TC61

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Plastics — Methods of exposure to natural weathering

Plastiques — Méthodes d'exposition aux intempéries

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FOREWORD

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

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It has been approved by the member bodies of the following countries :

Australia	India	Philippines
Austria	Iran	Poland
Belgium	Ireland	Portugal
Brazil	Israel	Romania
Bulgaria	Italy	Spain
Canada	Japan	Sweden
Czechoslovakia	Korea, Rep. of	Switzerland
Finland	Mexico	Turkey
France	Netherlands	United Kingdom
Germany, F.R.	New Zealand	U.S.A.
Hungary	Peru	Yugoslavia

No member body expressed disapproval of the document.

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Plastics — Methods of exposure to natural weathering

0 INTRODUCTION

Weathering tests of the type specified in this International Standard are needed to evaluate the performance of materials intended for outdoor use. The results of such tests should be regarded only as an indication of the effect of weathering. Results obtained at one time may not be strictly comparable with those obtained at another, although, in general, samples exposed for any period of several years and examined at the same time of year will show comparable behaviour. Even in long-term tests, the results may be affected by the season in which the tests are started.

The results of short-term exposure tests can give an indication of the relative outdoor performance but should not be used to predict the absolute long-term performance of a material. The results of tests carried out for less than 12 months will depend on the particular season of the year in which they are commenced.

It should be noted that the method of exposure is usually designed to expose the material to the most severe effects associated with any particular climate. It should therefore be borne in mind that the severity of exposure in actual use is, in most cases, likely to be less than that recommended in this International Standard, and allowance should be made accordingly when interpreting the results. For example, vertical exposure is considerably less severe in its effect on plastics, particularly in tropical regions, where the sun is at a high angle when it is most powerful, and also because rain-water drains more rapidly from samples. In the northern hemisphere, north-facing surfaces are likely to be less severely degraded than south-facing ones because they are less exposed to solar radiation, but the fact that they may remain wet for longer periods may be of significance for materials that are affected by moisture.

1 SCOPE AND FIELD OF APPLICATION

This International Standard describes procedures for exposing plastics to natural weathering in order to assess changes produced after specified stages of such exposure.

The methods are applicable to plastic materials of all kinds and to products or portions of products.

For the method of determination of changes in properties after exposure, reference is made to ISO 4582.

A system of classifying and characterizing climates in different parts of the world is given in 8.1.

2 REFERENCES

ISO 105, *Textiles — Tests for colour fastness.*

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

ISO 293, *Plastics — Compression moulding test specimens of thermoplastic materials.*

ISO 294, *Plastics — Injection moulding test specimens of thermoplastic materials.*

ISO 295, *Plastics — Compression moulding test specimens of thermosetting materials.*

ISO 2557, *Plastics — Amorphous thermoplastic moulding materials — Preparation of test specimens with a defined level of shrinkage.*

ISO 2818, *Plastics — Preparation of test specimens by machining.*

ISO 3167, *Plastics — Preparation and use of multipurpose test specimens.*

ISO 4582, *Plastics — Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or artificial light.*[1)]

ISO 4892, *Plastics — Methods of exposure to laboratory light sources.*[1)]

3 TEST SPECIMENS

If the material to be tested is an extrusion or moulding compound in granules or in chips or in another raw state, specimens shall be produced directly from it by an appropriate method, or a sheet shall be made from it by an appropriate method and the specimens cut from this sheet. The method used shall be agreed by the interested parties and should be closely related to the method by which the material is to be processed by the user.

NOTE — For the preparation of test specimens attention is drawn to ISO 293, ISO 294, ISO 295, ISO 2557 and ISO 3167.

1) At present at the stage of draft.

If the material to be tested is in the form of an extrusion, moulding, sheet, etc., test specimens may be prepared from the materials either before or after exposure, depending on the specific requirements of the tests and the nature of the material. For example, materials which embrittle markedly on weathering shall be exposed in the form in which they are to be tested, since subsequent machining is difficult; on the other hand, materials such as laminates which may delaminate at the edges shall be exposed in sheet form and test specimens shall be cut after exposure. In no circumstances shall any of the material be removed from the front exposed face during the course of specimen preparation.

NOTE – For the preparation of test specimens by machining, attention is drawn to ISO 2818.

Test specimens are always conditioned after machining, but in some circumstances it may be found necessary to pre-condition the sheets prior to machining to facilitate specimen preparation.

When the behaviour of a specific type of article is to be established, the article itself should be exposed wherever possible. Such articles or portions large enough for test purposes shall be exposed as they are. In cases where pieces of material are exposed and test specimens cut from them afterwards, the exposed weathered surface shall not be removed.

Wherever possible, test specimens shall be taken not less than 20 mm from fixtures holding the material or from supports that are not intended to simulate the conditions of exposure of the material in service. The amount of material or number of test specimens required will be determined by the relevant removal schedule and the requirements of the tests. It shall include sufficient material or test specimens for the determination of initial values and for further control tests at each exposure stage.

The control samples shall be stored in the dark under normal laboratory conditions, preferably in one of the standard atmospheres given in ISO 291.

NOTE – Attention is drawn to the fact that some materials will change colour during storage in the dark.

Test specimens and materials shall normally be exposed without backing, the rear surface being open to the air. Backing may be required to simulate conditions of use or to support thin films. The effect of backing may be highly significant through its influence on reflectance and heat absorption, and the sample exposed must be considered to consist of test specimen plus backing.

When backing is necessary to support the samples, it shall be of an inert material. The nature and thickness of the support may affect the test results. It shall be so designed that there is no pronounced sagging of the sample, but it shall be able to support the sample with a minimum of contact with its underside, to prevent retention of rain-water. In such cases, fine strand wire netting may be used.

Timber backing, in particular, often provides sufficient thermal insulation to cause exposed samples to become appreciably hotter in the sun than they would without support, with consequent acceleration of degradation.

In cases where the intended use of the material renders it necessary to consider exposure in contact with specific backing materials, the test may be modified to take account of this requirement.

The specimens shall be identified by suitable indelible markings, not on the portions to be used in testing. Engraved or scribed markings may be suitable for rigid materials. As a check, a plan of the mounting positions may be retained.

It is often useful to expose at the same time samples of one or more materials of known performance to monitor the exposure severity.

4 EXPOSURE ASPECT

Generally, the exposed surface of the material or test specimens shall be at 45° to the horizontal facing the equator. Other aspects may be required for particular sites or for special purposes; for example vertical exposure with any specified aspect may be required to reproduce the conditions on the outside of buildings. Exposure at 10° to the horizontal facing the equator approximates to horizontal exposure but provides definite run-off for rain-water.

To obtain maximum annual irradiation of the test specimens, the angle to the horizontal of the plane of the specimen shall be the exact site latitude angle.

Normally, test specimens should not be artificially washed during exposure, but if washing is required in special circumstances, it shall be carried out with distilled or deionized water and great care shall be taken to avoid abrasion or other damage to the weathered surface.

5 EXPOSURE SITE

Normally, the site shall be on open ground well away from trees and buildings. For exposures at 45° facing south, no obstruction, including adjacents racks, in an easterly, southerly or westerly direction shall subtend a vertical angle greater than 20°, or in a northerly direction greater than 45°. For exposures in the southern hemisphere facing north, corresponding provisions apply.

Natural soil covering is recommended, for example grass in temperate regions or sand in desert regions. Vegetable growth shall be kept cut low.

Additionally, for some applications, it may be desirable to include exposure in uncleared areas in jungle or forest in order to assess the effects of biological growth, termites and rotting vegetation. In choosing such sites, care shall be taken to ensure that

a) the uncleared site is truly representative of the general environment;

b) the exposure facilities and access paths do not grossly interfere with or modify the environment.

Regular inspection and maintenance at the site is required for refixing loose specimens and repairing damage or deterioration to equipment, particularly after storms.

6 APPARATUS

6.1 Test racks and specimen fixtures shall be made from inert materials that will not affect the test results. Wood, non-corrosive aluminium alloys, stainless steel or ceramics have been found suitable. However, the use of good heat conductors for the fixtures may affect the exposed material. Brass, steel or copper shall not be used in the vicinity of the test specimens.

The design of the racks shall be suited to the types of specimens to be tested, but for many purposes a flat frame mounted on a support is suitable. This frame shall consist of rails of wood or other approved material to which the specimens may be secured.

Specimens may be mounted directly on the rack or in suitable holders which are then fixed to the rack. No portion of the test specimen shall be closer than 0,5 m to the ground or any other obstruction. Fixtures shall be secure but should apply as little stress as possible to the specimens and permit shrinkage, expansion or warping to occur without constraint, so far as possible.

NOTE – For tests on finished products, it is recommended that wherever possible the fixtures should closely simulate those used in practice.

6.2 Apparatus for measurement of climatic factors, including solar radiation, shall be appropriate to the method adopted.

7 EXPOSURE STAGES

The exposure stages at which changes in properties of the test specimens are determined are specified by one of the following methods.

NOTE – The same exposure stage (by whichever method it is defined) will not necessarily give the same changes in a test specimen irrespective of the site of exposure. The exposure stages recommended must be regarded as giving only a general indication of the degree of exposure, and results should always be considered in terms of the characteristics of the exposure site as well.

7.1 Exposure time

The stages shall be specified in terms of the duration of exposure selected from the following, unless otherwise specified :

weeks : 1; 4; 16; 26

years : 1; 1,5; 2; 3; 4; 6

NOTE – The results for exposure stages of less than 1 year will depend on the season of the year in which the exposure was made. In the longer exposure stages, seasonal effects are averaged but results may still depend on the particular season in which exposure was started (for example whether started in Spring or Autumn).

7.2 Radiation measurement

Since solar radiation is one of the most important factors in the deterioration of plastics during weathering exposure, stages may be defined in terms of the amount of radiation received by the specimens. One of the following is required according to the method selected.

7.2.1 Blue dyed wool standards 1 to 7 as specified in ISO 105, section B01 exposed under a suitable transparent protective cover (see note), and the grey scale specified in ISO 105, section A02 (see also annex A).

NOTE – It is advisable to check that the covers are transparent to the incident light by running a comparison test on covered and uncovered standards under dry conditions.

7.2.2 Other physical standards agreed between the parties concerned.

NOTE – Work is currently in progress within ISO/TC 61 concerning standards based on poly(methyl methacrylate) and polyethylene.

7.2.3 Instrumental means

7.2.3.1 TOTAL ENERGY

In this method, the total radiant energy received by the test specimens shall be measured in joules per square metre[1] and exposure stages defined by specified amounts of energy.

7.2.3.2 ENERGY IN SPECIFIED WAVELENGTH INTERVALS

The method in 7.2.3.1 measures a considerable amount of energy in the infra-red region which has no direct photochemical effect in the weathering of plastics though it does affect the temperature of the specimen. It may therefore be preferred to confine the measurement to the wavelength ranges which are photochemically active, mainly the ultra-violet and, to some extent, visible light wavelengths.

As an example, radiation of wavelengths between 300 and 780 nm may be measured.

7.2.3.3 APPARATUS

A photoreceptor system shall be used sensitive to radiation received over a solid angle similar to that over which radiation is received by the test specimens and of known spectral response agreed between the interested parties. It shall be resistant to the weather and stable over the interval between calibrations, preferably 1 year at least.

It shall be mounted adjacent to the test specimens and in the same plane and connected to an integrating device to indicate the total energy received over a period.

1) Although not included in the SI, the langley, equivalent to 41,48 kJ/m^2, is quoted by some workers.

8 CLIMATIC CONDITIONS

8.1 Classes of climate

Climates are divided into five main classes, each sub-divided into several types.

Annex B gives details of two such classifications in use throughout the world.

The classification of climates given is such that significant differences are to be expected between the effects of exposure of plastics to each of the climatic conditions.

As an overriding influence upon this regional classification, marine and industrial conditions are likely to produce significantly different effects from the basic climatic conditions of the region. The particular conditions comprise the microclimate of the test site. In coastal regions, where the atmosphere may contain traces of salt but is generally clean, exposed samples receive a relatively higher amount of solar radiation and are likely to degrade more rapidly than in inland regions. In industrial areas, atmospheric pollution and dirt retained on the samples reduce the effect of solar radiation although the pollution and dirt may at the same time make the effects of moisture more pronounced.

To obtain the most reliable information, weathering trials should be conducted at sites in a number of different environments, in particular those that compare as closely as possible with the intended conditions of use.

8.2 Climatic observations

The general description of the climate at the site by class, type and special indications shall be supplemented by the following detailed observations.

8.2.1 *Temperature*

a) monthly mean of daily maxima;

b) monthly mean of daily minima;

c) monthly maximum and minimum.

8.2.2 *Relative humidity*

a) monthly mean of daily maxima;

b) monthly mean of daily minima;

c) monthly range.

8.2.3 *Radiation* (if not dealt with under clause 7)

Monthly total hours of sunshine.

8.2.4 *Precipitation*

Monthly total amount.

8.2.5 *Other observations*

Other observations such as wind strength and direction, incidence and nature of any atmospheric pollution, total hours of dew and rain, total incident energy and any special local features may also be recorded.

9 TEST METHODS

9.1 Test methods shall be chosen in accordance with the recommendations given in ISO 4582. The following additional considerations particular to outdoor exposure shall also be taken into account.

9.2 A decision shall be made as to whether specimens shall be washed or not. If washing is required, it shall be done whenever possible using only clean water and a minimum of abrasion. If water cleaning is inadequate, it is permissible to use a minimum of a mild detergent.

9.3 It is of prime importance that specimens be appropriately conditioned before test. The properties of some plastics are very sensitive to moisture content, and the duration of conditioning may need to be longer than that specified in ISO 291, particularly where specimens have been exposed to climatic extremes.

9.4 Tests shall be made as soon as possible after exposure, consistent with the time required for adequate conditioning; the interval between the end of the exposure and testing shall be stated in the test report.

10 DETERMINATION OF INITIAL PROPERTIES AND CHANGES AFTER EXPOSURE

These shall be determined as described in ISO 4582.

11 TEST REPORT

The test report shall include a reference to this International Standard and the following particulars :

a) the complete identification of the materials tested and the method of preparation of the test specimens;

b) aspect of exposure and details of washing, if any;

c) nature of backing, supports and attachments, if used;

d) location and details of exposure site;

e) class and type of climate, quoting reference authority (see annex B);

f) climatological data;

g) procedure for determining exposure stages;

h) exposure stages used, together with the relevant dates and the method of determining light dosage, if any (if instrumental methods are used, the exposure shall be expressed in joules per square metre),

j) presentation of results as required by ISO 4582.

ANNEX A

USE OF BLUE DYED WOOL STANDARDS TO MEASURE LIGHT DOSAGE

A.1 GENERAL

The blue dyed wool standards were developed for textile testing and historically have been used with plastics because of their availability. Because, in general, there is a need to expose plastics for longer periods than those normally used for testing the lightfastness of textiles, the consecutive use of the number 7 standard has been introduced.

Owing to the differences between the spectral sensitivity of the blue wool standards and the plastics materials, there is considerable doubt about the blue wool standards for this application. However, their ready availability and the fund of data based on their use ensures that there is still a demand for their application in exposure tests on plastics.

A.2 PROCEDURE

Expose a set of ISO blue dyed wool standards comprising one strip each from numbers 1 to 7 simultaneously.

Use the standards to determine the stages of radiation dosage (exposure stages) in accordance with the table, by comparing the difference in colour between the exposed and unexposed blue standards with the contrast 4 on the grey scale; thus, stage 1/1 is reached when standard 1 gives a contrast equal to 4 on the grey scale; 2/1 when standard 2 shows similar contrast, and in the same manner to stage 7/1 showing a contrast of 4 on the grey scale.

NOTE – The duration of stage 7/1 is about 1 year in natural daylight in temperate climates.

Inspect the blue standards as frequently as necessary to determine when each exposure stage is reached.

At stage 7/1, discard the blue standards, mount a second fresh standard 7 and continue exposure until this second standard 7 shows a contrast with the unexposed standard 7 equal to 4 on the grey scale. This storage is designated 7/2.

Then discard the second standard 7 and mount a third fresh standard 7. Stage 7/3 is reached when this standard in turn gives a contrast of 4.

Repeat this procedure as often as required, giving stages 7/4, . . ., 7/*N*.

NOTE – Consecutive exposure of No. 7 standard should only be employed when no better alternative is available.

Exposure stages

Stage	Description
1/1	Blue standard 1 to grey scale contrast 4
2/1	Blue standard 2 to grey scale contrast 4
3/1	Blue standard 3 to grey scale contrast 4
4/1	Blue standard 4 to grey scale contrast 4
5/1	Blue standard 5 to grey scale contrast 4
6/1	Blue standard 6 to grey scale contrast 4
7/1	First blue standard 7 to grey scale contrast 4
7/2	Second blue standard 7 to grey scale contrast 4
7/*N*	*N*th blue standard 7 to grey scale contrast 4

A.3 SUPPLY OF BLUE DYED WOOL STANDARDS

Sets of the ISO dyed wool light-fastness standards can be obtained from the following organizations :

British Standards Institution
10 Blackfriars Street
Manchester M3 5DT
United Kingdom

Beuth-Vertrieb GmbH
Burggrafenstrasse 4-7
D-1000 Berlin 30
Germany, F.R.

American Society for Testing and Materials
1916 Race Street
Philadelphia
Pennsylvania 19103
U.S.A.

Eidg. Materialprüfungs-und Versuchsanstalt
Unterstrasse 11
St Gallen
Switzerland

Association pour la détermination de la solidité des teintures et impressions sur textiles
12 rue d'Anjou
F 75 008 Paris
France

Japanese Standards Association
1-24 Akasaka 4
Minatoku
Tokyo
Japan

and other countries.

A.4 SUPPLY OF GREY SCALE

The grey scale for assessing change in colour can be obtained from the following organizations :

British Standards Institution
10 Blackfriars Street
Manchester M3 5DT
United Kingdom

The Society of Dyers and Colourists
P.O. Box 244, Perkin House
82 Gratton Road
Bradford BD1 2JB
West Yorks.
United Kingdom

Association pour la détermination de la solidité des teintures et impression sur textiles
12 rue d'Anjou
F 75 008 Paris
France

Eidg Materialprüfungs-und Versuchsanstalt
Unterstrasse 11
St Gallen
Switzerland

Japanese Standards Association
1-24 Akasaka 4
Minatoku
Tokyo
Japan

American Association of Textile Chemists and Colorists
P.O. Box 12215
Research Triangle Park
North Carolina 27709
U.S.A.

Beuth-Vertrieb GmbH
Burggrafenstrasse 4-7
1 Berlin 30
Germany, F.R.

ANNEX B

CLASSIFICATION OF CLIMATE

B.1 GENERAL

It is possible to classify climates into a number of different classes based on the characteristics of temperature and humidity. Each class can be sub-divided into a number of types.

Two classifications which have world-wide recognition are described below; full details and illustrative maps are given in *Deterioration of materials* (1954), edited by G. A. Greathouse and C. J. Wessel, Reinhold Publishing Corporation, New York, U.S.A.

B.2 CLASSIFICATIONS

Classification 1

Climatic conditions	Types
Hot and wet	Tropical rainforest Tropical savannah Humid sub-tropical with no dry season
Hot and dry	Tropical and sub-tropical desert Middle latitude desert Tropical and sub-tropical steppe
Mesothermal	Middle latitude steppe Humid continental with warm summer Mediterranean with dry summer Humid sub-tropical with dry winter
Temperate	Maritime with warm or cool summer Humid continental with cool summer
Cold	Sub-Arctic Tundra Ice-cap

Classification 2

This is based on the map proposed by Köppen and modified and simplified by Glenn T. Trewartha.

NOTE – An enlarged version of the map is available in the French national standard NF T 51-165 (1971).[1)]

In this classification, some geographical regions are unclassified as "Undifferentiated highlands".

Climatic conditions	Types
Tropical rainy	Tropical rainforest Tropical savannah
Dry	Tropical and sub-tropical steppe Middle latitude steppe Tropical and sub-tropical desert Middle latitude desert
Humid mesothermal	Mediterranean or dry summer Sub-tropical a) with dry winters b) with no dry season Marine west coast (cool summer)
Humid microthermal	Humid continental, warm summer Humid continental, cool summer Sub-Arctic
Polar climates	Tundra Ice-cap

1) Available from Association française de normalisation, Tour Europe, Cedex 7, 92080 Paris — La Défense, France, and its selling agents throughout the world.