INTERNATIONAL STANDARD

ISO 9291

First edition
1996-11-01

Textile-glass-reinforced plastics — Rovings — Preparation of unidirectional plates by winding

Plastiques renforcés de verre textile — Stratifils — Préparation de plaques unidirectionnelles par enroulement

Reference number
ISO 9291:1996(E)

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.

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.

International Standard ISO 9291 was prepared by Technical Committee ISO/TC 61, *Plastics,* Subcommittee SC 13, *Composites and reinforcement fibres.*

Annex A of this International Standard is for information only.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Introduction

Test specimens cut from unidirectional plates can be used to characterize the roving used; they can be used particularly for the determination of the properties listed in table 1.

Table 1 — Mechanical properties

Test	Property	Test method
3- and 4-point flexural tests	Longitudinal and transverse moduli of elasticity Longitudinal and transverse stresses	ISO 14125
Delamination	Breaking stress, by flexural rupture for example	ISO 4585
Impact (Charpy)	Impact strength	ISO 179
In tension	Longitudinal and transverse moduli of elasticity Longitudinal and transverse Poissons ratios Longitudinal and transverse stresses	ISO 527-4 ISO 527-5
In compression	Longitudinal and transverse moduli of elasticity Longitudinal and transverse stresses Longitudinal and transverse Poissons ratios	ISO 8515

When test specimens cut from such plates are not suitable for the test to be carried out, other ways of making test specimens may be used, such as that described in ISO 9163.

This page intentionally left blank

Textile-glass-reinforced plastics — Rovings — Preparation of unidirectional plates by winding

1 Scope

This International Standard describes the preparation, under optimum industrial conditions, of unidirectional reinforced plates from which test specimens for various static mechanical tests can be cut.

The standard was developed for glass-reinforced plastics made of polyester or epoxy resin, but it can be extended to other types of resin and reinforcement (see annex A).

The maximum dimensions of the plates that are made are approximately length 350 mm and width 220 mm. If these dimensions are exceeded, warping or cracking may occur.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 178:1993, *Plastics — Determination of flexural properties of rigid plastics.*

ISO 179:1993, *Plastics — Determination of Charpy impact strength.*

ISO 527-4:—[1], *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites.*

ISO 527-5:—[1], *Plastics — Determination of tensile properties — Part 5: Test conditions for unidirectional fibre-reinforced plastic composites.*

ISO 1144:1973, *Textiles — Universal system for designating linear density (Tex System).*

ISO 4585:1989, *Textile glass reinforced plastics — Determination of apparent interlaminar shear properties by short-beam test.*

ISO 8515:1991, *Textile-glass-reinforced plastics — Determination of compressive properties in the direction parallel to the plane of lamination.*

ISO 9163:1996, *Textile glass — Rovings — Manufacture of test specimens and determination of tensile strength of impregnated rovings.*

ISO 14125:—[1], *Fibre-reinforced plastic composites — Determination of flexural properties.*

3 Principle

A roving (or assembly of rovings) impregnated with resin is wound in several successive layers on to a former.

The final thickness of the winding is defined by placing flat lids over each face of the former. The winding is then cured either in a heated platen press or by heating in an oven with the lids clamped in place.

This method enables two similar plates to be prepared simultaneously.

1) To be published.

4 Apparatus

4.1 Reel, fitted with a tension-regulating system permitting the tension in the roving to be adjusted between 0 and 15 N (tension measured before the roving enters the impregnating bath).

4.2 Winding machine (see figure 1), with the following characteristics:

— speed of spindle: continuously variable from 0 to 70 rpm;

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

— (when necessary) a radiant panel permitting the roving to be wound on to the mandrel at a nearly constant temperature.

4.3 Impregnating bath (see figure 1), with a double wall permitting a temperature-regulating liquid to circulate, fitted with thread guides made of a material which will not abrade the roving (such as polytetrafluoroethylene or chromium-plated metal). The impregnating length is at least 400 mm, and the resin capacity is about 1 litre.

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;

— a thread guide at the exit, designed to ensure that the resin saturates the roving without squeezing any resin from the roving;

— resin foam retaining device;

— alternating flat and grooved guide rods.

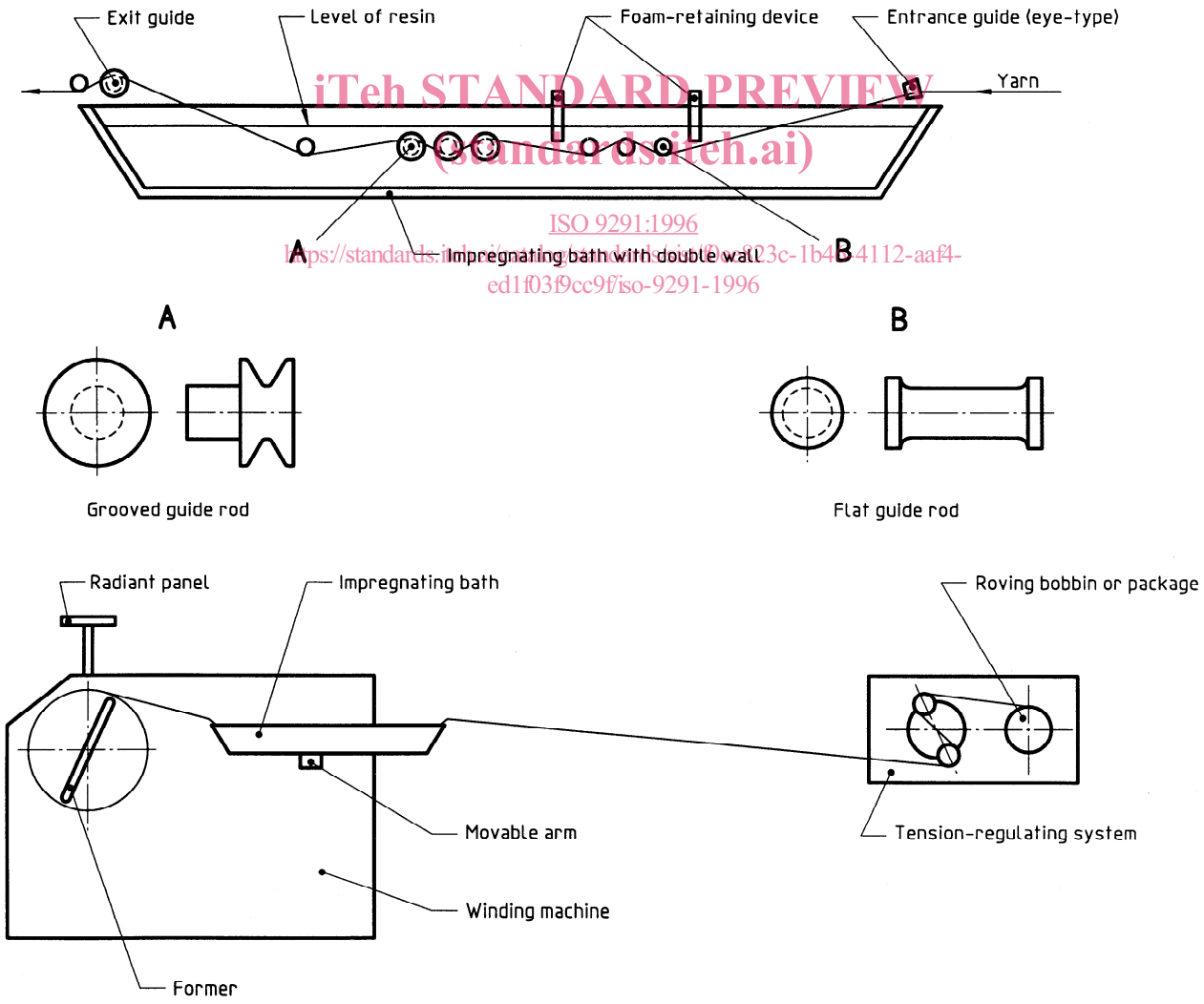

Figure 1 — Impregnating bath and winding machine

4.4 Former (see figure 2), consisting of a plate ground flat on which the roving is wound, plus two side-pieces on to which lids fit so that they cover each face of the plate, thus accurately defining the thickness of the winding. The faces of the lids shall be perfectly flat and shall be parallel to the mandrel faces.

4.5 Press with heated platens, having the following characteristics:

— minimum force: 20 kN;

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

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

— a system for clamping the lids in place;

— an oven capable of producing the curing temperature required by the resin and its catalyst system.

5 Impregnating system

Choose an impregnating system (polyester or epoxy resin + catalyst system), having the following characteristics:

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

— minimum elongation at break for the cured resin: 4 %;

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

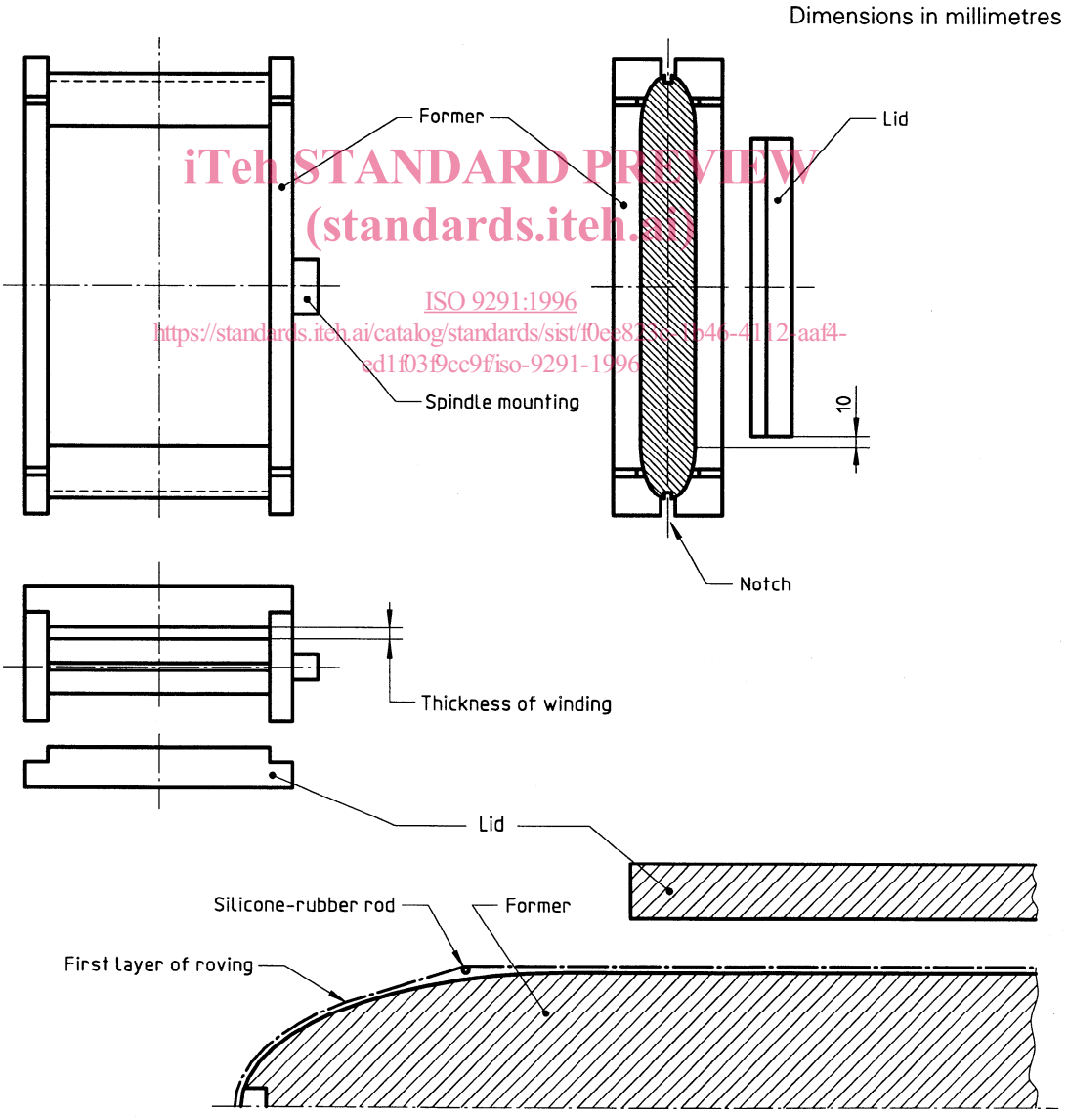

Figure 2 — Yarn winding and curing former

6 Procedure

Unless otherwise specified, process the rovings without previous conditioning.

Fix the former (4.4) on to the spindle of the winding machine (4.2).

When impregnating with an epoxy resin, keep the mandrel at a constant temperature by means of a radiant panel. The temperature used will depend on the viscosity of the resin; keep it constant to ± 5 °C.

Adjust the speed of rotation of the spindle to a value between 0 and 65 r/min, depending on the winding time selected and the parameters of the plates to be made (when necessary, calculate the speed as described in clause A.3).

This method applies to all rovings having a linear density between 220 tex and 4 800 tex. For lower linear densities, use several rovings to reach the minimum value of 220 tex (for example 10 rovings of 22 tex each).

Choose the winding parameters as follows:

— winding pitch: 0,5 mm $< p <$ 4 mm

— number of layers: 3m $\leqslant$ N $\leqslant$ 13

Table 2 gives examples of winding parameters which give plates having a final glass content of 70 % by mass (i.e. 52 % by volume) when using a resin of density 1,2 g/cm^3.

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.

Place the roving bobbin(s) on the unwinding reel (4.1).

Pass the free end(s) of the roving(s) from the reel to the former through the tension-regulating system, over the guide rods in the bath (4.3) and through the thread guide.

Adjust the tension-regulating system to give a tension in the roving of 3×10^{-2} N/tex (see ISO 1144).

Pour the impregnating system into the bath.

Maintain the temperature of the bath at the chosen temperature.

Coat the faces of the former with a release agent stable at the working temperature.

When using a former without any notches to permit the winding to be cut off, fix silicone-rubber rods to each end of the former to facilitate removal of the plates and to prevent damage to the former when cutting the winding.

Place the rods at each end of the two faces of the former as shown in figure 2. These rods are intended to keep the roving in tension during the winding operation. The rods shall be of a diameter such that the first layer of roving just touches the surface of the former.

Coat the former with a thin layer of the impregnating system to be used.

Wind a layer of roving.

Stop the winding machine.

Using a flexible spatula, remove the resin which has appeared on the surface. Recoat with fresh (non-emulsified) resin.

Table 2 — Recommended winding parameters

Linear density of roving tex	Number of rovings	Total linear density tex	Number of layers	Winding pitch mm
210	2	420	11	1,14
210	3	630	9	1,40
300	1	300	13	0,97
300	2	600	9	1,33
300	3	900	7	1,56
800	1	800	8	1,59
1 200	1	1 200	6	1,79
1 600	1	1 600	6	2,38
2 000	1	2 000	5	2,47
2 400	1	2 400	5	2,98
2 400	2	4 800	3	3,57

Repeat the last three operations for each layer if the number of layers is equal to or less than 4, and for every other layer if the number exceeds 4.

When winding has been completed, place the lids over the former (see figure 2).

Place the assembly either between the hot platens of the press (4.5), or, with clamps in place, into an oven.

When curing is complete, withdraw the assembly from the press or oven.

Allow the assembly to cool to room temperature without removing the lids (to avoid thermal shock).

Remove the lids.

Separate the wound plates by means of a saw as shown in figure 3.

Trim the plates to a length of 350 mm by means of an unnotched diamond saw.

Test specimens intended for mechanical tests shall be taken from these plates and cut to the dimensions given in the appropriate test standards. All cuts shall be made with an unnotched saw.

7 Report

The report shall contain the following information:

a) a reference to this International Standard;

b) details of the roving used;

c) the resin and catalyst system used;

d) the temperature of the impregnating bath;

e) the number of roving layers;

f) the curing cycle;

g) the thickness of the plate;

h) the glass content by mass;

i) details of any operations not specified in this International Standard, and any incidents that might have affected the properties of the plates;

j) the date of preparation.

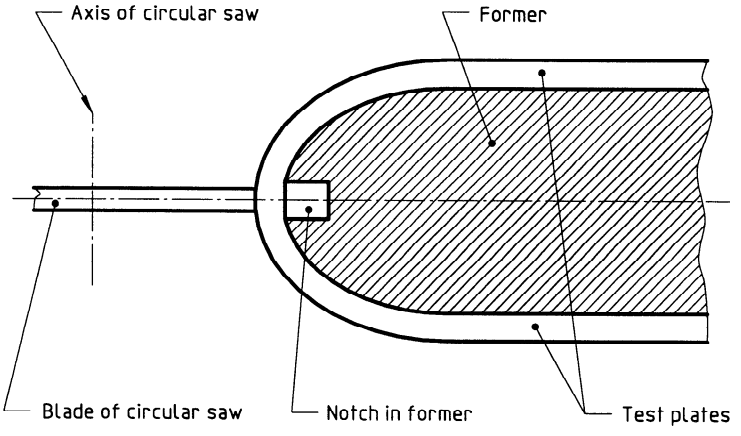

Figure 3 — Removal of test plates from former