

Weldable structural steels for fixed offshore structures — Technical delivery conditions

The European Standard EN 10225:2001 has the status of a
British Standard

ICS 77.140.10

National foreword

This British Standard is the official English language version of EN 10225:2001, incorporating Corrigendum July 2002. It supersedes BS 7191:1989 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/12, Structural steels, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 31 August 2001

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 86, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments
14055 Corrigendum No. 1	17 January 2003	Revision of 5.1.1, corrections to Tables 4, 5b and 10 and deletion of Annex H.

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ISBN 0 580 37002 X

English version

Weldable structural steels for fixed offshore structures — Technical delivery conditions

Aciers de construction soudables destinés à la fabrication
de structures marines fixes — Conditions techniques de
livraison

Schweißgeeignete Baustähle für feststehende Offshore-
Konstruktionen — Technische Lieferbedingungen

This European Standard was approved by CEN on 19 February 2001.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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Contents

Foreword	3
1 Scope	4
2 Normative references	4
3 Terms and definitions	7
4 Information to be supplied by the purchaser	8
5 Dimensions, mass and tolerances.....	9
6 Classification and designation.....	10
7 Manufacturing process	11
8 Requirements.....	12
9 Inspection and testing.....	19
10 Sampling.....	21
11 Test methods	24
12 Marking, bundling and protective coating	25
13 Options	27
Annex A (normative) Location of test samples for tensile and impact tests.....	48
Annex B (normative) Location of tensile test piece when two rolled surfaces cannot be retained	51
Annex C (normative when option 2 is specified by the purchaser) Details of manufacturing procedures to be supplied by the manufacturer for steels of groups 2 and 3.....	52
Annex D (normative when option 16 is specified by the purchaser) Cold forming characteristics for steel plate of groups 2 and 3	53
Annex E (normative when option 18 is specified by the purchaser) Weldability testing for steels of groups 2 and 3 and mechanical testing of butt welds	54
Annex F (normative when option 18 is specified by the purchaser) Weldability testing for steels of groups 2 and 3 — Bead-on-plate	74
Annex G (normative) Weldability testing for steels of groups 2 and 3 — Controlled thermal severity tests (CTS)	77
Annex H (informative) <i>deleted</i>	86
Bibliography	86

Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 10, Structural steels - Grades and qualities, the Secretariat of which is held by NEN.

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 February 2002, and conflicting national standards shall be withdrawn at the latest by February 2002.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies requirements for weldable structural steels to be used in the fabrication of fixed offshore structures in the form of plates up to and including 150 mm thick. It also specifies sections up to 63 mm thick except for sections delivered in the as-rolled condition which are permitted up to 25 mm thick only. Seamless hollow sections up to and including 40 mm thick and high frequency electric resistance welded hollow sections up to and including 20 mm thick are specified. Greater thicknesses for sections and hollow sections may be agreed, provided the technical requirements of this European Standard are maintained.

For plates the thickness limitations are:

S355G2+N, S355G5+M - up to and including 20 mm;

S355G3+N, S355G6+M - up to and including 40 mm;

S355G7+N, S355G8+N, S355G9+N, S355G10+N - up to and including 150 mm;

S355G7+M, S355G8+M, S355G9+M, S355G10+M - up to and including 100 mm;

S420G1+Q, S420G1+M, S420G2+Q, S420G2+M - up to and including 100 mm;

S460G1+Q, S460G1+M, S460G2+Q, S460G2+M - up to and including 100 mm.

The standard is applicable to steels for offshore structures, designed to operate in the offshore sector but not to steels supplied for the fabrication of subsea pipelines, risers, process equipment, process piping, and other utilities. It is primarily applicable to the North Sea sector, but may also be applicable in other areas provided that due consideration is given to local conditions, e.g. temperature.

In the case of hollow sections formed from plate with the seam fusion welded, this European Standard covers only the requirements of the plate material.

Minimum yield strengths up to 460 MPa are specified together with low temperature impact properties at temperatures down to -40 °C.

This European Standard applies to material supplied ex-mill or from merchant's stock.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revisions. For undated references the latest edition of the publication referred to applies (including amendments).

- EN 288-3, *Specification and approval of welding procedures for metallic materials — Part 3: Welding procedure tests for the arc welding of steels.*
- EN 473, *Non-destructive testing — Qualification and certification of NDT personnel — General principles.*
- EN 571-1, *Non-destructive testing — Penetrant testing — Part 1: General principles*
- EN 895, *Destructive tests of welds in metallic materials — Transverse tensile tests.*
- EN 1011-1, *Welding — Recommendations for welding of metallic materials — Part 1: General guidance for arc welding.*
- EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test (at ambient temperature).*
- EN 10020, *Definition and classification of grades of steels.*
- EN 10021, *General technical delivery requirements for steel and iron products.*
- EN 10024, *Hot rolled taper flange I sections — Tolerances on shape and dimensions.*
- EN 10027-1, *Designation systems for steels — Part 1: Steel names, principal symbols.*
- 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, shape and mass.*
- EN 10034, *Structural steel I and H sections — Tolerances on shape and dimensions.*
- EN 10045-1, *Metallic materials — Charpy impact test — Part 1: Test method.*
- EN 10052, *Vocabulary of heat treatment terms for ferrous products.*
- EN 10055, *Hot-rolled steel equal flange tees with radiused root and toes — Dimensions and tolerances on shape and dimensions.*
- EN 10056-2, *Structural steel equal and unequal leg angles — Part 2: 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 10113-1, *Hot-rolled products in weldable fine grain structural steels — Part 1: General delivery conditions.*
- EN 10113-2, *Hot-rolled products in weldable fine grain structural steels — Part 2: Delivery conditions for normalized/normalized rolled steels.*
- EN 10113-3, *Hot-rolled products in weldable fine grain structural steels — Part 3: Delivery conditions for thermomechanical rolled steels.*
- EN 10160, *Ultrasonic testing of steel flat product of thickness equal to or greater than 6 mm (reflection method).*
- EN 10163-2, *Delivery requirements for surface conditions of hot-rolled steel plates, sheets, wide flats and sections — Part 2: Plates and wide flats.*

EN 10225:2001 (E)

EN 10163-3, *Delivery requirements for surface conditions of hot-rolled steel plates, sheets, 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 10204, *Metallic products — Types of inspection documents.*

EN 10210-1, *Hot finished structural hollow sections of non-alloy and fine grain structural steels — Part 1: Technical delivery requirements.*

EN 10210-2, *Hot finished structural hollow sections of non-alloy and fine grain structural steels — Part 2: Tolerances, dimensions and sectional properties.*

EN 10233, *Metallic materials — Tube — Flattening test.*

EN 10246-3, *Non-destructive testing of steel tubes — Part 3: Automatic eddy current testing of seamless and welded (except submerged arc welded) steel tubes for the detection of imperfections.*

EN 10246-5, *Non-destructive testing of steel tubes — Part 5: Automatic full peripheral magnetic transducer/flux leakage testing of seamless and welded (except submerged arc welded) ferromagnetic steel tubes for the detection of longitudinal imperfections.*

EN 10246-7, *Non-destructive testing of steel tubes — Part 7: Automatic full peripheral ultrasonic testing of seamless and welded (except submerged arc welded) steel tubes for the detection of longitudinal imperfections.*

EN 10246-8, *Non-destructive testing of steel tubes — Part 8: Automatic ultrasonic testing of the weld seam of electric welded steel tubes for the detection of longitudinal imperfections.*

EN 10246-12, *Non-destructive testing of steel tubes — Part 12: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections.*

EN 10246-14, *Non-destructive testing of steel tubes — Part 14: Automatic ultrasonic testing of seamless and welded (except submerged arc welded) steel tubes for the detection of laminar imperfections.*

EN 10246-15, *Non-destructive testing of steel tubes — Part 15: Automatic ultrasonic testing of strip/plate in the manufacture of welded steel tubes for the detection of laminar imperfections.*

EN 10256, *Non-destructive testing of steel tubes — Qualifications and competence of levels 1 and 2 non-destructive testing personnel.*

EN 10279, *Hot rolled steel channels — Tolerances on shape, dimensions and mass.*

prEN 10306:1999, *Iron and steel — Ultrasonic testing of broad flanged beams with parallel flanges and IPE beams.*

EN ISO 4063, *Welding, brazing, soldering and braze welding of metals — Nomenclature of processes and reference numbers for symbolic representation on drawings (ISO 4063:1990).*

EN ISO 2566-1, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels (ISO 2566-1:1984).*

EN ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method (ISO 6507-1:1997).*

EN ISO 6947, *Welds — Working positions — Definitions of angles of slope and rotation (ISO 6947:1993).*

prEN ISO 9934-1, *Non-destructive testing — Magnetic particle testing — Part 1: General principles (ISO/DIS 9934-1:1996).*

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

3 Terms and definitions

For the purposes of this standard, the following terms and definitions and those given in EN 10020, EN 10021, EN 10052, EN 10079 and ISO 14284 apply.

3.1

parent product

product rolled from one piece of steel

3.2

manufacturer

manufacturer of the steel products

3.3

supplier

manufacturer of material supplied ex-mill or the merchant for material supplied from a merchant's stock (see clause 1)

3.4

purchaser

purchaser or his representative

3.5

concast

material produced by a continuous casting process route

3.6

primary elements

elements that are essential to the overall integrity of the installation including critical load transfer points and stress concentrations such as nodes

This definition also includes bracing and piling.

3.7

secondary elements

elements of minor importance, failure of which would be unlikely to affect the overall integrity of the installation

3.8

seamless hollow section (S)

hollow long product, open at both ends, of circular, square or rectangular section. Made by piercing a solid product to obtain a tube hollow which is further processed, hot or cold, into its final dimensions

3.9

high frequency welded hollow section (HFW)

hollow long product, open at both ends, of circular, square or rectangular section. Made by pressure welding in a continuous or non-continuous process, in which strip is formed cold into a hollow profile and the seam weld made by heating the adjacent edges through the resistance to the passage of a high frequency current and pressing the edges together. The electric current may be applied by direct electrode contact or by induction. After welding, the tube hollow is further processed, hot or cold, into its final dimensions

3.10

normalizing rolling

rolling process in which the final deformation is carried out in a particular temperature range leading to a material condition equivalent to that obtained after normalizing so that the specified values of the mechanical properties are retained even after normalizing

For the purposes of this European Standard, the designation of this delivery condition and of the normalized condition is +N.

EN 10225:2001 (E)

NOTE In international publications for both normalizing rolling and thermomechanical rolling, the expression “controlled rolling” may be found. However, in view of the different applicability of the products a distinction of the terms is necessary.

3.11

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

For the purposes of this European Standard, the designation of this delivery condition is +M.

NOTE Thermomechanical rolling leading to the delivery condition +M can include processes with an increasing cooling rate with or without tempering including self-tempering but excluding direct quenching and quenching and tempering.

3.12

quenching and tempering

3.12.1

quenching

operation which consists of cooling a ferrous product more rapidly than in still air

Quenching also includes direct quenching.

3.12.2

tempering

heat treatment applied to a ferrous product generally after quench hardening or other heat treatment to bring the properties to the required level. It consists of heating to specific temperatures ($<A_{c1}$) and soaking one or more times followed by cooling at an appropriate rate

For the purposes of this European Standard, the designation of delivery condition quenched and tempered is +Q.

4 Information to be supplied by the purchaser

4.1 General

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

- a) details of the product form;
- b) number of this European Standard, i.e. EN 10225;
- c) the steel grade (steel name or steel number);
- d) the type of inspection documents required (see **9.1**);
- e) where applicable, the number of additional copies of inspection documents required and the forwarding address (see **9.1.1**);
- f) nominal dimensions and when necessary tolerances;
- g) where applicable, that the material is required for the manufacture of piling;
- h) purchaser's order number and item number if applicable;
- i) quantity.

4.2 Options

A number of options are specified in clause 13. In the event that the purchaser does not indicate a wish to implement any of these options, the supplier shall supply in accordance with the basic specification.

5 Dimensions, mass and tolerances

5.1 Dimensions and tolerances

5.1.1 The dimensions and tolerances of the product shall be in accordance with one of the following relevant European Standards and as further specified in **5.1.2** and **5.1.3**:

EN 10024, EN 10029, EN 10034, EN 10055, EN 10056-2, EN 10067, EN 10210-2, EN 10279.

5.1.2 Unless otherwise agreed plate thickness tolerances shall be in accordance with EN 10029 Class A.

See option 1.

5.1.3 On plates with ripples or corrugations less than 2 m apart (peak to peak) the following criteria shall apply.

- The flatness tolerance shall, in all cases, be measured to the upper surface of the plate laid on a level surface.
- The maximum depth of any ripple or corrugation under the 2 m straight edge shall be 5 mm. The average depth of all ripples on any one plate shall not exceed 4 mm.
- The minimum depth to constitute a ripple or corrugation shall be 2 mm.
- The maximum number of ripples or corrugations allowed in any one plate shall be as given in Tables 1 and 2, and shall apply to all plates 10 mm thick and over and for all plate widths.

**Table 1 — Maximum number of ripples or corrugations in plate
with thickness ≥ 12 mm**

Length (L) m	Maximum number of ripples or corrugations
$L \leq 6$	2
$6 < L \leq 9$	3
$9 < L \leq 12$	4
$12 < L \leq 15$	5

Table 2 — Maximum number of ripples or corrugations in plate with thickness ≥ 10 mm < 12 mm

Length (L) m	Maximum number of ripples or corrugations
$L \leq 6$	4
$6 < L \leq 9$	5
$9 < L \leq 12$	6
$12 < L \leq 15$	8

5.2 Mass of steel

The calculated mass shall be determined using a density of 7,85 kg/dm³.

6 Classification and designation

6.1 Classification

The steel grade S355 specified in this European Standard is classified as an alloy quality steel and the steel grades S420 and S460 specified in this European Standard are classified as alloy special steels according to EN 10020.

This standard includes the following grades:

- a) group 1 grades with few changes from EN 10113 Parts 1-3 and EN 10210-1 (minor changes to chemical analysis, CEV and impact requirements only);
- b) groups 2 and 3 grades substantially modified from EN 10113 Parts 1-3 and EN 10210-1 including qualities with enhanced through-thickness ductility.

6.2 Designation

For the steel grades covered by this European Standard the steel names are based on EN 10027-1 and CR 10260. The steel numbers are allocated in accordance with EN 10027-2.

The designation consists of:

- a) the number of this European Standard, i.e. EN 10225;
- b) the symbol S;
- c) the indication of the minimum specified yield strength for thicknesses ≤ 16 mm expressed in MPa;
- d) the letter G, followed by the relevant digit(s) characterizing the steel grade
- e) where applicable, the letter indicating the delivery condition, i.e. +N, +M or +Q (see 7.3).

7 Manufacturing process

7.1 Steel manufacturing process

The steels shall be made by the basic oxygen or basic electric arc furnace process. All steels shall be fully killed and made to fine grain practice.

Steels of group 3 shall be vacuum degassed or ladle refined.

See option 2.

7.2 Thickness limits and segregation control

7.2.1 For concast steels of groups 2 and 3, provided that the resultant products comply with all the relevant requirements of this European Standard, the maximum thickness of product from the continuous casting process shall be at the manufacturer's discretion.

See option 3.

7.2.2 The minimum rolling reduction ratio of concast material for plate shall be 4:1 except for piling where it shall be 3:1.

See option 4.

7.2.3 Intermediate or finished products produced by the continuous casting route shall be examined for centre line segregation in accordance with the manufacturer's procedures and as agreed by the purchaser. This does not apply to seamless hollow sections.

See option 2.

7.3 Delivery condition

7.3.1 Plates of group 1

Plates shall be supplied in the furnace normalized/normalized rolled (+N) or thermomechanically rolled (+M) condition. The customer shall specify the appropriate grade at the time of enquiry and order.

Delivery conditions (+N) and (+M) are limited to a maximum thickness of 40 mm.

See option 5.

Examples:

a) Plate to grade S355G2+N

Plate with few changes from EN 10113-2 and with minimum specified $R_e = 355$ MPa and impact values measured at -20 °C, supplied in the normalized or normalized rolled condition.

b) Plate to grade S355G6+M

Plate with few changes from EN 10113-3 and with minimum specified $R_e = 355$ MPa and impact values measured at -40 °C, supplied in the thermomechanically rolled condition.

7.3.2 Plates of groups 2 and 3

Plates shall be supplied in the furnace normalized (+N), thermomechanically rolled (+M) or quenched and tempered (+Q) condition. The customer shall specify the appropriate grade at the time of enquiry and order.

Delivery condition (+N) is limited to a maximum thickness of 150 mm and delivery conditions (+M) and (+Q) to 100 mm.

EN 10225:2001 (E)

See option 5.

Examples:

a) Plate to grade S355G7+N (or S355G7+M)

Plate substantially modified from EN 10113-2 (or EN 10113-3) and with minimum specified $R_e = 355$ MPa and impact values measured at -40 °C, supplied in the normalized or normalized rolled (or thermomechanically rolled) condition.

NOTE The normalized rolled condition is only permitted when option 5 has been called up.

b) Plate to grade S460G2+Q (or S460G2+M)

Plate substantially modified from EN 10137-2 (or EN 10113-3), with controlled chemistry, particularly carbon, minimum specified $R_e = 460$ MPa and impact values measured at -40 °C with specified through-thickness properties, supplied in the quenched and tempered (or thermomechanically rolled) condition.

7.3.3 Sections

Sections shall be supplied in the as-rolled, normalized/normalized rolled (+N) or thermomechanically rolled (+M) condition as shown in Tables 6 and 7, at the manufacturer's discretion.

The as-rolled delivery condition is limited to a maximum thickness of 25 mm.

7.3.4 Hollow sections

Hollow sections shall be supplied in the normalized/normalized rolled (+N) or quenched and tempered (+Q) condition as shown in Tables 8 to 11 at the manufacturer's discretion.

NOTE S420 and S460 grades are normally only available in circular form.

8 Requirements

8.1 General

In addition to the requirements of this European Standard, the general technical delivery requirements specified in EN 10021 also apply.

8.2 Chemical composition

8.2.1 Ladle analysis

- The chemical composition for all qualities determined by ladle analysis shall comply with the values in Tables 4, 6, 8 and 10.
- For residual element control in steels of groups 2 and 3, boron (B) shall not be intentionally added to the steel. The deliberate addition of any elements other than those listed in Tables 4, 6, 8 and 10 shall not be permitted.
- When a restricted ladle analysis is agreed for steels of groups 2 and 3, the steel shall comply with the agreed analysis range.

See option 7.

8.2.2 Product analysis

8.2.2.1 Steels of group 1

Product analysis shall not be carried out except when option 8 is specified.

8.2.2.2 Steels of groups 2 and 3

a) The chemical composition determined by product analysis shall comply with the values given in Tables 4, 6, 8 and 10.

See option 6.

b) When restricted product analysis is agreed the steel shall comply with the agreed analysis range.

See option 7.

8.2.3 Carbon equivalent value (CEV) and P_{cm}

8.2.3.1 General

CEV¹⁾ and P_{cm} shall be calculated using the following equations where each element is expressed as a mass percentage:

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

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn + Cu + Cr}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

8.2.3.2 Plates

The maximum permissible CEV and P_{cm} values for plates are given in Table 3. These apply to product analysis except for grades S355G2+N, G3+N, G5+M and G6+M which shall be based on ladle analysis.

The CEV value shall apply for all designations except S355G9+N, G9+M, G10+N and G10+M where the P_{cm} value shall apply.

See option 9.

¹⁾ IIW, International Institute of Welding formula.

Table 3 — CEV and P_{cm} values for plates

Steel name ^a	CEV max.	P_{cm} max.
S355G2+N S355G3+N S355G5+M S355G6+M	0,43	Not specified
S355G7+N S355G7+M S355G8+N S355G8+M	0,43	0,24
S355G9+N S355G10+N	0,43	0,22
S355G9+M S355G10+M	0,41 ^b /0,42 ^c	0,21 ^b /0,22 ^c
S420G1+Q S420G1+M S420G2+Q S420G2+M	0,42	0,22 ^d
S460G1+Q S460G1+M S460G2+Q S460G2+M	0,43	0,22 ^d
^a For steel numbers, see Tables 4 to 11. ^b For $t \leq 75$ mm. ^c For $75 \text{ mm} < t \leq 100$ mm. ^d A P_{cm} value of 0,23 for $t \leq 15$ mm is permitted.		

8.2.3.3 Sections

The CEV of all sections shall not exceed 0,43.

See option 9, where a P_{cm} value not exceeding 0,24 shall apply in lieu of CEV.

These values apply to the product analysis except for grades S355G1, G1+N, G4 and G4+M where ladle analysis shall apply.

8.2.3.4 Hollow sections

The CEV of all hollow sections shall not exceed 0,43.

See option 9, where a P_{cm} value not exceeding 0,25 shall apply in lieu of a CEV.

These values apply to the product analysis except for the grade S355G1+N where ladle analysis shall apply.

8.3 Mechanical properties

8.3.1 General

Under the inspection and testing conditions as specified in clause 9 and in the heat treatment conditions given in 8.3.2 for plates and hollow sections, the tensile properties and the impact properties at the verification test temperature shall comply with the relevant requirements given in Tables 5a, 5b, 5c and 5d for plates, Table 7 for sections and Tables 9 and 11 for hollow sections.

8.3.2 Heat treatment condition of test pieces

For plates and hollow sections, samples (from which the test pieces are prepared and tested) shall be tested in the following conditions.

- a) For nominal thicknesses up to and including 20 mm - as delivered condition only.
- b) For nominal thicknesses over 20 mm up to and including 40 mm - as delivered condition. In addition, when required by the purchaser, the manufacturer shall provide supporting data illustrating the effect of simulated post weld heat treatment (PWHT) on the tensile and impact properties of the type of products involved.
- c) For nominal thicknesses over 40 mm - as delivered condition. In addition, when required by the purchaser, the manufacturer shall provide supporting data illustrating the effect of simulated PWHT on the tensile and impact properties of the type of products involved. Alternatively, the purchaser may require the manufacturer to test the material in the simulated PWHT condition (see option 10).
- d) For supply conditions +N and +M, the simulated PWHT shall be at 580 ± 20 °C (see option 11) for a minimum time of 1 h per 25 mm thickness of product, or 4 h, whichever is the greater.

For the quenched and tempered supply condition, the simulated PWHT shall be within the range 550 °C to 620 °C with a maximum temperature of 25 °C below the tempering temperature on the test certificate, for a minimum time of 1 hr per 25 mm thickness or 4 h, whichever is the greater.

8.3.3 Reduced section impact test pieces

If the nominal product thickness is not sufficient for the preparation of full size impact test pieces, test pieces of smaller width [see 10.2.5 b)] shall be taken, with a minimum width of 5 mm using the full thickness where necessary.

EN 10225:2001 (E)

The average impact values obtained from three reduced section test pieces shall be as follows:

for 10 mm × 7,5 mm section: 75 % of specified value;

for 10 mm × 5 mm section: 50 % of specified value.

8.3.4 Strain age tests

Strain age tests shall not be carried out except when option 12 is specified.

See option 12.

8.3.5 Through-thickness testing

Through-thickness testing shall not be carried out, except for steels of group 3 in thickness ≥ 25 mm when option 13 is specified.

See option 13.

8.3.6 Flattening test

A flattening test shall not be carried out except when option 14 is specified for circular welded hollow sections.

See option 14.

8.3.7 Wide plate and CTOD data for parent plate steels of groups 2 and 3

Data is not required except when option 15 is specified.

See option 15.

8.4 Technological properties

8.4.1 Cold forming characteristics of steel plate of groups 2 and 3

When required by the purchaser, the supplier shall make available data which characterize the cold forming behaviour of these steels. If such data is not available or are deemed inadequate by the purchaser, additional testing may be specified (see annex D).

See option 16.

8.4.2 Hot forming procedures for steel plate of groups 2 and 3

When required by the purchaser the steel supplier shall provide general information on the procedures and effects of hot forming on material properties.

See option 17.

NOTE Materials in delivery condition +M or +Q are generally unsuitable for subsequent normalizing or hot forming above 580 °C. Heating above 580 °C may lower the strength values. If temperatures above 580 °C are required, reference should be made to the supplier.

8.4.3 Weldability data for steels of groups 2 and 3

At the time of the enquiry and order for all products exceeding 40 mm in thickness the manufacturer shall have available data on the weldability of the material. Weldability data for other thicknesses may be agreed between supplier and customer. Any previously obtained data which the manufacturer proposes to submit shall have been verified by a competent third party, acceptable to the purchaser and who witnessed the tests. All previously obtained data presented shall bear the stamp or seal of the third party.

See option 18.

NOTE This data refers only to the weldability of the material being supplied and is intended for use in development and preparation of fabrication procedures.

8.5 Surface condition and internal defects

8.5.1 Plates

8.5.1.1 Surface condition

All surfaces shall be 100 % visually inspected. The surface condition shall comply with EN 10163-2, Class A, sub-class 3 except as otherwise specified in this clause. Plates shall be presented for inspection such that the steel surface can be readily examined.

Repair of defects such as cracks, shells or seams (in accordance with EN 10163-2) shall be followed by magnetic particle inspection or dye penetrant inspection.

8.5.1.2 Internal soundness for steels of group 1

The material shall be sound and free from such internal defects as might preclude its use for the purpose for which it is intended.

See option 19.

8.5.1.3 Internal soundness for steels of groups 2 and 3

All plates shall be ultrasonically tested in accordance with EN 10160.

Ultrasonic testing shall be carried out either prior to, or after the final heat treatment and shall meet the requirements of EN 10160, class S₁/E₂ for steels of group 3 and EN 10160, class S₀/E₁ for steels of group 2.

8.5.2 Sections

8.5.2.1 Surface condition

All surfaces shall be 100 % visually inspected for defects and the surface condition shall comply with EN 10163-3, Class C, sub-class 2.

See option 20.

8.5.2.2 Internal soundness for steels of group 1

The material shall be sound and free from such internal defects as might preclude its use for the purpose for which it is intended.

See option 21.

8.5.2.3 Internal soundness for steels of groups 2 and 3

The material shall be sound and free from such internal defects as might preclude its use for the purpose for which it is intended.

Internal soundness for rolled sections with web thickness greater than 12 mm shall be subject to ultrasonic examination of webs and flanges when specified by the purchaser and shall meet the requirements of prEN 10306:1999, Class 21.

See option 21.

NOTE Testing of the region between the web and the flange should be subject to agreement between the supplier and the purchaser.

8.5.3 Hollow sections

8.5.3.1 Surface condition

Hollow sections shall be free from external and internal defects that can be detected by visual inspection in accordance with this European Standard as follows.

The outside surface condition and, where practical, the inside surface condition shall be such that surface imperfections requiring dressing and/or surface defects can be identified.

It shall be permissible to rectify surface imperfections by grinding or machining, provided that after so doing, the hollow section thickness in the dressed region is not less than the minimum permissible wall thickness. All dressed areas shall blend smoothly into the contour of the section.

Surface imperfections which encroach on the minimum permissible wall thickness shall be considered as defects and the product shall be deemed not to comply with this European Standard.

Hollow sections shall contain no dents greater than 3 mm or 1 % of the specified outside diameter or largest outside dimensions respectively, whichever is the lesser. This shall be measured as the gap between the lowest point of the dent and a prolongation of the original contour of the hollow section. The length of the dent in any direction shall not exceed 25 % of the section's largest outside dimension.

Any sharp bottom gouge within a dent or otherwise shall be removed by grinding. The use of shot peening or welding is not permitted.

When the wall thickness has been reduced by more than 7,5 % of the nominal wall thickness during rectification, magnetic particle inspection shall be used to confirm removal of imperfections (see **11.3.4**).

8.5.3.2 Internal soundness (laminations)

Hollow sections shall comply with the requirements of EN 10246-14 acceptance level U3 or EN 10246-15 acceptance level U3.

When required, compliance with this requirement shall be demonstrated.

See option 22.

8.5.3.3 Non-destructive testing of the weld seam of welded hollow sections

The weld seam of welded hollow sections shall be tested full length for longitudinal defects in accordance with EN 10246-3, EN 10246-5 or EN 10246-8 to acceptance levels E4, F4 or U4 respectively.

NOTE For rectangular or square hollow sections this is normally carried out in the circular form before squaring.

The method of test shall be at the discretion of the manufacturer.

When EN 10246-5 or EN 10246-8 are used, calibration shall be carried out using an external reference notch.

When the purchaser has indicated that welded hollow sections are to be used in primary elements, the internal weld bead shall be removed and the weld seam tested full length for longitudinal defects in accordance with EN 10246-8 to acceptance level U3. Calibration shall be carried out using both internal and external reference notches.

See option 23.

8.5.3.4 Non-destructive testing of seamless hollow sections

All seamless hollow sections shall be ultrasonically tested for longitudinal defects in accordance with EN 10246-7 to acceptance level U3/C.

When the purchaser has indicated that the seamless hollow section is to be used in primary elements, it shall be tested in accordance with EN 10246-7 to acceptance level U2/C.

See option 23.

9 Inspection and testing

9.1 General

The products shall be subjected to specific inspection and testing in accordance with EN 10021 and supplied with an inspection document in accordance with EN 10204. The purchaser shall indicate on the enquiry and order the type of inspection document required and, where applicable, their nominated representative.

9.1.1 Ex-mill supply

The relevant inspection documents shall be issued to the purchaser at the time of despatch. An additional number of copies as defined by the purchaser at the time of the order shall be sent to an address nominated by the purchaser [see 4.1 e)].

Inspection documentation of types 3.1A, 3.1B, 3.1C or 3.2 in accordance with EN 10204 shall contain at least the following information.

a) Identification

- product form;
- mill location;
- the purchaser's order and item number where applicable;
- method of steel manufacture;
- heat or cast number and/or the product identification number(s) where available (see 9.1.3);
- dimensions;
- designation of steel (see 6.2).

b) Composition

- ladle analysis;
- product analysis where applicable;
- carbon equivalent value where applicable (CEV);
- P_{cm} value where applicable.

c) Heat treatment

- details of heat treatment stating nominal temperature, nominal soaking times and cooling method.

d) Mechanical properties

- yield strength, tensile strength, elongation;
- yield strength/tensile strength ratio where applicable;
- Charpy V-notch impact test results;
- through-thickness properties (if required);
- strain age test results (if required).

e) Nominal or actual mass

f) Non-destructive test (NDT)

- confirmation that NDT has been satisfactorily carried out is to be included on the inspection document.

In addition to the above certification requirements, the analysis of residual elements and the results of any additional testing including details of segregation control monitoring requested by the purchaser at the time of enquiry and order shall be submitted.

Results of weldability testing in accordance with option 18 and annexes E, F and G shall not form any part of the inspection document.

9.1.2 Merchant supply

If any steel is supplied from a merchant's stock, the merchant shall be responsible for:

- supplying to the purchaser a copy of the original order requirements placed on the mill and the subsequent sales history of the product;
- supplying to the purchaser all documentation required by this standard including a copy of the mill inspection document (see **9.1.1**) verified by an independent inspection body;
- satisfying the purchaser by means of numbers or identification marks on the steel (or tab when parcels of steel are bundled) that such steel has been tested and complies with all the requirements of this European Standard as applicable.

9.1.3 Identification of cast

The manufacturer shall identify the ingots, billets, slabs, plates, sections and hollow sections etc. in such a way as to enable the finished product to be traced to the cast from which it was made.

9.1.4 Delivery

Steel shall be delivered together with an accompanying advice note which shall contain the following minimum information:

- mill location;
- the purchaser's purchase order and item number if applicable (see **4.1**);
- cast number and/or the product identification number(s) (see **9.1.3**);
- the plate/section/hollow section sizes;
- steel designation.

10 Sampling

The verification of the mechanical properties for plates, sections and hollow sections shall be by cast.

10.1 Frequency of testing

10.1.1 Tensile tests (general)

A sample product shall be taken for each 40 tonnes or part thereof, of the same thickness range as given in Tables 5, 7, 9 and 11 for the yield strengths, and for the same cast and in the same heat treatment condition but not showing a thickness variation of more than 5 mm above and below the thickness of the product sampled. Where ingot practice is used for plates, one sample product shall be taken from each parent plate.

10.1.2 Impact tests (general)

A sample product shall be taken for each 40 tonnes or part thereof, of the same thickness range as given in Tables 5, 7, 9 and 11 for the yield strengths, and for the same cast and in the same heat treatment condition.

10.1.3 Additional requirements for welded hollow sections

When required (see option 24) the weld of welded hollow sections shall be subjected to the following testing:

Test position	Group	Frequency	
		Tensile	Impact
Weld	1	1/test unit ^a	1/test unit ^b
Weld	2 and 3	1/test unit ^a	2/test unit ^b

^a For FFW hollow sections with a nominal length of side greater than 150 mm or diameter greater than 219 mm.
^b For HFW hollow sections with a nominal length of side greater than 150 mm or diameter greater than 168,3 mm.

10.2 Preparation of samples and test pieces

10.2.1 General

The manufacturer shall randomly select and identify samples in accordance with **10.2.2** and **10.2.3**.

NOTE Weld samples for tensile or impact testing may not be available on square or rectangular hollow sections when the weld occurs in the corner region.

10.2.2 Location of samples and orientation of tensile test pieces

10.2.2.1 General

One sample product shall be taken from each test unit for tensile testing.

10.2.2.2 Plates

Samples shall be taken from one end of the plate at a position approximately 1/4 of the plate width (see Figure A.1).

Tensile test pieces shall be prepared with their longitudinal axis transverse to the principal direction of rolling.

10.2.2.3 Sections

Samples from sections shall be taken from the relevant flange positions shown in Figure A.2. In the case of sections with tapered flanges, it is permissible, at the manufacturer's discretion, for the samples to be taken from the web at a quarter of the total height or from the flange.

Tensile test pieces shall be prepared with their longitudinal axis parallel to the principal direction of rolling.

10.2.2.4 Hollow sections

For hollow sections with an outside diameter equal to or less than 219,1 mm or a nominal length of side equal to or less than 150 mm, the test piece shall be either, at the manufacturer's discretion, a full tube section or a strip section and be taken in a direction longitudinal to the axis of the hollow section (see Figure A.3).

For hollow sections with an outside diameter greater than 219,1 mm or a nominal length of side greater than 150 mm, the test piece shall, at the manufacturer's discretion, be taken either longitudinal or transverse to the axis of the hollow section. Samples shall exclude any weld and, in the case of rectangular and square hollow sections, shall be taken from any side midway between the corners as shown in Figure A.3.

For transverse testing of the weld of HFW hollow sections, with an outside diameter greater than 219,1 mm or nominal length of side greater than 150 mm, samples shall be taken with the weld positioned in the centre of the sample (see 10.2.1).

10.2.3 Location of samples and orientation of impact test pieces

10.2.3.1 General

One sample sufficient for 6 test pieces shall be taken from each test unit.

10.2.3.2 Plates

Samples shall be taken from the position shown in Figure A.1.

The test piece shall be taken from the following positions:

- a) sub-surface: one face of a Charpy specimen shall be located within 2 mm from a rolled surface except for materials less than 12 mm thick; and
- b) mid-thickness: for steels of groups 2 and 3 when the test thickness is above 40 mm, additional impact test pieces shall be taken from the mid-thickness position.

Charpy V-notch test pieces shall be machined parallel to the principal direction of rolling for steels of group 1 and transverse to the principal direction of rolling for steels of groups 2 and 3 (see Figure 1).

10.2.3.3 Sections

Samples shall be taken from within 25 mm of the centres of the positions shown in Figure A.2. For sections of non-uniform thickness, samples shall be taken from the thickest part of the section at the locations specified.

Test pieces shall be cut parallel to the principal direction of rolling.

See options 26 and 27.

10.2.3.4 Hollow sections

For hollow sections with an outside diameter equal to or less than 168,3 mm or a nominal length of side equal to or less than 150 mm, the test piece shall be a longitudinal sample from a position as shown in Figure A.3 .

For hollow sections with an outside diameter greater than 168,3 mm or a nominal length of side greater than 150 mm the test piece shall, at the manufacturer's discretion, be taken either longitudinal or transverse to the axis of the hollow section. Samples shall exclude any weld and be taken from positions shown in Figure A.3.

For transverse testing of the weld of the HFW hollow sections with an outside diameter greater than 168,3 mm or nominal length greater than 150 mm, samples shall be taken with the notch centred on the weld.

See option 24.

10.2.4 Preparation of tensile test pieces

10.2.4.1 Tensile test pieces shall be prepared in accordance with EN 10002-1 from samples obtained in accordance with annex A so that, wherever practicable, the rolled surface of the steel is retained on two opposite sides of the test piece. Where this is not practicable, then:

- a) for grades S355, rectangular test pieces having a thickness of not less than 12,5 mm shall be taken from the relevant position shown in Figure B.1;
- b) for grades S420 and S460, rectangular test pieces having a thickness of approximately 1/2 of the product thickness and retaining one rolled surface shall be used;
- c) alternatively, for all grades, round tensile test pieces having a diameter of not less than 12,5 mm shall be taken from the relevant position shown in Figure B.1.

10.2.4.2 Any straightening of test pieces which is required shall be done cold. Test pieces cut from circular hollow sections shall be tested in the curved condition, but it is permissible for the ends to be flattened cold for gripping.

10.2.5 Preparation of impact test pieces

Test pieces shall be prepared in accordance with EN 10045-1. The axis of the notch shall be perpendicular to the rolled surface of the product (see Figure 1). In addition the following shall apply:

- a) for material equal to or greater than 12 mm thickness, standard 10 mm × 10 mm test pieces shall be so machined that one side is not further than 2 mm from a rolled surface;
- b) for material less than 12 mm thick, reduced width test pieces shall be used, with a minimum width of 5 mm, using the full thickness where necessary;
- c) for plate material of groups 2 and 3 and thicknesses greater than 40 mm, additional standard 10 mm × 10 mm test pieces shall be machined from samples taken from the mid-thickness.

NOTE Impact tests for material less than 6 mm thick are not normally carried out but may be agreed between the purchaser and the manufacturer at the time of the enquiry and order.

10.3 Verification of chemical composition

10.3.1 For ladle analysis determined for each cast, the values reported by the steel manufacturer shall apply.

10.3.2 Product analysis when required shall be determined twice per cast or once per 40 tonnes, or part thereof, whichever is the more stringent, on the test sample used for the verification of the mechanical properties (see 8.2).

11 Test methods

11.1 Chemical analysis

For the determination of the chemical composition the corresponding European Standards shall apply in cases of dispute.

11.2 Mechanical tests

Mechanical tests shall be carried out in the temperature range 10 °C to 35 °C, except where a temperature is specified for impact tests.

11.2.1 Tensile test

The tensile test shall be carried out in accordance with EN 10002-1. The tensile strength R_m , the yield strength R_e , and the elongation A , shall be determined. For transverse tensile testing of welds, only the tensile strength R_m shall be determined.

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 ($R_{p0,2}$) or the 0,5 % proof strength for total elongation ($R_{t0,5}$) shall be determined; in cases of dispute the 0,2 % proof strength ($R_{p0,2}$) shall be determined.

The specified elongation values relate to a proportional gauge length of $5,65 \sqrt{S_0}$ where S_0 is the original cross-sectional area of the test pieces.

If other gauge lengths are used, the percentage value obtained shall be converted to the value for a gauge length of $5,65 \sqrt{S_0}$ using the conversion tables in EN ISO 2566-1.

NOTE The scope of EN ISO 2566-1 precludes its use for quenched and tempered steels. However, it is technically acceptable to apply its provisions to the quenched and tempered steels in this standard.

11.2.2 Impact test

The impact test shall be carried out in accordance with EN 10045-1.

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 **10.2.5** and tested in 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 any one 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.

11.3 Non-destructive tests

11.3.1 Qualification of personnel

For implementation of the non-destructive testing procedures and evaluation, all NDT personnel shall be qualified in accordance with EN 473 or EN 10256 as appropriate.

11.3.2 Test methods for plates

- a) Ultrasonic testing shall be carried out in accordance with EN 10160 (see **8.5.1.3**).
- b) Magnetic particle inspection shall be carried out in accordance with prEN ISO 9934-1 (see **8.5.1.1**).
- c) Liquid penetrant inspection shall be carried out in accordance with EN 571-1 (see **8.5.1.1**).

11.3.3 Test methods for sections

- a) Ultrasonic testing shall be carried out in accordance with prEN 10306 (see **8.5.2.3**).

11.3.4 Test methods of structural hollow sections

- a) Ultrasonic testing shall be carried out in accordance with EN 10246-7, EN 10246-8, EN 10246-14 or EN 10246-15 (see **8.5.3.2**, **8.5.3.3** and **8.5.3.4**).
- b) Eddy current testing shall be in accordance with EN 10246-3 (**8.5.3.3**).
- c) Flux leakage testing shall be carried out in accordance with EN 10246-5 (**8.5.3.3**).
- d) Magnetic particle inspection shall be carried out in accordance with EN 10246-12 (see **8.5.3.1**).

11.3.5 General

When specified at the time of enquiry and order, the manufacturer shall submit written ultrasonic, magnetic particle (MPI) and dye penetrant inspection procedures for approval prior to production of the order.

See option 2.

11.4 Re-tests and re-submission for testing

EN 10021 shall apply in respect of all re-tests and re-submission for testing.

In the case of strip, re-tests 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.

12 Marking, bundling and protective coating

12.1 Die stamp and paint marking

Die stamp letters and digits [see also **12.1.1 a)**] shall be at least 8 mm high [see also **12.1.1 b)**]. Paint marking shall be in contrasting colours with letters and digits at least 40 mm high [see **12.1.1 b)**].

All markings shall be located in accordance with Figures 2 to 4.

If die stamping on bundled sections is required this may be performed on the saw cut surface.

The following information shall be die stamped except as provided in **12.2**:

- a) cast number and/or product identification number;