unfilled polymers.)

Table 5 — Characteristic properties of selected unfilled polymers

GS1

	Properties				
	Melting point (DSC)	Vicat B softening temperature (50 K/h)	Maximum allaowable temperature	Brittleness temperature	Impact strength at – 30 ° C (Charpy)
	° C	° C	° C	° C	MPa
Standard	ISO 11357 Parts 1 to 6	ISO 306	–	ASTM D746	ISO 179–1
PPS	280	220	200	– 50	no break
PEEK	335	259	250	– 65	no break
PTFE	325	300	260	– 200	no break
PAI	275	260	200	– 65	no break
PEI	220	220	170	– 60	no break
POM	165 to 175	115	80	– 50	no break
PCTFE	210	160	130	– 40	no break

•NOTE 1 The service temperature is strongly dependent on service stresses or pressure and sealing clearance. The ability to withstand stresses at applicable upper temperature must be documented.
NOTE 2 PAI is susceptible to hydrolysis when exposed to water containing fluids at 70 ° C or 80 ° C The same chemicals that impair the properties of PA11 and PA12 will affect the PAI material.
NOTE 3 The maximum operating temperature shall be set at 70° C when exposed to water containing fluids for long term service life.

For each of these types of polymers application limits are outlined.

Example:

Polyphenylensulfide (PPS)

PPS has good chemical resistance in aqueous and hydrocarbon media up to a temperature limit of 200 ° C. This includes sour environments and functional chemicals (detergents, surfactants, emulsifiers, demulsifiers and corrosion inhibitors). Stress corrosion cracking has not been observed with PPS

Polyether-etherketones (PEEK)

The max. allowable temp.: 250 ° C for unfilled polymer grades.

PEEK is generally resistant to media used in oil and gas service up to the temperature limit.

However, hydrogen sulfide can attack PEEK, specifically in the presence of amines and elemental sulfur and at high partial pressures and temperatures in the range of 200 ° C.

Limited chemical resistance exists also against halogenated hydrocarbons.

Stress corrosion cracking has not been observed with PEEK.
The mechanical properties are sensitive to the thermal treatment during the fabrication process, i.e. residual thermal stresses especially for larger thicknesses.

Encapsulations, electrical insulations, injection lines

Materials used for encapsulation, for electrical insulation of wires and cables and for injection or control lines include predominantly

- **PP,**
- **PA 11,**
- **PA12,**
- **PVDF,**
- **PTFE,**
- **PCTFE,**
- **ECTFE**
- **ETFE.**

Characteristic properties of these compounds are listed in tables.

5 Requirements for technical information

All materials used within the scope of this part of ISO 23936 shall be purchased in accordance with either a written material specification or an industry standard. The specification shall include measurable physical, mechanical and chemical characteristics.

All suppliers to the manufacturer shall have a documented quality assurance system.

The minimum requirements are valid for all applications.

Examples of Materials Properties documented for qualification of thermoplastic materials.

- Specific gravity (ASTM D 792)
- Hardness (ISO 868/ASTM D 2240, Shore D for seals)
- Tensile properties and elongation (ASTM D 638)
- Impact strength (ISO 179–1)
- Expansion coefficient
- Resistance to creep under permanent tensile and compressive loads at maximum temperatures(ASTM D 2990)
- Melting temperature
- Glass transition temperature
- Softening point (ISO 306)
- Data for permeation of gases
- Ageing characteristics
- Resistance to media related to petroleum and natural gas production
- Stress cracking resistance in media related to petroleum and natural gas production

Requirements for manufacturers
General requirements

A quality assurance system should be applied to ensure compliance with the requirements of this part of ISO 23936.

The intent of this standard is to define requirements and recommendations for the selection and qualification of thermoplastic materials for service in equipment used in oil and gas production.

It is important to note that various manufacturing procedures and practices can be used to make good quality thermoplastic products.

However, qualification of the production process is outside the scope of this standard.

Requirements for manufacturers
General requirements

1.Raw material manufacturer

2. Component manufacturer

3.Validity of qualification

Qualification of thermoplastic materials

General

The technical requirements for qualification of thermoplastic materials in oil and gas environments are described in Annex B.

The different chemical resistance test regimes shall be decided based on analysis of service requirements for the different equipment components and the material in question.

If possible, the standardised test fluids given in Annex B should be used. In case of fitness-for-purpose testing such assessment shall address all fluids that may come in contact with the polymer and the nature of these fluids, both on the high pressure and low pressure side.

Requirements for chemical resistance tests

Acceptance criteria

Table 7 — General acceptance criteria

	Property Change						
	Length	**Mass**	**Volume**	**Tensile strength (Break)**	**Elongation**	**E-modulus**	**Thermostability (DSC-Test) (ISO 11357–6)**
	Length %	Mass %	Vol. %	MPa %	Length %	MPa %	Δ° C
Piping, Liners	0 + 2	±5	Not applicable	± 20	± 30	± 20	0 – 5
Seals, Gaskets	Not applicable	Not applicable	+ 5 / – 1	± 50	± 50	± 50	Not applicable
Encapsulation, Electrical Insulation	± 5	Not applicable	+ 10 / – 5	± 50	± 50	± 50	0 – 5

Annex A(informative)

Typical chemical properties of commonly used thermoplastic materials in media encountered in oil and gas production

Table A.1 — Polyethylenes (PE) d

Table A.2 — Polypropylenes (PP)

Table A.3 — Polyamide 11 (PA 11) and Polyamide 12 (PA 12)

Table A.4 — Polyvinylidenfluoride (PVDF)

Table A.1 — Polyethylenes (PE) [d]

Media	Environmental conditions	
	Temperature °C	Description
H_2S	0 to 60 a	No influence of H_2S on the stability of PE in the typical temperature range of oil and gas transport (0 °C to 60 °C)
CO_2	0 to 60 a	like H_2S
HC/crude aliphatics, aliphatic oils	0 to 60 a, b	Cross-linked PEs exhibit better performance
HC/crude aromatics, aromatic oils	0 to 20 c	Only cross-linked PEs may be acceptable in special cases. Problem: swelling and permeation strongly influence the physical properties
HC/crude naphthenics, HC/crude cycloaliphatics, cycloaliphatic oils	0 to 20 c	like aromatics, dissolution at higher temperatures (e.g. > 100 °C)
Brine	0 to 60 a	like H_2S
Acids, bases	0 to 60 a	No effect by inorganic non-oxidizing acids or bases. Formic and acetic acid no effect up to 60 % concentration
Surface active compounds (inhibitors, emulsifiers, deemulsifiers)	0 to 60 c	Stress corrosion cracking has to be considered and tested accordingly. Cross-linked PE types are more stable.
Sulphur solvents	–	–
— amines	0 to 60 a	Cross-linked types are more stable.
— spindle oil, diesel	0 to 60 c	Effects like the corresponding crudes
— disulphides	0 to 60 c	–
NOTE Cross-linking of PEs generally improves the resistance to degradation by chemical interactions.		

a Proven applicability
b Limited applicability
c Testing required
d The temperature limitations relate to HDPE

Annex B (Normative)

Test media, conditions, equipment, procedures and test report requirements

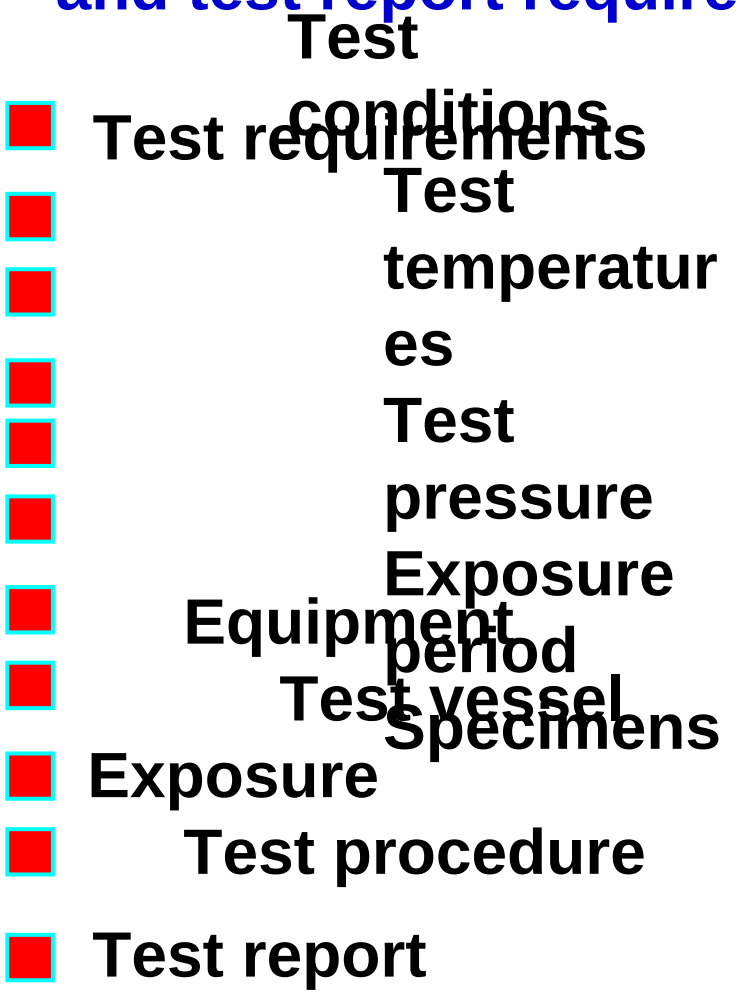

Table B.1 — Test condition for sour service conditions

Liquid Phase (Volume %)	Gas Phase (Volume %)	Initial Composition
–	30	5 % CO_2, 10 % H_2S, 85 % CH_4
10	–	Distilled water (conductivity < 5 µS)
60	–	70 % heptane, 20 % cyclohexane, 10 % toluene

Table B.2 — Test conditions for sweet service conditions

Liquid Phase (Volume %)	Gas Phase (Volume %)	Initial Composition
–	30	5 % CO_2, 95 % CH_4
10	–	Distilled water (conductivity < 5 µS)
60	–	70 % heptane, 20 % cyclohexane, 10 % toluene

Table B.3 — Test conditions for inhibited brine conditions

Liquid Phase (Volume %)	Gas Phase (Volume %)	Composition
–	30	Nitrogen (technical grade)
70	–	Brine (3 % NaCl + 0,5 % water-soluble or water dispersible amine based inhibitor, e.g. hexadecyl-trimethylammonium chloride/bromide)

Status of ISO 23936-1: FDIS submitted for voting to ISO-Secretariate of ISO TC67 at API on 15.08.2008

Petroleum, petrochemical and natural gas industries — Non-metallic materials in contact with media related to oil and gas production — Part 2: Elastomers

Elastomer applications

- Seals
- Hoses
- Insulations

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 should be considered as appropriate to the requirements and evaluated when selecting the material for specific applications.

However, not all of the following properties are relevant in all cases of application.

The following should be considered:

- **Adequate physical and mechanical properties (hardness, tensile strength, elongation at break, modulus of elasticity, etc.);**
- **Lower and upper temperature limits**
- **resistance to high pressure extrusion or creep;**
- **resistance against rapid gas decompression;**
- **resistance to thermal cycling and dynamic movement;**
- **low temperature flexibility, as defined in ASTM D 746 and ISO 178;**

- long term behaviour;
- gas permeation behaviour;
- chemical resistance to service environment.
- electrical resistance
- heat conductivity
- specific heat
- bonding strength

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

Most commonly used elastomeric materials

- Ethylene-propylene (EPM) ,
- Ethylene-propylene-diene-monomer (EPDM)
- Fluoroelastomers
  - FEPM - Fluorinated ethylene-propylene-monomer
  - FFKM – Perfluoroelastomer
  - FKM – Fluoroelastomer
  - FVMQ - Fluorosilicate
- Nitrile (NBR)
- Hydrogenated Nitrile (HNBR)
- Natural Rubber (NR)
- Polychloroprene (CR)
- Polyurethane Rubber (AU, EU)

Elastomer applications

- Seals
- Hoses
- Insulations

Qualification: Test conditions

For seals: incorporation of NORSOK M710 (revised)

ISO 23936-2: FDIS End of 2009 (planning)