
**High-pressure decorative laminates —
Sheets made from thermosetting
resins —**

**Part 1:
Classification and specifications**

*Stratifiés décoratifs haute pression — Plaques à base de résines
thermodurcissables —*

Partie 1: Classification et spécifications



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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 4586-1 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 11, *Products*.

This fifth edition cancels and replaces the fourth edition (ISO 4586-1:1997), of which it constitutes a minor revision intended

- a) to combine the 1997 edition with Amendment 3 to give a single document;
- b) to reintroduce a previously deleted method (determination of resistance to colour change in light from an enclosed carbon-arc lamp) (see Table 7, Lightfastness, Method C).

ISO 4586 consists of the following parts, under the general title *High-pressure decorative laminates — Sheets made from thermosetting resins*:

- *Part 1: Classification and specifications*
- *Part 2: Determination of properties*

High-pressure decorative laminates — Sheets made from thermosetting resins —

Part 1: Classification and specifications

1 Scope

This part of ISO 4586 establishes a classification system for high-pressure decorative laminated sheets according to their performance and main recommended fields of application, including materials with special characteristics, for example postformability or defined reaction to fire.

This part of ISO 4586 also specifies requirements on the properties of the various types of laminate covered by this classification. For several of the properties, more than one test method for checking the requirements is given. These methods have been included to cover cases where the results given by alternative methods are approximately equivalent, where expensive equipment of different types is already in satisfactory use, or where experience is limited to only one of the methods in certain countries.

Requirements are specified for those types of material that are most generally used, but additional types may be added as required. The limit values specified apply to the most commonly used types of material, but within each classification it may be possible to obtain variants having much higher performance figures.

These materials are characterized by their decorative surfaces, which are relatively hard and resistant to wear, scratching, impact, boiling water, domestic stains and moderate heat. They are intended for interior applications as follows:

- thin single-faced laminates usually less than 2 mm thick, for bonding to a substrate;
- compact laminates, single- or double-faced, approximately 2 mm to 5 mm thick, which need to be rigidly supported without necessarily being bonded to a substrate;
- compact laminates, self-supporting, double-faced, usually thicker than 5 mm, the thickness of which will be selected according to application and panel dimensions.

The back surface of sheets having only one decorative face is made suitable for adhesive bonding to a substrate.

This part of ISO 4586 applies only to decorative laminated sheets as defined in Clause 3. ISO 4586-2 specifies the methods of test relevant to this part of ISO 4586.

2 Normative references

The following referenced documents are indispensable for the application 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 178, *Plastics — Determination of flexural properties*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 4586-2:2004, *High-pressure decorative laminates — Sheets made from thermosetting resins — Part 2: Determination of properties*

3 Terms and definitions

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

3.1

high-pressure decorative laminate(s)

HPDL

HPL

sheet(s) consisting of layers of fibrous sheet material (for example paper) impregnated with thermosetting resins and bonded together by means of heat and a pressure of at least 5 MPa, the outer layer or layers on one or both sides having decorative colours or designs

NOTE 1 High-pressure decorative laminate(s) as defined in this part of ISO 4586 are made from core layers impregnated with phenolic and/or aminoplastic resins and a surface layer or layers impregnated with aminoplastic resins (mainly melamine resins).

NOTE 2 The abbreviation "HPDL" for high-pressure decorative laminate(s) is used in ISO 4586. It should be noted that the abbreviation "HPL" is frequently used instead of "HPDL", and the term "HPL" in the European standard EN 438 is equivalent to "HPDL" in ISO 4586.

4 Classification system

4.1 General

One classification system consists of a material type describing the specific characteristics of the laminate, together with three index numbers describing levels of performance. The system has been developed to cover the numerous HPDL product variants now available.

An alphabetical classification system can be used as an alternative (see 4.6), and Table 1 compares the two systems and shows how they relate to some typical applications.

Horizontal-grade laminates are those having a wear resistance index of 3 or greater. Vertical-grade laminates are those having a wear resistance index of less than 3.

4.2 Index numbers for specifying HPDL properties

First property = Resistance to surface wear (Table 2).

Second property = Resistance to impact by small-diameter ball (Table 3).

Third property = Resistance to scratching (Table 4).

4.3 Material type — Special characteristics

4.3.1 General

The classes of material listed in Table 1 are all available as standard-type decorative laminated sheet (type S) having the basic characteristics described in Clause 1.

For some classes of material, additional types (type P and type F) are also available, possessing the special properties described below.

4.3.2 Type P — Postformable decorative laminated sheet

Type P sheet is similar to type S, but it can also be formed in accordance with the manufacturer's recommendations.

4.3.3 Type F — Decorative laminated sheet having defined reaction to fire

Type F sheet is similar to type S, but it also meets special requirements of specified fire tests, which may vary according to the application of the material and the country of use.

4.4 Application characteristics

Materials are available in the grades shown in Table 1. The list of typical applications given for each category is for guidance only and is not intended to be comprehensive.

Other combinations of properties are possible and can be classified by the material type/index number system.

Table 1 — Classification system and typical applications

| Performance category | Material type | Property | | | Equivalent alphabetical classification | Examples of typical applications |
|--|------------------------|-----------------|-------------------|--------------------|---|---|
| | | Wear resistance | Impact resistance | Scratch resistance | | |
| | | Index number | | | | |
| Thick materials of high performance for special use in horizontal and vertical applications requiring particularly high impact and moisture resistance | Compact S or Compact F | 3 | — ^a | 3 | CGS (compact general-purpose standard) or CGF (compact general-purpose flame-retardant) | Doors, partitions, walls, various self-supporting components in construction and transportation |
| Very high resistance to surface wear High impact resistance Very high resistance to scratching | S or F | 4 | 3 | 4 | HDS (horizontal heavy-duty standard) or HDF (horizontal heavy-duty flame-retardant) | Counter tops, computer-room flooring |
| High resistance to surface wear High resistance to impact High resistance to scratching | S, F or P | 3 | 3 | 3 | HGS (horizontal general-purpose standard), HGF (horizontal general-purpose flame-retardant) or HGP (horizontal general-purpose postforming) | Kitchen working surfaces, restaurant and hotel tables, heavy-duty doors and wall coverings, interior walls of public-transport vehicles |
| High resistance to surface wear Medium resistance to impact High resistance to scratching | S, F or P | 3 | 2 | 3 | — | Horizontal applications for office (computer tables) and bathroom furniture |
| Medium resistance to surface wear Medium resistance to impact Medium resistance to scratching | S, F or P | 2 | 2 | 2 | VGS (vertical general-purpose standard), VGF (vertical general-purpose flame-retardant) or VGP (vertical general-purpose postforming) | Front panels for kitchen, office and bathroom furniture, wall coverings, shelves |
| Low resistance to surface wear Medium resistance to impact and scratching | S, F or P | — ^b | 2 | 2 | — | Special decorative surface effects for vertical use in kitchens, showrooms, etc. |
| Low resistance to surface wear and scratching Medium resistance to impact | S | 1 | 2 | 1 | VLS (vertical light-duty standard) | Exposed side components of cupboards |

^a The test method (ISO 4586-2:2004, Clause 12) is not applicable to compact S and compact F grades; however, in practical applications, the impact resistance of compact laminates is superior to that of other decorative laminate types.

^b No requirement. But requirements may be determined by interested parties.

4.5 Properties

4.5.1 General

Index numbers are used to specify the following three important HPDL properties.

4.5.2 Resistance to surface wear (first property)

Table 2 — Index numbers for resistance to surface wear

| Index number | Number of revolutions | |
|--------------|-----------------------|---------------------|
| | IP | $\frac{IP + FP}{2}$ |
| 1 | — | ≥ 50 |
| 2 | ≥ 50 | ≥ 150 |
| 3 | ≥ 150 | ≥ 350 |
| 4 | ≥ 350 | ≥ 1 000 |

4.5.3 Resistance to impact by small-diameter ball¹⁾ (second property)

Table 3 — Index numbers for resistance to impact

| Index number | Spring force N |
|--------------|-------------------|
| 1 | ≥ 12 |
| 2 | ≥ 15 |
| 3 | ≥ 20 |
| 4 | ≥ 25 |

4.5.4 Resistance to scratching²⁾ (third property)

Table 4 — Index numbers for resistance to scratching

| Index number | Load N |
|--------------|-----------|
| 1 | ≥ 1,5 |
| 2 | ≥ 1,75 |
| 3 | ≥ 2,0 |
| 4 | ≥ 3,0 |

4.6 Nomenclature

In addition to the abbreviation “HPDL” and the number of this International Standard, materials can be specified either by the material type/index number system, or by the alphabetical classification system. For example, horizontal general-purpose postformable laminate can be specified as HPDL-ISO 4586-P333 or ISO 4586-HGP.

1) Applies only to materials less than 2 mm thick.

2) See Annex B.

5 Requirements

5.1 Compliance

The material of each type classified in Table 1 shall meet the requirements of every property for which a value or range is specified in Clause 6.

Two methods of test are given for the measurement of dimensional stability, resistance to staining, resistance to cigarette burns, formability and resistance to blistering. Three are given for the measurement of lightfastness. When there is a choice of method, material satisfying the requirements of either/any of the methods shall be deemed to comply with the specification for that property; however, the choice of method may be agreed between the interested parties. The method selected shall be stated in the test report.

5.2 Notes on requirements for reaction to fire

The requirements for reaction to fire are determined by the fire regulations of the country in which the material is to be used.

At present, it is not possible, with any test, to predict compliance with all national and other requirements. No test is therefore included in this specification and reference must be made to those other requirements when appropriate.

The selection of a suitable test or tests for inclusion in this part of ISO 4586 will be considered when International Standards specifying fire tests for building materials and structures have been agreed upon.

6 Properties

6.1 Colour and pattern

When inspected in daylight or D_{65} standard illuminant and again under a tungsten illuminant, there shall be no significant difference between the corresponding colour reference sample held by the supplier and the specimen under test.

6.2 Surface finish

6.2.1 Finish matching

When inspected at different viewing angles, there shall be no significant difference between the corresponding surface-finish reference sample held by the supplier and the specimen under test.

NOTE For critical colour-matching applications, it is recommended that sheets be checked for colour/surface-finish compatibility before fabrication or installation.

6.2.2 Bonding

The reverse side of sheets having only one decorative surface shall be suitable for adhesive bonding if so required.

6.3 Thickness

No requirements for nominal thickness are specified for individual types of material listed in Table 7; however, variations from the nominal thickness supplied shall at no point exceed the limits shown in Table 5, when thickness is measured in accordance with ISO 4586-2:2004, Clause 4.

Table 5 — Permitted variations of thickness

Values in millimetres

| Nominal thickness, d | Maximum variation |
|------------------------|-------------------|
| $0,5 \leq d \leq 1,0$ | $\pm 0,10$ |
| $1,0 < d \leq 2,0$ | $\pm 0,15$ |
| $2,0 < d \leq 2,5$ | $\pm 0,18$ |
| $2,5 < d \leq 3,0$ | $\pm 0,20$ |
| $3,0 < d \leq 4,0$ | $\pm 0,25$ |
| $4,0 < d \leq 5,0$ | $\pm 0,30$ |
| $5,0 < d$ | as agreed |

6.4 Appearance

6.4.1 General

The following inspection requirements are intended as a general guide, indicating the minimum acceptable quality for laminates supplied as full-size sheets. Cut-to-size panels and certain applications involving full-size sheets may call for special quality requirements which can be negotiated between supplier and purchaser; in such cases, the following requirements may be used as a basis for discussion. It should be noted that only a small percentage of sheets in a batch (the level to be agreed with the customer) should be of the minimum acceptable quality.

6.4.2 Surface defects

6.4.2.1 Requirements

When inspected in accordance with ISO 4586-2:2004, Clause 5, at a distance of 1,5 m, the following surface defects are permissible.

6.4.2.2 Spots, dirt and similar surface defects

The admissible size of such defects is based on a maximum contamination area equivalent to $1,0 \text{ mm}^2/\text{m}^2$ of laminate and is proportional to the sheet size under inspection.

The total admissible area of contamination may be concentrated in one spot or dispersed over an unlimited amount of smaller defects.

6.4.2.3 Fibres, hairs, scratches

The admissible size of defects is based on a maximum contamination length equivalent to $10 \text{ mm}/\text{m}^2$ of laminate and is proportional to the sheet size under inspection.

The total admissible length of contamination may be concentrated in one defect or dispersed over an unlimited amount of smaller defects.

6.4.2.4 Combinations of surface defects

When defect types described in 6.4.2.2 and 6.4.2.3 occur in the same sheet, then the maximum level for each of the two types of defect shall not exceed half of the levels prescribed in 6.4.2.2 and 6.4.2.3.

6.4.3 Edge defects

Visual defects (e.g. moisture marks, lack of gloss, etc.) can be present on all four edges of the laminate, providing the defect-free length and width are not more than 20 mm shorter than the nominal length and width.

6.4.4 Broken corners

One broken corner of ≤ 3 cm or two broken corners of $\leq 1,5$ cm are allowed.

These values refer to the distance between the original corner and the fracture line (see Figure 1).

6.4.5 Sanding defects

Slight chatter marks (i.e. surface undulations due to the sanding process) are allowed.

6.4.6 Flatness

The flatness of laminates is dependent on atmospheric conditions in the storage area. Provided that the laminates are stored in the conditions recommended by the manufacturer, they shall not show a departure of the surface from a straightedge of 1 m length, in any position, of more than the limits listed in Table 6 when the laminate is laid concave side up on a flat surface.

Table 6 — Permitted departure from flatness

Values in millimetres

| Composition | Thickness, d | Maximum warp |
|-----------------------|--------------------|--------------|
| Single-faced laminate | $d < 2,0$ | 120 |
| | $2,0 \leq d < 5,0$ | 50 |
| Double-faced laminate | $2,0 \leq d < 5,0$ | 10 |
| | $5,0 \leq d$ | 5 |

6.4.7 Length and width of a full-size laminate

The laminate shall be the nominal size with a tolerance of $^{+10}_0$ mm.

6.4.8 Straightness of edges

The edges shall be straight within a tolerance of 1,5 mm per metre length of the edge (value a in Figure 2). The edge being measured shall be at least 1 m long.

6.4.9 Squareness of the laminate

The panel shall be rectangular within a tolerance of 1,5 mm per metre length of the edge (value b in Figure 3). The edge being measured shall be at least 1 m long.

6.5 Other properties

Each material type, when tested by the appropriate methods, shall meet the requirements specified in Tables 1 and 7.

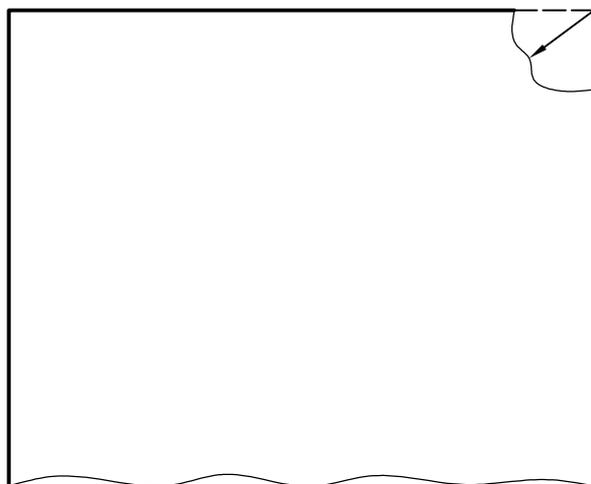


Figure 1 — Broken corner

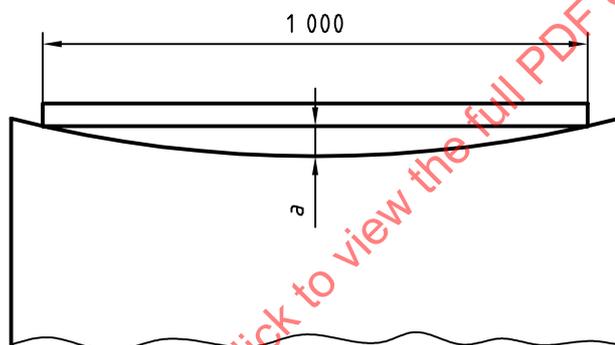


Figure 2 — Measurement of straightness

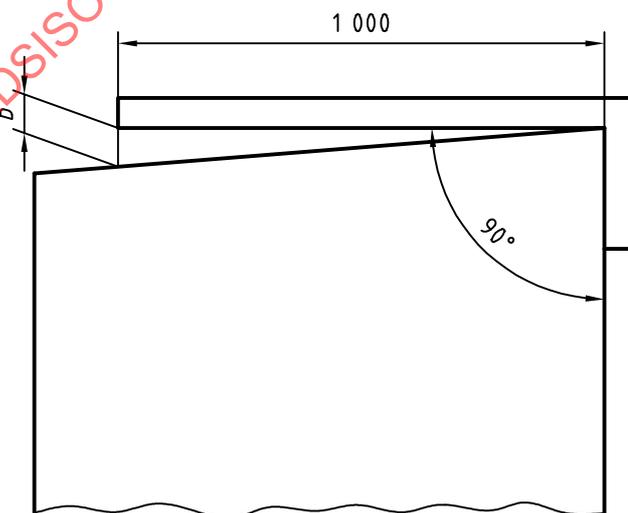


Figure 3 — Measurement of squareness

Dimensions in millimetres

Dimensions in millimetres

Table 7 — Property requirements

| Property | Test method (ISO 4586-2:2004, Clause No.) | Property or attribute | Unit (max. or min.) | Material type | | | | | | | | | | |
|---|---|---|---------------------------|--|--------------------|--------|--------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | | | | HDS HDF | HGS | HGP | HGF | VGS | VGP | VGF | VLS | CGS | CGF | |
| Resistance to surface wear | 6 | Wear resistance | revolutions (min) | See Tables 1 and 2 | | | | | | | | | | |
| Resistance to immersion in boiling water | 7 | Mass increase | % (max.) | See Annex A, Figure A.1 | | | | | | | | | | |
| | | Thickness increase | % (max.) | See Annex A, Figure A.2 | | | | | | | | | | |
| Resistance to dry heat (180 °C) | 8 | Appearance | Rating (not worse than) | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 4 |
| | | Appearance gloss finish other finishes | Rating (not worse than) | 3 | 3 | 3 | 3 | — ^b | 3 |
| Resistance to wet heat | 9 | Appearance | Rating (not worse than) | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Resistance to steam | 10 | Appearance | Rating (not worse than) | 4 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 4 |
| Dimensional stability at elevated temperature | 11 | Cumulative dimensional change | % (max.) (L) ^c | See Annex A, Figure A.3 | | | | | | | | | | |
| | | | % (max.) (T) ^d | See Annex A, Figure A.4 | | | | | | | | | | |
| Resistance to impact by small-diameter ball | 11 ^e Method B (alternative) | Cumulative dimensional change | % (max.) (L) ^c | See Annex A, Figure A.4 | | | | | | | | | | |
| | | | % (max.) (T) ^d | See Annex A, Figure A.4 | | | | | | | | | | |
| Resistance to impact by large-diameter ball | 12 ^f | Spring force | N (min.) | See Tables 1 and 3 | | | | | | | | | | |
| Resistance to cracking under stress (thin laminates) | 13 | Drop height | cm (min.) | May be agreed between interested parties | | | | | | | | | | |
| | | Diameter of indentation | mm (max.) | May be agreed between interested parties | | | | | | | | | | |
| Resistance to scratching | 14 ^f | Susceptibility | Rating (not worse than) | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | — ^g | — ^g |
| | | | Force | N (min.) (see Annex B) | See Tables 1 and 4 | | | | | | | | | |
| Resistance to staining | 16 Method A ¹ (alternative) | Appearance Groups 1 and 2 Groups 3 and 4 | Rating (not worse than) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | | | Appearance | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 |
| Lightfastness | 16 Method B (alternative) | Staining agents 1 to 10 Staining agents 11 to 15 Cleanability index | Rating (not worse than) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | | | Sum of ratings (max.) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Lightfastness | 17 Method A (alternative) | Contrast | Grey scale rating | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| | | | Contrast | 4 to 5 | 4 to 5 | 4 to 5 | 4 to 5 | 4 to 5 | 4 to 5 | 4 to 5 | 4 to 5 | 4 to 5 | 4 to 5 | 4 to 5 |
| Lightfastness | 17 Method B (alternative) | Appearance | Rating (not worse than) | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | | | Appearance | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Lightfastness | 17 Method C (alternative) | Contrast | Grey scale rating | May be agreed between interested parties | | | | | | | | | | |
| | | | Contrast | May be agreed between interested parties | | | | | | | | | | |

Table 7 — Property requirements (continued)

| Property | Test method (ISO 4586-2:2004, Clause No.) | Property or attribute | Unit (max. or min.) | Material type | | | | | | | | | | | | |
|---|---|---------------------------------|-------------------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | | | | HDS | HDF | HGS | HGP | HGF | VGS | VGP | VGf | VLS | CGS | CGF | | |
| Resistance to cigarette burns | 18 Method A (alternative) | Appearance | Rating (not worse than) | 3 | 3 | 3 | 3 | 3 | 3 | — ^b | 3 | 3 |
| | 18 Method B (alternative) | Time to failure | s (min.) | 110 | 110 | 100 | 100 | 100 | — ^b | — ^b | — ^b | — ^b | — ^b | — ^b | 110 | 100 |
| Formability | 19 Method A (alternative) | Radius | mm (max.) | — ^g | — ^g | 15 ^j | 15 ^j | 10 ^j | 10 ^j | — ^g |
| | 19 Method B (alternative) | Radius | mm (max.) | — ^g | — ^g | 15 ^j | 15 ^j | 10 ^j | 10 ^j | — ^g |
| Resistance to blistering | 20 Method A (alternative) | Time to blister ($t_2 - t_1$) | s (min.) | — ^g | — ^g | 15 | 15 | 10 | 10 | — ^g |
| | 20 Method B (alternative) | Time to blister ($t_2 - t_1$) | s (min.) | — ^g | — ^g | 15 | 15 | 10 | 10 | — ^g |
| Resistance to crazing (compact laminates) | 21 | Susceptibility | Rating (not worse than) | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | 4 | 4 |
| Resistance to moisture (double-faced compact laminates) | 22 | Appearance | Rating (not worse than) | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | 4 | 3 |
| | ISO 178 | Stress | MPa (min.) | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | 10 000 | 9 000 |
| Flexural modulus ^k | ISO 178 | Stress | MPa (min.) | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | 100 | 80 |
| Flexural strength ^k | ISO 527-2 | Stress | MPa (min.) | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | 70 | 60 |
| Tensile strength ^l | | | | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g | — ^g |

^a Test samples shall be reduced by machining to a thickness of < 15 mm.

^b No requirement.

^c L = in the longitudinal (or machine) direction of the fibrous sheet material (normally the direction of the longest dimension of the laminated sheet).

^d T = in the cross-longitudinal (or cross-machine) direction of the fibrous sheet material (at right angles to direction L).

^e Intended to indicate performance under normal climatic conditions.

^f Applies only to materials less than 2 mm thick.

^g Not applicable.

^h Test samples shall be reduced by machining to a thickness of < 8 mm.

ⁱ Acids and alkalis in concentrations stronger than those shown in group 3, which may be present in commercial cleaning agents, can cause surface damage or marking even with very short contact times. Any spillage of such materials must be washed off the laminate surface immediately.

^j Limits for laminates > 1,5 mm shall be agreed between the interested parties.

^k Test speed: 2 mm/min.

^l Specimen type 1A, test speed: 5 mm/min.

Annex A (normative)

Addendum to specifications Table 7, relating to test methods in Clauses 7 and 11

In Table 7, reference is made to Figures A.1 to A.4 in specifying resistance to boiling water and dimensional stability.

The characteristics are dependent on laminate thickness, and the curves therefore provide more complete information than discrete limits.

The curves give the maximum limiting values for each laminate type (S, P and F). No attempt has been made to prescribe specific laminate thicknesses for the various fields of application, but in determining the quality of a laminate of a given thickness it is important to know where these properties lie in relation to the appropriate limit curves.

Knowing the expected performance, the customer can select the laminate thickness which will best meet the requirements of a particular application.

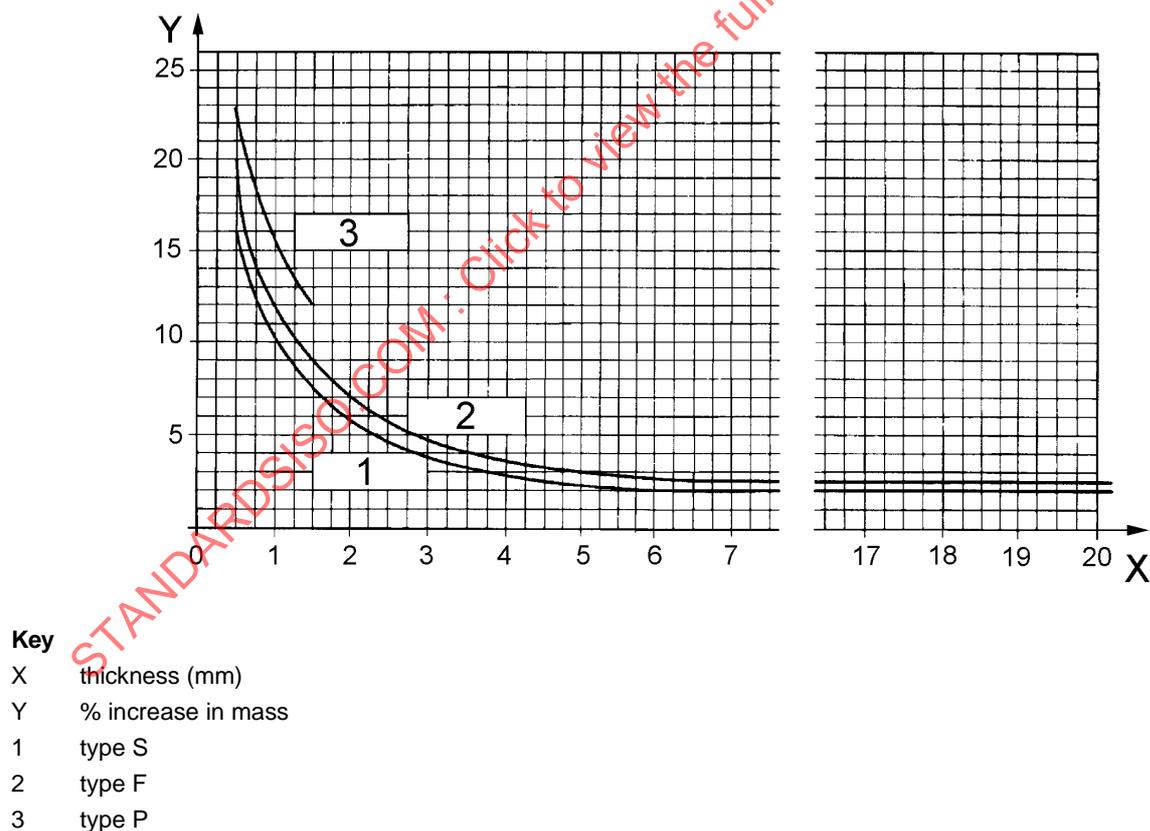
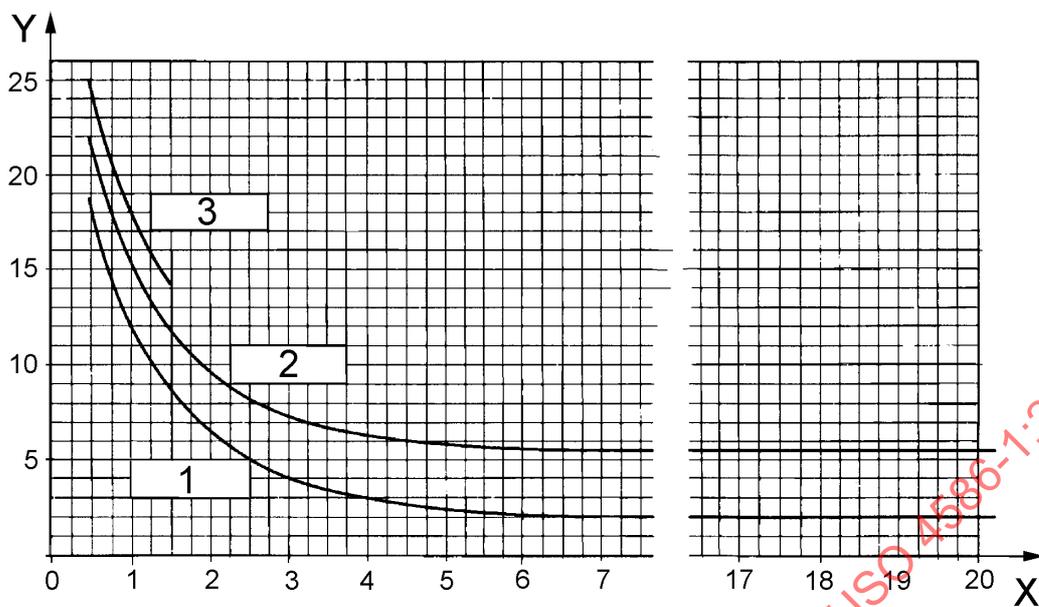


Figure A.1 — Water absorption — % increase in mass



- Key**
- X thickness (mm)
 - Y % increase in thickness
 - 1 type S
 - 2 type F
 - 3 type P

Figure A.2 — Water absorption — % increase in thickness

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