INTERNATIONAL STANDARD

ISO 1268-5

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Fibre-reinforced plastics — Methods of producing test plates —

Part 5: Filament winding

Plastiques renforcés de fibres — Méthodes de fabrication de plaques d'essai —

Partie 5: Moulage par enroulement filamentaire

Reference number
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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 3.

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 part of ISO 1268 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 1268-5 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 13, *Composites and reinforcement fibres*.

This first edition cancels and replaces ISO 9291:1996, which has been technically revised.

ISO 1268 consists of the following parts, under the general title *Fibre-reinforced plastics — Methods of producing test plates*:

— *Part 1: General conditions*

— *Part 2: Contact and spray-up moulding*

— *Part 3: Wet compression moulding*

— *Part 4: Moulding of prepregs*

— *Part 5: Filament winding*

— *Part 6: Pultrusion moulding*

— *Part 7: Resin transfer moulding*

— *Part 8: Compression moulding of SMC and BMC*

— *Part 9: Moulding of GMT/STC*

The following additional parts are in preparation:

— *Part 10: Injection moulding of SMC and BMC — General principles and moulding of multipurpose test specimens*

— *Part 11: Injection moulding of SMC and BMC — Small plates*

Annexes A and B of this part of ISO 1268 are for information only.

Fibre-reinforced plastics — Methods of producing test plates —

Part 5:
Filament winding

1 Scope

This part of ISO 1268 specifies a method of preparing reinforced-plastic test plates by the filament winding process, using textile glass rovings and themoset resins (preimpregnated fibres are excluded).

It specifies the preparation, under optimum industrial conditions, of unidirectionally reinforced plates, from which test specimens for various static mechanical tests can be cut.

This part of ISO 1268 has been established for glass-reinforced plastics made of polyester or epoxy resin, but it can be extended to other types of resin and reinforcement.

It is intended to be read in conjunction with ISO 1268-1.

NOTE To aid understanding of the method, the word “roving” is used throughout the text and is taken to include yarns, unless specifically mentioned to the contrary.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 1268. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 1268 are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1268-1, *Fibre-reinforced plastics — Methods of producing test plates — Part 1: General conditions*.

3 Health and safety

See ISO 1268-1.

4 Principle

A roving (or a number of rovings together) impregnated with resin is wound, in several successive layers, onto a former.

The required final thickness of the plates is obtained by strapping outer-mould pieces onto the former. Polymerization can be carried out either in a press with heated platens or in an oven.

This method leads to the preparation of two similar plates simultaneously.

5 Materials

5.1 Roving

This method applies to all rovings having a linear density between 200 tex and 4 800 tex. For lower linear densities, use several rovings in combination to reach a linear density between 200 tex and 4 800 tex (for example, 10 yarns of 22 tex to obtain 220 tex).

5.2 Resin system

It is recommended that the resin system used (polyester or epoxy resin + catalyst or hardener system) has the following characteristics:

— viscosity: less than 0,4 Pa · s at the winding temperature;

— minimum pot life: the minimum pot life of the resin system at the operating temperature should be such that the increase in viscosity of the resin at the end of the winding operation is less than 40 % of the initial value.

If a resin system that does not have the above characteristics is chosen, the viscosity and minimum pot life of the resin system used shall be stated in the test plate preparation report (clause 11).

6 Plate dimensions

The minimum dimensions of the plates produced are 300 mm in length and 220 mm in width.

7 Reinforcement content

The glass content shall be specified by the person requesting the plate. The glass content of this type of laminate is typically 70 % by mass.

NOTE A glass content of 70 % by mass corresponds to 52 % by volume.

8 Apparatus

8.1 Reel (optional)

The reel shall be fitted with a tension-regulating system permitting adjustment of the roving tension between 0 N and 15 N (tension measured before the roving enters the impregnating bath).

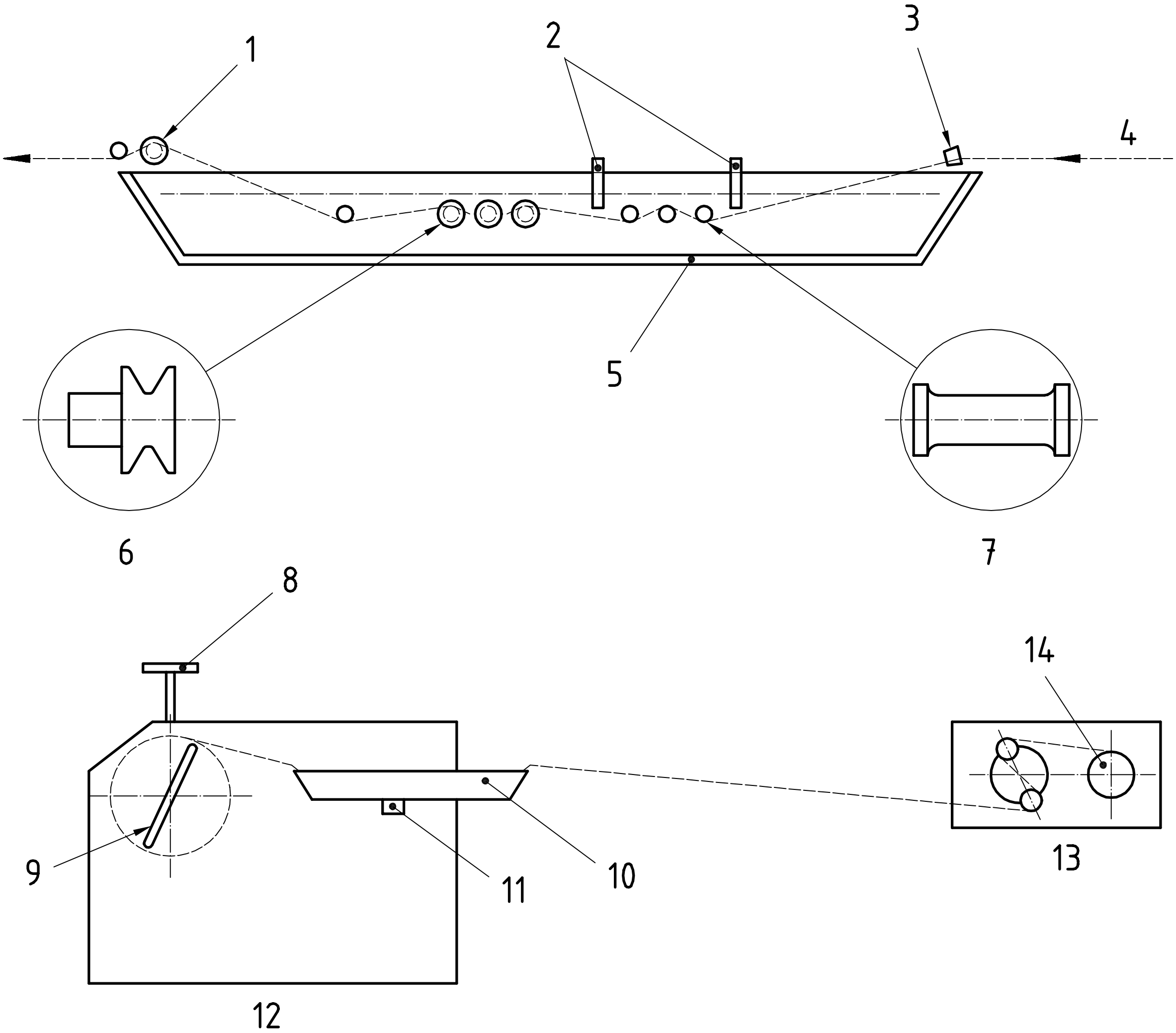
8.2 Winding machine (see Figure 1)

The winding machine shall have the following characteristics:

— speed of spindle: continuously variable from 0 r/min to 70 r/min;

— pitch: adjustable from 0,5 mm to 5 mm (the pitch is equal to the travel of the thread guide when the former makes a complete revolution);

— when necessary, a radiant panel permitting winding of the roving on to the former at a nearly constant temperature.



Key

1	Exit guide
2	Foam-retaining devices
3	Entrance guide (eye-type)
4	Roving
5	Impregnating bath with double wall
6	Grooved guide rod
7	Flat guide rod
8	Radiant panel
9	Former
10	Impregnating bath
11	Movable arm
12	Winding machine
13	Tension-regulating system
14	Roving bobbin or package

Figure 1 — Impregnating bath and winding machine

8.3 Impregnating devices

8.3.1 General

One of the impregnation devices described in 8.3.2 and 8.3.3 may be used. If a different system is used, details shall be given in the test plate preparation report (clause 11).

8.3.2 Impregnating bath (see Figure 1)

The temperature of the resin system in the bath shall be monitored to maintain its viscosity (see 5.2) as nearly constant as possible in order to ensure uniform and complete impregnation of the roving.

It is therefore recommended that the impregnating bath should have a double wall permitting the circulation of a temperature-regulating liquid, and that the dimensions of the bath allow an impregnation length of at least 400 mm and provide a resin capacity of about 1 l.

The type of bath shown in Figure 1 is given as an example. It is recommended that the bath have the following characteristics:

— an eye-type thread guide at the entrance to prevent abrasion (made of e.g. polytetrafluoroethylene or chromium-plated metal);

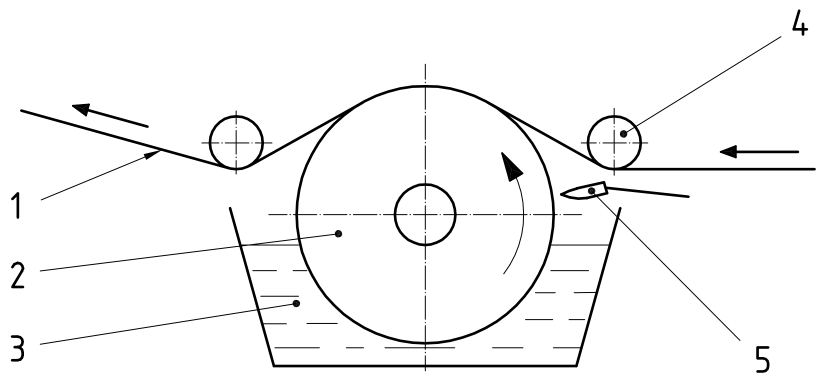
— a thread guide at the exit, ensuring complete impregnation without drying;

— devices for retaining resin foam;

— guide rods under the resin surface (alternating sets of flat and grooved).

8.3.3 Impregnating roller (see Figure 2)

The roller shall be corrosion- and wear-resistant. It shall be free-wheeling and have a minimum diameter of 120 mm. The length of the area of contact between the roving and the roller shall be not less than 20 % of the roller circumference, and the roller shall be immersed in the resin to a depth of approximately 20 % to 30 % of its diameter. A doctor blade shall be used to control the amount of resin on the roller. The distance between this blade and the roller shall be variable between 0 mm and 3 mm. The setting of this blade shall be determined by preliminary tests. A scraper blade shall be used to remove the resin the roving does not pick up.



Key

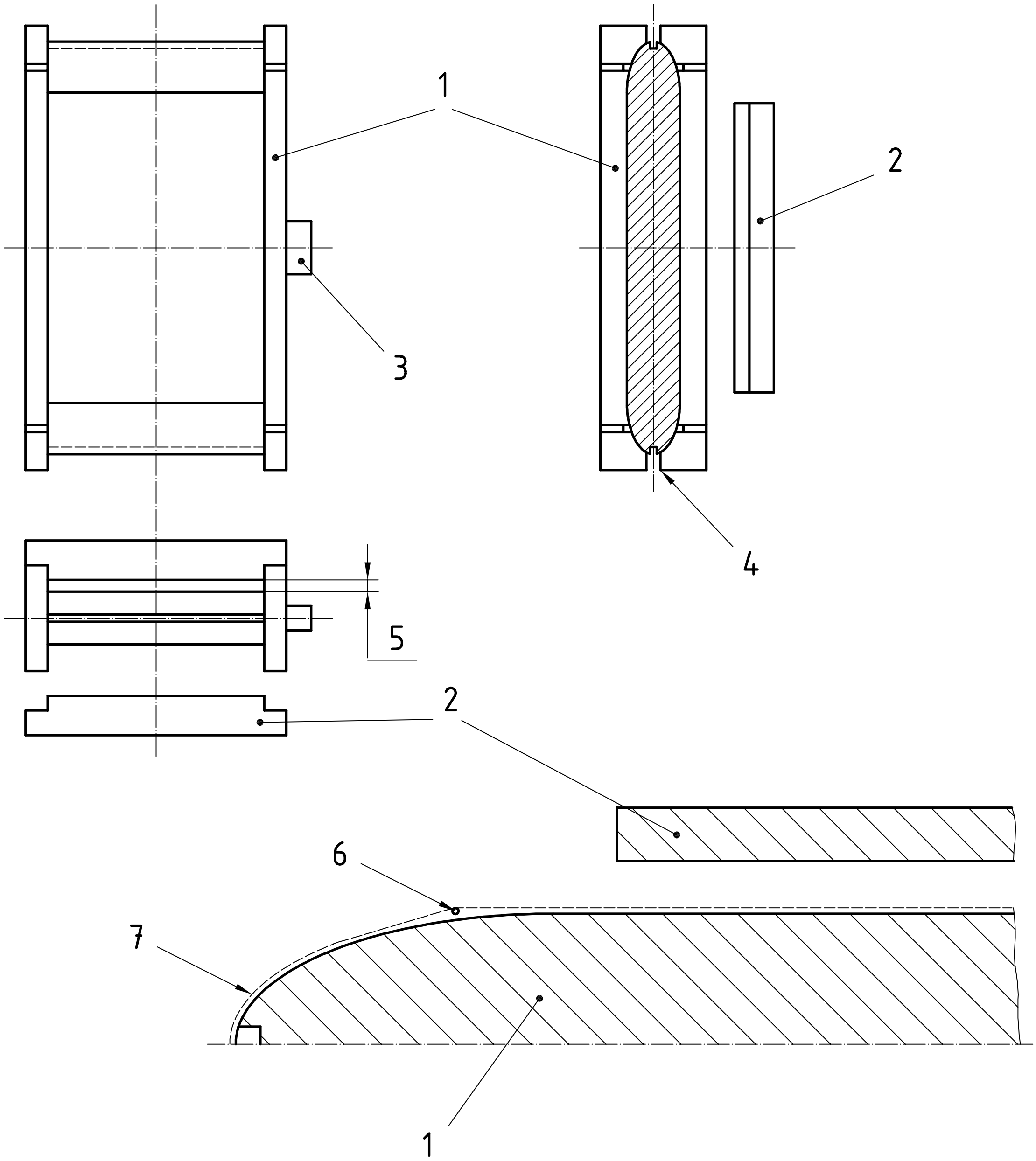
1 Roving
2 Roller
3 Resin
4 Guide
5 Doctor blade

Figure 2 — Impregnating roller

8.4 **Former** (see Figure 3)

This shall consist of a former frame, ground flat on both sides, onto which the roving is wound and outer-mould pieces designed to be placed over both faces of the winding and press onto the sides of the former, thus accurately defining the thickness of the winding. The faces of the outer-mould pieces shall be perfectly flat, and parallel to the former faces.

Rod-shaped silicone-rubber end pieces are required to seal the gap between the former and the outer-mould pieces and prevent resin loss during curing.



Key

1 Former frame
2 Outer-mould pieces
3 Spindle mounting
4 Notch
5 Thickness of winding
6 Silicone-rubber end piece
7 Roving

Figure 3 — Winding and curing former

8.5 Press with heated platens

The press shall have the following characteristics:

— minimum force: 20 kN;

— temperature adjustable according to the curing cycle required by the resin and its catalyst system.

If a press with heated platens is not available, the following may be used:

— a system for clamping the outer-mould pieces in place;

— an oven capable of maintaining the curing-cycle temperature required by the resin system.

9 Procedure

Unless otherwise specified, the rovings shall be processed without previous conditioning.

Mount the former on the spindle of the winding machine. When the impregnating bath has to be kept at a temperature higher than 50 °C, it is recommended that the former be maintained at as nearly constant a temperature as possible (by means of a radiant panel for example).

Adjust the speed of rotation of the spindle to obtain a roving speed of between 5 m/min and 15 m/min; the speed shall be selected such that the winding operation can be completed during the pot life of the resin (see 5.2).

Choose the winding parameters as follows:

— Winding pitch, p: 0,5 mm $< p <$ 4 mm

— Number of layers, n: 2 $\leqslant n \leqslant$ 12

See annex A for examples of convenient winding parameters and annex B for calculation if needed.

Place the roving bobbin(s) on the unwinding reel, if applicable.

Unwind a suitable length of roving by tangential or overhead take-off, feed it through the tension-regulating system, the guide rods in the bath and the thread guide, and attach it to the former.

By means of the tension-regulating system, adjust the tension in the roving to ensure the roving will be wound uniformly on the former.

Pour the resin system into the impregnating bath.

Maintain the temperature of the bath at the chosen temperature.

Coat the outer-mould pieces with a release agent which is stable at the operating temperature, or cover with a heat-resistant film.

If using a former without the notches that permit the winding to be cut off, fix to each end of the former a plastic rod to facilitate removal of the plates and to prevent damage to the former when cutting the winding.

Place the silicone-rubber end pieces at each end of the two sides of the former as shown in Figure 3. These rods are intended to keep the roving in tension during winding and to avoid any loss of resin at the mould closure. Their position and diameter shall be such that the part of the winding between them is flat.

Coat the outer-mould pieces with a thin layer of the resin system.

Wind a layer of roving. If necessary, remove the resin appearing on the surface with a flexible spatula or a roller. Repeat for each layer of winding.

When winding has been completed, fix the outer-mould pieces on the former (see Figure 3).

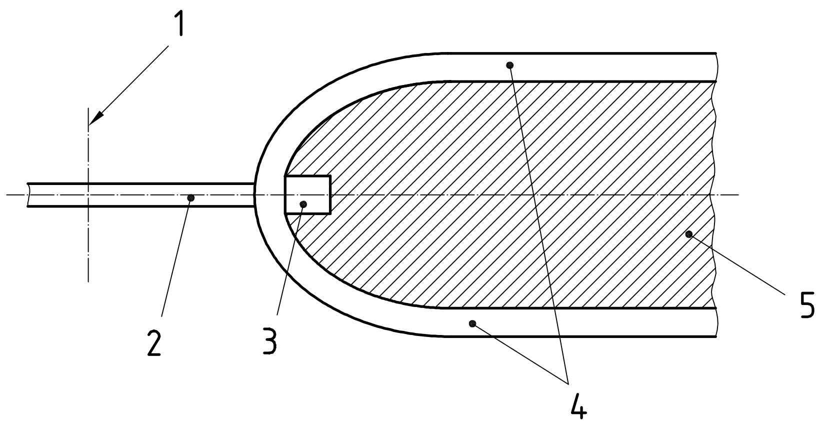
Place the assembly either between the hot platens of a press, or in an oven with the outer-mould pieces clamped in place.

Cure the moulding under the time and temperature conditions that are recommended for the resin system used.

Proceed to post-curing of the moulding (this may be done with or without the outer-mould pieces).

Allow to cool to room temperature.

Separate the plates by means of a saw as shown in Figure 4.



Key

1 Axis of rotation of circular saw
2 Blade of circular saw
3 Notch
4 Test plates
5 Former

Figure 4 — Removal of test plates from former

Trim the plates to length and width. To avoid edge damage, a diamond saw is recommended.

Test specimens intended for mechanical tests shall be taken from these plates and cut to the dimensions given in the appropriate test standards.

10 Verification of the characteristics of the plates obtained

10.1 Fibre content

See ISO 1268-1.

The fibre content shall not differ by more than 2 % from the specified value.

10.2 Void content

See ISO 1268-1.

10.3 Appearance and impregnation

After moulding, the visual appearance and quality of impregnation of the plates shall be investigated to confirm that the laminate is of suitable quality.

10.4 Dimensions of the plates

Measure the thickness, width and length of the plates.

11 Test plate preparation report

The test plate preparation report shall include the following information:

a) a reference to this part of ISO 1268;

b) the place and date of production of the test plates;

c) details of the number of layers and the winding pitch, in mm;

d) a description of the materials used (including type of reinforcement, type of resin, type of filler, if applicable, catalyst curing system, etc);

e) a description of the impregnating device used (bath, roller or other);

f) the operating conditions (resin system temperature, in °C, and the roving speed, in m/min);

g) whether a press or an oven was used;

h) the dimensions of the plates produced;

i) the fibre content and filler content, if applicable;

j) the quality of the test plates (appearance, impregnation);

k) any other information needed to reproduce the plates exactly;

l) any deviations from this part of ISO 1268.

Annex A
(informative)

Examples of winding parameters

Table A.1 gives parameters which lead to 3-mm-thick unidirectional plates having a final glass content near 70 % by mass when a resin of density 1,2 g/cm^3 is used.

The glass content can be increased by increasing the number of layers or by reducing the winding pitch, and decreased by following the opposite procedures.

Table A.1

			Calculated parameters		Alternative parameters for even number of layers	
Linear density of roving	Number of rovings	Overall linear density	Number of layers	Winding pitch	Number of layers	Winding pitch
tex		tex		mm		mm
210	2	420	11	1,14	6	0,56
210	3	630	9	1,40	6	0,68
300	1	300	13	0,97	8	0,47
300	2	600	9	1,33	6	0,67
300	3	900	7	1,56	4	0,82
800	1	800	8	1,59	4	0,77
1 200	1	1 200	6	1,79	4	0,94
1 600	1	1 600	6	2,38	4	1,09
2 000	1	2 000	5	2,47	4	1,22
2 400	1	2 400	5	2,98	4	1,33
2 400	2	4 800	3	3,57	2	1,89

Annex B
(informative)

Calculation of winding parameters for preparing unidirectional plates by winding

B.1 Number of layers

$$n = \sqrt{\frac{h^2 \times \rho \times \varphi \times 10}{\rho_l}}$$

where

n is the number of layers of winding;

ρ is the density of the glass, in grams/cubic centimetre;

φ is the glass content, expressed as a percentage by volume;

ρ_l is the linear density of the roving, in tex;

h is the thickness of the test plate, in millimetres.

The number of layers shall be a whole number. When necessary, round the result to the nearest whole number or the nearest even number.

B.2 Winding pitch

$$p = \frac{n \times \rho_l}{h \times 10 \times \rho \times \varphi}$$

where

p is the winding pitch in millimetres;

the other symbols are as defined in B.1.

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