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**Oil and gas industries including  
lower carbon energy — Non-metallic  
materials in contact with media  
related to oil and gas production —**

**Part 1:  
Thermoplastics**

*Industries du pétrole et du gaz y compris les énergies à faible teneur  
en carbone — Matériaux non-métalliques en contact avec les fluides  
relatifs à la production pétrole et de gaz —*

*Partie 1: Matières thermoplastiques*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 23936-1:2009), which has been technically revised.

The main changes are as follows:

- added a short-term, single temperature 28-day non-H<sub>2</sub>S material stability evaluation as Level 2;
- added a 56-day total duration target for the traditional three temperature Arrhenius material degradation evaluation as Level 3 and this is very similar to the previous edition;
- moved the life estimation analysis requirement to Level 4 and this new section has a 180-day total duration target for the Arrhenius material degradation evaluation;
- added life estimation analysis examples for plastics.

A list of all parts in the ISO 23936 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

Non-metallic materials are used in the petroleum, petrochemical and natural gas industries for a wide range of components. The purpose of this document is to establish requirements and guidelines for systematic and effective planning, for non-metallic material selection to achieve cost effective technical solutions, taking into account possible constraints due to safety and/or environmental issues.

This document 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 (e.g. thermoplastics, elastomers, thermosetting plastics) and includes the widest range of existing technical experience. Coatings are excluded from the scope of this document.

This document complements the ISO 15156 series on metallic materials in sour service. It differs in the form of guidance provided to the user related to the potential degradation of desired properties when used in equipment for oil and gas production environments. The ISO 15156 series provides application limits and qualification requirements for metallic materials in H<sub>2</sub>S-containing environments, which are related solely to relevant environmentally assisted cracking mechanisms.

This document recognizes that a wider range of compounds and parameters influence the degradation of non-metallic materials and thus provides guidance to permit selection of materials for hydrocarbon exploration and production applications based upon stability in appropriate test conditions.

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# Oil and gas industries including lower carbon energy — Non-metallic materials in contact with media related to oil and gas production —

## Part 1: Thermoplastics

**CAUTION — The non-metallic materials selected using this document are resistant to the given environments in the petroleum and natural gas industries, but not necessarily immune under all service conditions. This document allocates responsibility for suitability for the intended service in all cases to the equipment user.**

### 1 Scope

This document gives general principles, specifies requirements and gives recommendations for the assessment of the stability of non-metallic materials for service in equipment used in oil and gas exploration and production environments. This information aids in material selection. It can be applied to help avoid costly degradation failures of the equipment itself, which could pose a risk to the health and safety of the public and personnel or the environment. This document also provides guidance for quality assurance. It supplements but does not replace, the material requirements given in the appropriate design codes, standards or regulations.

This document 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 chemical treatment. Interaction with sunlight and ionizing radiation are excluded from the scope of this document.

This document 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.

Blistering by rapid gas decompression is not included in the scope of this document.

This document applies to the assessment of the stability of non-metallic materials in simulated hydrocarbon production conditions to aid the selection of materials for equipment designed and constructed using conventional design criteria. Designs utilizing other criteria are excluded from its scope.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 75-1, *Plastics — Determination of temperature of deflection under load — Part 1: General test method*

ISO 75-2, *Plastics — Determination of temperature of deflection under load — Part 2: Plastics and ebonite*

ISO 178, *Plastics — Determination of flexural properties*

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

## ISO 23936-1:2022(E)

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

ISO 604, *Plastics — Determination of compressive properties*

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

ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pycnometer method and titration method*

ISO 2039-2, *Plastics — Determination of hardness — Part 2: Rockwell hardness*

ISO 3451-1, *Plastics — Determination of ash — Part 1: General methods*

ISO 6721-11, *Plastics — Determination of dynamic mechanical properties — Part 11: Glass transition temperature*

ISO 11357-2, *Plastics — Differential scanning calorimetry (DSC) — Part 2: Determination of glass transition temperature and step height*

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

ASTM D648, *Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position*

ASTM D695, *Standard Test Method for Compressive Properties of Rigid Plastics*

ASTM D785, *Standard Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials*

ASTM D790, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*

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

ASTM E1640, *Standard Test Method for Assignment of the Glass Transition Temperature By Dynamic Mechanical Analysis*

ASTM D1708, *Standard Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens*

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

ASTM D5630, *Standard Test Method for Ash Content in Plastics*

### 3 Terms, definitions and abbreviated terms

#### 3.1 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

##### 3.1.1

##### **batch**

specified quantity of raw material, packaging material or product issued from one process or series of processes so that it could be expected to be homogeneous

[SOURCE: ISO 22716:2007, 2.3 with modification: “defined” changed into “specified”]



**3.1.2****certificate of conformance**

document issued by the manufacturer in accordance with specific requirements

Note 1 to entry: The specific requirements shall be the requirement stated in this document or in the purchase order.

**3.1.3****component**

individual, finished thermoplastic shape

**3.1.4****compound**

intimate mixture of a polymer or polymers with other ingredients such as fillers, plasticizers, catalysts and colorants

[SOURCE: ISO 472:2013, 2.184]

**3.1.5****conversion process**

manufacturing process that converts a compound into a plastic shape or component

**3.1.6****end user**

oil and/or gas operating company

**3.1.7****fluid**

liquid or gas

**3.1.8****gasket**

sealing component compressed in a joint

**3.1.9****glass transition temperature**

temperature of a thermoplastic material at which its mechanical properties change from elastic (glassy) to viscous (rubbery)

**3.1.10****liner**

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

**3.1.11****lot**

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

**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****maximum rated temperature**

upper limit temperature that the material can be used regardless the environment/fluid

**3.1.14****neat resin**

thermoplastic resin without additives

**3.1.15**

**operating temperature**

temperature to which a component is subjected during normal operation

**3.1.16**

**pipeline**

components of a pipeline system connected together to convey fluids between stations and/or plants, including pipe, pig traps, components, appurtenances, spools, risers, isolating valves, and sectionalizing valves

[SOURCE: ISO 13623:2017, 3.1.15, modified — Note 1 to entry has been deleted.]

**3.1.17**

**piping**

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

Note 1 to entry: Interruption by different components such as pumps, machines, vessels, does not preclude integration into one single piping system.

**3.1.18**

**preconditioning**

exposure to specified conditions in relevant fluids prior to ageing

**3.1.19**

**room temperature**

temperature of  $(23 \pm 2)$  °C

**3.1.20**

**seal**

deformable polymeric device designed to separate different environments

**3.1.21**

**swelling**

increase in volume due to absorption of fluids

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**3.1.22**

**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

[SOURCE: ISO 15750-3:2022, 3.3]

**3.1.23**

**washer**

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

**3.2 Abbreviated terms**

Af	acceleration factor
CDF	critical degradation factor
COC	certificate of conformance
COV	coefficient of variation
DMA	dynamic mechanical analysis
DSC	differential scanning calorimetry

FEP	fluorinated ethylene propylene
HDT	heat distortion temperature
KCl	potassium chloride
PA	polyamides
PFA	perfluoroalkoxy
PEEK	polyether-ether ketone
PTFE	polytetrafluoro-ethylene
PTFEm	polytetrafluoro-ethylene modified
PVDF	polyvinylidene fluoride
QC	quality control
ST	softening temperature

## 4 Technical requirements

### 4.1 General requirements

Thermoplastic selection depends upon material property characteristics and fluid ageing behaviour. This document establishes four levels of testing for the purpose of comparing the properties of various thermoplastic materials. Material property data will be generated at the four levels to allow consistent comparison of the subject materials. Generic data shall be derived per Level 1 and Level 2 including threshold criteria, solely for the purpose of producing information for preselection. Where the user requires accelerated ageing material stability data in a multi-phase H<sub>2</sub>S containing fluid, Level 3 shall apply. Where the user requires the material stability data beyond 56 days and an attempted long-term life estimation, Level 4 shall apply.

Level 1 conformance consists of the characterization and documentation of material properties in a material data report. It includes a COC for batch quality control testing. See [5.1](#) and [Table 1](#) for a list of the required material properties to be documented. Physical and mechanical properties shall be characterized on materials in their unaged condition. These standard properties assist with the selection of materials that meet a design specification. Some property tests are also used for quality assurance and control. Level 1 testing establishes a baseline for higher level testing.

Level 2 conformance pertains to material stability (ageing) behaviour and shall be accompanied by a report. [Clause 6](#) provides requirements for Level 2 conformance. The effect of the first three fluids listed in [6.2.4](#) on material properties shall be investigated with real-time ageing studies. A material's resistance to chemical/physical/mechanical change is determined.

Level 3 conformance pertains to material stability (accelerated ageing) behaviour and shall be accompanied by a report. [Clause 7](#) provides requirements for Level 3 conformance. The effects on material properties of three temperature aging evaluations shall be investigated. The intent of Level 3 evaluations is to accelerate material property changes specifically in multi-phase H<sub>2</sub>S-fluids.

Level 4 conformance pertains to a material stability (long-term) assessment of 180 days or longer following the methodology as shown by [Annex B](#). Level 4 attempts life estimation and shall be accompanied by a report. [Clause 8](#) provides requirements for Level 4 conformance. The intent of Level 4 assessment is to predict the material's progressive degradation, hence conformance threshold recommendations are offered for life estimation purposes. The report shall include a thorough account of data analysis, extrapolation, life estimation, and statistical confidence. Users shall evaluate the

threshold criteria, life estimation results and all methodology to determine the suitability of materials for application.

All reports shall detail the testing and analysis that was performed as well as a reference to this document, i.e. ISO 23936-1:2022.

Laboratory studies using standard test conditions may not derive data that can be used for design purposes. The user may require fit-for-purpose testing or alternative testing to simulate production conditions to allow materials selection for final application. Component functional testing is not detailed in this document.

For some highly resistant polymers, the chemicals used for ageing in Level 3 and Level 4 will not have any significant thermal-chemical effect on the polymer even at higher temperatures. In such cases, the first observable change in property would be related to fluid absorption or melting phase change rather than a degradation mechanism induced by the chemical. Fully fluorinated polymers (e.g. PTFE, PTFEm, PFA, FEP) either unfilled or filled exclusively with carbon-based fillers (e.g. graphite, carbon black, carbon fibre) are known to behave as such and shall be exempt from Level 3 or Level 4 evaluation. Performance of Level 3 or Level 4 testing may reveal other polymers e.g. PVDF in fluid 3.1 and fluid 3.2 in [7.4](#) also falling into this category.

If blistering by rapid gas decompression is a concern, a test should be performed according to API 17J 4<sup>th</sup> edition, section 6.2.3.3.

### 4.2 Cautionary remarks

Designers should not assume that properties provided in a material data report as explained in [Clause 5](#) will accurately represent those properties found in finished product geometries. The method of conversion is known to have an impact on these properties and that impact should be accounted for during design.

Life estimation usefulness and certainty can increase when longer term data are used to establish the degradation trend. Level 3 testing at durations up to 56 days are most useful for shorter term (up to 1 year) life estimations and can have reduced certainty for long-term (greater than 1 year) life estimations. Level 4 testing requires up to 180 day or longer data in an effort to create higher certainty in long-term life estimation.

In some cases, progressive degradation of thermoplastics over long periods of time at temperatures well above the target service temperature is not observed. The data and the attempted life estimation are still valuable because they demonstrate material stability in that test environment.

### 4.3 Traceability

For a final component to maintain its conformance, it shall be made from a thermoplastic material that conforms with this document. The entire compound manufacturing process shall be fully traceable. Conformance records shall include a reference to this document, i.e. ISO 23936-1:2022.

Each compound and accompanying COC shall be traceable back to the compound manufacturer. Each company that participates in the manufacture of a compound that conforms with this document shall maintain traceability records for a minimum of 10 years that include its own manufacturing procedures, locations, and dates.

Further requirements on conformance and traceability over the supply chain can be found in relevant product standards and agreed between interested parties.

## 4.4 Test specimen identification

### 4.4.1 Coding overview

The specimen fabrication details shall be reported using the following identification code system:

- moulding (for individual codes see [4.4.2](#));
- orientation (for individual codes see [4.4.3](#));
- form (for individual codes see [4.4.4](#));
- post treat (for individual codes see [4.4.5](#));
- shaping (for individual codes see [4.4.6](#)).

The test specimen identification shall give the following information:

- a) test standard;
- b) specimen type;
- c) test speed;
- d) identification code.

EXAMPLE Sample test call out for an ISO 527-1 or ASTM D638 tensile test with injection moulded Type 1BA and Type V specimens respectively:

- 1) ISO 527-1, 1BA, 50 mm/min (MI/OA/FN/PA/SN);
- 2) ASTM D638 – TV, 2"/min (MI/OA/FN/PA/SN).

### 4.4.2 Moulding

Process used to convert a pellet, flake, powder, resin, etc. into a shape and is the final forming step:

- a) injection (MI): process of moulding a material by injection under pressure from a heated cylinder through a sprue into the cavity of a closed mould;
- b) compression (MC): load/pour material into mould, heat, and then consolidate melted polymer under uniaxial or isostatic compression;
- c) transfer (MT): process of moulding a material by passing it from a heated pot into the cavity of a closed, heated mould;
- d) extrusion (ME): transfer melted material into a shape using a die in a continuous process;
- e) rotational moulding (MR): load material in mould, heat and rotate, where inertial forces are used to consolidate the thermoplastic;
- f) casting (MS): transfer melted material into a mould with only the force of gravity acting on the thermoplastic;
- g) additive (MA): manufacturing methods that add layers of material by a melt process;
- h) new methods (MZ).

#### 4.4.3 Orientation

Orientation pertains to the alignment of molecules or fillers compared to the longest dimension of the test specimen.

- a) none (ON): isotropic with insignificant x, y, z variation of properties;
- b) axial or flow direction (OA): longest dimension of the specimen is parallel to the orientation direction (i.e. injection moulded tensile bar);
- c) hoop or transverse (OT): longest dimension of the specimen is transverse to the orientation direction (i.e. flex specimen cut from hoop plane of an extruded tube).

#### 4.4.4 Form

Form describes the source of the test specimen.

- a) final part (FN): the finished test specimen;
- b) rod (FR): solid cylinder;
- c) tube (FT): hollow cylinder;
- d) plate/sheet (FP): greater than or equal to 1,27 mm (0,050 inch) thick;
- e) film (FF): less than 1,27 mm (0,050 inch) thick;
- f) other finished (FO): part that the specimen is cut from.

#### 4.4.5 Post treatment

Annealing or post cure comprising temperature cycles that alter the physical properties of the moulded form.

- a) none (PN): has not undergone a post-moulding heat cycle process and in which conditioning “dry as moulded” according to material standards, e.g. for PA-U 12 see ISO 16486-2;
- b) annealed (PA): has undergone a post-moulding heat cycle process, e.g. annealing for 48 h according to ISO 2578 or according to material standards;
- c) sintered (PS): hot sintering of a cold moulded precursor (or green parts);
- d) environmentally conditioned (PE), e.g. 98 % humidity at 50 °C for 48 h.

#### 4.4.6 Shaping

Cite the process used to shape the specimen.

- a) net shape (SN): moulded into test specimen with no post process;
- b) machined (SM): material removed with cutting tool;
- c) stamped (SS): specimen die cut from a formed sheet or a sheet machined from a different form.

#### 4.4.7 Test specimen fabrication for Level 2, Level 3 and Level 4 ageing experiments

Test specimens shall be produced using a single fabrication process suitable for test specimens.

## 4.5 Validation of conformance

A compound loses its conformance if changes are made to the raw material supply, the compound formulation or the compound manufacturing process. New testing is required for each desired level of conformance.

If Level 4 conformance is complete prior to change, new Level 4 testing is not required if Level 1, Level 2 and Level 3 test results are equal or improved compared to previous Level 1, Level 2 and Level 3 test results.

If compounding is carried out at different plants/locations, a separate Level 1 conformance is required for each plant.

Level 1 to Level 4 testing is not required on the component if no compositional changes have been made to the compound during the conversion process, regardless of the conversion process being used. The influence of the conversion process on the physical properties and fluid ageing behaviour of the component is outside the scope of this document. To evaluate this influence testing should be performed for the level of information needed, as described by [Clause 5](#) to [Clause 8](#), using test specimens that are manufactured from the conversion process used to produce the component.

## 5 Level 1 – Material property characterization

### 5.1 General

[Table 1](#) gives the required documentation of material properties. Requirements pertaining both to initial documentation of properties and batch QC are given.

[Table 1](#) documentation properties shall be presented as a material data report. This material data report shall be made available to all companies in the supply chain.

[Table 1](#) QC properties for each batch of thermoplastic shall be presented as a COC. This COC shall then be passed through each company within the supply chain to the end user. Each company in the supply chain shall ensure that the COC of the compound is available if requested.

The material's QC threshold criteria shall be based on batch testing of the compound. The material's QC threshold criteria shall be noted in the COC and in the material data report. The user can further specify the necessary requirements with tolerances in the purchase specification.