International Standard

ISO 8605

Fibre-reinforced plastics — Sheet moulding compound (SMC) — Requirements and specifications

Plastiques renforcés de fibres — Préimprégnés en feuille SMC — Exigences et spécifications

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Foreword

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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 document 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).

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

This third edition cancels and replaces the second edition (ISO 8605:2001), which has been technically revised.

The main changes are as follows:

— the title has been modified from "Textile-glass-reinforced plastics — Sheet moulding compound (SMC) — Basis for a specification" to " Fibre-reinforced plastics — Sheet moulding compound (SMC) — Requirements and specifications";

— fibre type and shrinkage code have been added;

— the designation of SMC has been added;

— test properties have been added;

— sampling position has been added.

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.

Fibre-reinforced plastics — Sheet moulding compound (SMC) — Requirements and specifications

1 Scope

This document establishes requirements and specifications for sheet moulding compound (SMC) used in the production of composite parts by hot moulding.

It is suitable for sheet moulding compound with glass fibres (GF) and carbon fibres (CF) as the sole or main reinforcement. Other fibre (e.g. natural fibre) reinforced sheet moulding compounds can also be used with this document.

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 62:2008, *Plastics — Determination of water absorption*

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

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

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

ISO 180, *Plastics — Determination of Izod impact strength*

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

ISO 472, *Plastics — Vocabulary*

ISO 527-4:2023, *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites*

ISO 1172, *Textile-glass-reinforced plastics — Prepregs, moulding compounds and laminates — Determination of the textile-glass and mineral-filler content using calcination methods*

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 1183-3, *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 2577, *Plastics — Thermosetting moulding materials — Determination of shrinkage*

ISO 4589-2, *Plastics — Determination of burning behaviour by oxygen index — Part 2: Ambient-temperature test*

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

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

ISO 11359-2, *Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

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

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

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

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

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

ISO 14127, *Carbon-fibre-reinforced composites — Determination of the resin, fibre and void contents*

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

ISO 17771, *Plastics — Thermoset moulding compounds — Determination of the degree of fibre wetting in SMC*

ISO 22821, *Carbon-fibre-reinforced composites — Determination of fibre weight content by thermogravimetry (TG)*

ISO 22836, *Fibre-reinforced composites — Method for accelerated moisture absorption and supersaturated conditioning by moisture using sealed pressure vessel*

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

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

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

IEC 60695-11-10, *Fire hazard testing — Part 11-10: Test flames — 50 W horizontal and vertical flame test methods*

IEC 61621, *Dry, solid insulating materials — Resistance test to high-voltage, low-current arc discharges*

IEC 62631-2-1, *Dielectric and resistive properties of solid insulating materials — Part 2-1: Relative permittivity and dissipation factor — Technical Frequencies (0,1 Hz - 10 MHz) — AC Methods*

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*

IEC 62631-3-2, *Dielectric and resistive properties of solid insulating materials — Part 3-2: Determination of resistive properties (DC methods) — Surface resistance and surface resistivity*

EN 1842, *Plastics — Thermoset moulding compounds (SMC - BMC) — Determination of compression moulding shrinkage*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
sheet moulding compound
SMC
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 1 to entry: Additives can be added to the mixture to obtain an SMC with specific properties.

Note 2 to entry: The term sheet moulding compound covers products which can be complex mixtures and which can differ from the definition of "mat" given in ISO 472.

4 Classification of SMC

4.1 General

A large number of combinations of resin systems, reinforcements, fillers and additives 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 (PU);

— vinyl ester resin (VE);

— phenolic resin (P).

For a description of the resin concerned, refer to the relevant International Standard (see ISO 3672-1 for unsaturated-polyester resins, ISO 3673-1 for epoxy resins, ISO 10082 for phenolic resins).

4.2.2 Reinforcement(s)

4.2.2.1 Form (type)

The reinforcements covered include glass fibres (GF), carbon fibres (CF) and natural fibres (NF), other fibre types can also be used. Reinforcements containing two or more reinforcing fibres are designated as hybrid fibres (HF).

The reinforcements generally take 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).

The type of glass fibre includes basalt fibre (BF), refer to ISO 2078. The type of carbon fibre includes recycled carbon fibre (RCF), and sheet moulding compound is a promising application field for recycled carbon fibre.

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 can be continuous or discontinuous. 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 mode of reinforcement. If the formulation contains recycled material, the proportion of recycled fibre shall be stated, some properties may be changing with recycled material contents more than 10 % by mass.

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 Sheet moulding compound-random (SMC-R)

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.

4.2.3.3 Sheet moulding compound-continuous (SMC-C)

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 Sheet moulding compound-directional (SMC-D)

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.

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.

4.2.3.6 SMC with looped-strand reinforcement

This type of SMC is produced using a reinforcement consisting of either continuous-strand mat or continuous strands arranged in partly overlapping loops of specified dimensions. It can 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 can 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 improve the dimensional stability;

— to adjust the viscosity of resin paste;

— to reduce the cost of the moulding composition.

4.2.5 Additives

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-shrinkage, 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 % in length. General-purpose SMC code is named as S_4.

4.3.2 Low-shrinkage SMC

Designates products for which shrinkage during curing is between 0,05 % and 0,2 % (contain) in length. Low-shrinkage SMC code is named as S_3.

4.3.3 Low-profile SMC

Designates products for which shrinkage during curing is less than 0,05 % in length. Low-profile SMC code is named as S_2.

4.3.4 Class A SMC

Designates products for which shrinkage during curing is close to zero (with some formulations a slight expansion is possible). Class A SMC code is named as S_1.

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 Designation of SMC

5.1 General

In order to facilitate the identification and use of SMC by interested parties, it is recommended that the designation be based on the following elements:

— Block 1: SMC code and reinforcement (mode, proportion, type);

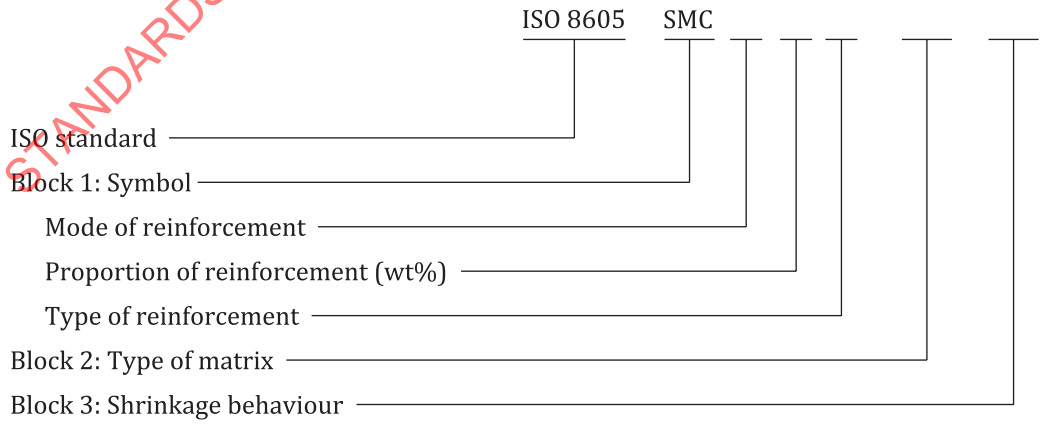
— Block 2: type of matrix;

— Block 3: shrinkage behaviour.

The designation system of EN 14598-1 can also be used with the agreement of the interested parties.

5.2 Examples of designations

The designation of SMC will give the following general form:



EXAMPLE 1

Basalt fibre reinforced unsaturated polyester resin sheet moulding compound, the mode of basalt fibre is random, the mass fraction of basalt fibre is 40 %, shrinkage during curing is 0,3 %.

Designation: ISO 8605-SMC-R40-BF, UP, S_4

EXAMPLE 2

Glass fibre reinforced epoxy resin sheet moulding compound, the mode of glass fibre is combinations of random and continuous, the mass fraction of random glass fibre is 25 % and the mass fraction of unchopped directional glass fibre is 15 %, shrinkage during curing is 0,04 %.

Designation: ISO 8605-SMC-C15/R25-GF, EP, S_2

EXAMPLE 3

Carbon fibre reinforced phenolic resin sheet moulding compound, the mode of carbon fibre is directional, the mass fraction of carbon fibre is 50 %, shrinkage during curing is 0,2 %.

Designation: ISO 8605-SMC-D50-CF, P, S_3

EXAMPLE 4

Hybrid fibre reinforced vinyl ester resin sheet moulding compound, the mode of hybrid fibre is random, the mass fraction of hybrid fibre is 30 %, the type of hybrid fibre is combinations of recycled carbon fibre and glass fibre, shrinkage during curing is 0,4 %.

Designation: ISO 8605-SMC-R30-RCF/GF, VE, S_4 or ISO 8605-SMC-R30-HF, VE, S_4

6 Properties

6.1 General

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

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.

6.2 Properties to describe SMC (for the acceptance test)

6.2.1 Physical and chemical characteristics

The following methods shall be used to describe physical and chemical characteristics:

— sheet dimensions;

— mass per unit area and fibre mass per unit area: ISO 10352;

— reinforcement content: ISO 11667, ISO 1172 (GF), ISO 14127 (CF) or ISO 22821 (CF);

— filler content: ISO 11667 or ISO 1172 (GF);

— fibre length;

— degree of fibre wetting in SMC: ISO 17771;

— volatile-matter content: ISO 9782;

— reactivity: ISO 12114;

— mouldability: ISO 12115.

6.2.2 Appearance

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.

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.

6.3 Properties to describe moulded specimens

6.3.1 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 can be used to describe properties indicated where appropriate. Other properties and methods in EN 14598-2 can also be used with the agreement of the interested parties.

6.3.2 Mechanical properties

The following methods shall be used to describe mechanical properties:

— tensile strength, tensile elongation, tensile modulus of elasticity and Poisson's ratio: ISO 527-4:2023, using type II test specimens [except for SMC with directionally oriented reinforcements (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 179-1, ISO 179-2 or ISO 180;

— compression strength: ISO 14126;

— shear strength: ISO 14130;

— temperature of deflection under load: ISO 75-2:2013, method A (1,80 MPa).

6.3.3 Physical properties

The following methods shall be used to describe physical properties:

— reinforcement content: ISO 11667, ISO 1172 (GF), ISO 14127 (CF) or ISO 22821 (CF);

— filler content: ISO 11667 or ISO 1172 (GF);

— density: the appropriate part of ISO 1183;

— moulding shrinkage: ISO 2577 or EN 1842;

— surface roughness (using a profilometer);

— hardness;

— loss on ignition: ISO 1172 (GF) or ISO 14127 (CF);

— coefficient of thermal expansion: ISO 11359-2;

— moisture absorption: ISO 62:2008, method 1 or ISO 22836;

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

— fire hazard (horizontal and vertical flame test): IEC 60695-11-10;

— oxygen index: ISO 4589-2.

6.3.4 Electrical properties

The following methods shall be used to describe electrical properties:

— proof tracking index: IEC 60112;

— electric strength: IEC 60243;

— volume resistance and volume resistivity: IEC 62631-3-1;

— surface resistance and surface resistivity: IEC 62631-3-2;

— dielectric constant (permittivity): IEC 62631-2-1;

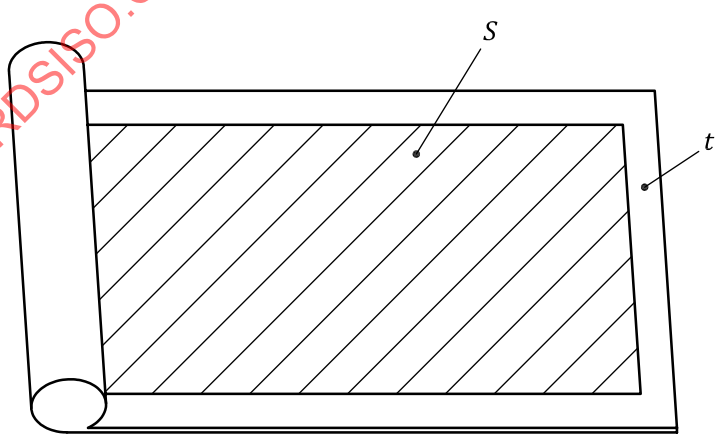
— arc resistance: IEC 61621.

7 Sampling

7.1 Sampling procedure

A consignment may be made up of one or more batches. Each batch is identified by a number. It may be agreed that samples are taken from each batch.

The test specimens shall be taken from the sample and prepared as specified in the relevant test methods. The composition content at the edge of sheet moulding compound may be inhomogeneous, which can affect the test properties, it is recommended to cut the test samples off over the sheet moulding compound, where is no less than 40 mm to any edge of the sheet moulding compound (see Figure 1).



Key

S sampling position

t distance from edge (≥40 mm)

Figure 1 — Sampling position of SMC

Care shall be taken to protect the rolls or cases in the sample in order to prevent their moulding properties from deteriorating (for example by loss of volatile components such as styrene) and to prevent premature curing before moulding.

7.2 Conditioning of sample

If no specific conditioning is required, the sample shall be wrapped in suitable protective film impermeable to styrene (e.g. cellophane, polyamide) to avoid any loss of volatile products, and shall be kept for at least 6 h in the standard atmosphere 23 °C ± 2 °C and 50 % ± 5 % R.H., in accordance with ISO 291.

8 Shelf life

The manufacturer shall state the maximum storage life of the material, in its original unopened packaging, under the conditions recommended by him (for example maximum temperature, relative humidity).

The material shall be mouldable and conform to the requirements specified (see Clause 6) during the whole of the stated storage life, provided the SMC is used directly after removal of the protective film.

9 Packing, packaging and labelling

9.1 Packing

In rolls of SMC and in cases containing flat sheets of SMC, each layer shall be separated by a barrier sheet made for instance of a suitable plastic or paper.

At the time the product is used, it shall be possible to remove the barrier sheet easily without leaving any traces.

Rolls of SMC shall be wound on tubes of adequate strength.

The requirements concerning the length and mass of rolls shall be specified.

9.2 Packaging

The contents of each unit package (roll or case) shall be protected by a film of a material, such as cellophane, polyamide or aluminized kraft paper, which is impermeable to volatile products, for example styrene. The unit packages shall then be palletized or otherwise assembled and protected (especially the ends of rolls and the edges of sheets in cases) in such a manner that they will not suffer any damage under normal conditions of transport and storage.

If it is known that a consignment will be sampled (by the customs in international trade, for instance), it is recommended that a small, representative sample be included with the consignment, in order to avoid the packages being opened and damage being caused.

9.3 Labelling

Each unit package shall be identified with the following information:

a) the designation of the product;

b) the classification code for the material and the manufacturer's code;

c) the name and address of the manufacturer;

d) the number of cases or rolls;

e) the batch number;

f) the colour code for the material;