November 2019

DIN EN 10225-2

ICS 77.140.10

Together with DIN EN 10225-1:2019-11, DIN EN 10225-3:2019-11 and DIN EN 10225-4:2019-11
supersedes
DIN EN 10225:2009-10

Weldable structural steels for fixed offshore structures – Technical delivery conditions – Part 2: Sections; English version EN 10225-2:2019, English translation of DIN EN 10225-2:2019-11

Schweißgeeignete Baustähle für feststehende Offshore-Konstruktionen –
Technische Lieferbedingungen –
Teil 2: Profile;
Englische Fassung EN 10225-2:2019,
Englische Übersetzung von DIN EN 10225-2:2019-11

Aciers de construction soudables destinés à la fabrication de structures marines fixes –
Conditions techniques de livraison –
Partie 2: Profilés;
Version anglaise EN 10225-2:2019,
Traduction anglaise de DIN EN 10225-2:2019-11

Document comprises 46 pages

Translation by DIN-Sprachendienst.

In case of doubt, the German-language original shall be considered authoritative.

www.din.de
www.beuth.de

10.19 3116924

A comma is used as the decimal marker.

National foreword

This document (EN 10225-2) has been prepared by Technical Committee CEN/TC 459/SC 3 "Structural steels other than reinforcement" (Secretariat: DIN, Germany) of the European Committee for Iron and Steel Standardization (ECISS).

The responsible German body involved in its preparation was *DIN-Normenausschuss Eisen und Stahl* (DIN Standards Committee Iron and Steel), Subcommittee NA 021-00-04-03 UA "Steels for offshore-structures".

The DIN document corresponding to the international document referred to in this document is as follows:

ISO 15653 DIN EN ISO 15653

Amendments

This standard differs from DIN EN 10225:2009-10 as follows:

a) the standard has been separated into four parts;

b) the short names for steels have been adapted to EN 10027-1;

c) steel grades will no longer be delivered in the "as rolled" condition;

d) an informative Annex C on the prequalification of steels for fixed offshore structures in arctic areas has been added;

e) the standard has been editorially revised.

Previous editions

DIN EN 10225: 2002-01, 2009-10

National Annex NA
(informative)

Bibliography

DIN EN ISO 15653, *Metallic Materials — Method of test for the determination of quasistatic fracture toughness of welds*

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 10225-2

May 2019

ICS 77.140.10

Supersedes EN 10225:2009

English Version

Weldable structural steels for fixed offshore structures - Technical delivery conditions - Part 2: Sections

Aciers de construction soudables destinés à la fabrication de structures marines fixes - Conditions techniques de livraison - Partie 2: Profilés

Schweißgeeignete Baustähle für feststehende Offshore-Konstruktionen - Technische Lieferbedingungen - Teil 2: Profile

This European Standard was approved by CEN on 23 December 2018.

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 CEN-CENELEC 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 CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. EN 10225-2:2019 E

Contents

Page

European foreword

This document (EN 10225-2:2019) has been prepared by Technical Committee CEN/TC 459 “ECISS - European Committee for Iron and Steel Standardization”[1], the secretariat of which is held by AFNOR.

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 November 2019, and conflicting national standards shall be withdrawn at the latest by November 2019.

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, together with EN 10225-1:2019, EN 10225-3:2019, and EN 10225-4:2019, supersedes EN 10225:2009.

This European Standard consists of the following parts, under the general title *'Weldable structural steels for fixed offshore structures – Technical delivery conditions*'.

— Part 1: Plates

— Part 2: Sections

— Part 3: Hot finished hollow sections

— Part 4: Cold formed hollow sections

In comparison to the previous edition following technical changes were made:

— split of the standard in four parts;

— the steel names were adapted to EN 10027-1;

— steel grades will no longer be delivered in the 'as rolled' condition;

— an informative Annex C was added for the prequalification of steels for fixed offshore structures in arctic areas.

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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Through its subcommittee SC 3 “Structural steels other than reinforcements” (secretariat: DIN)

1 Scope

This document specifies requirements for weldable structural steels, in the form of sections (e.g. H-, I-, Z-sections, U-channels, angles and tees) excluding hollow sections, to be used in the fabrication of fixed offshore structures. The thickness limitation in this standard is up to and including 63 mm.

For steel qualities with mechanical properties in the transverse direction (named xL1O) sections with flange widths smaller than 180 mm and channels with flange widths smaller than 90 mm cannot be ordered.

Greater thicknesses may be agreed, provided the technical requirements of this European Standard are maintained.

This European 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. design temperature.

NOTE This document has an informative Annex C on the prequalification of steels for fixed offshore structures in arctic areas.

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

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 1011-1, *Welding — Recommendations for welding of metallic materials — Part 1: General guidance for arc welding*

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

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

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

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

EN 10079, *Definition of steel products*

EN 10163-1, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 1: General requirements*

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*

CEN/TR 10261, *Iron and steel — European standards for the determination of chemical composition*

EN 10306, *Iron and steel — Ultrasonic testing of H beams with parallel flanges and IPE beams*

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 643, *Steels — Micrographic determination of the apparent grain size (ISO 643)*

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

EN ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers (ISO 4063)*

EN ISO 4136, *Destructive tests on welds in metallic materials — Transverse tensile test (ISO 4136)*

EN ISO 4885, *Ferrous materials — Heat treatments — Vocabulary (ISO 4885)*

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

EN ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1)*

EN ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel (ISO 9712)*

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

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1)*

ISO 11484, *Steel products — Employer's qualification system for non-destructive testing (NDT) personnel*

ISO 12135, *Metallic materials — Unified method of test for the determination of quasistatic fracture toughness*

ISO 15653, *Metallic materials — Method of test for the determination of quasistatic fracture toughness of welds*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10020, EN 10021, EN ISO 4885, EN 10079 and EN ISO 14284 and the following apply.

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

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

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

3.1
continuous casting process route (concast)
steel produced by a continuous casting process route

3.2
fine grain steel
steels with fine grain structure with an equivalent index of ferritic grain size ≥ 6 for steel grades with ferritic/perlitic microstructure or with an equivalent index of former austenitic grain size ≥ 5 for steel grades with martensitic/bainitic microstructure

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

3.3
intermediary
organization that is supplied with products by the manufacturers and that then, in turn, supplies them without further processing or after processing without changing the properties specified in the purchase order and referenced product specification

3.4
manufacturer
organization that manufactures the respective products according to the requirements of the order and to the properties specified in the referenced product specification to the final customer

3.5
normalized rolled
rolling process in which the final deformation is carried out in a certain 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

Note 1 to entry: In international publications for both the normalizing rolling, as well as the 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.

3.6
parent product
product rolled from one piece of steel

3.7
purchaser
purchaser or their representative

3.8
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: Hot forming or post weld heat treatment at a temperature above 580 °C may lower the strength values and it is not recommended to be performed. Flame straightening can be applied in accordance with CEN/TR 10347.

Note 2 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 3 to entry: In some publications the word TMCP (Thermomechanical Control Process) is also used.

4 Classification and designation

4.1 Classification

All steel grades specified in this European Standard are classified as alloy special steels according to EN 10020.

NOTE The steel grades in this European Standard are substantially modified from steel grades in EN 10025-2, -3, -4 and -6.

4.2 Designation

4.2.1 For the products covered by this European Standard the steel names are allocated in accordance with EN 10027-1; the steel numbers are allocated in accordance with EN 10027-2.

4.2.2 For steels for offshore structures the steel designation consists of:

— the number of this European Standard (EN 10225-2);

— the capital letter S for structural steel;

— the indication of the minimum specified yield strength for thicknesses ≤ 16 mm expressed in MPa;

— further designations for either

  — normalized rolled structural steels: capital letters NL - letter N to indicate normalized rolled, letter L to indicate specified impact properties at –40 °C (see 6.3); or

  — thermomechanical rolled structural steels: capital letters ML - letter M to indicate thermomechanical rolled, letter L to indicate specified impact properties at –40 °C (see 6.3);

— no number or number 1:

  — no number for longitudinal Charpy –V-notch impact test (test pieces are cut parallel to the rolling direction); or

  — number 1 for transverse Charpy-V-notch impact test (test pieces are cut transverse to the rolling direction); and

— the capital letter O for offshore structures.

EXAMPLE 1 Structural steel (S) with a specified minimum yield strength for a thickness not greater than 16 mm of 355 MPa, thermomechanical rolled condition with a minimum impact energy value of 50 J at –40 °C (longitudinal Charpy-impact test pieces), for offshore application:

EN 10225–2 — S355MLO

or

EN 10225–2 — 1.8811

NOTE For a transition period the old steel names and numbers are given in Tables 3 to 8 in brackets.

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 enquiry and order:

a) the quantity (number of sections or total length);

b) details of the product form: H-, I-, L-, T-, U- or Z-section;

c) the name of the standard for dimensions and tolerances and the dimensions and tolerances (see Annex D);

d) the name of this standard (EN 10225-2) and the steel designation (steel name or steel number, see 4.2.2);

e) standard designation in accordance with EN 10204 for an inspection certificate 3.1 or, if required, inspection certificate 3.2 (see also *Option 24*).

5.2 Options

A number of options are specified in Clause 12. In the event that the purchaser does not indicate a wish to implement any of these options, the manufacturer shall supply in accordance with the basic specification (see 5.1). The options in Clause 12 are numbered through all four parts of EN 10225, therefore some options are not available for this part.

5.3 Example of an order

30 sections HEA500 with specified dimensions according to EN 10365 of 10 m length each and tolerances according to EN 10034 made of steel S355ML0 for offshore application according to EN 10225-2 supplied with inspection document 3.1:

30 sections HEA500 according to EN 10365, length 10 m, tolerances according to EN 10034, EN 10225-2 — S355MLO – inspection certificate 3.1

or

30 sections HEA 500 – according to EN 10365, length 10 m, tolerances according to EN 10034, EN 10225-2 — 1.8811 inspection certificate 3.1

6 Manufacturing process

6.1 Steel manufacturing process

The steel manufacturing process shall be at the discretion of the manufacturer with the exception that the open hearth (Siemens-Martin) process shall not be employed.

All steels shall be fully killed.

All steels shall be made to fine grain practice.

See ***Option 1*** (further details of steel manufacturing process)

See ***Option 2*** (vacuum degassed and/or ladle refined)

All products shall be traceable to the cast.

6.2 Qualification of personnel for NDT-activities

All NDT activities shall be carried out by qualified and competent level 1, 2 and/or 3 personnel authorized to carry out this work by the employer.

The qualification shall be in accordance with ISO 11484 or, at least, an equivalent to it.

It is recommended that the level 3 personnel be certified in accordance with EN ISO 9712 or, at least, an equivalent to it.

The operating authorization issued by the employer shall be in accordance with a written procedure.

NDT operations shall be authorized by a level 3 NDT individual approved by the employer.

NOTE The definition of levels 1, 2 and 3 can be found in the appropriate standards, e.g. EN ISO 9712 and ISO 11484.

6.3 Delivery condition

Sections shall be supplied in the normalized rolled (N) or thermomechanically rolled (M) condition as shown in Tables 3 to 8.

6.4 Thickness limits

6.4.1 The maximum thickness of product from the continuous casting process shall be at the manufacturer's discretion.

7 Requirements

7.1 General

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

7.2 Chemical composition

7.2.1 Heat analysis

The chemical composition determined by heat analysis shall comply with the values in Tables 3 and 6.

The deliberate addition of any elements other than those listed in Tables 3 and 6 shall not be permitted. For residual element control, Boron (B) shall not be intentionally added to steel grades up to and including S460.

Any further restrictions in heat analysis shall be agreed between the manufacturer and the purchaser at the time of the enquiry and order, see ***Option 6*** (restricted heat analysis).

7.2.2 Product analysis

The chemical composition determined by product analysis shall comply with the values given in Tables 3 and 6, for verification see ***Option 7*** (product analysis).

Any further restrictions in product analysis shall be agreed between the manufacturer and the purchaser at the time of enquiry and order, see ***Options 6 and 7*** (restricted product analysis).

7.2.3 Carbon equivalent values (CEV) and P_{cm}

CEV[2] and P_{cm} shall be calculated using the following formulae where each element is expressed as a mass percentage:

$$CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (1)$$

$$Pcm = C + \frac{Si}{30} + \frac{Mn + Cu + Cr}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B \quad (2)$$

The maximum permissible CEV and P_{cm} values are given in Tables 4 and 7. Either the P_{cm} or/and the CEV is reported at the discretion of the manufacturer, unless otherwise agreed between manufacturer and purchaser at the time of enquiry and order. See ***Option 8*** (agreement whether to report a P_{cm} or/and CEV value).

7.3 Mechanical properties

7.3.1 General

Under the inspection and testing conditions as specified in Clauses 8, 9 and 10 the mechanical properties at the verification test temperature shall comply with the relevant requirements given in Tables 5 and 8.

7.3.2 Through-thickness testing

Through-thickness testing shall not be carried out, except when ***Option 12*** is specified.

See ***Option 12*** (through thickness testing)

7.3.3 Prequalification for arctic areas

If specified at the time of enquiry and order testing at specified lower temperatures shall be carried out.

See informative Annex C (testing at lower temperatures as prequalification for arctic areas shall be done, e.g. for arctic area 1, 2 or 3 at −20 °C, −30 °C or −40 °C).

7.4 Weldability data

Weldability data is not required, except when option 17 is specified.

See ***Option 17*** (weldability data, this option shall already be requested at the time of enquiry)

Regardless of the revision of the standard, weldability studies performed with a former version of EN 10225 remains valid, provided chemical composition and mechanical properties comply with the current version.

This data refers only to the weldability of the material being supplied and is intended for use in development and preparation of fabrication procedures. The manufacturer does not have to fulfil the requirements of a welding procedure qualification test (WPQT), nor provide data to it.

7.5 Internal soundness and non-destructive testing

Internal soundness for rolled sections with web thickness greater than 12 mm shall be subject to an ultrasonic examination of webs and flanges if specified by the purchaser.

See ***Option 19*** (Ultrasonic test)

---

[2] IIW, International Institute of Welding formula

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

7.6 Surface quality

All surfaces of rolled sections shall be 100 % visually inspected for defects and the surface condition shall comply with EN 10163-1 and EN 10163-3, Class C, sub-class 2.

See ***Option 23*** (other surface conditions according to EN 10163-3).

7.7 Dimensions, tolerances, mass

7.7.1 Dimensions and tolerances on dimensions and shape

The dimensions and tolerances of the product shall be in accordance with one of the relevant European Standards in Annex D.

7.7.2 Mass of steel

The calculated mass shall be determined using a density of 7,85 kg/dm^3.

8 Inspection

8.1 General

Products complying with this European Standard shall be ordered and delivered with an inspection certificate 3.1 or 3.2 as specified in EN 10204. The type of document shall be agreed upon at the time of enquiry and order. If the order does not contain any specification of this type, an inspection certificate 3.1 shall be issued.

See ***Option 24*** (inspection certificate 3.2).

8.2 Types of inspection documents

The inspection certificate 3.1 or 3.2 shall include, in accordance with EN 10168, the following codes and/or relevant information where applicable:

A — Commercial transactions and parties involved;

B — Description of products to which the inspection certificate applies;

C01-C03 — Location of the samples, direction of test pieces and test temperature;

C10-C13 — Tensile test — Test piece shape and test results;

C40-C43 — Impact test — Test piece type and test results, if applicable;

C50-C69 — other tests if applicable (e.g. through thickness properties);

C71-C92 — Heat analysis and, if applicable, product analysis (as a minimum all the elements referred to in Tables 3 and 6 as applicable), the CEV or the P_{cm} shall be reported;

D01 — statement that marking and identification, surface appearance, shape and dimensional properties are satisfactory;

D02-D50 — if applicable, statement confirming that the NDT testing has been carried out and that the test results are satisfactory;

D51-D99 —results on the agreed additional product tests (options);

Z — Validation.

In addition, if an inspection certificate 3.2 is ordered, the purchaser shall notify the manufacturer of the address of the organization or person nominated by him to carry out the inspection and validate the inspection document.

Results of weldability testing in accordance with *Option 17* and Annex B shall not form any part of the inspection document.

8.3 Summary of inspections

Table 1 — Mandatory specific inspection for structural steels for offshore structures

Inspection requirements				Inspection programme
Type of test			Subclause reference(s)	
Mandatory tests	1	Heat analysis	7.2 10.1	see 9.1.1 One per cast
	2	Tensile test	7.3.1 10.2.2	see 9.1.2 One test per test unit each 40 tonnes
	3	Impact test	7.3.1 10.2.3	see 9.1.3 One set of test pieces per test unit each 40 tonnes
	4	Surface condition and dimensions	7.6, 7.7 10.3	see 10.3

8.4 Intermediary supply

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

a) supplying to the purchaser a copy of the original order requirements placed on the mill and the subsequent sales history of the product;

b) supplying to the purchaser all documentation required by this standard;

c) satisfying the purchaser by means of numbers or identification marks on the steel (or label when parcels of sections are bundled) that such steel has been tested and complies with all the requirements of this European Standard as applicable.

9 Frequency of testing and preparation of samples and test pieces

9.1 Frequency of test

9.1.1 Chemical analysis

The heat analysis and, if required, the product analysis (see *Option 7*) shall be determined once per cast.

9.1.2 Tensile test

The verification of the mechanical properties shall be carried out by test unit. A test unit comprises 40 tonnes or part thereof, of material from the same steel cast in the same heat treatment condition and of the same thickness range for the yield strength as given in Tables 5 and 8 providing that the thickness

variation for the order quantity is not more than 5 mm above or below the thickness of the product sample. One sample for one tensile test shall be taken from one sample product of each test unit.

9.1.3 Impact test

For the test unit see 9.1.2. One sample sufficient for 2 sets of three impact test pieces shall be taken from one sample product of each test unit.

9.2 Selection and preparation of samples for product analysis

Samples for product analysis, if required, shall be taken from the sample product or alternatively from test pieces used for mechanical testing or from the full thickness at the same location as for the mechanical test samples. The preparation of samples shall be in accordance with EN ISO 14284.

9.3 Location of samples and orientation of tensile test pieces

Samples shall be taken from the relevant flange positions shown in Figure 1. 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.

9.4 Location of samples and orientation of impact test pieces

Samples shall be taken of the positions shown in Figure 1. 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 or transverse to the principal direction of rolling i.e.: longitudinal or transverse test pieces (see Tables 5 and 8).

For sections with flange width smaller than 180 mm and channels with flange smaller widths than 90 mm the CVN test in transverse direction is not possible.

9.5 Preparation of test pieces for mechanical tests

9.5.1 General

The requirements of EN ISO 377 shall apply.

9.5.2 Preparation of tensile test pieces

Tensile test pieces shall be prepared in accordance with EN ISO 6892-1 and according to Figure 1.

9.5.3 Preparation of impact test pieces

9.5.3.1 Three V-notch test pieces shall be machined and prepared in accordance with EN ISO 148-1. The axis of the notch shall be perpendicular to the rolled surface of the product. In addition the following shall apply:

a) for nominal thicknesses > 12 mm 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 nominal thicknesses ≤ 12 mm, reduced width test pieces shall be used, with a minimum width of 5 mm.

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

9.5.3.2 If the nominal product thickness is not sufficient for the preparation of full size impact test pieces, test pieces of smaller width [see 9.5.3.1 b)] shall be taken, but not less than 5 mm; the largest obtainable standard width, either 7,5 mm or 5 mm, shall be used.

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.

10 Test methods

10.1 Chemical analysis

The elements to be determined and reported shall be those given in Tables 3 and 6 as applicable. 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 taking into account CEN/TR 10261.

10.2 Mechanical tests

10.2.1 Test temperatures

Tensile tests shall be carried out in the temperature range 10 °C to 35 °C. Impact tests shall be carried out at the temperatures specified in Tables 5 and 8.

10.2.2 Tensile test

The tensile test shall be carried out in accordance with EN ISO 6892-1. The tensile strength R_m, the yield strength R_e, and the elongation A, 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.

The specified elongation values relate to a proportional gauge length of 5,65 $\sqrt{S_o}$ where S_o 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 $\sqrt{S_o}$ using the conversion tables in EN ISO 2566-1.

For the R_e to R_m ratio, the 0,2 % proof strength ($R_{p0,2}$) or the 0,5 % proof strength for total elongation ($R_{t0,5}$) shall be used.

10.2.3 Impact test

The impact test shall be carried out in accordance with EN ISO 148-1 on V-notch specimens using the 2 mm radius striker. In addition, the following requirements shall apply:

a) the average value of a set of three test pieces shall be equal to or greater than the specified value. One individual value may be below the specified value, provided that it is not less than 70 % of that value;

b) if the conditions under a) are not satisfied then an additional set of three test pieces may be machined in accordance with 9.5.3, at the discretion of the manufacturer, from the same sample

and tested. To consider the test unit as conforming after testing the second set, the following conditions shall all be satisfied simultaneously:

1) the average value of the six tests shall be equal to or greater than the minimum average specified value;

2) not more than two of the six individual values may be lower than the minimum average specified value;

3) not more than one of the six individual values may be lower than 70 % of the minimum average specified value;

c) if these conditions are not satisfied, the sample product is rejected and retests shall be carried out on the remainder of the test unit.

10.3 Visual inspection and dimensional check

The steel products for offshore structures shall be visually inspected for compliance with the requirements of 7.6. The dimensions shall be checked for compliance with the requirements of 7.7.

10.4 Non-destructive tests

10.4.1 General

When specified at the time of enquiry and order, the manufacturer shall submit written ultrasonic inspection procedures for approval prior to production of the order.

10.4.2 NDT for sections

Ultrasonic testing shall be carried out in accordance with EN 10306 (see 7.5), if *Option 19* is specified.

10.5 Retests, sorting and reprocessing

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

Sorting and reprocessing shall be in accordance with the provisions given in EN 10021.

11 Marking and bundling

11.1 Die stamping, paint marking and labelling

Stamping area shall be highlighted by colour for easy detectability. Die stamp letters and digits shall be at least 5 mm high. Paint marked letters and digits shall be at least 25 mm high.

All markings shall be located in accordance with Figure 2 unless otherwise agreed.

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

The following information shall be die-stamped, paint marked or shown on a label, except as provided in 11.2:

a) manufacturer's name or trademark;

b) item size (length and section identification, etc.);

c) steel designation (see 4.2);

d) cast number and/or product identification number;

NOTE This may not be possible at some section mills, in which case it will be highlighted by the manufacturer at the time of the enquiry and order.

e) stamp of the inspection representative (where applicable);

f) purchaser's item/order number (where applicable).

The following may also be used:

g) vibro-etching or laser marking may be used instead of die stamping;

h) where the manufacturer’s name or trademark is normally rolled onto the section, this shall be permitted.

See ***Option 28*** (marking by another method)

11.2 Bundling

Bundling is permitted for section sizes 600 mm and below.

See ***Option 29*** (Sections not bundled)

The information detailed in 11.1 a) to h) shall be shown on a label securely attached to the bundle.

Bundles shall be restricted to material from one cast. When a bundle is split by an intermediary for redistribution the information contained on the original label shall be transferred to the label on the new bundles or individual items as appropriate.

12 Options

Option 1 Further details of steel manufacturing procedures (see 6.1 and Annex A).

Option 2 The steel shall be vacuum degassed and/or ladle refined.

Option 6 A restricted heat analysis range shall be agreed between manufacturer and purchaser at the time of enquiry and order (see 7.2.1). For a restricted product analysis range the purchaser shall order *Options 6* and *7* (see 7.2.2).

Option 7 The manufacturer shall carry out and report a product analysis. This shall cover all elements listed in Tables 3 and 6 and also include a heat analysis of the residual elements required to be reported for each material type and manufacturing route (see 7.2.1 and 7.2.2).

Option 8 At the time of enquiry and order the manufacturer and purchaser agree whether a P_{cm} or/and a CEV value shall be reported (see 7.2.3).

Option 12 Through-thickness testing shall be carried out in the delivery condition. Testing is not required for thicknesses below 15 mm (see 7.3.2). Testing shall be in accordance with EN 10164, to meet the following:

a) EN 10164 Quality Class Z 35;

b) through-thickness tensile strength shall be not less than 80 % of the specified minimum tensile strength.

Option 17 At the time of the enquiry for all products exceeding 40 mm in thickness the manufacturer shall have available data on the weldability of the material. The material is defined by the steel grade, processing route (steelmaking and rolling practice and delivery condition), manufacturer location and the limits given in Table 2. Weldability data for other thicknesses may be agreed between manufacturer and purchaser. Any previously obtained data which the manufacturer proposes to submit shall have

been verified by a competent third party, who witnessed the tests. All previously obtained data presented shall bear the stamp or seal of the third party.

Weldability tests shall be performed (see 7.4) by means of the series of tests described in Annex B. The purchaser shall specify which of the tests in Annex B are to be carried out.

A steel shall be considered for the same grade if it is within the range of the product analysis of this specification and manufactured using the same alloying system. The individual elements shall be within the ranges given in Table 2 with respect to the steel for which the data are being provided.

Table 2 — Tolerances of individual elements

Element	Tolerances	
C	+ 0,02	- 0,06
Si	+ 0,15	- 0,15
Mn	+ 0,20	- 0,30
S	+ 0,005	- 0,010
P	+ 0,010	- 0,015
Ni	+ 0,5	- 0,20
Cu	+ 0,15	- 0,20
N	+ 0,002 5	- 0,004 5
Al	+ 0,02	- 0,03
Nb	+ 0,010	- 0,015
V	+ 0,02	- 0,03
Ti	+ 0,008	- 0,008
Cr	+ 0,10	- 0,20
Mo	+ 0,04	- 0,06
CEV (IIW)	+ 0,02	- 0,06
P_{cm}	+ 0,02	- 0,04

Test materials shall be selected from products whose mechanical and chemical properties and manufacturing routes are typical for the production materials which the manufacturer intends to supply.

Material for the weldability evaluation shall preferably be selected with chemical compositions corresponding to the top end of the production range, particularly in respect of carbon equivalent and shall be approved by the purchaser.

On completion of each weld evaluation programme and verification of test results the steel manufacturer shall prepare a report.

Option 19 H and I- Sections shall be ultrasonically tested and shall meet the requirements of EN 10306:2001, Class 2.1. For other forms of sections the ultrasonic testing can be agreed between the manufacturer and purchaser (see 7.5).

Option 23 Other surface conditions in accordance with EN 10163-3 shall be agreed (see 7.6).

Option 24 Inspection certificate 3.2 is to be delivered.

Option 28 If agreed at the time of the enquiry and order the products can be marked by another method (see 11.1).

Option 29 Sections shall be supplied individually (not bundled) (see 11.2).

Option 30 Sections with thicknesses greater than specified in this standard shall be supplied. All the technical requirements of this European Standard shall be maintained (see Tables 5 and 8).

Table 3 — Chemical composition for normalized rolled steels (heat and product analysis)

Steel grades		% (mass fraction) [a] [b] [d]														
Steel name	Steel number	C	Si	Mn	P	S	Cr	Ni	Mo	N	Al_{tot} [c]	Cu	Nb	Ti	V	Nb+V	Nb+V+Ti
S355NLO (S355G11+N)	1.8808 (1.8806+N)	0,14	0,55	1,00 to 1,65	0,025	0,015	0,25	0,70	0,08	0,012	0,015 to 0,055	0,30	0,050	0,025	0,060	0,060	0,08
S355NL1O (S355G12+N)	1.8809 (1.8809+N)	0,14	0,55	1,00 to 1,65	0,020	0,007	0,25	0,70	0,08	0,012	0,015 to 0,055	0,30	0,050	0,025	0,060	0,060	0,08

[a] Max. values unless otherwise indicated.

[b] The levels of the residual elements arsenic, antimony, tin, lead, bismuth, calcium and boron shall not exceed 0,03 % As, 0,010 % Sb, 0,020 % Sn, 0,010 % Pb, 0,010 % Bi, 0,005 % Ca and 0,000 8 % B. These elements shall be checked at least once every 5 000 tonnes at each manufacturing location and shall be reported as a heat analysis to the customer if option 7 is confirmed.

[c] The total aluminium to nitrogen ratio shall be a minimum of 2:1. When other nitrogen binding elements are used, the minimum Al value and Al/N-ratio does not apply.

[d] For sections some values are slightly different against plates according to part 1.

Table 4 — Maximum carbon equivalent value (CEV) for normalized rolled steels based on heat and product analysis

Steel grades		CEV	P_{cm}
Steel name	Steel number	Sections	Sections
S355NLO (S355G11+N)	1.8808 (1.8806+N)	0,43	0,24
S355NL1O (S355G12+N)	1.8809 (1.8809+N)	0,43	0,24

Table 5 — Mechanical properties for normalized rolled steels

Steel grades		Minimum yield strength R_{eH} in MPa for thickness (t) in mm				Tensile Strength R_m in MPa	R_e/R_m ratio	Minimum elongation A gauge length of $5{,}65\sqrt{So}$.	Minimum average Charpy V-notch impact energy		
									Temp.	Energy J	
Steel name	Steel number	$t \leq 16$	$16 < t \leq 25$	$25 < t \leq 40$	$40 < t \leq 63$	$t \leq 63$	max.	%	°C	long.	trans.
S355NLO (S355G11+N)	1.8808 (1.8806+N)	355	355	345	335	460 to 630	0,87	22	−40	50	-
S355NL1O (S355G12+N)	1.8809 (1.8809+N)	355	355	345	335	460 to 630	0,87	22	−40	-	50
When agreed at the time of enquiry and order, sections with thicknesses greater than specified shall be supplied, see ***Option 30***.											

Table 6 — Chemical composition for thermomechanical rolled steels (heat and product analysis)

Steel grade		% (mass fraction) [a] [b] [d]														
Steel name	Steel number	C	Si	Mn	P	S	Cr	Ni	Mo	N	Al_{tot} [c]	Cu	Nb	Ti	V	Nb+V	Nb+V+Ti
S355MO (S355G4+M)	1.8803 (1.8803+M)	0,16	0,50	1,60	0,035	0,030	-	0,30	0,20	0,015	0,015 to 0,055	0,35	0,050	0,050	0,100	-	-
S355MLO (S355G11+M)	1.8811 (1.8806+M)	0,14	0,55	1,00 to 1,65	0,025	0,015	0,25	0,70	0,08	0,012	0,015 to 0,055	0,30	0,050	0,025	0,060	0,06	0,08
S355ML1O (S355G12+M)	1.8665 (1.8809+M)	0,14	0,55	1,00 to 1,65	0,020	0,007	0,25	0,70	0,08	0,012	0,015 to 0,055	0,30	0,050	0,025	0,060	0,06	0,08
S420MLO (S420G3+M)	1.8830 (1.8851+M)	0,14	0,55	1,65	0,025	0,015	0,25	0,70	0,25	0,012	0,015 to 0,055	0,30	0,050	0,025	0,080	0,09	0,11
S420ML1O (S420G4+M)	1.8859 (1.8859+M)	0,14	0,55	1,65	0,020	0,007	0,25	0,70	0,25	0,012	0,015 to 0,055	0,30	0,050	0,025	0,080	0,09	0,11
S460MLO (S460G3+M)	1.8878 (1.8883+M)	0,16	0,55	1,70	0,025	0,015	0,25	0,70	0,25	0,012	0,015 to 0,055	0,30	0,050	0,025	0,080	0,12	0,13
S460ML1O (S460G4+M)	1.8889 (1.8889+M)	0,16	0,55	1,70	0,020	0,007	0,25	0,70	0,25	0,012	0,015 to 0,055	0,30	0,050	0,025	0,080	0,12	0,13

[a] Max. values unless otherwise indicated.

[b] The levels of the residual elements arsenic, antimony, tin, lead, bismuth, calcium and boron shall not exceed 0,03 % As, 0,010 % Sb, 0,020 % Sn, 0,010 % Pb, 0,010 % Bi, 0,005 % Ca and 0,000 8 % B. These elements shall be checked at least once every 5 000 tonnes at each manufacturing location and shall be reported as a heat analysis to the customer if option 7 is confirmed.

[c] The total aluminium to nitrogen ratio shall be a minimum of 2:1. When other nitrogen binding elements are used, the minimum Al value and Al/N-ratio does not apply.

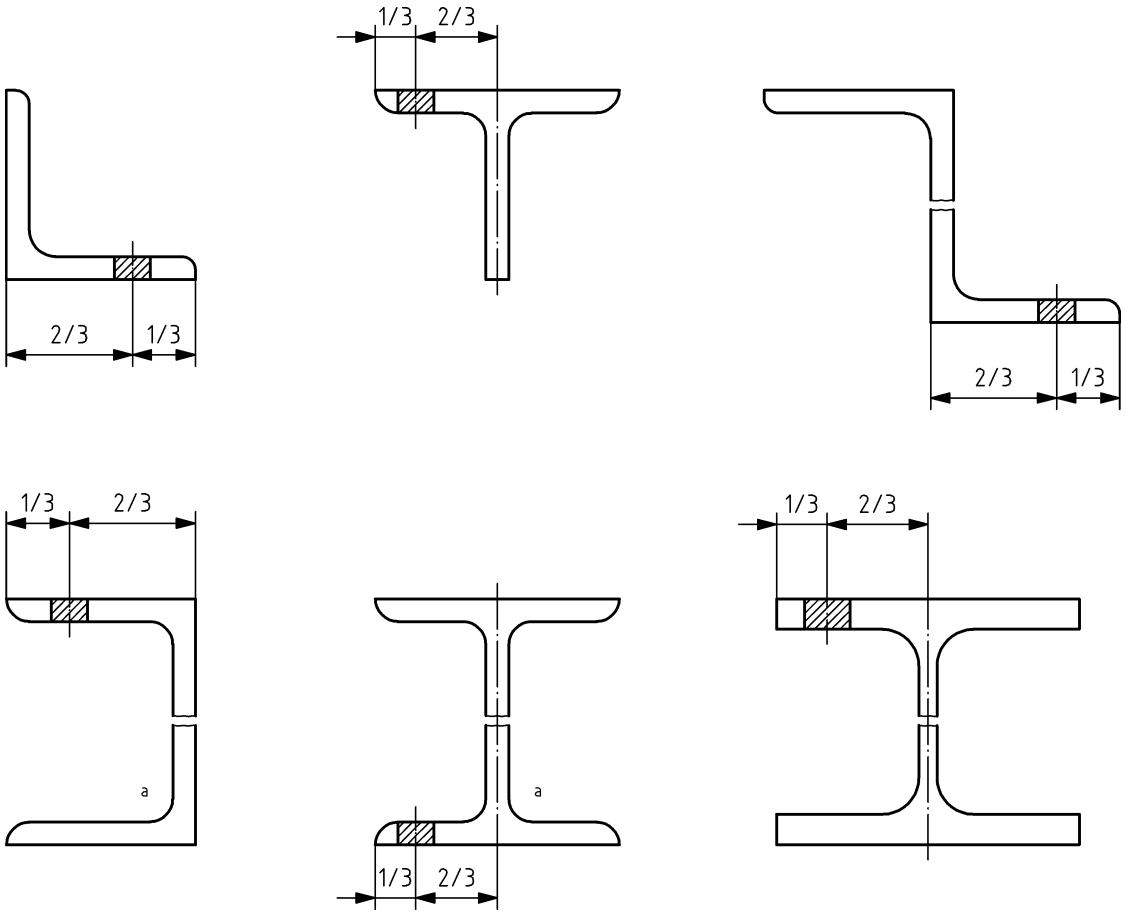
[d] For sections some values are slightly different against plates according to part 1.

Table 7 — Maximum carbon equivalent value (CEV) for thermomechanical rolled steels based on heat and product analysis

Steel grade		CEV	P_{cm}
Steel name	Steel number	Sections	Sections
S355MO (S355G4+M)	1.8803 (1.8803+M)	0,43	0,24
S355MLO (S355G11+M)	1.8811 (1.8806+M)	0,43	0,24
S355ML1O (S355G12+M)	1.8665 (1.8809+M)	0,43	0,24
S420MLO (S420G3+M)	1.8830 (1.8851+M)	0,43	0,24
S420ML1O (S420G4+M)	1.8859 (1.8859+M)	0,43	0,24
S460MLO (S460G3+M)	1.8878 (1.8883+M)	0,45	0,26
S460ML1O (S460G4+M)	1.8889 (1.8889+M)	0,45	0,26

Table 8 — Mechanical properties for thermomechanical rolled steels

Steel grade		Minimum yield strength R_{eH} in MPa for thickness (t) in mm				Tensile strength R_m in MPa	R_e/R_m ratio	Minimum elongation A gauge length of $5{,}65\sqrt{S_o}$.	Minimum average Charpy V-notch impact energy		
									Temp.	Energy J	
Steel name	Steel number	$t \leq 16$	$16 < t \leq 25$	$25 < t \leq 40$	$40 < t \leq 63$	$t \leq 63$	max.	%	°C	long.	trans.
S355MO (S355G4+M)	1.8803 (1.8803+M)	355	345	345	-	450 to 610	0,87	22	−20	50	-
S355MLO (S355G11+M)	1.8811 (1.8806+M)	355	355	345	335	470 to 630	0,87	22	−40	50	-
S355ML1O (S355G12+M)	1.8665 (1.8809+M)	355	355	345	335	470 to 630	0,87	22	−40	-	50
S420MLO (S420G3+M)	1.8830 (1.8851+M)	420	400	390	380	500 to 660	0,90	19	−40	50	-
S420ML1O (S420G4+M)	1.8859 (1.8859+M)	420	400	390	380	500 to 660	0,90	19	−40	-	50
S460MLO (S460G3+M)	1.8878 (1.8883+M)	460	440	420	415	520 to 700	0,90	17	−40	50	-
S460ML1O (S460G4+M)	1.8889 (1.8889+M)	460	440	420	415	520 to 700	0,90	17	−40	-	50
When agreed at the time of enquiry and order, sections with thicknesses greater than specified shall be supplied, see ***Option 30.***											



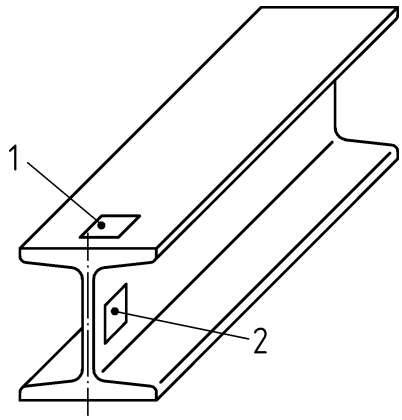
Key

▨ "location of samples (test pieces are taken from the samples)":

a at the manufacturer's discretion, the sample can be taken from the web, at a quarter of the total height

NOTE For sections with inclined flanges, machining of the inclined surface is permitted in order to make it parallel to the other surface.

Figure 1 — Beams, channels, angles, T sections and Z sections (see 9.3 and 9.4)



Key

1 die stamp (ringed with white paint)

2 label

Figure 2 — Rolled section – Labelling and die stamping

Annex A
(normative when Option 1 is specified by the purchaser)

Further details of steel manufacturing procedures to be supplied by the manufacturer

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

a) location and name of steel mill(s);

b) recent production data to demonstrate that the values proposed for heat and product analysis are achievable;

c) steel manufacturing procedures as follows:

   1) steel making process;

   2) nominal mass of heat;

   3) any hot metal treatment e.g. degassing, desulfurization or sulfide treatment technique;

   4) ingot or continuous cast (concast);

d) casting format (including thickness ranges on each size).

The manufacturer shall not change any of the practices listed without the approval of the purchaser.

Annex B
(normative when Option 17 is specified by the purchaser)

Weldability testing and mechanical testing of butt welds

B.1 General requirements

A series of butt welds with heat inputs in accordance with B.3.5 shall be made. The welds shall be carried out in accordance with normal fabrication practices but square-edge weld preparation shall be used for one side of the preparation. The welds shall comply with the mechanical properties specified in B.4.1.

Precautions should be taken to prevent the occurrence of defects which could invalidate the test.

Additional welds and test criteria, if specified by the purchaser at the time of the enquiry and/or order, shall be subject to agreement between the purchaser and the manufacturer.

B.2 Welding processes and procedure

The welding processes referred to in this standard are defined in Table B.1 (the process numbers are in accordance with EN ISO 4063).

Table B.1 — Welding process

Process	**Process number**
Manual metal arc welding (MMA/SMAW)	111
Self-shielded tubular cored arc welding (FCAW-S)	114
Submerged arc welding (SAW)	**12**
Submerged arc welding with solid wire electrode	121
Gas shielded metal arc welding (GMAW)	**13**
MIG (Metal-arc inert gas) welding with solid wire electrode	131
MAG (Metal-arc active gas) welding with solid wire electrode	135
MAG (Metal-arc active gas) welding with flux cored electrode (FCAW-G)	136
MAG (Metal-arc active gas) welding with metal cored electrode (MCAW)	138

The manufacturer shall submit detailed welding procedure specification in accordance with EN ISO 15614-1. The procedures shall include wire or electrode size, welding parameters, welding position and other relevant parameters, e.g. number of submerged arc welding (SAW) wires, iron powder additions and weld bevel angle.

Only welding consumables, which have previously demonstrated consistently high fracture mechanic values at −10 °C, shall be used. Welding of test sections shall be carried out by fabricators or other organizations employing suitably qualified personnel, acceptable to the purchaser. Such organizations

shall have previous satisfactory experience of qualifying fracture mechanic tested welding procedures typical of those used on off-shore structures or sub-assemblies.

Parameters chosen for the test welding procedures should reflect good practice for the chosen process.

B.3 Butt-weld requirements

B.3.1 General

The weldability test requirements for butt welds on sections are given in Table B.2.

B.3.2 Test piece dimensions

The test piece thickness shall either correspond to the maximum thickness of material to be supplied by concast and ingot routes or a value to be agreed between manufacturer and purchaser.

For sections, the direction of welding relative to the principal rolling direction shall be such as to allow the same orientation of Charpy and fracture mechanic specimens as required by Tables 5 or 8.

The dimensions of each welded assembly shall be sufficient to accommodate the testing requirements of this annex plus any re-tests. In case one welded assembly is not enough, several assemblies have to be welded.

Table B.2 — Weldability test requirements for butt welds on sections

Grade	Type	Test piece condition	Nominal heat input Q (kJ/mm) [f]			
			GMAW [a] 0,85 ± 0,2	SAW [b] 3,0 ± 0,2	SAW [b] 3,5 ± 0,2	SAW [b] 5,0 ± 0,2
			Min. preheat temperature [c] Max. interpass temperature = 250 °C [c]			
S355	NLO NL1O MO MLO ML1O	As welded	×	× [d]	× [d]	× [e]
S420	MLO ML1O	As welded	x	× [d]	× [d]	× [e]
S460	MLO ML1O	As welded	x	× [d]	× [d]	× [e]

× indicates that testing is required

– indicates that testing is not required

[a] Gas shielded metal arc welding (GMAW) process 13:
MAG welding with solid wire electrode (135) or
MAG welding with flux cored electrode (FCAW-G, 136) or
MAG welding with metal cored electrode (MCAW, 138)
are allowed.

[b] Where agreed between purchaser and manufacturer processes 111 or 114 may be used instead of SAW (121) (see B.3.5).

[c] The definition of the minimum preheat temperature should be based on maximum carbon equivalent and material thickness (see EN 1011-2:2001, Annex C) and should reflect accepted practice. Alternative preheat/interpass temperatures may be adopted subject to agreement between purchaser and manufacturer.

[d] For all grades tests may also be required at 3,0 kJ/mm if test at 3,5 kJ/mm produces results below the purchaser's acceptance criteria.

[e] If specified by the purchaser.

[f] see Formula (B.1).

B.3.3 Bevel detail

For all test welds a square-edge weld preparation shall be adopted for one side of the preparation in order to facilitate the production of a straight fusion line and heat affected zone (HAZ) normal to the rolled surface. The preferred weld preparation for the other side of the preparation is a single bevel having an angle of not greater than 45°. The joint shall be fully restrained and may be made with or without backing strip. The root gap shall not exceed 10 mm, unless otherwise agreed.

B.3.4 Welding processes

Tack welds and initial passes of each test section may be deposited by the gas metal arc (GMAW) or shielded metal arc welding (SMAW) or flux-cored arc welding (FCAW) process. Subsequent weld passes shall be deposited by FCAW, SMAW or SAW, as appropriate.

B.3.5 Nominal heat input

The nominal heat input for each weld pass other than initial e.g. root passes apply unless other values consistent with the proposed fabrication procedures, or base material are agreed at the time of enquiry and order.

A record shall be kept of all process parameters including preheat and interpass temperatures.

Heat input, Q (in kJ/mm) shall be calculated from the following Formula (B.1):

$$Q = k\frac{UI}{v} \times 10^{-3} \tag{B.1}$$

where

k is the thermal efficiency factor for the welding process as defined in EN 1011–1 (k = 0,8 for GMAW and 1,0 for SAW);

U is the arc voltage (in V);

I is the welding current (in A);

v is the welding speed (in mm/s).

For the purposes of this standard the heat input for tandem arc welding shall be calculated in accordance with EN 1011-1.

B.3.6 Dehydrogenation of test pieces

When considered necessary, dehydrogenation of as-welded test pieces shall be carried out by a low temperature heat treatment, prior to fracture mechanic testing. The use of any dehydrogenation treatment shall be declared with the test results.

Heat treatment conditions of 150 °C for 48 h are recommended, and the exact parameters shall be notified with the fracture mechanic test results.

In some instances, e.g. test pieces of exceptionally high thickness, alternative parameters may be necessary to reduce hydrogen content and these may be agreed between the steelmaker and purchaser. This may involve higher temperatures and/or longer times, but in no instance should the temperature exceed 250 °C.

B.4 Mechanical testing

B.4.1 General

A series of mechanical tests shall be carried out in accordance with Table B.3. For sections, weldability testing shall be carried out on the cut-off flanges butt welded together in such a way as to allow either testing in the longitudinal or in the transverse directions [see Figures B.6 a) and b)]. Pieces shall be taken from the 1/6 flange width positions, except when the testing refers to the weld metal characterisation (e.g. for fracture mechanic weld metal and CVN (FL-2)) for which an alternate location may be taken at the manufacturer's discretion.

A sufficient amount of each test weld should be prepared to permit repeat testing particularly in case of invalid fracture mechanic test (see B.4.3.3).

Where weldability testing of sections exceeding 40 mm thick is specified by the purchaser, test welds shall be prepared as given in Table B.2. Testing shall be confined to Charpy V-notch and macro/hardness. Fracture mechanic tests and cross weld tensile tests shall only be carried out at the discretion of the purchaser.

The following mechanical test requirements shall be achieved for each weld:

a) Charpy V-notch tests. Specimens shall be taken from the locations and the orientations in Table B.3 and shall meet test acceptance criteria specified in Table B.3. Retest procedures shall be in accordance with EN 10021.

b) fracture mechanic tests. The test pieces shall be tested at –10 °C and shall meet the purchaser's acceptance criteria;

c) hardness tests. Hardness tests shall be made on transverse sections of the test weld as specified in B.4.4 and Figure B.2, and meet the acceptance criteria defined in Table B.3 as appropriate;

d) cross-weld tensile tests. These tests shall be as specified in Table B.3. Only the tensile strength R_m shall be determined and the tensile strength of the test specimen shall not be less than the corresponding specified minimum value for the parent metal.

Table B.3 — Mechanical test requirements for sections for each butt weld

Type of test	No. of tests	Position of tests	Acceptance criteria
Charpy V-notch	One set of 3 tests per position	Position of tests as follows: a) - longitudinal to rolling direction (or transverse for grades S355NL1O, S355ML1O, S420ML1O and S460ML1O if agreed between purchaser and manufacturer); b) at FL-2; FL; FL+2, FL+5 on specimens from the straight edge; for t ≤ 50 mm 1 set of CVN taken at maximum 2 mm from the outer surface, for t > 50 mm, 3 CVN sets taken at maximum 2 mm from the outer surface, at mid-thickness and from the inner surface [see B.4.1 a), B.4.2, and Figure B.1]. Tests may also be taken from the bevel edge preparation if agreed between purchaser and manufacturer.	Tested at −40 °C to meet the following: a) for S355 grades a minimum average of 36 J and a minimum individual value of 26 J; b) for S420 grades a minimum average of 42 J and a minimum, individual value of 29 J; c) for S460 grades a minimum average of 46 J and a minimum individual value of 32 J.
Fracture mechanic testing	3 tests per position Optional	Position of tests as follows: a) - longitudinal to rolling direction (or transverse for grades S355NL1O, S355ML1O, S420ML10 and S460ML1O if agreed between manufacturer and purchaser); b) at each of the following positions: 1) GCHAZ; 2) SCHAZ/ICHAZ boundary; 3) weld metal. (See B.4.3.3).	Tested at –10 °C to meet a fracture mechanic value as defined by the purchaser (see B.4.1).
Macro/ hardness	2	See B.4.4 and Figure B.2.	325 HV10, except for 0,85 kJ/mm heat input when acceptance value is 350 HV10 (see B.4.1).
Cross weld tensile	2 Optional	Cross weld (see B.4.5)	See B.4.1

B.4.2 Charpy-V-notch impact tests

Charpy V-notch impact test specimen locations shall be in accordance with Figure B.1 and testing shall be carried out in accordance with EN ISO 148-1 with a striker radius of 2 mm.

Prior to notching, all samples shall be etched to allow the notch location to be marked.

B.4.3 Fracture mechanic test

B.4.3.1 General

Fracture mechanics testing for welded specimen shall be performed according to ISO 15653 to derive either CTOD or J1c values at the discretion of the manufacturer.

B.4.3.2 Classification of HAZ structures

When a single weld bead is deposited on sections, the following four HAZ zones shall be defined in the sections in order moving away from the weld depending on the peak temperature experienced:

a) grain-coarsened HAZ (GCHAZ): 1 400 °C ≥ ϑ > 1 100 °C;

b) fine grained HAZ (FGHAZ): 1 100 °C ≥ ϑ > A_{C3};

c) intercritical HAZ (ICHAZ): A_{C3} ≥ ϑ > A_{C1};

d) subcritical HAZ (SCHAZ): A_{C1} ≥ ϑ;

In a multi-pass weld some regions of the HAZ of the first pass are eliminated, others are significantly altered and others remain unaltered. In a single bevel multi-pass weld the overlapping heat affected zones that penetrate the unbevelled edge appear as shown in Figure B.3.

NOTE The zones of particular importance are as follows and are highlighted in Figure B.3.

e) the intercritically re-heated GCHAZ (IRGCHAZ);

f) the subcritically re-heated GCHAZ (SRGCHAZ);

g) the SCHAZ/ICHAZ boundary.

B.4.3.3 Test requirements

Three fracture mechanic tests shall be conducted for each of the following:

— grain-coarsened HAZ (GCHAZ);

— the subcritical HAZ (SCHAZ) intercritical HAZ (ICHAZ) boundary;

At the option of the purchaser fracture mechanic tests shall be carried out on weld metal (2 mm into the weld metal from the fusion line).

All fracture mechanic samples shall be transverse to the rolling direction.

Testing should be carried out preferably in accordance with ISO 12135 and/or ISO 15653 using displacement control and test pieces which shall be notched in the through-thickness direction.

Tests shall be checked for validity and invalid specimens shall be disregarded and test(s) repeated. In addition to the requirements of ISO 15653 validity of test specimens should be checked according to the following criteria.

— Grain-coarsened HAZ. To be considered a valid test, the fatigue crack shall maximize the amount of grain coarsened region sampled and a proportion should be within 0,5 mm of the fusion line. It is important to sample the grain coarsened region in the central 75 % portion of the material thickness. The percentage grain coarsened HAZ shall be reported. In order to maximize the chance of meeting the requirements of fatigue crack position, the objective, when manufacturing the weldment from which the fracture mechanic test piece will be prepared, should be to create a fusion line that is as planar in form as possible.

— Subcritical/intercritical HAZ boundary. To be considered a valid test, the fatigue crack shall sample the boundary between the subcritical HAZ and the intercritical HAZ;

— Weld metal. To be considered a valid test, the fatigue crack shall sample 90 % minimum weld metal and remains within 2 mm from the fusion line.

B.4.3.4 Sectioning methods

B.4.3.4.1 Grain-coarsened HAZ

Following testing, each fracture mechanic specimen shall be examined as follows to confirm that the fatigue crack sampled the grain-coarsened HAZ (GCHAZ):

a) remove a 15 mm slice containing the fracture face from each specimen half;

b) section the sample from the weld metal side. If required to confirm validation, sample both fracture faces parallel to the root of the machined notch as shown in Figure B.4;

Specimens should be sectioned to allow examination of the central 3/4 of the fatigue crack. If fracture initiation falls outside the central 3/4 of the specimen, sectioning should include this point.

c) polish and etch the exposed top face of the bottom half for micro examination as shown in Figure B.5;

d) examine and take a photomicrograph at an appropriate magnification. The recorded evidence shall show the full flange thickness;

e) the percentage of grain coarsened areas sampled by the fatigue crack shall be calculated as shown in Figure B.5. The percentage should include the IRGCHAZ and the SRGCHAZ adjacent to the columnar weld metal.

If the distance between the polished face and the deepest point of the fatigue crack exceeds 2 mm, as a result of excessive bowing or the existence of an irregular fatigue crack profile, additional sections may be required as agreed with the purchaser.

B.4.3.4.2 Subcritical/intercritical HAZ boundary

For each SCHAZ fracture mechanic specimen, sectioning and relevant reporting shall be as given in B.4.3.4.1.

B.4.3.4.3 Weld metal

For each weld metal fracture mechanic specimen only one of the two specimen halves shall be sectioned. The half containing the HAZ (not the half containing the bulk of the weld metal) shall be sectioned, prepared and photographed.

B.4.4 Macrohardness

Two macro specimens shall be prepared and hardness surveys shall be performed at the positions shown in Figure B.2.

The hardness indentations closest to the fusion line should remain clear of the fusion line, but have their centres within 0,4 mm of it. The hardness surveys should be made with indentations 1 mm spaced (centre to centre); apart from this spacing requirement, EN ISO 6507-1 should be adhered to.

To ensure all regions of the HAZ are sampled a second traverse may be made parallel to and at a distance of 1,0 mm to 1,5 mm from the first traverse and with staggered hardness indentation.

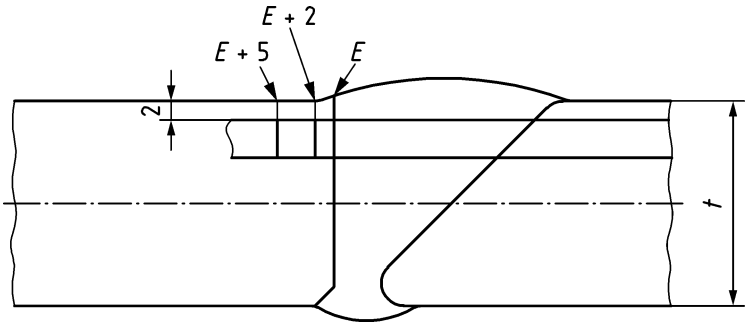
All hardness surveys shall be performed with 10 kg load (HV10 = 98,07 N).

When required by the purchaser, additional parallel spaced hardness traverses may be specified.

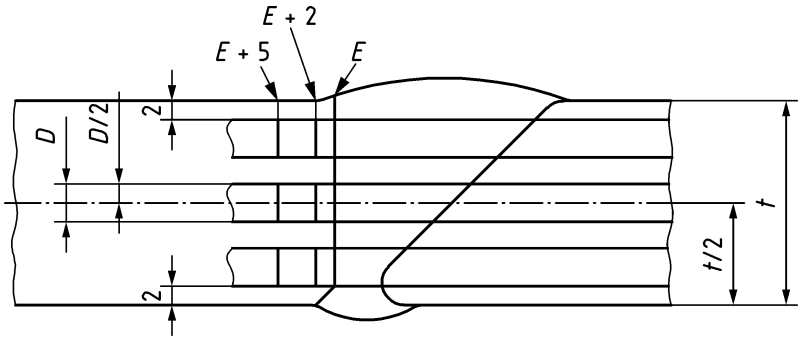
B.4.5 Cross-weld tensile test

If specified by the purchaser, two cross-weld tensile tests shall be carried out in accordance with EN ISO 4136.

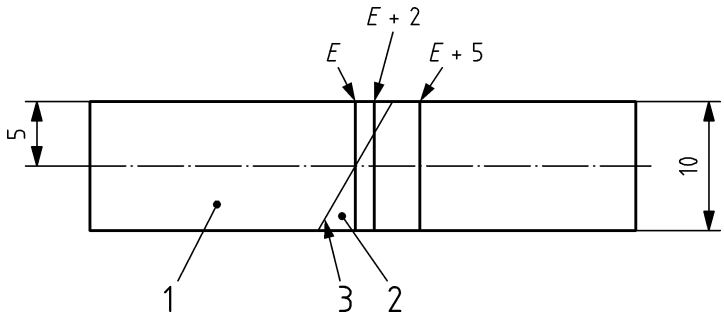
Dimensions in millimetres



a) Single bevel for $t \leq 50$ mm



b) Single bevel for $t > 50$ mm



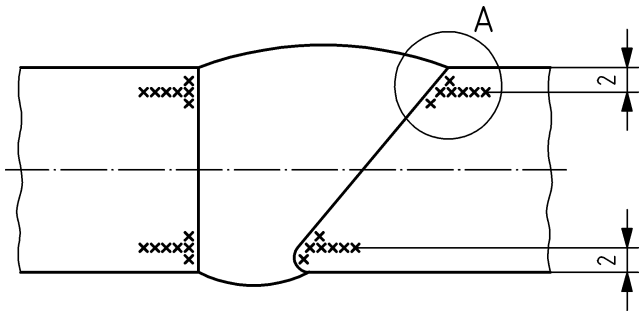
c) Notch positions for HAZ Charpy V-notch test pieces on bevelled side of weld

Key

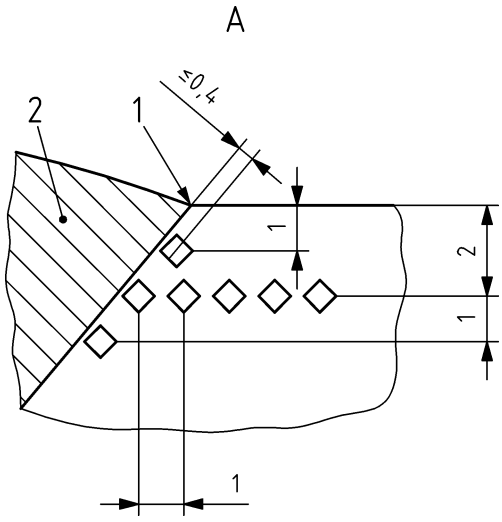
1	weld metal	*D*	specimen size
2	heat affected zone (HAZ)	*E*	fusion line
3	weld fusion line	*t*	nominal flange thickness

Figure B.1 — Location of Charpy V-notch impact test pieces for section butt weld (see B.4.2)

Dimensions in millimetres



a) General arrangement



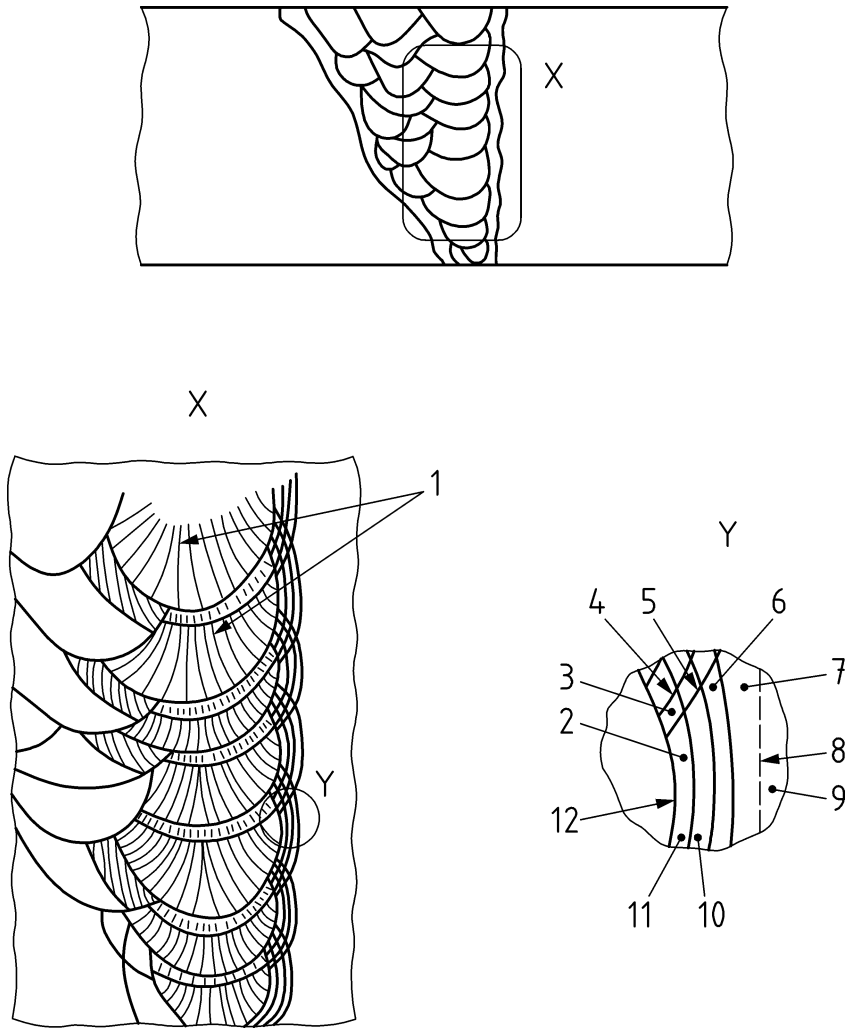
b) Enlargement of area A

Key

1 fusion line

2 weld

Figure B.2 — Hardness surveys on butt weld test pieces (see B.4.4)

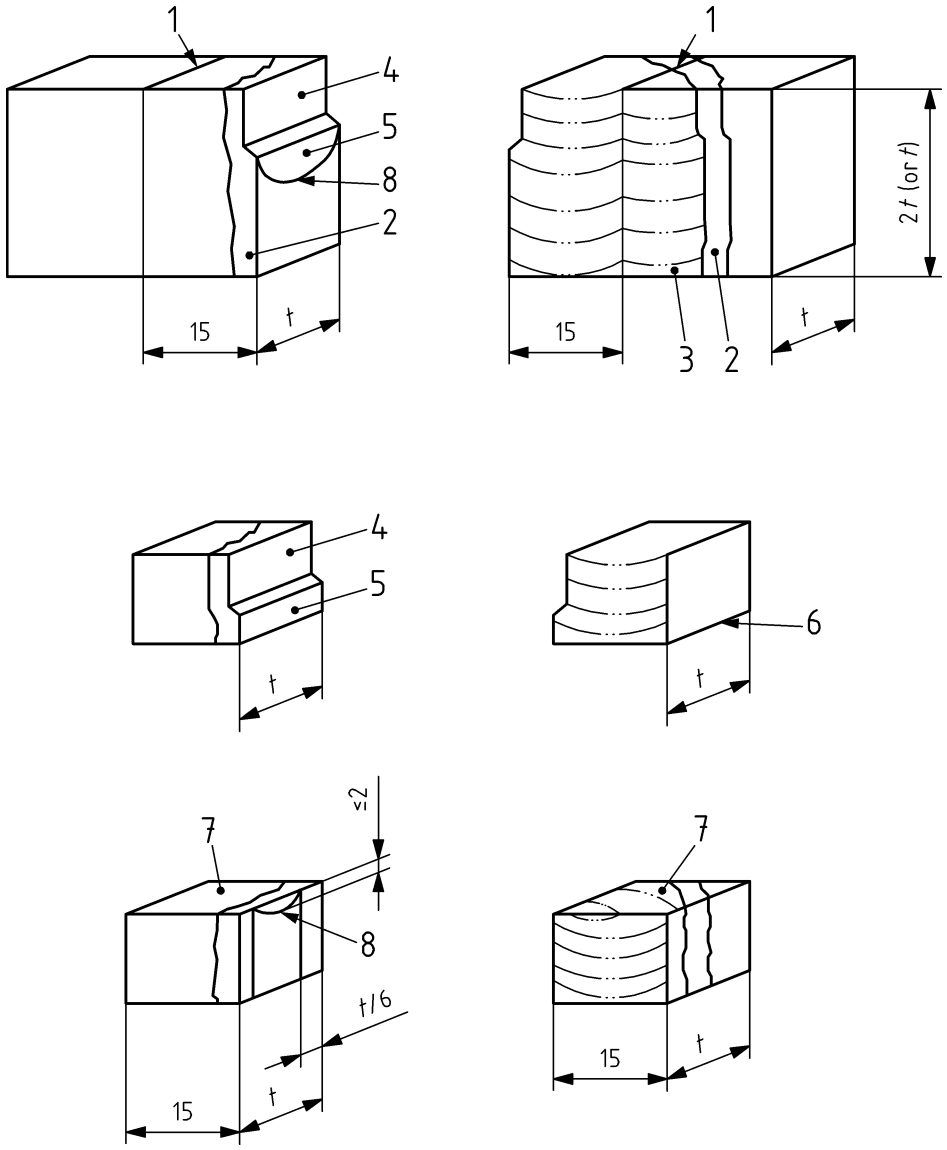


Key

1 columnar weld metal
2 SRGCHAZ Subcritically re heated GCHAZ (grain coarsened heat affected zone) [a]
3 IRGCHAZ Intercritically re heated GCHAZ (grain coarsened heat affected zone) [a]
4 Ac_3
5 Ac_1
6 Unaltered [b] ICHAZ (intercritical heat affected zone)
7 Unaltered [b] SCHAZ (subcritical heat affected zone)
8 non visible boundary
9 parent metal
10 Unaltered [b] FGHAZ (fine grain heat affected zone)
11 Unaltered [b] GCHAZ (grain coarsened heat affected zone)
12 fusion line
a zone created by a multiple weld run
b zone created by a single weld run

Figure B.3 — The HAZ regions in a single bevel multi-pass weld (see B.4.3.2)

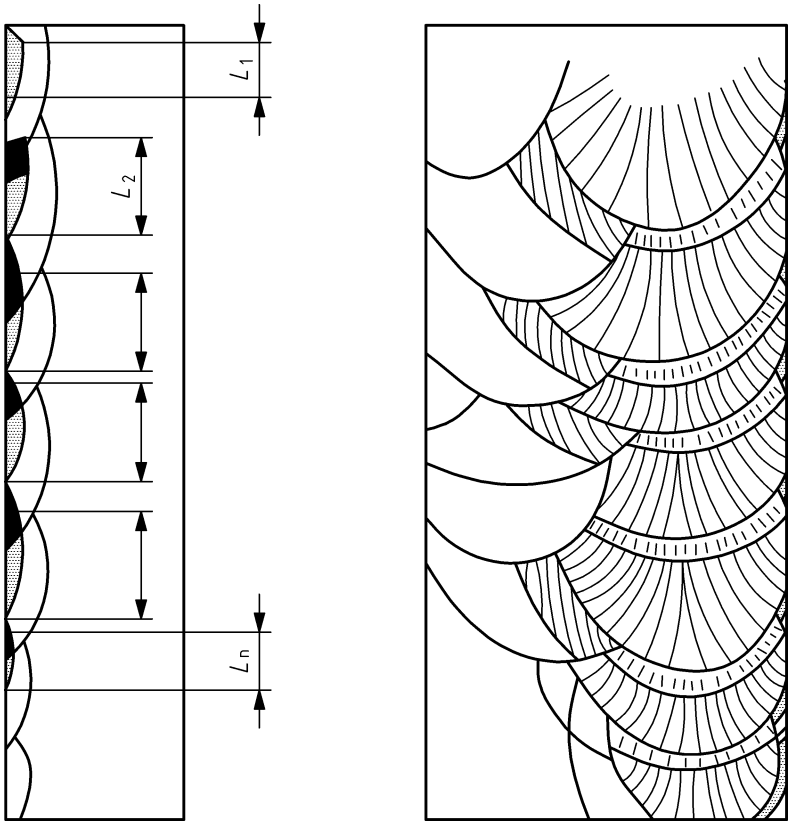
Dimensions in millimetres



Key

1 saw cut lines
2 heat affected zone
3 weld cap
4 machined notch
5 fatigue crack
6 sectioned plane
7 polished and etched surface
8 fatigue crack tip
t sample thickness

Figure B.4 — Fracture mechanic specimen sectioning details (see B.4.3.4)



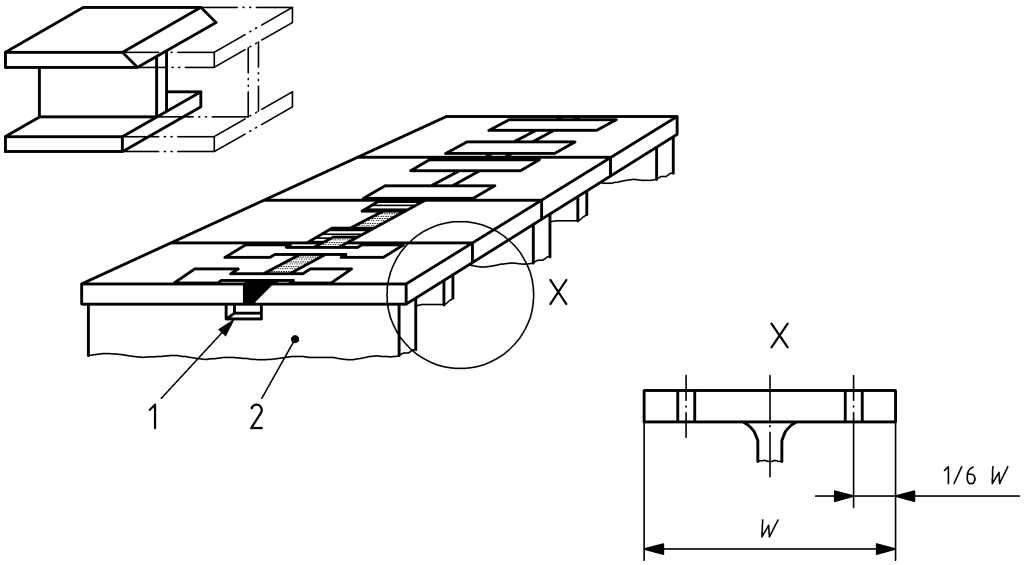
$$\% \text{ GC areas sampled} = 100\left\{\frac{\sum_1^n L}{t}\right\}$$

Key

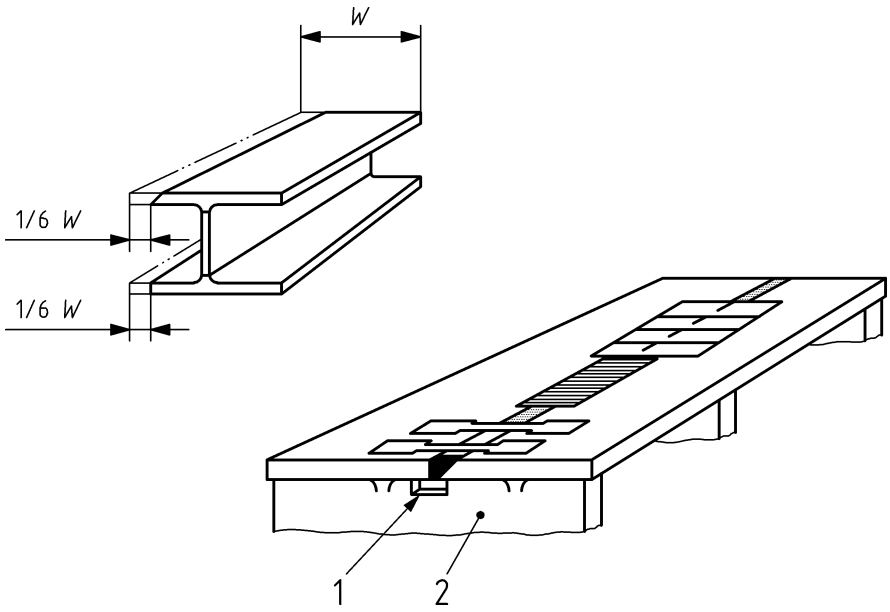
L sum of grain coarsened areas measured

t nominal flange thickness

Figure B.5 — Plan view of polished section halves showing method to calculate GCHAZ percentage [see B.4.3.4.1 e)]



a) Longitudinal testing



b) Transverse testing

Key

1 backing (optional)

2 strong backs (fillet welded on test section)

W flange width

Figure B.6 — Welding assembly for longitudinal and transverse testing of sections

Annex C
(informative)

Prequalification of steels for offshore structures operating in arctic areas

Arctic areas are defined as regions where the specified minimum design temperature is less than −10 °C, the minimum temperature limit given in current European and International standards. One of the main challenges with steels used in arctic areas is to ensure adequate material toughness to prevent brittle fracture. Hence prequalification testing in accordance with the following principles shall be performed:

— fracture mechanic testing shall be performed at the minimum design temperature;

— tensile testing shall be performed at room temperature, with additional testing when also the stress-strain curves are needed at the minimum design temperature;

— Charpy testing shall be performed at temperatures lower than the design temperature of the structure or component.

Agreements on the mechanical properties must be made between manufacturer and purchaser at the time of enquiry and order.

The prequalification of weldable structural steels for offshore structures operating in arctic or cold areas shall be performed at a temperature related to the lowest anticipated service temperature, LAST. This temperature is dependent on how far north in the arctic areas the offshore structure is to be located. Arctic or cold areas are divided into LAST temperature areas as follows:

— Arctic area 1: −20 °C;

— Arctic area 2: −30 °C;

— Arctic area 3: −40 °C.

On the manufacturer's and purchaser’s discretion, prequalification of offshore steels for arctic applications shall be performed at temperatures related to the arctic areas as shown in Table C.1. A lower temperature qualifies the steels for use at higher temperatures.

Table C.1 — Test temperature for arctic areas

Arctic area	Fracture mechanic test temperature °C	Charpy test temperature °C	Tensile test temperature °C [a]
1	−20	−50	−20
2	−30	−60	−30
3	−40	−60	−40
[a] If required.			

Annex D
(normative)

Applicable dimensional standards

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

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

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 10067, *Hot rolled bulb flats — Dimensions and tolerances on shape, dimensions and mass*

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

EN 10365, *Hot rolled steel channels, I- and H-sections — Dimensions and masses*

Bibliography

[1] EN 1011-2:2001, *Welding — Recommendations for welding of metallic materials — Part 2: Arc welding of ferritic steels*

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

[3] EN 10025-2, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

[4] EN 10025-3, *Hot rolled products of structural steels — Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels*

[5] EN 10025-4, *Hot rolled products of structural steels — Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels*

[6] CEN/TR 10347, *Guidance for forming of structural steels in processing*