SLOVENSKI STANDARD
oSIST prEN ISO 14126:2022

01-december-2022

Z vlakni ojačeni polimerni kompoziti - Ugotavljanje tlačnih lastnosti v ravnini laminiranja (ISO/DIS 14126:2022)

Fibre-reinforced plastic composites - Determination of compressive properties in the in-plane direction (ISO/DIS 14126:2022)

Faserverstärkte Kunststoffe - Bestimmung der Druckeigenschaften in der Laminatebene (ISO/DIS 14126:2022)

Composites plastiques renforcés de fibres - Détermination des caractéristiques en compression dans le plan (ISO/DIS 14126:2022)

Ta slovenski standard je istoveten z: **prEN ISO 14126**

ICS:

83.120	Ojačani polimeri	Reinforced plastics

oSIST prEN ISO 14126:2022 **en,fr,de**

DRAFT INTERNATIONAL STANDARD
ISO/DIS 14126

ISO/TC **61**/SC **13** Secretariat: **JISC**

Voting begins on: **2022-09-28** Voting terminates on: **2022-12-21**

Fibre-reinforced plastic composites — Determination of compressive properties in the in-plane direction

Composites plastiques renforcés de fibres — Détermination des caractéristiques en compression dans le plan

ICS: 83.120

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/DIS 14126:2022(E)

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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).

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).

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.

This document was prepared by Technical Committee ISO/TC 61, Plastics, Subcommittee SC 13, Composites and reinforcement fibres.

This second edition cancels and replaces the first edition (ISO 14126:1999), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Annexes A and B form normative parts of this document.

— Annexes C to G are for information only.

— The addition of informative Annex H covering the use of digital image correlation (DIC).

The main technical changes are concerned with adding Annex A on alignment as a normative requirement, and making Annex B on specimen preparation normative. Both Annexes are aimed at improving the quality and consistency of these factors. Also, Annex H (informative) has been added to cover the use of digital image correlation (DIC) for strain and bending measurements.

In addition, more detailed guidance is given on the appropriate specimens to be used according to the format and dimension of the reinforcement repeating unit.

Finally, it is intended to run an international round robin to obtain precision data, both repeatability and reproducibility, across a range of both material types and loading fixtures. The measurement of compression strength has always been difficult leading to a range of test approaches. Initially, most beams loaded in compression would buckle prior to compression failure, however fracture is more likely now with thick sections.

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

This standard, originally published in 1999, was based on ISO 8515 with the scope extended from glass-fibre reinforcement to include all fibre-reinforced plastic composites, such as composites based on carbon and aramid fibres. Other source documents consulted included ASTM D 3410, SACMA SRM1, prEN 2850, CRAG 400, DIN 65380 and JIS K 7076 (see bibliography). Several different types of anti-buckling fixtures/loading jigs, different materials and different specimen sizes are covered by these source documents, although all are parallel-sided coupons. New or modified geometry support jigs are still being developed, for example in JIS K7018: 2019 (see bibliography).

This International Standard harmonizes and rationalizes the current situation by:

a) concentrating on the quality of the test by limiting the maximum bending strain allowable (i.e. 10 % between 10 % and 90 % of the maximum load, as recommended by ASTM), so that an axial-load case can be assumed,

b) standardizing on two related specimen designs, one principally for aerospace type unidirectional pre-impregnated materials (i.e. Specimen A) and one for other materials/formats (i.e. Specimen B1/B2). The chosen specimen design can be used with different loading fixtures,

c) defining acceptable failure criteria (e.g. avoiding within grip failures),

d) including an equation for determining the specimen minimum thickness to avoid Euler buckling proposed by ASTM for harmonization purposes (taken from ASTM D 3410 in a modified form),

e) allowing any design of support/loading fixture to be used that meets the above bending requirements, using different principles of loading (i.e. essentially shear and combined loading),

f) ensuring that the test specimen and loading/support fixture are well aligned (see Annex A),

NOTE 1 Compression properties measured in the through-thickness direction (direction 3 in Figure 1) are covered by ISO 20975-1: Carbon fibre-reinforced plastics — Methods for measurement of through-thickness laminate properties — Part 1: Direct tension and compression (in development and RR completed) (see bibliography),

NOTE 2 - Compression properties of rigid plastics having only unaligned short (< 7,5 mm) fibres or no fibre content (rather than long (> 7,5 mm) discontinuous or continuous fibres) is covered by ISO 604 (see bibliography).

Fibre-reinforced plastic composites — Determination of compressive properties in the in-plane direction

1 Scope

1.1 This document specifies methods for determining the compressive properties, in directions parallel to the plane of lamination, of fibre-reinforced plastic composites, based on thermosetting or thermoplastic matrices. The compressive properties are of interest for specifications and quality-control purposes. The test specimens are machined from a flat test plate, or from suitable finished or semi-finished products

1.2 Three loading methods and two types of specimen are described.

The loading methods are:

— Method 1: provides shear loading of the specimen (gauge length unsupported)

— Method 2: provides combined loading of the specimen (gauge length unsupported)

— Method 3: provides end-loading of a plain specimen (i.e. no tabs) (gauge length unsupported)

NOTE 1 For tabbed specimens loaded using method 2, load is transferred through a combination of end-loading and shear-loading through the tabs.

NOTE 2 End-loading of un-tabbed specimens is used only for modulus measurement.

The specimen designs are:

— Type A specimen: rectangular cross-section, fixed thickness, end-tabbed (mainly for aerospace style preimpregnates (~ 0,125 mm ply thickness)

— Type B specimen: rectangular cross-section, range of thicknesses, untabbed or end-tabbed, two specimen sizes are available (B1and B2).

The type A specimen is the preferred specimen for unidirectionally or biaxially reinforced materials tested in the fibre direction, where the fibres are normally either aligned continuous or aligned long (>7,5 mm) discontinuous. The B1 and B2 specimen are preferred for multi-directional aligned; mat, fabric and other multi-directionally reinforced materials where the fibre structure is more complex and/or coarser.

1.3 Criteria are given for checking that the combination of test method and specimen design result in valid failures. It is noted that alternative test method/specimen combinations will not necessarily give the same result.

1.4 The methods specify required dimensions for the specimen. Tests carried out on specimens of other dimensions, or on specimens that are prepared under different conditions, may produce results that are not comparable. Other factors, such as the speed of testing, the support fixture used and the conditioning of the specimens, can influence the results. Consequently, when comparative data are required, these factors must be carefully controlled and recorded.

1.5 Fibre-reinforced plastics are usually anisotropic. It is therefore often useful or required to prepare test specimens in at least the two main orthogonal directions (in the plane) of anisotropy (see Figure 1), or in directions previously specified (for example a lengthwise direction associated with the production process).

NOTE Examples of tests required to be undertaken at different orientations (i.e. 0° and 90°) in the test plate are given in ISO 10350-2 and ISO 20144 (see bibliography).

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 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 1268, *Fibre-reinforced plastics — Methods of producing test plate (Parts 1-10)*

ISO 2602, *Statistical interpretation of test results — Estimation of the mean — Confidence interval*

ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

ISO 5893, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Specification*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

3 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/

3.1
compressive stress
σ_c
the compressive force experienced by the test specimen, at a particular time, divided by the initial cross-sectional area of the parallel-sided portion of the specimen

Note 1 to entry: It is expressed in megapascals.

3.2
compressive strength
compressive failure stress
σ_{cM}
the maximum compressive stress sustained by the specimen

Note 1 to entry: It is expressed in megapascals.

3.3
compressive strain
ε_c
decrease in length per unit length of the original gauge length

Note 1 to entry: It is expressed as a dimensionless ratio or in percent.

3.4
compressive failure strain
ε_{cM}
the longitudinal compressive strain at the compressive failure stress

Note 1 to entry: It is expressed as a dimensionless ratio or in percent.

3.5
modulus of elasticity in compression
chord modulus
E_c
the stress difference (σ" minus σ') divided by the corresponding strain difference [ε" (= 0,002 5) minus ε' (= 0,000 5)] (see subclause 10.2)

Note 1 to entry: It is expressed in megapascals.

3.6
specimen coordinate axes
the orthogonal coordinate axes for material with the fibres preferentially aligned in one direction within a planar laminate (see Figure 1). The directions, in the plane of the laminate, parallel to the fibre axes is defined as the "1"-direction and the direction perpendicular to the fibre axes the "2"-direction. For other materials, the "1"-direction is normally defined in terms of a feature associated with the production process, such as the long or warp direction for a continuous-sheet or fabric process. The "2"-direction is again perpendicular, in the plane, to the "1" direction. The direction perpendicular to the plane is the “3” direction. Results for specimens cut parallel to the "1"-direction are identified by the subscript "11" (e.g. E_{c11}). Similarly, results for specimens cut parallel to the "2"-direction are identified by the subscript "22" (e.g. E_{c22}).

Note 1 to entry: The "1"-direction is also referred to as the 0° or longitudinal direction, and the "2"-direction as the 90° or transverse direction. More generally, the X, Y and Z (through-thickness) coordinate system for any material can be equated to the "1"-, "2"- and "3"-directions.

3.7
gauge length
L_0
initial distance between the gauge marks on the central part of the test specimen

Note 1 to entry: It is expressed in millimetres (mm).

3.8
thickness
h
smaller initial dimension of the rectangular cross-section in the central part of a test specimen

Note 1 to entry: It is expressed in millimetres (mm).

3.9
width
b
larger initial dimension of the rectangular cross-section in the central part of a test specimen

Note 1 to entry: It is expressed in millimetres (mm).

4 Principle

An axial force is applied to the unsupported gauge length of a rectangular specimen held in an anti-buckling loading/support fixture, while the applied load and strain in this gauge length area are monitored. The test method concentrates on the quality of the axial deformation experienced by the specimen. Any loading fixture can be used, provided specimen failure occurs below a 10 % bending strain in the specimen (between 10 % and 90 % of the maximum load); and fails in the prescribed manner and location.

The compressive load is applied to the specimen

— by shear loading through end tabs (Method 1),

— by a combined loading mode through direct specimen end loading and shear loading though the support fixture using a tabbed specimen (Method 2),

— by end loading a specimen, without tabs for modulus measurement only, or with tabs to allow increased load introduction for strength tests without end failure occurring (Method 3) (see NOTE 2).

NOTE 1 It is noted that the test results obtained by these methods using different specimen designs/sizes and different loading fixtures are not necessarily comparable.

NOTE 2 The fixture in Method B of EN 2850 for end-loading (c.f. modified ASTM D695, see bibliography) is not suitable for the standard Type A or B specimens in this document and therefore Method 3 is not covered further by this document.

NOTE 3 Each of these methods shows specific advantages and disadvantages. For example, shear loading is not adapted for very thick laminates, because it causes strain distributions over the laminate thickness caused by shear strains and the tabs may shear off at high forces. End loading is in many cases a sufficient and simple method for determination of compressive modulus but is very limited for ultimate strength determination. Combined loading overcomes several of the problems described before and can also be used for higher laminate thicknesses. The disadvantage is the need for supplementary machining of the specimen ends to ensure parallelism and squareness tolerances are met when using end-tabbed specimens.

5 Apparatus

5.1 Test machine

5.1.1 General

The test machine shall comply with ISO 7500 1 and ISO 9513, and meet the specifications given in 5.1.2 to 5.1.3. The test machine should be kept in good condition and worn parts (e.g. threads, grip faces) replaced. The test machine, gauge specimen and loading/support fixture alignment on the machine axis must be checked regularly or after any part of the loading train is moved/reassembled using the procedures given in Annex A.

5.1.2 Speed of testing

The test machine shall be capable of maintaining the required speed of testing (see 9.5).

5.1.3 Load measurement

The force measurement system shall comply with class 1 as defined in ISO 7500-1 (i.e. error for indicated load shall not exceed ±1 % of the true value). Suitable data recording equipment (data-loggers) shall be used to record the load values throughout the tests.

5.2 Strain measurement

Strain shall be determined by means of strain gauges, mechanical extensometers, or optical extensometers, (including digital image correlation (DIC)) meeting the requirement that the error for the indicated strain shall not exceed ±1 % (see ISO 9513). Strain shall be measured on both faces of the specimens to determine the degree of bending or on the sides (narrow face) of specimens if using DIC (see Annex H). Strain gauge elements for type A and B1 specimens shall be less than 3 mm in length. B2 specimens will accommodate longer strain gauges (e.g. ≥ 10 mm).

