



BSI Standards Publication

Hot rolled products of structural steels

Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels

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National foreword

This British Standard is the UK implementation of EN 10025-4:2019+A1:2022. It supersedes BS EN 10025-4:2019, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by $\boxed{A1}$ $\langle A1 \rangle$.

The UK participation in its preparation was entrusted to Technical Committee ISE/103, Structural Steels Other Than Reinforcements.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Hot rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels

Produits laminés à chaud en aciers de construction -
Partie 4 : Conditions techniques de livraison pour les
aciers de construction soudable à grains fins obtenus
par laminage thermomécanique

Warmgewalzte Erzeugnisse aus Baustählen - Teil 4:
Technische Lieferbedingungen für thermomechanisch
gewalzte schweißgeeignete Feinkornbaustähle

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European foreword

This document (EN 10025-4:2019+A1:2022) has been prepared by Technical Committee CEN/TC 459/SC 3 “Structural steels other than reinforcements”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2023 and conflicting national standards shall be withdrawn at the latest by June 2023.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes ^{A1} EN 10025-4:2019 ^{A1}.

This document includes Amendment 1 approved by CEN on 25 October 2022.

The start and finish of text introduced or altered by amendment is indicated in the text by tags ^{A1} ^{A1}.

This document consists of the following parts, under the general title *Hot rolled products of structural steels*:

- *Part 1: General technical delivery conditions*
- *Part 2: Technical delivery conditions for non-alloy structural steels*
- *Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels*
- *Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels*
- *Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance*
- *Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition*

For a short transition period there will be a coexistence of EN 10025-1:2004 with EN 10025-2:2019 to ^{A1} EN 10025-6:2019+A1:2022 ^{A1}, since the new EN 10025-1 has to fulfil the requirements of the CPR and will therefore be published later. For this short transition period up-to-the publication of the next edition of part 1 the following is to be taken into account for EN 10025-1:2004:

- a) all dated and undated references to EN 10025-1:2004 to EN 10025-6:2004 are unchanged to this version with following exception: In 9.2.2.1 the references are 8.3.1 and 8.3.2 instead of 8.4.1 and 8.4.2,
- b) Clauses 5, 12 and 13 of EN 10025-1:2004 are no longer relevant.

The main changes with respect to the previous ^{A1} edition EN 10025-4:2004 ^{A1} are listed below:

- a) part 4 is now a stand-alone standard for technical delivery conditions including the preparation of samples and test pieces, the test methods, the marking, labelling and packaging and the drawings;
- b) for applications under the CPR this document and part 1 are used together;
- c) requirements for elements not defined were added to 7.2.1 and 7.2.2;
- d) Option 33 was added, Option 3 was renumbered to Option 24 and Option 9 was deleted;
- e) Si-content in 7.2.4 was changed;

- f) 7.4.3 concerning hot-dip zinc coating was modified;
- g) key to Figure A.1 was updated;
- h) steel grade S500M was added;
- i) Annex B concerning the corresponding EURONORMS deleted;
- j) references were updated and document editorial revised.

A1 In comparison with the previous version EN 10025-4:2019, the following modifications have been made:

- references were updated in the European foreword;
- a sentence was added to 9.2.3.2. **A1**

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

1 Scope

This document specifies technical delivery conditions for flat and long products of hot rolled weldable fine grain structural steels in the thermomechanical rolled condition in the grades and qualities given in Tables 1 to 3 (chemical composition) and Tables 4 to 6 (mechanical properties) in thickness ≤ 150 mm.

The steels specified in this document are especially intended for use in heavily loaded parts of welded structures such as, bridges, flood gates, storage tanks, water supply tanks, etc., for service at ambient and low temperatures.

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.

EN 1011-2, *Welding — Recommendations for welding of metallic materials — Part 2: Arc welding of ferritic steels*

EN 10017, *Steel rod for drawing and/or cold rolling — Dimensions and tolerances*

EN 10020:2000, *Definition and classification of grades of steel*

EN 10021, *General technical delivery conditions for steel products*

EN 10024, *Hot rolled taper flange I sections — Tolerances on shape and dimensions*

EN 10025-1, *Hot rolled products of structural steels — Part 1: General technical delivery conditions*

EN 10027-1, *Designation systems for steels — Part 1: Steel names*

EN 10027-2, *Designation systems for steels — Part 2: Numerical system*

EN 10029, *Hot-rolled steel plates 3 mm thick or above — Tolerances on dimensions and shape*

EN 10034, *Structural steel I and H sections — Tolerances on shape and dimensions*

EN 10048, *Hot rolled narrow steel strip — Tolerances on dimensions and shape*

EN 10051, *Continuously hot-rolled strip and plate/sheet cut from wide strip of non-alloy and alloy steels — Tolerances on dimensions and shape*

EN 10055, *Hot rolled steel equal flange tees with radiused root and toes — Dimensions and tolerances on shape and dimensions*

EN 10056-1, *Structural steel equal and unequal leg angles — Part 1: Dimensions*

EN 10056-2, *Structural steel equal and unequal leg angles — Part 2: Tolerances on shape and dimensions*

EN 10058, *Hot rolled flat steel bars and steel wide flats for general purposes — Dimensions and tolerances on shape and dimensions*

EN 10059, *Hot rolled square steel bars for general purposes — Dimensions and tolerances on shape and dimensions*

- EN 10060, *Hot rolled round steel bars for general purposes — Dimensions and tolerances on shape and dimensions*
- EN 10061, *Hot rolled hexagon steel bars for general purposes — Dimensions and tolerances on shape and dimensions*
- EN 10067, *Hot rolled bulb flats — Dimensions and tolerances on shape, dimensions and mass*
- EN 10079, *Definition of steel products*
- EN 10160, *Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)*
- EN 10163-1, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 1: General requirements*
- EN 10163-2, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 2: Plate and wide flats*
- EN 10163-3, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 3: Sections*
- EN 10164, *Steel products with improved deformation properties perpendicular to the surface of the product — Technical delivery conditions*
- EN 10168, *Steel products — Inspection documents — List of information and description*
- EN 10204, *Metallic products — Types of inspection documents*
- EN 10279, *Hot rolled steel channels — Tolerances on shape, dimensions and mass*
- EN 10306, *Iron and steel — Ultrasonic testing of H beams with parallel flanges and IPE beams*
- EN 10308, *Non destructive testing — Ultrasonic testing of steel bars*
- EN 10315, *Routine method for analysis of high alloy steel by X-ray Fluorescence Spectrometry (XRF) by using a near by technique*
- CR 10320, *Optical emission analysis of low alloy steels (routine method) — Method for determination of C, Si, S, P, Mn, Cr, Ni and Cu*
- CEN/TR 10347, *Guidance for forming of structural steels in processing*
- EN 10363, *Continuously hot-rolled patterned steel strip and plate/sheet cut from wide strip — Tolerances on dimensions and shape*
- EN 10365, *Hot rolled steel channels, I and H sections — Dimensions and masses*
- EN ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method (ISO 148-1)*
- EN ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing (ISO 377)*
- EN ISO 2566-1, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels (ISO 2566-1)*
- EN ISO 6892-1:2016, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1:2016)*

EN ISO 9443, *Surface quality classes for hot-rolled bars and wire rod (ISO 9443)*

EN ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition (ISO 14284)*

EN ISO 14713-2:2009, *Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures — Part 2: Hot dip galvanizing (ISO 14713-2:2009)*

EN ISO 15350, *Steel and iron — Determination of total carbon and sulfur content — Infrared absorption method after combustion in an induction furnace (routine method) (ISO 15350)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10079 and the following apply.

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

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1 thermomechanical rolling

rolling process in which the final deformation is carried out in a certain temperature range leading to a material condition with certain properties which cannot be achieved or repeated by heat treatment alone

Note 1 to entry: Thermomechanical rolling can include processes with an increasing cooling rate with or without tempering including self-tempering but excluding direct quenching and quenching and tempering.

Note 2 to entry: In some publications the word TMCP (Thermomechanical Control Process) is also used.

3.2 fine grain steels

steels with fine grain structure with an equivalent index of ferritic grain size ≥ 6

Note 1 to entry: For the determination of grain sizes see EN ISO 643.

4 Classification and designation

4.1 Classification

4.1.1 Main quality classes

All steel grades specified in this document shall be classified as alloy special steels according to EN 10020 except grade S275 which is a non-alloy quality steel.

4.1.2 Grades and qualities

This document specifies five steel grades S275, S355, S420, S460 and S500. All steel grades may be supplied in the following qualities as specified at the time of the order:

- with specified minimum values of impact energy at temperatures not lower than -20 °C , designated as M;
- with specified minimum values of impact energy at temperatures not lower than -50 °C , designated as ML.

4.2 Designation

4.2.1 For the steel grades covered by this document the steel names shall be allocated in accordance with EN 10027-1; the steel numbers shall be allocated in accordance with EN 10027-2.

4.2.2 The designation shall consist of:

- number of this document (EN 10025-4);
- steel name or the steel number; the steel name consisting of:
 - symbol S (for structural steel);
 - indication of the minimum specified yield strength for thickness ≤ 16 mm expressed in MPa;
 - delivery condition M;
 - capital letter L for the quality with specified minimum values of impact energy at temperatures not lower than -50 °C.

EXAMPLE Thermomechanical rolled structural steel (S) with a specified minimum yield strength at room temperature of 355 MPa and with a specified minimum impact energy at -50 °C:

EN 10025-4 - S355ML

Or

EN 10025-4 - 1.8834

5 Information to be supplied by the purchaser

5.1 Mandatory information

The following information shall be supplied by the purchaser at the time of the order:

- a) quantity to be delivered;
- b) product form and the number of the standard for dimensions and tolerances (see 2.2);
- c) nominal dimensions and tolerances on dimensions and shape (see 7.7.1);
- d) steel designation (see 4.2.2);
- e) additional requirements of inspection and testing and all required options (see 5.2 and Clause 13);
- f) type of inspection document according to EN 10204 (see 8.1).

5.2 Options

A number of options are specified in Clause 13. In the event that the purchaser does not indicate his wish to implement any of these options, the supplier shall supply in accordance with the basic specification, see 5.1 a) to d) and f).

6 Manufacturing process

6.1 Steel making process

The steel making process is at the discretion of the manufacturer with the exclusion of the open hearth (Siemens-Martin) process.

See **Option 1**, Clause 13 (details of manufacturing process).

6.2 Deoxidation and grain structure

Steels of EN 10025-4 shall

- be fully killed;
- have a fine grain structure;
- contain nitrogen binding elements in amounts sufficient to bind the available nitrogen (for example min. 0,020 % total aluminium). The usual guideline is a minimum aluminium to nitrogen ratio of 2:1, when no other nitrogen binding elements are present. Such other elements and their content (% mass) shall be reported in the inspection document (see Table 1).

6.3 Delivery conditions

The products shall be supplied in the thermomechanical rolled condition as defined in Clause 3.

7 Requirements

7.1 General

The requirements in 7.2 and 7.3 apply for sampling, preparation of test pieces and testing specified in Clauses 9 and 10.

7.2 Chemical composition

7.2.1 The chemical composition determined by heat analysis shall comply with the specified values of Table 1.

For elements not defined in the table for the chemical composition for heat analysis, limit values of Table 1 of EN 10020:2000 shall apply as maximum values.

7.2.2 The limits applicable for the product analysis are given in Table 2. The product analysis shall be carried out when specified at the time of the order.

See **Option 2**, Clause 13 (product analysis).

For elements not defined in tables for the chemical composition for product analysis, limit values of Table 1 of EN 10020:2000 shall apply as maximum values.

7.2.3 The maximum carbon equivalent values based on the heat analysis, given in Table 3 shall apply.

For determining the carbon equivalent value the following IIW (International Institute of Welding) formula shall be used:

$$CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

7.2.4 When products are supplied with a control on Si e.g. for hot-dip zinc-coating so that there could be a need to increase the content of other elements like C and Mn to achieve the required tensile properties, the maximum carbon equivalent values of Table 3 shall be increased as follows:

- for Si ≤ 0,04 %, increase the value of the CEV by 0,02;
- for Si ≤ 0,25 %, increase the value of the CEV by 0,01.

7.3 Mechanical properties

7.3.1 General

7.3.1.1 Under the inspection and testing conditions as specified in Clauses 8, 9 and 10 and in the delivery condition as specified in 6.3 the mechanical properties shall comply with the values given in Tables 4 to 6.

Stress relieving at more than 580 °C or for over 1 h may lead to a deterioration of the mechanical properties of the steel grades. If the purchaser intends to stress relief the products at higher temperatures or for longer times than mentioned above, the minimum values of the mechanical properties after such a treatment should be agreed upon at the time of the order.

7.3.1.2 For flat products the nominal thickness applies. For long products of irregular section the nominal thickness of that part from which the samples are taken applies (see Annex A).

7.3.2 Impact properties

7.3.2.1 The verification of the impact energy value shall be carried out, unless otherwise agreed upon (see 7.3.2.2 and 7.3.2.3) with longitudinal test pieces for:

- quality M at -20 °C;
- quality ML at -50 °C.

7.3.2.2 Another temperature (given in Tables 5 and 6) may be agreed upon at the time of the order.

See **Option 24**, Clause 13 (Agreement on another impact test temperature).

7.3.2.3 If agreed upon at the time of the order the impact properties shall be verified on transverse V-notch test pieces instead of longitudinal test pieces with minimum values as given in Table 6.

See **Option 30**, Clause 13 (Impact properties verified on transverse test pieces).

7.3.2.4 If specified at the time of the order for flat products out of each parent plate or coil the impact properties only or the impact properties and the tensile properties shall be verified.

See **Option 13**, Clause 13 (For flat products on each parent plate or coil impact properties only to be verified).

See **Option 14**, Clause 13 (For flat products on each parent plate or coil impact and tensile properties to be verified).

7.3.3 Improved deformation properties perpendicular to the surface

If agreed upon at the time of the order flat and long products shall comply with one of the requirements of EN 10164.

See **Option 4**, Clause 13 (Deformation properties perpendicular to the surface).

7.4 Technological properties

7.4.1 Weldability

The steels specified in this document shall be suitable for welding.

General requirements for arc welding of the steels specified in this document shall be as given in EN 1011-2.

NOTE 1 With increasing product thickness and strength level cold cracking can occur. Cold cracking is caused by the following factors in combination:

- the amount of diffusible hydrogen in the weld metal;
- a brittle structure of the heat affected zone;
- significant tensile stress concentrations in the welded joint.

NOTE 2 Due to their favourable chemical composition in comparison to a normalized steel at the same yield strength level, thermomechanically treated steels according to EN 10025-4 exhibit enhanced weldability.

7.4.2 Formability and flame straightening

7.4.2.1 General

Recommendations regarding hot forming, cold forming and flame straightening are laid out in CEN/TR 10347.

7.4.2.2 Hot forming

Hot forming shall not be undertaken.

NOTE The products ordered and supplied in the thermomechanical rolled condition are not suitable for hot forming.

7.4.2.3 Cold formability

7.4.2.3.1 General

NOTE Cold forming leads to reduction in the ductility. Furthermore, it is necessary to draw the attention to the risk of brittle fracture in connection with hot-dip zinc coating.

7.4.2.3.2 Flangeability

If specified at the time of the order plate, sheet, strip and wide flats with a nominal thickness ≤ 12 mm shall be suitable for flanging without cracking with the following minimum bend radii:

- 2 times the nominal thickness with the axis of the bend in transverse direction and 2,5 times the nominal thickness in longitudinal direction for the steel grades S275 and S355;
- 4 times the nominal thickness with the axis of the bend in transverse direction and 5 times the nominal thickness in longitudinal direction for the steel grades S420, S460 and S500.

See **Option 11**, Clause 13 (Flangeability without cracking).

7.4.2.3.3 Roll forming

If specified at the time of the order plate, sheet and strip with a nominal thickness ≤ 8 mm shall be suitable for the production of sections by cold rolling (for example according to EN 10162), with the same minimum bend radii as given in 7.4.2.3.2.

See **Option 12**, Clause 13 (Roll forming for flat products).

NOTE The products suitable for roll forming are also suitable for the manufacture of cold-finished square and rectangular hollow sections.

7.4.3 Hot-dip zinc-coating

EN ISO 1461 should be used to specify coating requirements. EN ISO 14713-2 provides further guidance, including information on the influence of various factors, including steel chemical composition, on the coating formation.

Option 5, Clause 13, can be used to order steels with a chemical composition required for hot-dip zinc coating. When option 5 is implemented, the purchaser and manufacturer shall agree to a steel composition (heat analysis) of silicon and phosphorous according to either Category A (or steels satisfying the formula $Si \leq 0,03 \%$ and $Si+2,5P \leq 0,09 \%$) or Category B (limited to $0,14 \% \leq Si \leq 0,25 \%$) or Category D (limited to $0,25 \% < Si \leq 0,35 \%$) with required values as cited by the ranges given in EN ISO 14713-2:2009, Table 1, column 2.

NOTE EN ISO 14713-2:2009, Table 1, gives guidance on typical coating characteristics associated with certain steel compositions on the basis of the surface composition of silicon and phosphorous.

The maximum carbon equivalent shall be increased by 0,02 or by 0,01 (see 7.2.4).

In some cases steels above S460 may be sensitive to cracking during galvanizing and therefore special care should be taken.

See **Option 5**, Clause 13 (Chemical composition for hot dip zinc coating).

7.5 Surface properties

7.5.1 Strip

The surface condition should not impair an application appropriate to the steel grade if adequate processing of the strip is applied.

7.5.2 Plates and wide flats

EN 10163-1 and EN 10163-2 shall apply for the permissible surface discontinuities and for the repair of surface defects by grinding and/or welding. Class A, subclass 1 of EN 10163-2 shall apply, class B regarding grinding or subclasses 2 or 3 regarding repair by welding can be agreed upon at the time of the order.

See **Option 15**, Clause 13 (Other surface class for plates and wide flats).

7.5.3 Sections

EN 10163-1 and EN 10163-3 shall apply for the permissible surface discontinuities and for the repair of surface defects by grinding and/or welding. Class C, subclass 1 of EN 10163-3 shall apply. Class D regarding grinding or subclasses 2 or 3 regarding repair by welding can be agreed upon at the time of the order.

See **Option 16**, Clause 13 (Other surface class for sections).

7.5.4 Bars and rods

EN ISO 9443 applies for the permissible surface discontinuities and for the repair of surface defects by grinding and/or welding. Class A of EN ISO 9443 shall apply, unless otherwise agreed upon at the time of the order.

See **Option 17**, Clause 13 (Other surface class for bars and rods).

7.6 Internal soundness

Ultrasonic testing may be agreed upon at the time of the order and shall comply with 10.3.

See **Option 6**, Clause 13 (Ultrasonic testing for flat products).

See **Option 7**, Clause 13 (Ultrasonic testing for H beams with parallel flanges and IPE beams).

See **Option 8**, Clause 13 (Ultrasonic testing for bars).

7.7 Dimensions, tolerances on dimensions and shape, mass

7.7.1 Dimensions, tolerances on dimensions and shape shall be in accordance with the requirements given in the order by reference to following standards: EN 10017, EN 10024, EN 10029, EN 10034, EN 10048, EN 10051, EN 10055, EN 10056-1, EN 10056-2, EN 10058, EN 10059, EN 10060, EN 10061, EN 10067, EN 10279, EN 10363 and EN 10365.

For hot rolled plate tolerances the basic requirements shall be in accordance with EN 10029, including thickness tolerances to class A, unless otherwise agreed upon at the time of the order.

See **Option 18**, Clause 13 (For plates other thickness tolerance than class A).

For plates cut from continuously hot rolled strip, the thickness tolerances shall be in accordance with EN 10051, unless otherwise agreed upon at the time of the order.

See **Option 34**, Clause 13 (For plates cut from strip thickness tolerances according to EN 10029).

7.7.2 The nominal mass shall be determined from the nominal dimensions using a volumetric mass of 7 850 kg/m³.

8 Inspection

8.1 Type of inspection and inspection document

The products shall be delivered with specific inspection and testing to indicate compliance with the order and this document. The manufacturer shall obtain from the purchaser which of the inspection documents specified in EN 10204 is required.

NOTE Some application standards, e.g. EN 1090-2, require particular inspection documents according to EN 10204.

Unless otherwise agreed upon steel grades of this standard are delivered with CE marking and they shall not only fulfil these technical delivery conditions but also the requirements of EN 10025-1.

It can be agreed upon at the time of enquiry and order to abstain from CE-marking, see Option 33, Clause 13, in this case EN 10025-1 does not apply.

See **Option 33**, Clause 13 (no application of CE-marking).

8.2 Content of inspection document

The inspection document shall include, in accordance with EN 10168, the following codes and/or information, where applicable:

- A commercial transactions and parties involved;
- B description of products to which the inspection document applies;
- C00-C03 identification of the sample, location of the sample, direction of the test pieces, test temperature;
- C10-C13 shape of the test piece, yield or proof strength, tensile strength, elongation after fracture;
- C40-C43 type of test piece, width of test piece, individual values, mean value;
- C70-C92 steelmaking process, chemical composition;
- D other tests;
- Z validation.

8.3 Tests to be carried out

8.3.1 The following tests shall be carried out:

- the heat analysis;
- the tensile test;
- the impact test with thickness limitations as specified in 9.2.3.3.

8.3.2 At the time of the order the following additional tests can be agreed upon (see also Clause 13):

- a) the product analysis, see 7.2.2 and **Option 2**, Clause 13;
- b) for all products the impact test at another temperature, see 7.3.2.2 and **Option 24**, Clause 13, or/and on transverse test pieces, see 7.3.2.3 and **Option 30**, Clause 13.

9 Frequency of testing and preparation of samples and test pieces

9.1 Frequency of testing

9.1.1 Chemical analysis

The heat analysis shall be determined once per cast. If a product analysis has been agreed upon at the time of enquiry and order, the purchaser shall specify the frequency if not once per cast.

9.1.2 Mechanical tests

The verification of the mechanical properties (tensile strength, yield strength, impact energy and elongation) shall be by test unit(s) from within each cast.

For verifying the mechanical properties the following test unit shall apply:

- 60 tonnes or part thereof;
- 80 tonnes or part thereof for heavy sections with a mass > 200 kg/m;
- 80 tonnes or part thereof for all sections if the mass of the cast exceeds 200 tonnes.

The test unit shall contain products of the same form, grade and quality and of the same thickness range as specified in Table 4 for the yield strength.

The following samples shall be taken from one sample product of each test unit:

- one sample for tensile testing;
- one sample sufficient for one set of six impact test pieces.

9.2 Preparation of samples and test pieces

9.2.1 Selection and preparation of samples for chemical analysis

The selection and preparation of samples for product analysis shall be in accordance with EN ISO 14284.

9.2.2 Location of samples and orientation of test pieces for mechanical tests

The samples shall be taken from any product of the test unit, from the location in the product as shown in Annex A.

Additionally for plates, sheet, wide strip and wide flats the samples shall be taken so that the axes of the test pieces are approximately midway between the edge and centre line of the products.

For wide strip and rod the sample shall be taken at an adequate distance from the end of the product.

For narrow strip (<600 mm wide) the sample shall be taken at an adequate distance from the end of the coil and at one third of the width.

9.2.3 Preparation of test pieces for mechanical tests

9.2.3.1 General

The requirements of EN ISO 377 shall apply.

9.2.3.2 Preparation of tensile test pieces

The requirements of EN ISO 6892-1 shall apply.

A1) For flat products either the full product thickness or half the product thickness can be used, but one product surface shall be retained. **A1**

For flat products of nominal thickness > 30 mm a round test piece may be used with the longitudinal axis at $1/4$ thickness, if a testing machine with an adequate capacity is not available. In cases of dispute, the total thickness of the plate shall be subdivided in equal thick flat test pieces. The average of the individual results of the mechanical tests shall be valid.

NOTE For bars round test pieces are commonly used but other forms are not prohibited (see EN ISO 6892-1).

9.2.3.3 Preparation of impact test pieces

V-notch test pieces shall be machined and prepared in accordance with EN ISO 148-1. In addition the following requirements apply:

a) flat products:

- for nominal thicknesses $12 < t < 40$ mm, standard $10 \text{ mm} \times 10 \text{ mm}$ test pieces shall be machined in such a way that one side is not further away than 2 mm from a rolled surface, for nominal thicknesses ≥ 40 mm impact test pieces shall be taken from $1/4t$ position for plates;
- for nominal thicknesses ≤ 12 mm, when test pieces with reduced widths are used, the largest width possible has to be chosen;
- for nominal thickness < 6 mm no impact tests are required;

b) sections:

- for nominal thicknesses $12 < t < 150$ mm, standard $10 \text{ mm} \times 10 \text{ mm}$ test pieces shall be machined in such a way that one side is not further away than 2 mm from a rolled surface;
- for nominal thicknesses ≤ 12 mm, when test pieces with reduced widths are used, the largest width possible has to be chosen;
- for nominal thickness < 6 mm no impact tests are required;

c) bars and rod:

- for nominal diameter ≥ 16 mm (round cross section) or nominal thickness ≥ 12 mm (rectangular cross section), standard $10 \text{ mm} \times 10 \text{ mm}$ test pieces shall be machined;

- for nominal diameter < 16 mm (round cross section) or nominal thickness < 12 mm (rectangular cross section) no impact tests are required.

9.3 Identification of samples and test pieces

Samples and test pieces shall be marked so that the original products and their location and orientation in the product are known.

10 Test methods

10.1 Chemical analysis

Test methods shall be in accordance with EN 10315, EN ISO 15350 or CR 10320 depending on the elements to be analysed and their content. The choice of a suitable physical or chemical analytical method for the analysis shall be at the discretion of the manufacturer. In case of dispute, the method used shall be agreed upon taking into account CEN/TR 10261.

For the heat analysis the manufacturer shall report values of all elements defined in Table 1 for the steel grade concerned for each cast as well as of the elements for determining the carbon equivalent value.

For the product analysis, if not otherwise agreed upon, the manufacturer shall report values of all elements defined in Table 2 for the steel grade concerned, see Option 2, Clause 13.

10.2 Mechanical tests

10.2.1 Tensile test

The tensile test shall be carried out in accordance with EN ISO 6892-1. The manufacturer may choose between method A or B specified in EN ISO 6892-1 for the tensile test.

For the specified yield strength the upper yield strength (R_{eH}) shall be determined.

If a yield phenomenon is not present, the 0,2 % proof strength ($R_{p0,2}$) shall be determined.

Test pieces may be non-proportional but in cases of dispute proportional test pieces having a gauge length $L_0 = 5,65 \sqrt{S_0}$ shall be used.

For flat products with a nominal thickness < 3 mm the test pieces shall always have a gauge length $L_0 = 80$ mm and a width of 20 mm (test piece number 2 EN ISO 6892-1:2016, Annex B).

For normal testing, for reasons of economy, test pieces of a constant measuring length may be used provided the result obtained for elongation after fracture is converted by the formula in EN ISO 2566-1.

10.2.2 Impact test

The impact test shall be carried out in accordance with EN ISO 148-1 on V-notch specimen using 2 mm striker.

The average value of the three test results shall meet the specified requirement. One individual value may be below the minimum average value specified, provided that it is not less than 70 % of that value.

Three additional test pieces shall be taken from the same sample in accordance with 9.1.2 and tested in any one of the following cases:

- if the average of three impact values is lower than the minimum average value specified;
- if the average value meets the specified requirement, but two individual values are lower than the minimum average value specified;
- if anyone value is lower than 70 % of the minimum average value specified.

The average value of the six tests shall be not less than the minimum average value specified. Not more than two of the individual values may be lower than the minimum average value specified and not more than one may be lower than 70 % of this value.

10.3 Ultrasonic testing

If specified at the time of the order (see 7.6), ultrasonic testing shall be carried out:

- for flat products in nominal thicknesses ≥ 6 mm, except for hot rolled strip and plate cut from strip in accordance with EN 10160;
- for H beams with parallel flanges and IPE beams in accordance with EN 10306;
- for bars in accordance with EN 10308.

10.4 Retests

The retests shall be in accordance with EN 10021.

In the case of strip and rod, retests on a rejected coil shall be carried out after the cutting of an additional longitudinal section of sufficient length to remove the coil end effect with a maximum of 20 m.

11 Marking, labelling, packaging

11.1 The products shall be legibly marked using methods such as painting, stamping, laser marking, bar coding, durable adhesive labels or attached tags with the following:

- the grade, the quality and if applicable the delivery condition indicated by its abridged designation;
- a number by which the cast and if applicable the sample can be identified;
- the manufacturer's name or trademark.

The type of marking may be specified at the time of the order.

See **Option 10**, Clause 13 (special type of marking).

NOTE 1 Where the option for hot dip galvanizing is chosen (see Clause 13), the marking methods and materials used can be agreed upon in order to avoid interference with preparation for hot dip galvanizing (see EN ISO 14713-2).

The mark of the external inspection representative may be marked (where applicable).

NOTE 2 This depends on the type of inspection document (see 8.1).

In addition if specified at the time of the order there shall be either no die stamping or only die stamping in positions indicated by the purchaser.

See **Option 31**, Clause 13 (Die stamping not allowed or at special position).

11.2 Marking shall be at a position close to one end of each product or on the end cut face at the manufacturer's discretion.

11.3 Where products are supplied in securely tied bundles the marking shall be on a label attached to the bundle or on the top product of the bundle.

12 Complaints

Any complaints shall be dealt with in accordance with EN 10021.

13 Options

A list of options for parts 2 to 6 is given in Annex B for information. The following options (see 5.2) apply for this part:

- 1 The steel making process shall be indicated (see 6.1).
- 2 Product analysis shall be carried out; the number of samples shall be as agreed upon (see 7.2.2 and 9.1.1).
- 4 Products shall comply with one of the improved properties perpendicular to the surface of EN 10164 (see 7.3.3).
- 5 The product shall have a chemical composition required for hot-dip zinc-coating (see 7.4.3).
- 6 For flat products in nominal thickness ≥ 6 mm, except for hot rolled strip and plate cut from strip, the freedom from internal defects shall be verified in accordance with EN 10160 (see 7.6 and 10.3).
- 7 For H beams with parallel flanges and IPE beams the freedom from internal defects shall be verified in accordance with EN 10306 (see 7.6 and 10.3).
- 8 For bars the freedom from internal defects shall be verified in accordance with EN 10308 (see 7.6 and 10.3).
- 10 The type of marking required (see Clause 11).
- 11 Sheet, plate, strip and wide flats with a nominal thickness ≤ 16 mm shall be suitable for flanging without cracking (see 7.4.2.3.2).
- 12 Plate, sheet and strip with nominal thickness ≤ 8 mm shall be suitable for the production of sections by cold rolling with bend radii given in 7.4.2.3.2 (see 7.4.2.3.3).
- 13 For flat products out of each parent plate or coil the impact properties only shall be verified (see 7.3.2.4).
- 14 For flat products out of each parent plate or coil the impact properties and the tensile properties shall be verified (see 7.3.2.4).
- 15 For plates and wide flats the permissible surface discontinuities and for the repair of surface defects by grinding and/or welding another class than class A, subclass 1 of EN 10163-2 applies (see 7.5.2).
- 16 For sections the permissible surface discontinuities and for the repair of surface defects by grinding and/or welding another class than class C, subclass 1 of EN 10163-3 applies (see 7.5.3).
- 17 For bars and rods the permissible surface discontinuities and for the repair of surface defects by grinding and/or welding another class than class A of EN ISO 9443 applies (see 7.5.4).
- 18 For hot rolled plates other tolerances than class A of EN 10029 apply (see 7.7.1).
- 24 At which temperature the impact properties shall be verified (see 7.3.2.2 and 8.3.2).
- 30 The impact properties shall be verified on transverse V-notch test pieces (see 7.3.2.3 and 8.3.2).
- 31 Die stamping is not allowed or the position for die stamping shall be as indicated by the purchaser (see Clause 11).
- 32 For some applications, e.g. for railways, a maximum S content of 0,010 % for heat analysis and 0,012 % for product analysis is required (see Tables 1 and 2, footnote b).
- 33 No application of CE-marking according to EN 10025-1, and no application of assessment and verification of constancy of performance according to EN 10025-1, for products, which are not covered by the Construction Product Regulation.
- 34 For plates cut from continuously hot rolled strip thickness tolerances according to EN 10029 apply (see 7.7.1).

Table 1 — Chemical composition of the heat analysis

Designation		C	Si	Mn	P	S	Nb	V	Al _{total}	Ti	Cr	Ni	Mo	Cu	N
Steel name	Steel number	% max.	% max.	% max.	% max. a	% max. a b	% max.	% max.	% min. c	% max.	% max.	% max.	% max.	% max.	% max.
S275M	1.8818	0,13 d	0,50	1,50	0,025	0,025	0,05	0,08	0,020	0,05	0,30	0,30	0,10	0,55	0,015
S275ML	1.8819				0,025	0,020									
S355M	1.8823	0,14 d	0,50	1,60	0,025	0,025	0,05	0,10	0,020	0,05	0,30	0,50	0,10	0,55	0,015
S355ML	1.8834				0,025	0,020									
S420M	1.8825	0,16 e	0,50	1,70	0,030	0,025	0,05	0,12	0,020	0,05	0,30	0,80	0,20	0,55	0,025
S420ML	1.8836				0,025	0,020									
S460M	1.8827	0,16 e	0,60	1,70	0,030	0,025	0,05	0,12	0,020	0,05	0,30	0,80	0,20	0,55	0,025
S460ML	1.8838				0,025	0,020									
S500M	1.8829	0,16	0,60	1,70	0,030	0,025	0,05	0,12	0,020	0,05	0,30	0,80	0,20	0,55	0,025
S500ML	1.8839				0,025	0,020									

a For long products the P and S content can be 0,005 % higher.

b For some applications, e.g. for railways, a maximum S content of 0,010 % may be agreed upon at the time of the order, see **Option 32**, Clause 13.

c If sufficient other N-binding elements are present the minimum total Al content does not apply.

d For long products a maximum C content of 0,15 % for grade S275 and a maximum C content of 0,16 % for grade S355 applies.

e For long products of the grades S420 and S460 a maximum C content of 0,18 % applies.

Table 2 — Chemical composition of the product analysis based on Table 1

Designation	Steel name	Steel number	C	Si	Mn	P	S	Nb	V	Al _{total}	Ti	Cr	Ni	Mo	Cu	N
			% max.	% max.	% max.	% max. ^a	% max. ^{a b}	% max.	% min. ^c	% max.	% max.	% max.	% max.	% max.	% max.	% max.
S275M	S275ML	1.8818	0,15 ^d	0,55	1,60	0,030	0,030	0,06	0,10	0,015	0,06	0,35	0,35	0,13	0,60	0,017
		0,030				0,025										
S355M	S355ML	1.8823	0,16 ^d	0,55	1,70	0,030	0,030	0,06	0,12	0,015	0,06	0,35	0,55	0,13	0,60	0,017
		0,030				0,025										
S420M	S420ML	1.8825	0,18 ^e	0,55	1,80	0,035	0,030	0,06	0,14	0,015	0,06	0,35	0,85	0,23	0,60	0,027
		0,030				0,025										
S460M	S460ML	1.8827	0,18 ^e	0,65	1,80	0,035	0,030	0,06	0,14	0,015	0,06	0,35	0,85	0,23	0,60	0,027
		0,030				0,025										
S500M	S500ML	1.8829	0,18	0,65	1,80	0,035	0,030	0,06	0,14	0,015	0,06	0,35	0,85	0,23	0,60	0,027
		0,030				0,025										

a For long products the P and S content can be 0,005 % higher.

b For some applications, e.g. for railways, a maximum S content of 0,012 % may be agreed upon at the time of the order. See **Option 32**, Clause 13.

c If sufficient other N-binding elements are present the minimum total Al content does not apply.

d For long products a maximum C content of 0,17 % for grade S275 and a maximum C content of 0,18 % for grade S355 applies.

e For long products of the grades S420 and S460 a maximum C content of 0,20 % applies.

Table 3 — Maximum CEV based on the heat analysis ^a

Designation		Maximum CEV in % for nominal product thickness in mm			
Steel name	Steel number	≤ 16	> 16 ≤ 40	> 40 ≤ 63	> 63 ≤ 150
S275M S275ML	1.8818 1.8819	0,34	0,34	0,35	0,38
S355M S355ML	1.8823 1.8834	0,39	0,39	0,40	0,45
S420M S420ML	1.8825 1.8836	0,43	0,45	0,46	0,47
S460M S460ML	1.8827 1.8838	0,45	0,46	0,47	0,48
S500M S500ML	1.8829 1.8839	0,47	0,47	0,47	0,48

^a Max. CEV is increased for **Option 5**, see 7.2.4.

Table 4 — Mechanical properties – Tensile test properties at room temperature

Designation		Minimum yield strength R_{eH}^a MPa					Tensile strength R_m^a MPa					Minimum percentage elongation after fracture b % $L_0 = 5,65 \sqrt{S_0}$	
		Nominal thickness mm					Nominal thickness mm						
		≤ 16	> 16 ≤ 40	> 40 ≤ 63	> 63 ≤ 80	> 80 ≤ 100	> 100 ≤ 150	≤ 40	> 40 ≤ 63	> 63 ≤ 80	> 80 ≤ 100		> 100 ≤ 150
S275M	1.8818	275	265	255	245	245	240	370 to 530	360 to 520	350 to 510	350 to 510	350 to 510	24
S275ML	1.8819												
S355M	1.8823	355	345	335	325	320	470 to 630	450 to 610	440 to 600	440 to 600	440 to 600	430 to 590	22
S355ML	1.8834												
S420M	1.8825	420	400	390	380	365	520 to 680	500 to 660	480 to 640	470 to 630	460 to 620	460 to 620	19
S420ML	1.8836												
S460M	1.8827	460	440	430	410	385	540 to 720	530 to 710	510 to 690	500 to 680	490 to 660	490 to 660	17
S460ML	1.8838												
S500M	1.8829	500	480	460	450	450	580 to 760	580 to 760	580 to 760	560 to 750	560 to 750	560 to 750	15
S500ML	1.8839												

a For plate, strip and wide flats with widths ≥ 600 mm the direction transverse (t) to the rolling direction applies. For all other products the values apply for the direction parallel (l) to the rolling direction.

b For product thickness < 3 mm for which test pieces with a gauge length of $L_0 = 80$ mm shall be tested, the values shall be agreed upon at the time of the order.

Table 5 — Mechanical properties - Impact energy KV_2 on longitudinal test pieces ^a

Designation		Minimum values of impact energy KV_2 in J at test temperatures, in °C						
Steel name	Steel number	+ 20	0	- 10	- 20	- 30	- 40	- 50
S275M	1.8818							
S355M	1.8823							
S420M	1.8825	55	47	43	40 ^b	-	-	-
S460M	1.8827							
S500M	1.8829							
S275ML	1.8819							
S355ML	1.8834							
S420ML	1.8836	63	55	51	47	40	31	27
S460ML	1.8838							
S500ML	1.8839							
For subsized specimens the minimum values shall be reduced in direct proportion to the cross-sectional area of the test piece.								
^a Exceptions due to product size restrictions see 9.2.3.3.								
^b This value corresponds with 27 J at - 30 °C (see EN 1993-1-10).								

Table 6 — Mechanical properties - Impact energy KV_2 on transverse test pieces ^a (Option 30)

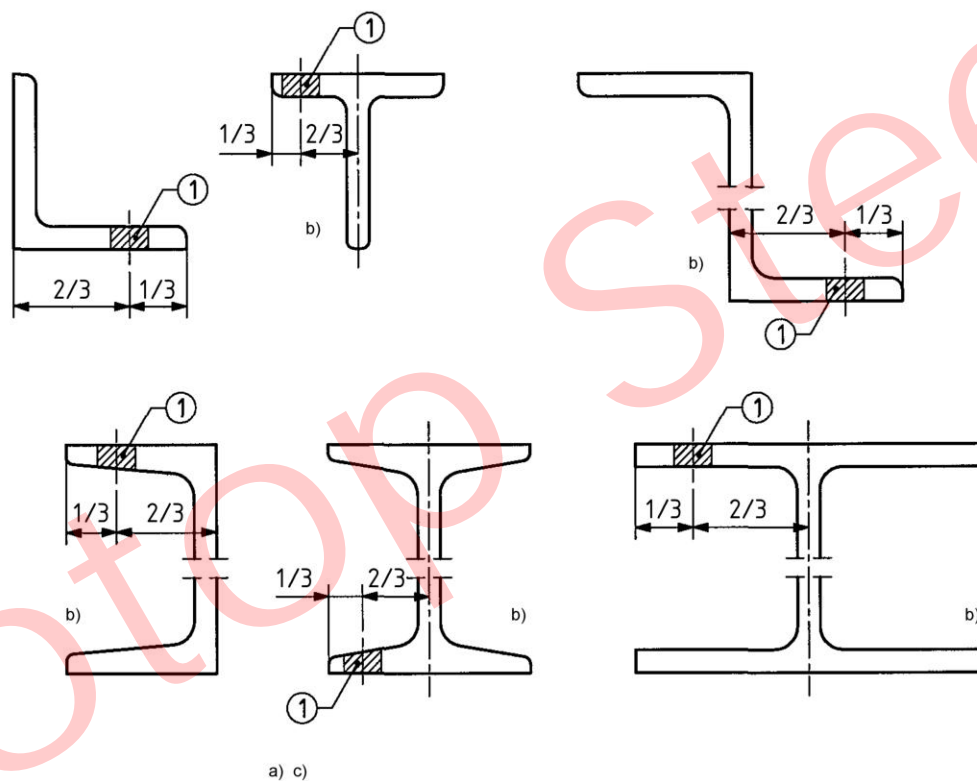
Designation		Minimum values of impact energy KV_2 in J at test temperatures, in °C						
Steel name	Steel number	+ 20	0	- 10	- 20	- 30	- 40	- 50
S275M	1.8818							
S355M	1.8823							
S420M	1.8825	31	27	24	20	-	-	-
S460M	1.8827							
S500M	1.8829							
S275ML	1.8819							
S355ML	1.8834							
S420ML	1.8836	40	34	30	27	23	20	16
S460ML	1.8838							
S500ML	1.8839							
For subsized specimens the minimum values shall be reduced in direct proportion to the cross-sectional area of the test piece.								
^a Exceptions due to product size restrictions see 9.2.3.3.								

Annex A (normative)

Location of samples and test pieces

The following three categories of products are covered:

- Sections (beams, channels, angles, T sections and Z sections) (Figure A.1);
- bars and rod (Figure A.2);
- flat products (Figure A.3).



Key

- 1 Location of the sample (s) in respect to the edge (s) of the product.^{c)}
- a) Usually the samples shall be taken from the flange location
- b) By agreement at the time of the order, the sample may be taken from the web, at a quarter of the total height
- c) Test pieces shall be taken from the sample in respect to the surface of the product as indicated in Figure A.3. Footnote d) of Figure A.3 does not apply for products covered by Figure A.1. For sections with inclined flanges, machining of the inclined surface shall be permitted in order to make it parallel to the other surface

Figure A.1 — Beams, channels, angles, T sections and Z sections

Dimensions in millimetres

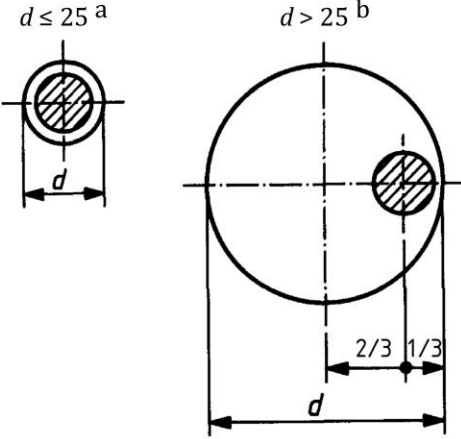
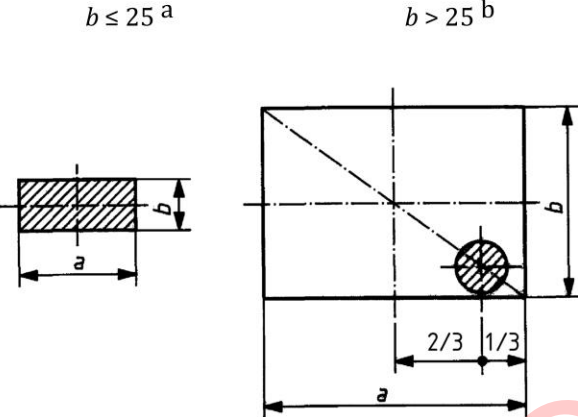
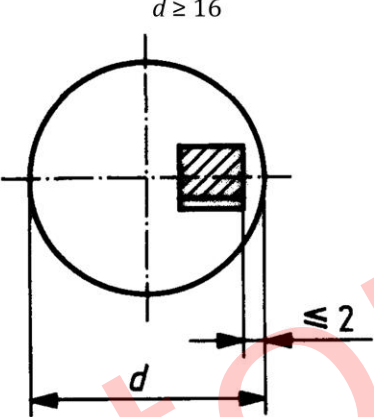
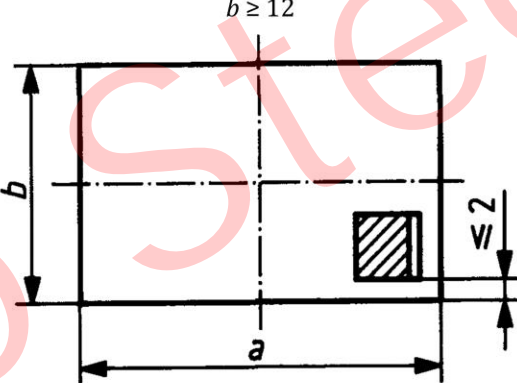
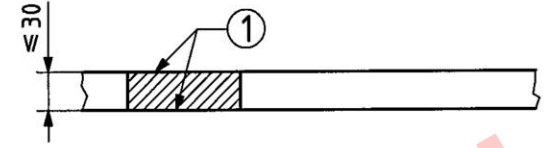
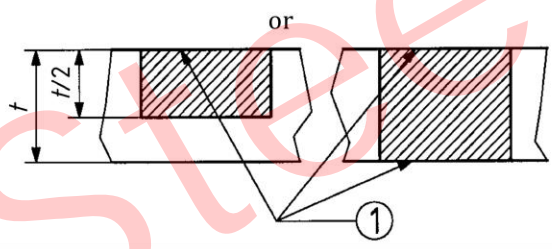
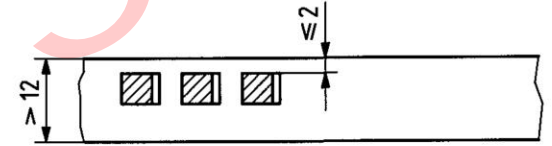
Type of test	Products with round cross-section	Products with rectangular cross-section
Tensile ^a	 <p>$d \leq 25$ ^a $d > 25$ ^b</p>	 <p>$b \leq 25$ ^a $b > 25$ ^b</p>
Impact ^c	 <p>$d \geq 16$</p>	 <p>$b \geq 12$</p>
<p>^a For products with small dimensions (d or $b \leq 25$ mm) the test piece, if practical, shall consist of an un-machined full section of the product.</p> <p>^b For products of diameter or nominal thickness ≤ 40 mm the manufacturer may either apply: the rules specified for products of diameter or nominal thickness ≤ 25 mm, or take the test piece at a location nearer the centre than indicated in the figure.</p> <p>^c For products of round cross-section, the axis of the notch is perpendicular to axis of the product; for products with rectangular cross-section, the axis of the notch is perpendicular to the greatest rolled surface.</p>		

Figure A.2 — Bars and rod

Dimensions in millimetres

Type of test	Nominal thickness of product	Direction of the longitudinal axis of the test piece in relation to the principal direction of rolling for product nominal widths of		Distance of the test piece from the rolled surface
		< 600	≥ 600	
Tensile ^a	≤ 30	longitudinal	transverse	 <p>1 rolled surface</p>
	> 30			 <p>or</p>
Impact ^{b d}	> 12 ^c	longitudinal	longitudinal	

^a In case of dispute, for products of nominal thickness greater than or equal to 3 mm use proportional test pieces of gauge length $L_0 = 5,65 \sqrt{S_0}$, see 9.2.3.2 and 10.2.1.

^b The axis of the notch shall be perpendicular to the surface of the product.

^c For nominal thicknesses $t \leq 12$ mm see 9.2.3.3.

^d For products ordered according to EN 10025-3, EN 10025-4 and EN 10025-6 for nominal thickness $t \geq 40$ mm impact test pieces shall be taken from 1/4 t position.

Figure A.3 — Flat products

Annex B
(informative)

List of Options of EN 10025-2 to -6

Table B.1 — List of Options in EN 10025-2 to -6

Number of Option	Options	Part 2	Part 3	Part 4	Part 5	Part 6
1	Details of manufacturing process	x	x	x	x	x
2	Product analysis	x	x	x	x	x
3	Verification of impact properties Part 2: for qualities JR Part 5: for qualities S355 class WP	x	-	-	x	-
4	Deformation properties perpendicular to the surface	x	x	x	x	x
5	Chemical composition for hot dip zinc coating	x	x	x	-	x
6	Ultrasonic testing for flat products	x	x	x	x	x
7	Ultrasonic testing for sections	x	x	x	x	-
8	Ultrasonic testing for bars	x	x	x	x	-
9	-	-	-	-	-	-
10	Special type of marking	x	x	x	x	x
11	Flangeability without cracking Part 2: nominal thickness ≤ 30 mm Part 3: nominal thickness ≤ 16 mm Part 4: nominal thickness ≤ 12 mm Part 5: nominal thickness ≤ 20 mm Part 6: nominal thickness ≤ 16 mm	x	x	x	x	x
12	Roll forming of flat products	x	x	x	-	-
13	For flat products out of each parent plate or coil impact properties only to be verified. Part 2: for qualities J2 and K2 Part 3 and 4: for all qualities Part 5: for qualities J2, J4, J5 and K2 Part 6: for each heat treatment unit and for all qualities	x	x	x	x	x
14	For flat products out of each parent plate or coil impact and tensile properties to be verified. Part 2: for qualities J2 and K2 Part 3 and 4: for all qualities Part 5: for qualities J2, J4, J5 and K2 Part 6: for each heat treatment unit and for all qualities	x	x	x	x	x
15	Other surface class for plates and wide flats	x	x	x	x	x
16	Other surface class for sections	x	x	x	x	-
17	Other surface class for bars and rods	x	x	x	x	-

Number of Option	Options	Part 2	Part 3	Part 4	Part 5	Part 6
18	For plates other thickness tolerance than class A (EN 10029)	x	x	x	x	x
19	Special delivery condition: Part 2: +AR, +N or +M for long products and strip, +AR, +N for quarto plates Part 5: +AR, +N, +M	x	-	-	x	-
20	Cu alloyed	x	-	-	-	-
21	-	-	-	-	-	-
22	Drawing of bars	x	-	-	-	-
23	Certificate of compliance for S185	x	-	-	-	-
24	Agreement on another impact test temperature	-	x	x	-	x
25	Sample preparation for semi-finished products	x	-	-	-	-
26	Max. Carbon for sections thickness > 100 mm	x	-	-	-	-
27	Higher S-content for better machinability	x	-	-	-	-
28	Min. impact values for sections thickness > 100 mm	x	-	-	-	-
29	-	-	-	-	-	-
30	Impact properties verified on transverse test pieces	-	x	x	-	x
31	Die stamping not allowed or at special position	-	x	x	-	x
32	Max. S-content	-	x	x	-	-
33	No application of CE-marking	x	x	x	x	x
34	For plates cut from strip thickness tolerances according to EN 10029	x	x	x	x	x

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**Plastics — Thermosetting moulding
materials — Determination of shrinkage**

*Plastiques — Matières à mouler thermodurcissables — Détermination
du retrait*



Reference number
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Foreword

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The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 2577 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 12, *Thermosetting materials*.

This third edition cancels and replaces the second edition (ISO 2577:1984), which has been technically revised.

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Plastics — Thermosetting moulding materials — Determination of shrinkage

1 Scope

This International Standard specifies a method of determining the moulding shrinkage and the shrinkage after heat treatment of moulded test specimens of thermosetting moulding materials.

These characteristics are useful for the production control of thermosetting material and for checking uniformity of manufacture. Furthermore, knowledge of the initial shrinkage of thermosetting materials is important for the construction of moulds, and knowledge of post-shrinkage for establishing the suitability of the moulding material for the manufacture of moulded pieces with accurate dimensions.

2 Normative references

The following referenced documents are indispensable for the application 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 295, *Plastics — Compression moulding of test specimens of thermosetting materials*

ISO 10724-1, *Plastics — Injection moulding of test specimens of thermosetting powder moulding compounds (PMCs) — Part 1: General principles and moulding of multipurpose test specimens*

ISO 10724-2, *Plastics — Injection moulding of test specimens of thermosetting powder moulding compounds (PMCs) — Part 2: Small plates*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

moulding shrinkage

difference in dimensions between a moulding and the mould cavity in which it was moulded, both the mould and the moulding being at normal temperature when measured

3.2

post-shrinkage

shrinkage of a plastic product after moulding, during post-treatment, storage or use

4 Apparatus

4.1 Mould, press, etc., suitable for moulding the test specimens specified in Clause 6. For compression moulding, a positive or a semi-positive mould with single or multiple cavities shall be used. For injection moulding, the type D2 ISO mould, giving 60 mm × 60 mm × 2 mm specimens, as specified in ISO 10724-2:1998, Clause 4, shall be used.

If required, marks may be engraved in the mould near opposite ends of the specimen to facilitate the accurate measurement of the length of the cavity and the specimens.

NOTE If multiple cavities are used with a positive mould, resulting variations in test specimen density may be sufficient to produce inconsistent shrinkage.

4.2 Equipment, suitable for measuring the lengths of the test specimen and the corresponding cavity of the mould to within 0,02 mm.

4.3 Oven (for post-shrinkage only).

5 Sampling

A representative sample shall be taken from the moulding material and be kept at room temperature in airtight containers, without any conditioning, until moulded into test specimens.

6 Test specimens

6.1 The test specimens shall be:

- a) for compression moulding — bars of length 120 mm, width 15 mm and thickness 10 mm;
- b) for injection moulding — flat square plates measuring approximately 60 mm × 60 mm × 2 mm.

6.2 The specimens shall be moulded to shape by compression or injection moulding using a mould with single or multiple cavities.

7 Procedure

7.1 If not already known, measure the lengths of the cavities (or the distances between the engraved marks in the mould) to the nearest 0,02 mm at a temperature of $23\text{ °C} \pm 2\text{ °C}$.

Record these measurements for use in the calculation of shrinkage.

From time to time, moulds should be checked for wear, etc. As an alternative to measuring directly the lengths of the cold moulds, the gauge for the moulds may be obtained very precisely by cold-moulding specimens from lead and measuring their lengths.

7.2 Mould at least two specimens from the sample to be tested, under the conditions given below:

a) For compression moulding:

Mould the specimens under the conditions of pressure, temperature, time, etc., specified in ISO 295 or in the relevant specification for the material.

b) For injection moulding:

Mould the specimens under the conditions specified in ISO 10724-2:1998, Clause 5, and ISO 10724-1.

In the case of fibrous materials that are to be injection-moulded as a plate, at least four specimens shall be tested.

7.3 After removal from the mould, allow the test specimens to cool to room temperature by placing them on a material with low thermal conductivity and under an appropriate load to avoid warping. Store them at a

temperature of $23\text{ °C} \pm 2\text{ °C}$ and a relative humidity of 45 % to 55 % for between 16 h and 72 h, or for such shorter time as can be shown to give the same test results.

7.4 Before measuring the lengths of the test specimens, place them on a flat surface or against a straight edge in order to determine any warp or distortion. Any test specimen that has a warp exceeding 1 % of its length shall be discarded.

7.5 For the determination of moulding shrinkage, measure, to the nearest 0,02 mm, the lengths of bar specimens parallel to their major axis between opposite end faces or the distances between the gauge marks, at a temperature of $23\text{ °C} \pm 2\text{ °C}$. Measurement of plate specimens shall be made at distance of 20 mm from the corners, making two measurements in the same direction.

NOTE In order to measure the effect of orientation on the shrinkage of an injection-moulded specimen, shrinkages in two directions at right-angles (each of which is calculated from an average of two measurements in the same direction) are measured and calculated independently.

7.6 For the determination of post-shrinkage, place the test specimens, measured as described in 7.5, in an oven maintained at the temperature given below. Support the specimens to avoid deformation and in such a way that they are separated from each other.

The heating temperatures shall be:

80 °C \pm 2 °C for urea-formaldehyde moulding materials;

110 °C \pm 3 °C for all other thermosetting moulding materials.

The times of exposure shall be:

48 h \pm 1 h for rapid determination;

168 h \pm 2 h for normal determination.

Post-shrinkage depends strongly on the time of exposure. Therefore the exposure time shall be noted [see 8.2 and Clause 9, item f)] and shall be as specified in the specification for the material.

At the end of the heating period, remove the test specimens from the oven and allow them to cool in a standard atmosphere of $23\text{ °C} \pm 2\text{ °C}$ and a relative humidity of 45 % to 55 % for at least 3 h.

After the cooling period, measure the test specimens again, at a temperature of $23\text{ °C} \pm 2\text{ °C}$, to the nearest 0,02 mm, as specified in 7.5.

8 Expression of results

8.1 The moulding shrinkage (MS) is given, as a percentage, by the equation:

$$MS = \frac{L_0 - L_1}{L_0} \times 100$$

where

L_0 is the length, in millimetres, of the dimension of the mould, determined as in 7.1;

L_1 is the length, in millimetres, of the corresponding dimension measured on the test specimen in accordance with 7.5.

NOTE When shrinkage is being determined using injection-moulded plates, L_0 and L_1 are each the average of two readings, measured in the same direction, taken 20 mm from the corners of the mould and the test specimen, respectively.

8.2 Post-shrinkage (PS) is given, as a percentage, by the equation:

$$PS_{48\text{ h}} \text{ or } PS_{168\text{ h}} = \frac{L_1 - L_2}{L_1} \times 100$$

where

L_1 is as defined in 8.1;

L_2 is the length, in millimetres, of the same dimension of the test specimen, measured after heat treatment for 48 h or 168 h in accordance with 7.6.

NOTE When post-shrinkage is being determined using injection-moulded plates, L_2 is the average of two readings, measured in the same direction, taken 20 mm from the corners of the test specimen.

9 Test report

The test report shall include the following particulars:

- a) a reference to this International Standard;
- b) the grade and designation of the moulding material;
- c) the type of test specimen used (bar or plate);
- d) the method of moulding the specimens (compression or injection) and the moulding conditions;
- e) the number of test specimens discarded because of excessive warping;
- f) the conditions of heat treatment for the determination of post-shrinkage;
- g) the moulding shrinkage (MS) and the post-shrinkage ($PS_{48\text{ h}}$ and/or $PS_{168\text{ h}}$), as a percentage, including the individual values, the arithmetic mean and, for injection-moulded plates, the direction of measurement with respect to the direction of injection;
- h) the dates of moulding the test specimens, measurement of moulding shrinkage, post-shrinkage heat treatment, and measurement of post-shrinkage.

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