INTERNATIONAL STANDARD

**ISO 1268-7**

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# Fibre-reinforced plastics — Methods of producing test plates —

## Part 7: Resin transfer moulding

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

*Partie 7: Moulage par transfert de résine*



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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 1268-7 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 13, *Composites and reinforcement fibres*.

Together with the other parts (see below), this part of ISO 1268 cancels and replaces ISO 1268:1974, 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*

# Fibre-reinforced plastics — Methods of producing test plates —

# Part 7: Resin transfer moulding

## 1 Scope

This part of ISO 1268 specifies a method of preparing reinforced-plastic test plates by resin transfer moulding (RTM). It is intended to be read in conjunction with ISO 1268-1.

## 2 Normative references

The following normative documents contain 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 editions of the normative documents 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 1172:1996, *Textile-glass-reinforced plastics — Prepregs, moulding compounds and laminates — Determination of the textile-glass and mineral-filler content Calcination methods*.



ISO 1183 (all parts), *Plastics — Methods for determining the density of non-cellular plastics*.

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

ISO 7822:1990, *Textile glass reinforced plastics — Determination of void content — Loss on ignition, mechanical disintegration and statistical counting methods*.

ISO 11357-2:1999, *Plastics — Differential scanning calorimetry (DSC) — Part 2: Determination of glass transition temperature*.

ISO 11357-5:1999, *Plastics — Differential scanning calorimetry (DSC) — Part 5: Determination of characteristic reaction-curve temperatures and times, enthalpy of reaction and degree of conversion*.

## 3 Health and safety

See ISO 1268-1.

## 4 Principle

Resin transfer moulding (RTM) is a low-pressure fabrication method carried out in a closed mould. The fibre reinforcement may be preformed. The reinforcement is placed in the cavity of the mould and the mould is closed. The resin system is injected into the cavity to impregnate the reinforcement. Subsequently, the resin is cured to form a composite plate. The procedure can be modifed, for instance by applying a vacuum to extract the air prior to resin injection, heating the resin to reduce its viscosity and curing time or, when the resin is a highly reactive one, introducing the resin and hardener separately, using two pumps, into a mixing chamber and then into the mould.

## 5 Materials

### 5.1 Reinforcement

Reinforcement fibres, such as glass, carbon, aramid, etc., in the form of mats (chopped-strand or continuous-strand mats), chopped rovings, woven fabrics, knitted fabrics, braids, unidirectional reinforcements and combinations thereof can be used.

The reinforcement may be preshaped into a preform in such a way that it retains its shape. Preforms can be fabricated by spraying binder on to the assembled reinforcement and subsequently heat-setting. Alternatively, ordinary reinforcements can be converted into preforms by sewing, stitching or knitting them together using auxiliary yarns.

The reinforcement shall be such that it can be easily placed in the mould cavity and impregnated with resin. Injection of the resin shall not cause the reinforcement to move.

### 5.2 Resin

The viscosity and cure characteristics of the resin shall be such that the mould cavity is properly filled and the reinforcement properly wetted prior to curing.

## 6 Plate dimensions



The length and width of the plate produced shall be large enough to yield test specimens of the correct size for testing. The size of the test specimens shall conform to the relevant International Standards. A length and a width of 300 mm are recommended. The thickness shall be 1 mm to 4 mm. Plates over 4 mm thick are generally not suitable for use in the determination of mechanical properties.



## 7 Reinforcement content

For randomly oriented products, it is recommended that the fibre content be in the range 15 % to 30 % by volume.

For woven products, the recommended range is 35 % to 55 % by volume.

For unidirectional products, the recommended range is 40 % to 60 % by volume.

## 8 Apparatus

**8.1 Mould**, made of steel, aluminium or fibre-reinforced plastic, and composed of a male mould plate and a female mould plate with a cavity between them. An inlet for the resin and an outlet for the air (optional) are provided on the mould. The mould shall be fitted with bolts or other secure fasteners to enable it to be closed tightly. Rubber packing is usually placed between the mould plates. Temperature-measurement devices may also be inserted in the mould plates. The surfaces of the mould plates shall be coated with release agent.

**8.2 Press with heated platens**, the temperature of which can be controlled to within ± 5 °C and the pressure to within ± 20 kPa of the specified values.

**8.3 Air-circulation oven**, the temperature of which can be controlled to within ± 5 °C.

**8.4 Resin tanks**, the temperature of which can be regulated.

**8.5 Pump**, capable of transferring resin at 800 kPa maximum.

**8.6 Vacuum pump** or **vacuum source** (optional).

**8.7** **Flexible tubing**, to connect the mould with the resin pump or vacuum source.

**8.8** **Temperature and pressure control and recording equipment**.

## 9 Procedure

### 9.1 Preparation of preform

#### 9.1.1 Examples of methods of producing preforms

— Sheets of mat are cut and plied to shape in accordance with the instructions. A small amount of polymeric binder is applied. The stacked mat is then heated and compressed in a forming die.

— Reinforcement fibre is chopped and sprayed onto a rotating screen where they are kept in place by air suction. A small amount (2 % to 5 %) of polymeric binder is added to the stream of chopped reinforcement. The chopped reinforcement is then heated (sometimes in a forming die). Continuous fibres and/or woven fabrics may be added to the random-fibre mats produced in the previous method before heat-setting.

— Sheets of woven fabric are cut and stacked in a predetermined orientation. The stacked fabrics are sewn, stitched or knitted together using auxiliary yarns made, for instance, of polyamide, polyester, aramid, glass or carbon fibre. Unidirectional fabrics are used to provide preforms for high-fibre-content plates.

— Three-dimensional fabrics of a shape specific to a particular moulding are prepared by weaving, knitting or braiding.

**9.1.2** The mass per surface area of the preform shall be such that the plates produced have the required fibre content by volume.



**9.1.3** The preform design shall be such that it matches the shape of the mould and correct alignment of the fibres is maintained.



### 9.2 Resin injection and cure

**9.2.1** Depending on the nature of the resin and reinforcement, different procedures may be required, examples of which are given in 9.2.2 to 9.2.4.

**9.2.2** Place the reinforcement in the cavity of the mould. Close the mould and clamp it shut with the bolts or other secure fasteners. Connect the mould to the resin pump and resin tank with flexible tubing. Inject resin into the cavity by means of the pump. When the cavity is full, place the mould between the heated platens of a press or in a hot-air oven to cure the resin.

**9.2.3** Place the reinforcement in the cavity of the mould, close the mould and clamp it shut. Connect the mould to a vacuum pump, and to the resin pump and resin tank, with flexible tubing. Apply a vacuum to extract the air. Transfer resin from the resin tank to the cavity through the tubing under atmospheric pressure, or slightly higher than atmospheric pressure, by means of the resin pump.

**9.2.4** The injection-moulding process can also be used with highly reactive resins. Place the preform in the mould cavity, close the mould and clamp it shut. Inject the resin and hardener from two separate tanks into a mixing chamber and then inject the mixture into the mould. In this method, the flow rate of the resin has to be high, which can cause movement of the reinforcement in the cavity. It is recommended that a check be carried out to ensure that the reinforcement does not move during injection.

**9.2.5** For all methods, record the temperature, pressure, duration under pressure and cure time.

### 9.3 Stabilization

On completion of curing, open the mould and remove the test plate. When required by the material specification or the manufacturing method, the plate shall be postcured. Unless otherwise specified, it is recommended that all plates

be conditioned for 48 h in the atmosphere of the test laboratory before cutting out test specimens. It is also recommended that at least 15 mm be discarded from the plate edges since the fibre content and fibre alignment is likely to be non-representative in this area.

## 10 Verification of the characteristics of the plate obtained

### 10.1 General

The plate obtained shall be examined prior to cutting out the test specimens. The criteria used for acceptance or rejection of a plate shall be as given in the material specification or as agreed between the interested parties, taking into account the requirements given in 10.2 to 10.7.

### 10.2 Fibre content

The fibre content shall be determined in accordance with ISO 1172 for glass-reinforced plastics and by a method agreed between the interested parties for carbon-reinforced plastics.

NOTE The mass of the plate and that of the preform give a rough idea as to whether the fibre content of the plate is acceptable or not.

### 10.3 Void content



Determine the void content of the plate by visual examination of a polished cross-section under a microscope (see ISO 7822), by ultrasonic scanning or by another suitable method.



### 10.4 Density



Determine the density by one of the methods given in ISO 1183.

### 10.5 Dimensions of the plate

Measure the thickness, width and length of the plate. Measure any bend or twist (or other distortion) of the plate as well. The location(s) at which the plate thickness was measured shall be stated in the test plate preparation report, together with the type of micrometer probe used (flat or hemispherical) and the diameter of the probe.

### 10.6 Degree of cure

If requested, determine the degree of cure using digital scanning calorimetry (DSC) to measure the glass-transition temperature (see ISO 11357-2) and/or the residual enthalpy (see ISO 11357-5).

### 10.7 Fibre alignment

If requested, measure the degree of misalignment of the reinforcement fibres. Misalignment is often observed when the resin injection rate is high.

## 11 Marking

The fibre content of the plate may vary from one face to the other. Flexural and interlaminar shear properties can be different depending whether a test specimen is loaded on the top face or the bottom face. It is recommended that each plate be marked so as to identify which face is which.

## 12 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 plate;

c) details of number of layers (plies), the stacking sequence and the orientation of the layers;

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 mould used;

f) the operating conditions (moulding pressure, moulding temperature, closing speed, etc.);

g) the thickness of the test plate produced, plus the location(s) at which the thickness was measured and details of the micrometer used (see 10.5);

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

i) the quality of the plate (appearance, impregnation);

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

k) any deviations from this part of ISO 1268.