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# Textile-glass-reinforced plastics — Sheet moulding compound (SMC) — Basis for a specification

*Plastiques renforcés au verre textile — Mats préimprégnés SMC — Base de spécification*

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

International Standard ISO 8605 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 13, *Composites and reinforcement fibres*.

This second edition cancels and replaces the first edition (ISO 8605:1989), in which the lists of methods for determining the properties of SMC have been revised.

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# Textile-glass-reinforced plastics — Sheet moulding compound (SMC) — Basis for a specification

## 1 Scope

This International Standard establishes a basis for a specification for sheet moulding compound (SMC) used in the production of composite parts by hot moulding.

It applies only to sheet moulding compound having glass fibres as the sole or main reinforcement.

It should be noted that the term sheet moulding compound covers products which can be complex mixtures and which may differ from the definition of "mat" given in ISO 472.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard 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 62:1999, *Plastics — Determination of water absorption.*

ISO 75-2:—[1)], *Plastics — Determination of temperature of deflection under load — Part 2: Plastics and ebonite*.

ISO 179-1:2000, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*.

ISO 179-2:1997, *Plastics — Determination of Charpy impact properties — Part 2: Instrumented impact test*.

ISO 180:2000, *Plastics — Determination of Izod impact strength*.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing*.

ISO 472:1999, *Plastics — Vocabulary*.

ISO 527-4:1997, *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites.*

ISO 1172:1996, *Textile-glass-reinforced plastics — Prepregs, moulding compounds and laminates — Determination of the textile-glass and mineral-filler content — Calcination methods.*

ISO 1183-1:—[2)], *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pyknometer method and titration method*.

1) To be published. (Revision of ISO 75-2:1993)

2) To be published. (Revision, in parts, of ISO 1183:1987)

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ISO 1183-2:—[3], *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method*.

ISO 1183-3:1999, *Plastics — Methods for determining the density of non-cellular plastics — Part 3: Gas pyknometer method*.

ISO 1268 (all parts), *Fibre-reinforced plastics — Methods of producing test plates*.

ISO 1886:1990, *Reinforcement fibres — Sampling plans applicable to received batches.*

ISO 2577:1984, *Plastics — Thermosetting moulding materials — Determination of shrinkage*.

ISO 3672-1:2000, *Plastics — Unsaturated-polyester resins (UP-R) — Part 1: Designation system*.

ISO 3673-1:1996, *Plastics — Epoxy resins — Part 1: Designation*.

ISO 9782:1993, *Plastics — Reinforced moulding compounds and prepregs — Determination of apparent volatile-matter content*.

ISO 10352:1997, *Fibre-reinforced plastics — Moulding compounds and prepregs — Determination of mass per unit area.*

ISO 11667:1997, *Fibre-reinforced plastics — Moulding compounds and prepregs — Determination of resin, reinforced-fibre and mineral-filler content — Dissolution methods*.

ISO 12114:1997, *Fibre-reinforced plastics — Thermosetting moulding compounds and prepregs — Determination of cure characteristics*.

ISO 12115:1997, *Fibre-reinforced plastics — Thermosetting moulding compounds and prepregs — Determination of flowability, maturation and shelf life*.

ISO 14125:1998, *Fibre-reinforced plastic composites — Determination of flexural properties.*

ISO 14126:1999, *Fibre-reinforced plastic composites — Determination of compressive properties in the in-plane direction.*

ISO 14130:1997, *Fibre-reinforced plastic composites — Determination of apparent interlaminar shear strength by short-beam method*.

IEC 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*.

IEC 60112:1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*.

IEC 60243 (all parts), *Electrical strength of insulating materials — Test methods*.

IEC 60250:1969, *Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths*.

IEC 60695-2-12:2000, *Fire hazard testing — Part 2-12: Glowing/hot-wire based test methods — Glow-wire flammability test method for materials*.

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3) To be published. (Revision, in parts, of ISO 1183:1987)


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## 3 Term and definition

For the purposes of this International Standard, the following term and definition apply.

**3.1**
**sheet moulding compound**
**SMC**
a homogeneous mixture of resin and chopped and/or unchopped reinforcement, with or without fillers, produced in sheet form in thicknesses generally between 1 mm and 25 mm, and capable of being cured by moulding under heat and pressure

NOTE Additives may be added to the mixture to obtain an SMC with specific properties.

## 4 Classification of SMC

### 4.1 General

A large number of combinations of resin systems, reinforcements, additives and fillers are necessary in order to manufacture a wide variety of different types of moulded part, each of which requires a well-defined composition to give it its particular

— shape;

— mechanical properties;

— electrical properties;

— surface finish.

In view of this large number of possible combinations, two systems of classification are proposed:

— the first one based on the composition;

— the second one based on the shrinkage.

### 4.2 Classification based on composition

#### 4.2.1 Resin (matrix)

Various types of resin can be used, such as:

— unsaturated-polyester resin (UP);

— epoxy resin (EP);

— polyurethane resin (PUR);

— vinyl ester resin (VE);

— phenolic resin (P).

For a description of the resin concerned, refer to the relevant International Standard (for polyester resins, see ISO 3672-1; for epoxy resins, see ISO 3673-1).

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### 4.2.2 Reinforcement(s)

#### 4.2.2.1 Form

Although this International Standard covers only glass reinforcements, other types may nevertheless be used together with the main (glass) reinforcement.

The glass reinforcement generally takes the form of chopped or unchopped strands, used alone or in combination with continuous yarns deposited in various ways, depending on the properties required for the parts to be produced from the SMC (e.g. continuous-strand mats, looped-strand mats).

#### 4.2.2.2 Strand length

With isotropic reinforcements produced using chopped strands, the length varies from one type of SMC to another (usually 25 mm and/or 50 mm). The length of the chopped strands shall be stated in the specification.

With directional reinforcements, the fibres may be continuous or discontinuous, with lengths varying between 10 cm and 40 cm. The orientation of these directional fibres is generally such that their ends are distributed in a homogeneous manner in a direction longitudinal to the sheet or to the roll of SMC (i.e. staggered).

#### 4.2.2.3 Proportion of reinforcement

Sheet moulding compound may contain between 15 % by mass and 70 % by mass of reinforcing material. The proportion of reinforcement shall be stated after the designation of the type of SMC.

### 4.2.3 Modes of reinforcement

#### 4.2.3.1 General

Depending on the length of the fibres (i.e. whether they are chopped or not) and their orientation, distinction can be made between the following types of SMC.

#### 4.2.3.2 **SMC-R** (R = random)

This type of SMC is produced using strands chopped and deposited without preferential orientation. This is the type called “standard”, which permits flow in all directions and has mechanical properties which are average and isotropic.

EXAMPLE SMC-R containing 40 % by mass of reinforcement is designated SMC-R40.

#### 4.2.3.3 **SMC-C** (C = continuous)

This is produced using a continuous reinforcement deposited with a roughly defined orientation.

The values of the mechanical properties in the direction of the reinforcement are distinctly higher than those in the other direction. The tendency to creep in the direction of the reinforcement is very slight, however.

In certain types of SMC, fabrics may be used as a continuous reinforcement. The mechanical properties and creep characteristics of the resulting laminate will depend on the structure of the fabric.

#### 4.2.3.4 **SMC-D** (D = directional)

This is produced from strands chopped to give fibres having a length greater than for SMC-R and deposited with a roughly defined orientation. SMC-D is in fact a compromise between SMC-R and SMC-C with regard to mechanical properties and creep.

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#### 4.2.3.5 Combinations of SMC-R with directional reinforcements

These combinations, which are more widely used than SMC-C or SMC-D, are designated SMC-C/R and SMC-D/R, respectively.

They give a moulded part in which the mechanical properties and creep characteristics are predominant in one direction in the laminate.

EXAMPLE SMC-C/R with 25 % by mass of isotropic reinforcement and 15 % by mass of unchopped directional reinforcement is designated SMC-C15/R25.

#### 4.2.3.6 SMC with looped-strand reinforcement

This is produced using a reinforcement consisting of either continuous-strand mat or continuous strands arranged in partly overlapping loops of specified dimensions. It could be designated SMC-FC as for SMC-C/R or D/R.

Chopped strands deposited without preferential orientation may be added to the principal continuous-strand mat reinforcement. This combination could be designated SMC-FC/R.

### 4.2.4 Fillers

Fillers are relatively inert, solid materials. They are used for specific reasons, such as:

— to improve the properties (e.g. fire behaviour, stiffness, mechanical strength) and to ensure that the properties are retained over a long period;

— to improve the surface finish;

— to reduce the cost of the moulding composition.

### 4.2.5 Additives

As well as the additives required for the actual manufacturing of the SMC as such (cure initiator, thickening agent, internal release agent), the following additives may be specified:

a) pigments: added in the form of a powder, paste or paste dispersion;

b) shrinkage modifiers: usually thermoplastic resins used for low-shrink, low-profile or Class A SMC (see 4.3);

c) other additives:

— fire-retarding agents;

— UV absorbers;

— crosslinking retarders (inhibitors);

— etc.

## 4.3 Classification based on shrinkage behaviour

### 4.3.1 General-purpose SMC

Designates products for which shrinkage during curing is between 0,2 % and 0,5 %.

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#### 4.3.2 Low-shrinkage SMC

Designates products for which shrinkage during curing is between 0,05 % and 0,2 %.

#### 4.3.3 Low-profile SMC

Designates products for which shrinkage during curing is less than 0,05 %.

#### 4.3.4 Class A SMC

Designates products for which shrinkage during curing is zero (with some formulations a slight expansion is possible).

The shrinkage will depend on the orientation and length of the reinforcing fibres. It will thus be different from one direction to another for SMC-C and SMC-D, as well as for SMC-C/R and SMC-D/R. In these cases, the maximum value of the shrinkage shall be used to classify the product. It will be lower in the case of SMC reinforced with looped-strand mat (SMC-FC).

NOTE With SMC, shrinkage is one of the major causes of sink marks on moulded parts with ribs or bosses.

## 5 Properties

### 5.1 General

The following list gives properties which may be specified, with tolerances, in the specification for a given sheet moulding compound.

### 5.2 Properties measured on SMC, as received

#### 5.2.1 Physical and chemical characteristics

NOTE For some of these properties, a suitable test method is not yet available as an International Standard. It is intended to add such methods at a later date.

— sheet dimensions;

— mass per unit area: ISO 10352;

— reinforcement and filler content: ISO 1172 or ISO 11667;

— fibre length;

— volatile-matter content: ISO 9782;

— reactivity: ISO 12114;

— mouldability: ISO 12115.

#### 5.2.2 Defects

The specification shall include all the information required to define the normal visual appearance of the SMC and to define acceptable defects.

The types of defect permitted, and the maximum number of each per unit mass, shall be defined in the specification or by agreement between the parties concerned.

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The following are usually considered as defects, either of the product itself or of the roll or other unit of manufacture:

— patches short of resin (dry spots caused by incomplete impregnation);

— patches with excess resin;

— contamination (foreign matter);

— colour heterogeneity;

— creases and wrinkles;

— tears, holes or cracks in the container or protective cover in which the product is packed.

## 5.3 Properties measured on moulded specimens

### 5.3.1 General

Specimens shall be prepared from flat plates manufactured in accordance with the relevant part of ISO 1268. In the case of anisotropic materials, the specification shall define the direction(s) in which properties are to be measured.

The following methods shall be used to measure the properties indicated.

### 5.3.2 Mechanical properties

— tensile strength, tensile elongation and tensile modulus of elasticity: ISO 527-4:1997, using type II test specimens [except for SMC with directionally oriented renforcements (SMC-C, SMC-D and combinations of SMC-C/R and D/R), for which type III specimens shall be used, and their width shall be equal to or greater than 20 mm in order to ensure that the dispersion of the results is acceptable];

— flexural strength and flexural modulus of elasticity: ISO 14125;

— impact strength (unnotched test specimen): ISO 179 or ISO 180;

— compression strength: ISO 14126;

— shear strength: ISO 14130;

— temperature of deflection under load: ISO 75-2:—, method A.

### 5.3.3 Physical properties

— density: the appropriate part of ISO 1183;

— moulding shrinkage: ISO 2577;

— surface roughness (using a profilometer);

— loss on ignition: ISO 1172;

— coefficient of thermal expansion: ISO 11359-2;

— moisture absorption: ISO 62:1999, method 1;

— fire hazard (glow-wire test): IEC 60695-2-12.

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