SLOVENSKI STANDARD
oSIST prEN ISO 23936-4:2024

01-januar-2024

Naftna in plinska industrija, vključno z nizkoogljično energijo - Nekovinski materiali v stiku z mediji v povezavi s proizvodnjo nafte in plina - 4. del: Z vlakni ojačan kompozit (ISO/DIS 23936-4:2023)

Oil and gas industries including lower carbon energy - Non-metallic materials in contact with media related to oil and gas production - Part 4: Fiber-reinforced composite (ISO/DIS 23936-4:2023)

Öl- und Gasindustrie einschließlich kohlenstoffarmer Energieträger - Nichtmetallische Werkstoffe mit Medienkontakt bei der Öl- und Gasproduktion - Teil 4: Verbundwerkstoffe (ISO/DIS 23936-4:2023)

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 de pétrole et de gaz - Partie 4: Composites renforcés de fibres (ISO/DIS 23936-4:2023)

Ta slovenski standard je istoveten z: **prEN ISO 23936-4**

ICS:

75.180.01	Oprema za industrijo nafte in zemeljskega plina na splošno	Equipment for petroleum and natural gas industries in general

oSIST prEN ISO 23936-4:2024 **en,fr,de**

DRAFT INTERNATIONAL STANDARD
ISO/DIS 23936-4

ISO/TC **67**

Secretariat: **NEN**

Voting begins on:
2023-10-30

Voting terminates on:
2024-01-22

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

Part 4: Fiber-reinforced composite

ICS: 75.180.01

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/DIS 23936-4:2023(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.

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 document 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).

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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, *Oil and gas industries including lower carbon energy,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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.

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 document for metallic materials in sour service (ISO 15156 series). 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_2S-containing environments which are related solely to relevant environmentally assisted cracking mechanisms.

This document provides general principles, requirements and recommendations for the assessment of non-metallic materials' comparative stability to aid selection and quality assurance. The 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 oil and gas exploration and production applications based upon stability in appropriate test conditions.

This document applies to the assessment of the stability of non-metallic materials in simulated oil and gas production conditions to aid the selection of materials for equipment designed and constructed.

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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. This document allocates responsibility for suitability for the intended service in all cases to the equipment user.

1 Scope

This document presents general principles and gives requirements and recommendations for the assessment of stability of non-metallic materials for service in equipment used in oil and gas 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. It supplements but does not replace, the material requirements given in the appropriate design codes, standards or regulations.

This document describes the procedures for comparative testing of polymeric composite materials consisting of polymers (thermoplastics and thermosets) and re-enforcing materials e. g. glass, carbon, aramid or metals as continuous fibres or woven fabric used in equipment for oil and gas production. The compounded particulate- and short fibre-reinforced composites have been included in ISO 23936-1.

Mechanical properties and the environmental stability of composite materials depend on the properties and environmental stability of matrix resins, fibres and fibre/resin bonding interfaces. This document focuses on the overall composite properties and their environmental stability. To permit this assessment this document utilizes flat plates and/or tubular shapes made specifically for these tests. Testing and characterization of neat resins and fibre products are beyond this scope.

The equipment considered includes, but is not limited to, non-metallic pipelines, piping, liners and downhole tool components.

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

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 175, *Plastics — Methods of test for the determination of the effects of immersion in liquid chemicals*

ISO 527-4, *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites*

ISO 527-5, *Plastics — Determination of tensile properties — Part 5: Test conditions for unidirectional fibre-reinforced plastic composites*

ISO 1172, *Textile-glass-reinforced plastics, prepregs, moulding compounds and laminates — Determination of the textile-glass and mineral-filler content — Calcination methods*

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

ISO 1268-1, *Fibre-reinforced plastics — Methods of producing test plates — Part 1: General conditions*

ISO 1268-3, *Fibre-reinforced plastics — Methods of producing test plates — Part 3: Wet compression moulding*

ISO 1268-4, *Fibre-reinforced plastics — Methods of producing test plates — Part 4: Moulding of prepregs*

ISO 1268-5, *Fibre-reinforced plastics — Methods of producing test plates — Part 5: Filament winding*

ISO 1268-7, *Fibre-reinforced plastics — Methods of producing test plates — Part 7: Resin transfer moulding*

ISO 1268-9, *Fibre-reinforced plastics — Methods of producing test plates — Part 9: Moulding of GMT/STC*

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

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

ISO 7822, *Textile glass reinforced plastics — Determination of void content — Loss on ignition, mechanical disintegration and statistical counting methods*

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

ISO 14126, *Fibre-reinforced plastic composites — Determination of compressive properties in the in-plane direction*

ISO 14129, *Fibre-reinforced plastic composites — Determination of the in-plane shear stress/shear strain response, including the in-plane shear modulus and strength, by the ±45° tension test method*

ISO 14130, *Fibre-reinforced plastic composites — Determination of apparent interlaminar shear strength by short-beam method*

ISO 15024, *Fibre-reinforced plastic composites — Determination of mode I interlaminar fracture toughness, G_{IC}, for unidirectionally reinforced materials*

ISO 15114, *Fibre-reinforced plastic composites — Determination of the mode II fracture resistance for unidirectionally reinforced materials using the calibrated end-loaded split (C-ELS) test and an effective crack length approach*

EN 2564, *Aerospace series – Carbon fibre laminates – Determination of the fibre, resin and void contents*

ASTM D792, *Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement*[1)]

ASTM E1131, *Standard Test Method for Compositional Analysis by Thermogravimetry*

ASTM D2290, *Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe*

ASTM D2344, *Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates*

ASTM D2412, *Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading*

ASTM D3039, *Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials*

ASTM D3171, *Standard Test Methods for Constituent Content of Composite Materials*

1) www.astm.org

ASTM D3410, *Standard Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading*

ASTM D3418, *Standard Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry*

ASTM D3518, *Standard Test Method for In-Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a ±45° Laminate*

ASTM D5229, *Standard Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials*

ASTM D5379, *Standard Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method*

ASTM D5448, *Standard Test Method for Inplane Shear Properties of Hoop Wound Polymer Matrix Composite Cylinders*

ASTM D5449, *Standard Test Method for Transverse Compressive Properties of Hoop Wound Polymer Matrix Composite Cylinders*

ASTM D5450, *Standard Test Method for Transverse Tensile Properties of Hoop Wound Polymer Matrix Composite Cylinders*

ASTM D5528, *Standard Test Method for Mode I Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites*

ASTM D5687/D5687M-95, *Standard Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation*

ASTM D6641, *Standard Test Method for Compressive Properties of Polymer Matrix Composite Materials Using a Combined Loading Compression (CLC) Test Fixture*

ASTM D7028, *Standard Test Method for Glass Transition Temperature (DMA Tg) of Polymer Matrix Composites by Dynamic Mechanical Analysis (DMA)*

ASTM D7078, *Standard Test Method for Shear Properties of Composite Materials by V-Notched Rail Shear Method*

ASTM D7905, *Standard Test Method for Shear Properties of Composite Materials by V-Notched Rail Shear Method Standard Test Method for Determination of the Mode II Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites*

NPL 2020) Measurement Good Practice Guide No. 38, *Fibre Reinforced Plastic Composites – Machining of Composites and Specimen Preparation;* National Physical Laboratory *(* UK)[2)]

3 Terms and 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 terminological 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/

2) www.npl.co.uk

3.1.1
composite material
material system consisting of two or more distinct phases in composition or form on a macroscopic scale, normally matrix phase and reinforcement phases, with recognizable interfaces between them

3.1.2
fabricator
producer of test plates and specimens

3.1.3
glass transition temperature
Tg
characteristic value of the temperature range over which the glass transition takes place which its mechanical properties change from elastic (glassy) state to viscous (rubbery) state

Note 1 to entry: The assigned glass transition temperature (Tg) may vary, depending on the specific property and on the method and conditions selected to measure it (for instance, by differential scanning calorimetry (DSC) or by dynamic-mechanical analysis (DMA)).

3.1.4
lamina
thin sheet of reinforcing fibres in a resin matrix built up into a flat or curved arrangement

[SOURCE: ISO 14692-1:2017, 3.2.64]

3.1.5
laminate
a combination of laminas

3.1.6
manufacturer
producer of the materials used for creation of semi-finished and/or finished products

3.1.7
polymer-matrix composite
composite material formed with polymer resins as the binding matrix

3.1.8
sizing
treatments applied to yarn usually by yarn manufacturer for instance for increasing fibre-matrix compatibility

3.1.9
wet Tg
glass transition temperature of the fluid saturated material

3.2 Abbreviated terms

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

AE	acoustic emission
ATM	accelerated testing method
CA	autoclave cured
CH	hot-press cured
CNC	computerized numerical control

CO	oven cured
COA	certificate of analysis
COC	certificate of conformance
COV	coefficient of variation
CRS	constant strain rate
CU	UV cured
DMA	dynamic mechanical analysis
DSC	differential scanning calorimetry
GFRP	glass fibre reinforced polymer
GMT	glass fibre mat reinforced thermoplastic
HDT	heat deflection temperature
HPHT	high-pressure high-temperature
HTP	hot transfer pressing
IPS	in plane shear
LF	filament winding lamination
LP	prepreg lamination
LR	vacuum-assisted resin-transfer moulding
LW	wet layup lamination
MOL	material operational limit
NDT	non-destructive testing
PA	Polyamide
QC	quality control
QD	quality documentation
SEM	scanning electron microscopy
STC	sheet thermoplastic composite
TA	autoclave consolidation
TI	isothermal consolidation
TP	hot pressing
TGA	thermogravimetric analysis
TTR	time to rupture
TTSP	time temperature superposition principle

UD unidirectional

UV ultraviolet light

4 Technical requirements

4.1 General requirements

Composite 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 composite materials. The testing methods at the material level shall focus upon the laminate and specimen geometry and do not represent a functional application test which is beyond the scope of this document. The specimen layup described is to provide a consistent, common basis for generating comparable data for different composite materials. Specific testing shall be required for the actual layup for samples representative of the final product form. 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_2S 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.

NOTE Ageing of composites faces combined challenges. Polymer or thermoset ageing alone will deal in most cases with quasi-isotropic material properties alone. Composites of any configuration furthermore deal with polymeric challenges as well as with highly anisotropic properties resulting from fibre and interface properties, which can age very differently than the matrix material. All effects can overlay and become apparent in different failure modes or shifts thereof over the ageing period.

Ageing experiments can be designed in the following way to extract meaningful information, especially with regards to establishing lifetime models with these complex effects in mind:

a) identify possible ageing mechanisms for matrix material;

b) identify possible ageing mechanisms for fibre material;

c) identify possible ageing mechanisms for interface;

d) differentiate between physical and chemical ageing;

e) differentiate between reversible and irreversible ageing;

f) identify possible overlaps;

g) rank mechanisms for severity;

h) rank for material characterization or application related testing;

i) exclude any unwanted ageing mechanism by physical/chemical exclusion of other ageing influences (monitored and protocolled), choosing variations in layup to promote specific failure, or some combination of both.

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 3 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.

