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Aerospace series — Fibre reinforced plastics — Determination of the effect of exposure to humid atmosphere on physical and mechanical characteristics

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Aerospace series - Fibre reinforced plastics - Determination of the effect of exposure to humid atmosphere on physical and mechanical characteristics

Série aérospatiale - Plastiques renforcés de fibres - Détermination de l'influence de l'exposition à l'atmosphère humide sur les caractéristiques mécaniques et physiques

Luft- und Raumfahrt - Faserverstärkte Kunststoffe - Ermittlung des Einflusses der Auslagerung in feuchtem Klima auf die mechanischen und physikalischen Eigenschaften

This European Standard was approved by CEN on 6 February 2017.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 2823:2017) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2017, and conflicting national standards shall be withdrawn at the latest by September 2017.

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1 Scope

This European Standard specifies the method for determining the effect of exposure to a humid atmosphere on the physical and mechanical characteristics of fibre reinforced plastics.

This standard applies to all laminates, whatever the nature of the reinforcement and organic matrix used, unless otherwise indicated in the material standard and/or technical specification.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 2743, *Aerospace series — Fibre reinforced plastics — Standard procedures for conditioning prior to testing unaged materials*

EN 2744, *Aerospace series — Non-metallic materials — Preferred test temperatures*

EN 3615, *Aerospace series — Fibre reinforced plastics — Determination of the conditions of exposure to humid atmosphere and moisture absorption* 1)

3 Terms and definitions

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

3.1
"pilot" specimens
specimens intended to establish the exposure temperature required to achieve an equilibrium condition at the specified humidity level in a limited period of time

3.2
specimens "to be aged"
specimens intended to determine the mechanical and physical characteristics after exposure

3.3
"traveller" specimens
specimens representative of specimens "to be aged" which accompany these in the climatic chamber and are intended to monitor moisture absorption

3.4
equilibrium condition
condition of the material at a specified hygrometry when it has reached constant mass

3.5
constant mass
mass of the specimen obtained after several successive weighings carried out at regular intervals when the difference between weighings is less than a specified value

1) Published as ASD-STAN Prestandard at the date of publication of this standard by AeroSpace and Defence industries Association of Europe - Standardization (ASD-STAN) (www.asd-stan.org)

3.6
as-cured condition
see EN 2743

4 Methodology

The test results obtained with the specimens in the as-cured condition are compared with those obtained with specimens "to be aged" after exposure to the specified humid atmosphere, in accordance with the following procedure:

a) carry out the mechanical or physical test according to the appropriate standard on specimens in the as-cured condition (see EN 2743A);

b) using pilot specimens determine the highest possible exposure temperature guaranteeing a behaviour of the material in conformity with Fick's law (reaching an equilibrium condition).
This determination shall be carried out at least once for each case of fibre/resin/temperature combination;

c) expose the specimens "to be aged" to the specified hygrometry and to the temperature as determined above until they reach the equilibrium condition. Traveller specimens shall be permanently subjected to the same exposure conditions;

d) carry out the mechanical or physical tests according to the applicable standards.

NOTE 1 In the preparation of this standard both Langmuir model and Fick's law were considered. While acknowledging that Langmuir Models more exact, Fick's law will be used to define equilibrium conditions in composite materials.

A temperature of 70 °C is chosen as the initial verification temperature in order to achieve a reasonable rate of moisture pick-up. If the pilot specimens results suggest a significant deviation from Flick's law then a lower temperature should be selected.

5 Apparatus

5.1 Climatic chamber capable of keeping the specified temperature to within ± 1 °C and relative humidity to within ± 3 %.

5.2 Desiccator.

5.3 Balance accurate to within 0,1 mg.

5.4 Air circulating oven capable of keeping the specified temperature to within ± 5 °C.

5.5 Clean and dry absorbent cloth or filter paper.

5.6 Sealed container: metallized polythene bag or airtight metal or glass enclosure.

6 Specimens

All the aspects of the manufacturing process (in particular the surface finish) influence the test results.

6.1 Pilot specimens

The panels intended to make up the pilot specimens shall be symmetrically arranged in layers:

— unidirectional preimpregnates: unidirectional (0°) or crossed (0°/90°) lay-up;

— fabrics: all plies warpwise in the same direction.

The dimensions of the pilot specimens shall be in conformity with Figure 1 and Table 1.

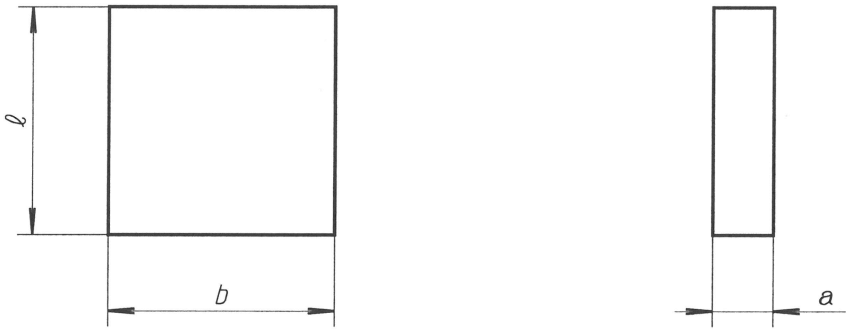


Figure 1

Table 1

Dimensions in millimetres

ℓ	75 ± 1
b	75 ± 1
a	the lowest possible

6.2 Specimens "to be aged" (specimens for mechanical and physical tests)

The shape, dimensions and manufacturing procedure for the specimens are specified in the material standard or test method.

They shall be in their final form, for example, machined, drilled, tabbed, etc.

6.3 Traveller specimens

A minimum of three traveller specimens, taken from the same panel as the specimens "to be aged", but without tabs, holes, etc. shall be used.

The traveller specimens shall be rectangular or square, their length and width equal to or greater than 25 mm and their mass greater than 1,5 g.

The quality of the faces and edges shall be identical to that of the ageing specimens.

7 Procedure

7.1 Conditioning before exposure

Specimens to be aged shall not undergo any special conditioning, a condition of equilibrium being the only criterion sought.

7.2 Exposure conditions

7.2.1 The humidity level shall be specified.

Standard condition: $\left(85^{+5}_{-1}\right)\%$

Optional: $\left(95^{+5}_{-1}\right)\%$

7.2.2 Determination of exposure temperature

It shall be determined on the pilot specimens according to the following procedure:

— expose a pilot specimen to the exposure temperature of (70 ± 2) °C;

— check that the condition of equilibrium has been reached (see 7.2.3) at this temperature;

— if this is not the case, expose a new pilot specimen to a lower temperature chosen from EN 2744;

— check that the condition of equilibrium has been reached (see 7.2.3) at this new temperature;

— if this is not the case, redo the procedure until a temperature is determined whereby the condition of equilibrium is reached.

NOTE 1 If the condition of equilibrium is reached at 70 °C, a higher exposure temperature may be sought, chosen from EN 2744.

NOTE 2 This operation may be replaced by a continuous weighing (thermobalance type setup) of the pilot specimen in a humid atmosphere.

7.2.3 Determination of the condition of equilibrium

The total period of exposure for all specimens shall be continued until they reach the equilibrium condition.

Constant mass is achieved for test specimens of a thickness of (2 ± 0,2) mm when the difference between three successive weighings carried out at an interval of 168 h on traveller specimens (see figure 2) and in conformity with the formula below:

$$\frac{\left|M_{j-2} - M_j\right|}{M_j} \leq 5 \times 10^{-4}$$

where

M_j represents the mean weights of the travellers specimens at the time t_j.

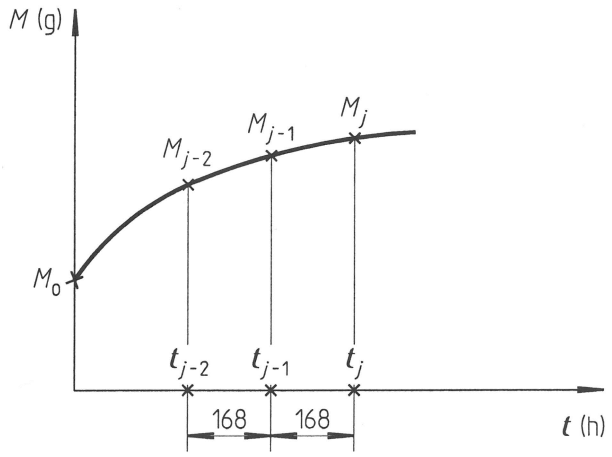


Figure 2

If the exposure temperature is less than 70 °C or if the thickness differs from (2 ± 0,2) mm, the time interval between two successive weighings to determine constant mass shall be obtained by trials; with the value of the difference remaining as above.

7.3 Exposure to humid atmosphere

Place the traveller specimens and specimens to be aged in the climatic chamber. The contact between:

— the specimens themselves;

— the specimens and the walls of the chamber and (or) specimen supports;

shall be point contact in order to ensure maximum exposure.

7.4 Monitoring humidity absorption

7.4.1 Remove the traveller specimens from the climatic chamber and wipe them to remove any condensation with the cloth or paper (see 5.5).

7.4.2 Allow them to cool to room temperature in a sealed container to reduce moisture loss to a minimum.

7.4.3 Immediately weigh them to the nearest 0,1 mg. M_1 is the mean of the weighings of the traveller specimens in the equilibrium condition (see 7.2.3).

7.5 Physical and mechanical tests after exposure

7.5.1 Testing at ambient temperature

Remove the specimens "to be aged" from the climatic chamber and follow the same procedure as in 7.4.1 and 7.4.2.

The specimens may be maintained for a maximum of 72 h in a sealed container.

The physical or mechanical test shall be carried out according to the relevant standard within the 30 min following removal from the sealed contained.

7.5.2 Testing at temperatures other than ambient

Follow the instructions given in 7.5.1.

Place the specimen in the test fixture which has been maintained at the specified temperature.

In order to limit moisture loss but ensure thermal equilibrium, the period between placing the specimen in the fixture and completion of the test shall be as short as possible, while ensuring that the specimen test zone is at the specified temperature.

If the test duration permits, this period shall be:

— less than 15 min, for temperatures ranging from ambient to 50 °C;

— less than 5 min, for carbon fibre based specimens of a thickness ranging from 1 mm to 2 mm and for temperatures ranging from 50 °C to 100 °C.

For other temperatures, dimensions and materials, if the tests duration does not allow the above mentioned requirements to be met, this period shall be determined by prior test designed to check that the specified temperature is reached at all points subject to an acceptable moisture loss.

If it is not possible to achieve thermal equilibrium with an acceptable moisture loss, use a fixture or chamber which minimises the moisture loss of the specimen during testing. This is essential for lengthy tests such as fatigue or creep, for example. The actual change in moisture level when measuring the characteristic to be determined, shall be verified with a traveller specimen or calculated according to an agreed mathematical model. Any change shall be recorded to enable interpretation of the test results.

7.6 Amount of moisture absorbed by traveller specimens

Dry the traveller specimens in an oven using the sequence:

a) $\left(72^{+20}_{0}\right)$ h at (50 ± 5) °C

b) $\left(72^{+20}_{0}\right)$ h at (70 ± 5) °C

c) x h at (90 ± 5) °C

Prior to each weighing allow the traveller specimens to cool down to room temperature in a desiccator. Moisture pick-up shall be avoided during this operation.

Weigh immediately after removal from the desiccator.

The drying period x corresponds to the time required for the specimens to reach a constant mass. Constant mass being defined as three successive weighings of the traveller specimens carried out at 72 h intervals (see Figure 3) and which complies with the formula below:

$$\frac{\left|P_{j-2} - P_j\right|}{P_j} \leq 5 \times 10^{-4}$$

where

P_j represents the mean weights of the travellers specimens at the time t_j.

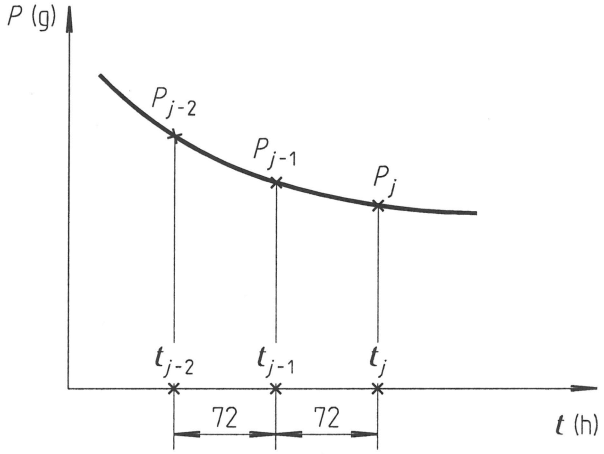


Figure 3

If the criterion above is not satisfied, resume drying at c) as many times as necessary.

M_2 is the mean of three weighings, see above, after drying.

8 Expression of results

8.1 Percentage of absorbed moisture (*HL*)

$$HL = \frac{M_1 - M_2}{M_2} \times 100$$

where

HL is the percentage of absorbed moisture;

M_1 is the mean of weighings of the traveller specimens at the condition of equilibrium, in grammes;

M_2 is the mean of weighings of the traveller specimens after drying, in grammes.

NOTE If it is necessary to express the absorbed moisture percentage to a standard resin content, see EN 3615.

8.2 Influence of moisture on characteristics

8.2.1 Absolute change

$$HE = R_f - R_i$$

where

HE is the absolute change in a characteristic due to the exposure;

R_i is the mean of the results of the tests obtained on specimens "to be aged" in the "as cured" condition and subjected to the test at the specified temperature according to the appropriate method;

R_f is the mean of the results obtained on test specimens after exposure and tested under the same conditions.

8.2.2 Percentage change

$$HI = \frac{R_f - R_i}{R_i} \times 100$$

where

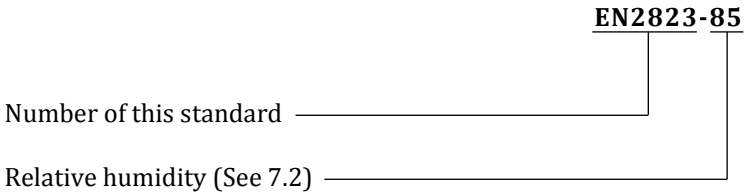
HI is the percentage change of a characteristic due to the exposure;

R_i is the mean of the results of tests obtained on specimens "to be aged" in the "as cured" condition and subjected to tests at the specified temperature according to the appropriate method;

R_f is the mean of the results obtained on test specimens after ageing and tested under the same conditions.

9 Designation

EXAMPLE



10 Test report

It shall contain the following information:

— designation (see 9);

— complete information ensuring traceability of the material (trade mark, acceptance date, batch number, etc.);

— type of traveller specimens (manufacturing method, dimensions, surface finish, etc.);

— temperatures and length of exposure;

— method of storing specimens (if required) before testing (see 7.5.1);

— time that the specimens are maintained at test temperature before testing (see 7.5.2);

— actual testing time (see 7.5.2);

— percentage of moisture absorbed (see 8.1);

— calculated changes (see 8.2);

— any incidents which may have affected the results.

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