INTERNATIONAL STANDARD

ISO 11833-1

Fourth edition
2019-07

Plastics — Unplasticized poly(vinyl chloride) sheets —

Part 1: Types, dimensions and characteristics for sheets of thickness not less than 1 mm

Plastiques — Feuilles en poly(chlorure de vinyle) non plastifié —

Partie 1: Types, dimensions et caractéristiques pour des plaques d'épaisseur non inférieure à 1 mm

Reference number
ISO 11833-1:2019(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 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 11, *Products*.

This fourth edition cancels and replaces the third edition (ISO 11833-1:2012), which has been technically revised. The main changes compared to the previous edition are as follows:

— the title has been editorially revised to read "Plastics — Unplasticized poly(vinyl chloride) sheets — Part 1: Types, dimensions and characteristics for sheets of thickness not less than 1 mm";

— the "colour" requirements (former 5.3) have been incorporated with the "appearance" requirements in 6.2 (former 5.2);

— the requirements for measurement at any other temperature (t °C) than 23 °Chas been added to 7.3.1 (former 6.3.1);

— the method of handling the results of 7.4.1, 7.4.2 and 7.4.3 (former 6.4.1 to 6.4.3) have been added;

— “Testing of sheets with a thickness between 1,0 mm and <1,5 mm shall be subject between the interested parties” has been added in 7.5.1 (former 6.5.1);

— a new Table 7 "Frequency and measurement positions of appearance tests and dimensional measurements" has been added and the subsequent tables have been renumbered..

A list of all parts in the ISO 11833 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.

Plastics — Unplasticized poly(vinyl chloride) sheets —

Part 1: Types, dimensions and characteristics for sheets of thickness not less than 1 mm

1 Scope

This document specifies the requirements for flat extruded sheets and pressed sheets of unplasticized poly(vinyl chloride) (PVC-U) and the test methods to be used to measure the required values.

It applies only to sheets of thickness not less than 1,0 mm.

It does not cover biaxially stretched PVC-U sheets.

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 75-2:2013, *Plastics — Determination of temperature of deflection under load — Part 2: Plastics and ebonite*

ISO 178, *Plastics — Determination of flexural properties*

ISO 179-1, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

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

ISO 306:2013, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST)*

ISO 472, *Plastics — Vocabulary*

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

ISO 899-2, *Plastics — Determination of creep behaviour — Part 2: Flexural creep by three-point loading*

ISO 21306-1:2019, *Plastics — Unplasticized poly(vinyl chloride) (PVC-U) moulding and extrusion materials — Part 1: Designation system and basis for specifications*

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

ISO 1183-2, *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method*

ISO 2039-1, *Plastics — Determination of hardness — Part 1: Ball indentation method*

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

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 13468-1, *Plastics — Determination of the total luminous transmittance of transparent materials — Part 1: Single-beam instrument*

IEC 62631-3-1, *Dielectric and resistive properties of solid insulating materials — Part 3-1: Determination of resistive properties (DC methods) — Volume resistance and volume resistivity — General method*

3 Terms and definition

For the purposes of this document, the terms and definitions given in ISO 472 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 http://www.electropedia.org/

4 Material

Sheets shall be fabricated from PVC-U compounds as defined in ISO 21306-1:2019, Clause 1. Compounds may contain additives such as stabilizers, lubricants, processing aids, impact modifiers, fillers, flame retardants and colourants. Compounds and additives of unknown identity and composition shall not be used for the processing of sheets.

5 Classification

Extruded and pressed sheets are each classified into the following five groups, characterized by type of sheet as well as by the numerical values of the three most important properties, i.e. tensile stress at yield, Charpy impact strength and Vicat softening temperature (see Table 5):

— Group 1: General-purpose grade;

— Group 2: Transparent grade;

— Group 3: High-modulus grade;

— Group 4: High-impact grade;

— Group 5: Heat-resistant grade.

6 Requirements

6.1 Masking

Protection of the sheet surface with a suitable material (for example polyethylene or paper) shall be agreed between the interested parties as required.

6.2 Appearance

The surface shall be free of noticeable flaws, cracks, mottling, voids, bubbles, impurities, colour unevenness (both within one sheet and between sheets) and other defects which are not acceptable for the application envisaged. The sheet shall have a smooth surface, except for embossed sheets which shall have a uniform pattern. Requirements concerning defects shall be agreed upon between the interested parties.

6.3 Dimensions

6.3.1 Length and width

The nominal length and width of sheets shall be agreed between the interested parties. For any individual sheet selected at random from any delivery, the tolerances shall be as specified in Table 1.

Table 1 — Tolerances on length and width

Dimensions in millimetres

Nominal dimension d_n	Tolerance on length and width	
	Extruded sheet	Pressed sheet
$d_n \leq 500$	$^{+3}_{0}$	$^{+4}_{0}$
$500 < d_n \leq 1\,000$	$^{+4}_{0}$	
$1\,000 < d_n \leq 1\,500$	$^{+5}_{0}$	
$1\,500 < d_n \leq 2\,000$	$^{+6}_{0}$	
$2\,000 < d_n \leq 4\,000$	$^{+7}_{0}$	

6.3.2 Rectangularity

For any individual sheet selected at random from any delivery, the tolerance on rectangularity, expressed as the difference in length of the diagonals, shall be as specified in Table 2.

Table 2 — Tolerances on rectangularity

Dimensions in millimetres

Nominal dimensions (length × width)	Tolerance (difference between diagonals)	
	Extruded sheet	Pressed sheet
1 800 × 910	7	5
2 000 × 1 000	7	5
2 440 × 1 220	9	7
3 000 × 1 500	11	8
4 000 × 2 500	17	13

The tolerances specified in Table 2 assume that the length and width of the sheet comply with Table 1.

Tolerances on sheets of other nominal dimensions shall be calculated, in millimetres, using Formulae (1) and (2) and rounded to the nearest integer:

Extruded sheet:

$$\left|\overline{AC}-\overline{BD}\right| = \sqrt{\left(\overline{AB}+4\overline{BC}/1\,000\right)^2+\overline{BC}^2} - \sqrt{\left(\overline{AB}-4\overline{BC}/1\,000\right)^2+\overline{BC}^2} \quad (1)$$

Pressed sheet:

$$\left|\overline{AC}-\overline{BD}\right| = \sqrt{\left(\overline{AB}+3\overline{BC}/1\,000\right)^2+\overline{BC}^2} - \sqrt{\left(\overline{AB}-3\overline{BC}/1\,000\right)^2+\overline{BC}^2} \quad (2)$$

where $\left|\overline{AC}-\overline{BD}\right|$ is the deviation from rectangularity (see Figure 1).

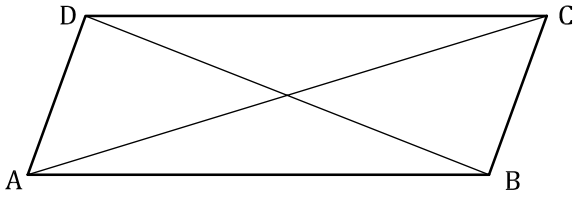


Figure 1 — Deviation from rectangularity

6.3.3 Thickness

The thickness shall be determined in accordance with 7.3.2 The tolerance on the thickness shall be as specified in Table 3 for non-critical applications (T_1) or as specified in Table 4 for critical applications (T_2), as agreed between the interested parties.

Table 3 — Tolerances on thickness for non-critical applications (T_1)

Nominal thickness, d mm	Tolerance %	
	Extruded sheet	Pressed sheet
$1 < d \leq 5$	±13	±15
$5 < d \leq 20$	±10	±10
$d > 20$	±7	±7
Tolerances for embossed sheets shall be agreed between interested parties as required.		

Table 4 — Tolerances on thickness for critical applications (T_2)

	Tolerance mm
Extruded sheet	±(0,1 + 0,03 × nominal thickness)
Pressed sheet	±(0,1 + 0,05 × nominal thickness)
Tolerances for embossed sheets shall be agreed between interested parties as required.	

6.4 Basic properties

The basic mechanical, thermal and optical properties of sheets of each group shall be as specified in Table 5.

Table 5 — Basic properties of sheets

Properties	Test method	Unit	Requirements by manufacturing methods and types (average values)									
			Extruded sheets					Pressed sheets				
			Group 1 General purpose	Group 2 Transparent	Group 3 High modulus	Group 4 High impact	Group 5 Heat resistant	Group 1 General purpose	Group 2 Transparent	Group 3 High modulus	Group 4 High impact	Group 5 Heat resistant
Tensile stress at yield	ISO 527-2 Type 1B	MPa	≥50	≥45	≥60	≥45	≥50	≥50	≥45	≥60	≥45	≥50
Nominal strain at break	ISO 527-2 Type 1B	%	≥8	≥5	≥3	≥8	≥10	≥5	≥5	≥8	≥10	≥8
Modulus of elasticity in tension	ISO 527-2 Type 1B	MPa	≥2 500	≥2 000	≥3 200	≥2 300	≥2 500	≥2 500	≥2 500	≥3 000	≥2 000	≥2 500
Charpy impact strength of notched specimens	ISO 179-1 Type 1epA	kJ/m^2	≥2	≥1	≥2	≥5	≥2	≥2	≥1	≥2	≥10	≥2
Vicat softening temperature	ISO 306:2013 Method B50	°C	≥70	≥60	≥70	≥70	≥85	≥75	≥65	≥78	≥70	≥90
Dimensional change on heating	7.5.2	%	Nominal thickness 1,0 mm to 2,0 mm: from −10 to +10 Nominal thickness over 2,0 mm to 5,0 mm: from −5 to +5 Nominal thickness over 5,0 mm to 10,0 mm: from −4 to +4 Nominal thickness over 10,0 mm: from −4 to +4					from −3 to +3				
Delamination	7.5.2	—	Not applicable					No blisters, cracks or flaking (delamination)				
Total luminous transmittance (Applicable to group 2 only)	ISO 13468-1	%	Thickness of sheets			Class A: General purpose		Class B: High transparency				
			Nominal thickness 2,0 mm or less:			≥80		≥82				
			Nominal thickness over 2,0 mm to 6,0 mm:			≥71		≥78				
			Nominal thickness over 6,0 mm to 10,0 mm:			≥61		≥75				
			Nominal thickness over 10,0 mm:			—		—				
Requirements for embossed sheets shall be agreed between interested parties as required.												

6.5 Other mechanical and physical properties

Requirements for the properties in Table 6 shall be agreed between the interested parties as required.

The other mechanical properties shall be determined in accordance with 7.7.

Table 6 — Other mechanical and physical properties

Property	Test method	Unit
Charpy impact strength of unnotched specimens at 0 °C and −20 °C	ISO 179-1 Type 1eU/pendulum energy 4 J	kJ/m^2
Temperature of deflection under load	ISO 75-2:2013 Method A	°C
Creep modulus in flexure under stress of 5 MPa	ISO 899-2 40 °C	MPa
Density	ISO 1183-1 or ISO 1183-2	g/cm^3
Flexural strength	ISO 178 b^a = 35 mm	MPa
Ball indentation hardness	ISO 2039-1	N/mm^2
Volume resistivity	IEC 62631-3-1	Ω·cm
[a] b = width of test specimen.		

6.6 Chemical and physiological properties

6.6.1 Flammability

Requirements for flammability shall be agreed between the interested parties as required. Relevant national and International Standards shall be considered in the agreement.

6.6.2 Chemical resistance

Requirements for chemical resistance for critical applications shall be agreed between the interested parties as required.

6.6.3 Physiological behaviour

Requirements for physiological behaviour shall be agreed between the interested parties as required. The relevant legislation shall be taken into consideration if the sheet is likely to come into contact with food.

7 Test methods

7.1 General

7.1.1 Sampling

Take a sample sufficient to investigate the compliance of the material with this specification. The sampling shall be done in accordance with ISO 2859-1.

7.1.2 Preparation of specimens

Prepare all specimens in accordance with ISO 2818. The surface of the specimens shall be free of any damage or faults in order to avoid notch effects. Should any burrs be present on a specimen, remove them without damaging the surface. If necessary, finish the edges of the machined surfaces with sandpaper. When it is necessary to machine the sheet to reduce the thickness for a particular test, leave one original surface intact.

7.1.3 Conditioning and testing of specimens

Unless otherwise specified in Clause 6 or hereafter, carry out testing in one of the standard atmospheres specified in ISO 291, after conditioning the specimens for at least 16 h in the same atmosphere. However, it is not applicable for appearance inspection and dimensions measurement.

7.2 Appearance examination

Examine the original and cut surfaces with the naked eye, from a distance of 60 cm, for noticeable flaws, cracks, mottling, voids, bubbles, impurities and other defects, inspecting the sheet in the direction opposite to that of the incident light. Ultrasonic or X-ray examination may also be used to detect voids.

7.3 Dimensions

7.3.1 Measure the length, width and diagonals of the sheet to the nearest 1 mm, using a calibrated ruler or tape measure. For dimension measurement, 23 °C shall be the standard. When measurement is performed at any other temperature (t °C) than 23 °C, the value converted to 23 °C by using Formula (3) shall be adopted.

$$L_{23} = L / \left[1 + 7 \times 10^{-5} \times (t - 23) \right] \tag{3}$$

where

L_{23} is the length or width converted to 23 °C (mm);

t is the temperature at the time of measurement (°C);

L is the length or width measured at t °C (mm);

7×10^{-5} is the linear expansion coefficient of sheet (1/°C).

7.3.2 Measure the thickness to the nearest 0,01 mm, using a calibrated thickness gauge.

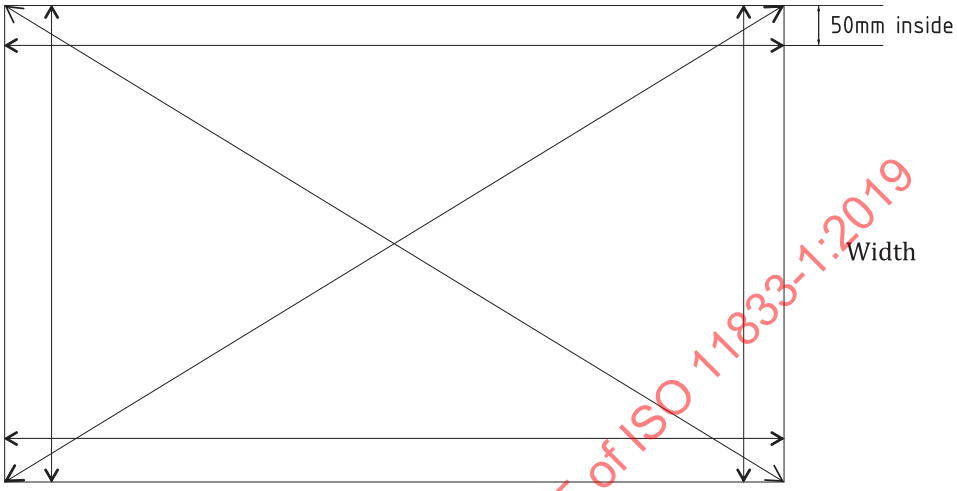
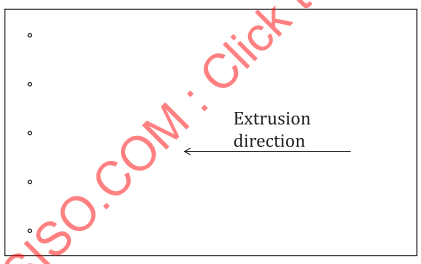
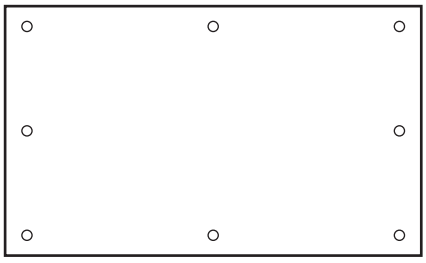
7.3.3 Frequency of measurement and measurement positions.

The frequency of dimensional measurements of the sheet and measurement positions shall be as shown in Table 7.

Table 7 — Frequency and measurement positions of appearance tests and dimensional measurements

Frequency and positions	Extruded sheet (E)	Pressed sheet (P)
Frequency of appearance tests and dimensional measurement	Take at least one specimen from each lot consisting of manufactured products of the same size.	Take at least one specimen from each lot consisting of continuously cut products of the same size.

Table 7 *(continued)*

Frequency and positions	Extruded sheet (E)	Pressed sheet (P)
Measurement positions of length, width and rectangularity	At four arrows 50 mm inside from each edge and at two diagonal lines drawn from four corners.  	
Measurement positions of thickness	At five points positioned not less than 10 mm but not more than 50 mm inside from the edge of the sheet: two points at ends, one at the centre, and the two intermediate points between the end points and the centre point.  	At eight points positioned not less than 10 mm but not more than 50 mm inside from the edge of the sheet: four corner points and the centre point of each of the four sides. 

7.4 Mechanical properties

7.4.1 Tensile stress at yield and nominal strain at break

Determine the tensile stress at yield and the nominal strain at break in accordance with ISO 527-2, using at least five type 1B specimens for each direction and a test speed of 50 mm/min. Express the result with the average of measurements of longitudinal specimens and that of orthogonal specimens, respectively.

7.4.2 Modulus of elasticity in tension

Determine the modulus of elasticity in tension in accordance with ISO 527-2, using at least three type 1B specimens for each direction and a test speed of 1 mm/min. Express the result with the average of measurements of longitudinal specimens and that of orthogonal specimens, respectively.

7.4.3 Charpy impact strength of notched specimens

For nominal thicknesses ≥ 4 mm, determine the Charpy impact strength of notched specimens in accordance with ISO 179-1, using at least 10 type 1epA specimens cut out in the extrusion direction and at least 10 cut out in the transverse direction. Machine direction (MD) and transverse direction (TD) shall be expressed by the average value of each test pieces. Testing of sheets with a thickness between 1,0 mm and <4,0 mm shall be subject between the interested parties.

7.5 Thermal properties

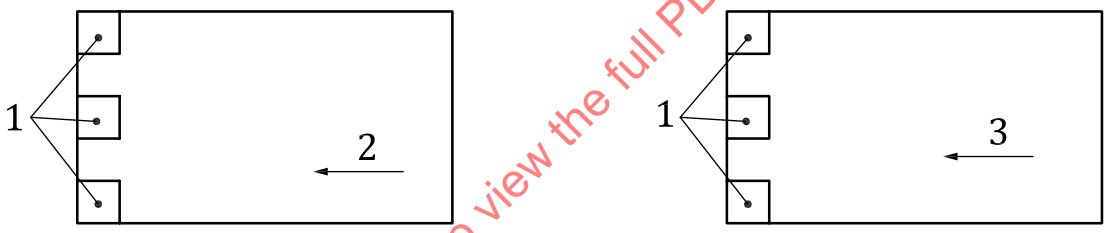
7.5.1 Vicat softening temperature

Determine the Vicat softening temperature in accordance with ISO 306:2013, method B50. Testing of sheets with a thickness between 1,0 mm and <1,5 mm shall be subject between the interested parties.

7.5.2 Dimensional change on heating and resistance to delamination

7.5.2.1 Specimens

Cut out at least three specimens measuring 120 mm · 120 mm at the locations in the sample sheet shown in Figure 2.



a) Extruded sheet **b) Pressed sheet**

Key

1 specimens
2 direction of extrusion
3 direction of calendering of sublayers

Figure 2 — Locations of specimens

Mark straight lines of length 100 mm ± 2 mm on the specimens in the longitudinal (extrusion or calendering) and transverse directions at a minimum of two places as shown in Figure 3.

Dimensions in millimetres

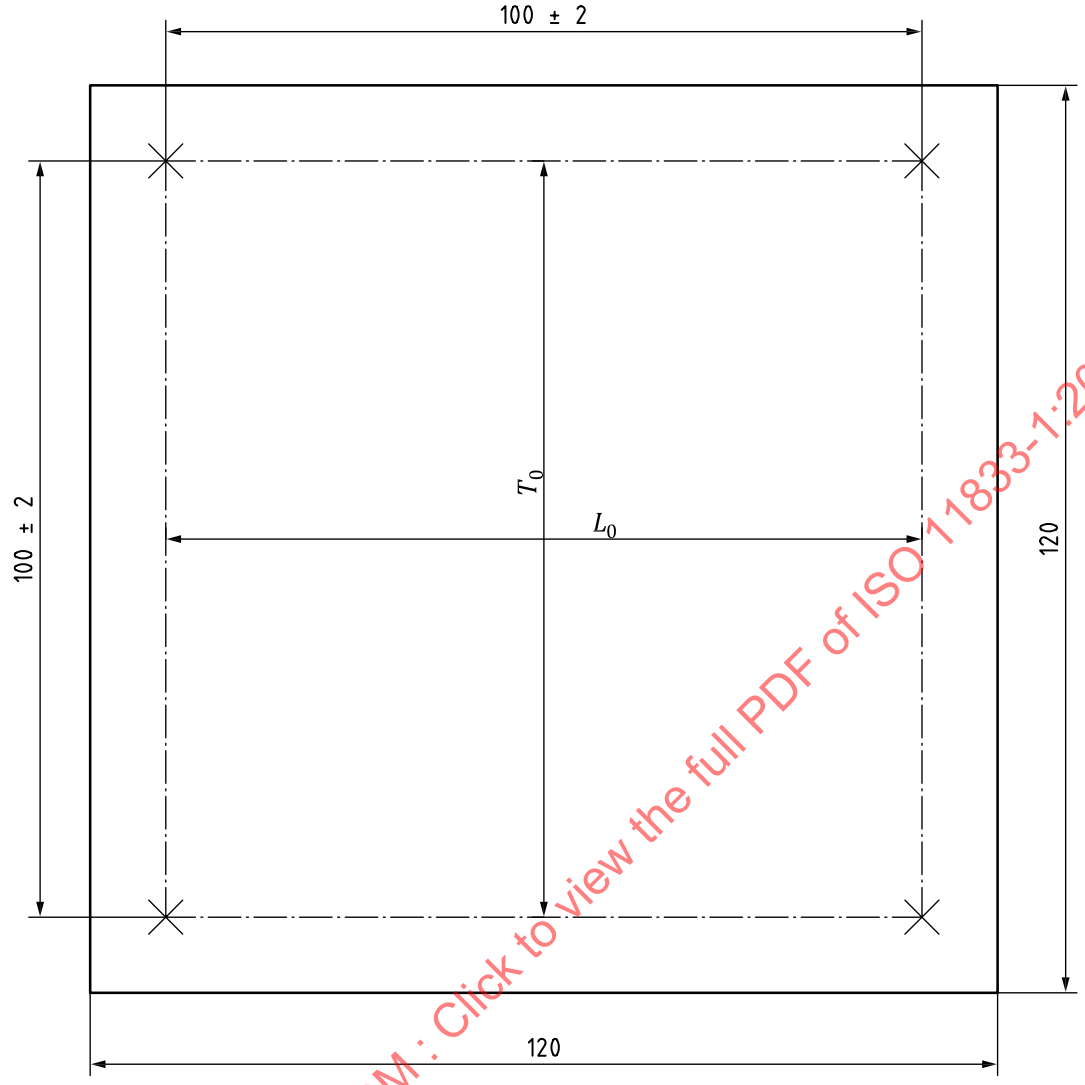


Figure 3 — Marking of specimens

7.5.2.2 Procedure

Heat the specimens in an oven at the temperature and for the time specified in Table 8.

Table 8 — Temperature and duration of heating

Nominal sheet thickness, d_n mm	**Temperature** °C	**Heating time** min
$1 \le d_n \le 2$	140 ± 2	30 ± 1
$2 < d_n \le 4$		45 ± 1
$4 < d_n \le 6$		55 ± 1
$6 < d_n \le 10$		75 ± 1
$10 < d_n \le 30$		90 ± 2
$d_n > 30$		120 ± 5
NOTE Heating time means the residence time at the test temperature used.		

Remove the specimens from the oven and allow them to cool to room temperature. Measure the lengths L and T of the marked lines and calculate the change ΔL and ΔT in each, in percent, using Formulae (4) to (5):

$$\Delta L = \frac{L - L_0}{L_0} \times 100 \tag{4}$$

$$\Delta T = \frac{T - T_0}{T_0} \times 100 \tag{5}$$

where

L_0 is the length of the line in the longitudinal direction prior to heating, expressed in millimetres (100 mm ± 2 mm);

L is the length of the line in the longitudinal direction after heating, expressed in millimetres;

T_0 is the length of the line in the transverse direction prior to heating, expressed in millimetres (100 mm ± 2 mm);

T is the length of the line in the transverse direction after heating, expressed in millimetres.

Calculate the arithmetic average of ΔL and ΔT and report.

Examine the original and cut surfaces of pressed sheets with the naked eye for delamination.

7.5.2.3 Resistance to delamination of pressed sheets

The resistance to delamination of pressed sheets may be determined using a wedge (see Annex A) and the resistance of sheets thicker than 20 mm may also be determined using thermal bending, as required (see Annex B).

7.6 Total luminous transmittance

Determine the total luminous transmittance of colourless transparent sheets in accordance with ISO 13468-1.

7.7 Other mechanical and physical properties

7.7.1 Charpy impact strength of unnotched specimens

Determine the Charpy impact strength of unnotched specimens in accordance with ISO 179-1 at 0 °C or −20 °C with a pendulum impact testing machine, using a pendulum of energy 4 J and at least 10 ISO 179-1/1eU (edgewise, unnotched) specimens cut out in each direction.

7.7.2 Temperature of deflection under load

Determine the temperature of deflection under load in accordance with ISO 75-2:2013, method A.

7.7.3 Creep modulus

Determine the flexural creep modulus in accordance with ISO 899-2 under a stress of 5 MPa, at 40 °C and after 10 h, 100 h and 1 000 h.

7.7.4 Density

Determine the density of the sheet in accordance with ISO 1183-1 or ISO 1183-2.

7.7.5 Flexural strength

Determine the flexural strength in accordance with ISO 178.

7.7.6 Ball indentation hardness

Determine the ball indentation hardness in accordance with ISO 2039-1.

7.7.7 Volume resistivity

Determine the volume resistivity in accordance with IEC 60093.

8 Marking

The following information shall be marked on each package of sheets:

a) the number of this document, the material and the product designation, as shown below:

ISO 11833-1 — PVC-U — E or P — T_1 or T_2 — 1,2,3,4 or 5 — A or B:

- PVC-U: material
- E or P: Extruded or Pressed
- T_1 or T_2: Tolerance on thickness
- 1,2,3,4 or 5: Group
- A or B: Total luminous transmittance class

b) the dimensions;

c) the manufacturer's name and country, and the year and month of manufacture or lot number.