

COLD-FORMED WELDED HOLLOW SECTIONS HIGH-STRENGTH & WEATHER-RESISTANT STEELS

BS EN 10219-3:2020

Technical delivery conditions for high-strength and weather-resistant steels

MANUFACTURING PROCESS

CHEMICAL COMPOSITION

MECHANICAL PROPERTIES

INSPECTION & TESTING

HIGH-STRENGTH GRADES

WEATHER-RESISTANT GRADES

Technical reference prepared for product and project requirement review.

Confirm final material, dimensions, testing and documentation before ordering.

BS EN 10219-3:2020

Technical data navigation

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REFERENCE NOTE

Source dimensional values and footnotes are retained. Confirm the applicable material, grade, schedule and project specification before ordering.

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REFERENCE NOTE

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European foreword

This document (EN 10219-3:2020) has been prepared by Technical Committee CEN/TC 459/SC 3 “Structural steels other than reinforcements”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2021, and conflicting national standards shall be withdrawn at the latest by March 2021.

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.

EN 10219 consists of the following parts:

- EN 10219-1, Cold formed welded steel structural hollow sections - Part 1: Technical delivery conditions
- EN 10219-2, Cold formed welded steel structural hollow sections - Part 2: Tolerances, dimensions and sectional properties
- EN 10219-3, Cold formed welded steel structural hollow sections - Part 3: Technical delivery conditions for high strength and weather resistant steels.

It forms part of a series of standards on hollow sections together with EN 10210-1 to EN 10210-3.

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

1 Scope

This document specifies the technical delivery conditions for high strength and weather resistant electric welded and submerged arc welded cold formed steel structural hollow sections of circular, square, rectangular or elliptical forms and formed cold without subsequent heat treatment other than the heat treatment of the weld line.

NOTE 1 The requirements for tolerances, dimensions and sectional properties can be found in EN 10219-2.

NOTE 2 The attention of users is drawn to the fact that whilst cold formed grades in this document can have equivalent mechanical properties to hot-finished grades in EN 10210-3, the sectional properties of square and rectangular hollow sections in EN 10219-2 and EN 10210-2 are not equivalent.

NOTE 3 A range of steel grades is specified in this document and the user can select the grade most appropriate to the intended use and service conditions. The grades and mechanical properties, but not the final supply condition of cold formed hollow sections are generally comparable with those in EN 10025-3, EN 10025-4, EN 10025-5, EN 10025-6, EN 10149-2 and EN 10149-3.

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

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 10160, *Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)*

EN 10168, *Steel products - Inspection documents - List of information and description*

EN 10204, *Metallic products - Types of inspection documents*

EN 10219-1, *Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery conditions*

EN 10219-2, *Cold formed welded steel structural hollow sections - Part 2: Tolerances, dimensions and sectional properties*

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

EN 10266, *Steel tubes, fittings and structural hollow sections - Symbols and definitions of terms for use in product standards*

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 4885, *Ferrous materials - Heat treatments - Vocabulary (ISO 4885)*

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

EN ISO 9606-1, *Qualification testing of welders - Fusion welding - Part 1: Steels (ISO 9606-1)*

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

EN ISO 10893-2, *Non-destructive testing of steel tubes - Part 2: Automated eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections (ISO 10893-2)*

EN ISO 10893-3, *Non-destructive testing of steel tubes - Part 3: Automated full peripheral flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal and/or transverse imperfections (ISO 10893-3)*

EN ISO 10893-6, *Non-destructive testing of steel tubes - Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections (ISO 10893-6)*

EN ISO 10893-7, *Non-destructive testing of steel tubes - Part 7: Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections (ISO 10893-7)*

EN ISO 10893-8, *Non-destructive testing of steel tubes - Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections (ISO 10893-8)*

EN ISO 10893-9, *Non-destructive testing of steel tubes - Part 9: Automated ultrasonic testing for the detection of laminar imperfections in strip/plate used for the manufacture of welded steel tubes (ISO 10893-9)*

EN ISO 10893-10, *Non-destructive testing of steel tubes - Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections (ISO 10893-10)*

EN ISO 10893-11, *Non-destructive testing of steel tubes - Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections (ISO 10893-11)*

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

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

EN ISO 15607, *Specification and qualification of welding procedures for metallic materials - General rules (ISO 15607)*

EN ISO 15609-1, *Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding (ISO 15609-1)*

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*

SNT TC-1A, *Personnel Qualification and Certification in Nondestructive Testing*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions given in EN 10020, EN 10021, EN 10266 and EN ISO 4885 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 <https://www.iso.org/obp>

3.1.1

cold forming

process where the forming to final shape of the welded hollow section is carried out at ambient temperature

Note 1 to entry: Circular hollow sections produced from normalized strip with a normalized weld seam and with a cold forming ratio of $D/T \geq 20$ may be classified as hot-finished hollow sections.

3.1.2

normalizing rolling for feedstock material

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 subsequent normalizing

3.1.3

thermomechanical rolling for feedstock material

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

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

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

3.1.4

steel with improved atmospheric corrosion resistance for feedstock material

steel in which a certain number of alloying elements has been added in order to increase its resistance to atmospheric corrosion, by forming an auto-protective oxide layer on the base metal under the influence of weather conditions

Note 1 to entry: Steel with improved atmospheric corrosion resistance is often called weathering steel.

Note 2 to entry: Additional information for the use of steel with improved atmospheric corrosion resistance is given in Annex E.

3.1.5

quenching and tempering for feedstock material

process which consists of the following two steps:

- first quenching, where the steel is heated up above the A_{c3} temperature and then rapidly cooled down in liquids to create a process specific grain structure;
- afterwards tempering, during which the steel is heated up to a certain temperature to adjust the desired properties and cooled down in air afterwards

3.1.6

fine grain steel

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

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

3.1.7

hot-dip zinc coating

application of a zinc coating by immersing the prepared strip or hollow section in a molten bath containing a zinc content of at least 98%

3.2 Symbols

For the purposes of this document, the symbols defined in EN 10266 apply.

4 Classification and designation

4.1 Classification

4.1.1 Within the grades of steels given in Annex B, C and D seven qualities N, NL, M, ML, Q, QL and QL1 are specified. These differ in respect of the carbon, sulphur and phosphorus content, low temperature impact properties, production process, heat treatment and grain size.

In accordance with the classification system in EN 10020, all steel grades are alloy special steels.

4.1.2 Within the grades of steels given in Annex E, three qualities J0, J2 and K2 are specified. These differ in respect of specified impact requirements and limits on values of various elements.

In accordance with the classification system in EN 10020, all steel grades in Annex E are alloy special steels.

4.2 Designation

4.2.1 For the products covered by this document, 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 The designation of steel hollow sections consists of:

- a) the number of this document (EN 10219-3);
- b) the capital letter S for structural steel;
- c) the indication of the minimum specified yield strength for thicknesses ≤ 16 mm expressed in MPa;
- d) further designations for either:
 - 1) normalized/normalized rolled structural steels:
 - i) capital letter N to indicate normalized or normalized rolled with specified impact properties at -20 °C (see 6.4);
 - ii) capital letters NL for qualities with specified impact properties at -50 °C; or
 - 2) thermomechanical rolled structural steels:
 - i) capital letter M to indicate thermomechanical rolled with specified impact properties at -20 °C (see 6.4);
 - ii) capital letters ML for qualities with specified impact properties at -50 °C; or
 - 3) structural steels in the quenched and tempered condition:
 - i) capital letter Q to indicate the quenched and tempered condition with specified impact properties at -20 °C (see 6.4);
 - ii) capital letters QL or QL1 for qualities with specified impact properties at -40 or -50 °C; or
 - 4) steels with improved atmospheric corrosion resistance:
 - ii) the characters J0 for the qualities with specified impact properties at 0 °C;
 - ii) the characters J2 or K2 for the qualities with specified impact properties at -20 °C; and
 - iii) the letter W (weather) for improved atmospheric corrosion resistance; and;
- e) the capital letter H to indicate hollow sections.

EXAMPLE 1 Hollow section made of structural steel (S) with a specified minimum yield strength for thickness not greater than 16 mm of 460 MPa, quenched and tempered condition (Q), with a minimum impact energy value of 30 J at -20 °C, hollow section (H):

EN 10219-3 — S460QH

or

EN 10219-3 — 1.8608

EXAMPLE 2 Hollow section made of structural steel (S) with a specified minimum yield strength for thickness not greater than 16 mm of 355 MPa, with a minimum impact energy value of 27 J at -20 °C (J2), weather resistant steel (W), hollow section (H):

EN 10219-3 — S355J2WH

or

EN 10219-3 — 1.8645

5 Information to be obtained by the manufacturer

5.1 Mandatory information

The following information shall be contained in the order document at the time of enquiry and order:

- a) the quantity (mass or total length);
- b) details of the product form:
 - 1) CFCBS = cold formed circular hollow section;
 - 2) CFRHS = cold formed square or rectangular hollow section;
 - 3) CFEHS = cold formed elliptical hollow section;
- c) the name of the standard for dimensions and tolerances (EN 10219-2);
- d) the dimensions and the type of length, length range or length (see EN 10219-2);
- e) the steel designation (see 4.2).

5.2 Options

A number of options are specified in EN 10219-2 and this document. These are listed below with appropriate clause references. In the event that the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the hollow sections shall be supplied in accordance with the basic specification.

- 3.1 Internal weld bead trimmed (see 6.5.2);
- 3.2 Other surface condition than as rolled (see 6.6);
- 3.3 Product analysis (see 7.1.1);
- 3.4 Empty;
- 3.5 Tensile test in corner region (see 7.2.1);
- 3.6 Impact test in corner region (see 7.2.2);
- 3.7 Verification of impact properties for quality J0 (see 7.2.3);
- 3.8 The product shall have a chemical composition suitable for hot-dip-zinc coating (see 7.3.2);
- 3.9 Weld repairs to the body of structural steel hollow sections are permitted (see 7.4.4);
- 3.10 Full peripheral NDT (non-destructive testing) of the circular tube for imperfections – not possible for elliptical, rectangular, square and SAW (submerged arc welded) hollow sections (see 7.5);

- 3.11 Ultrasonic testing for laminar imperfections (see 7.5);
- 3.12 Inspection certificate 3.1 for steel grade S355J0WH of Annex E instead of a test report 2.2 (see 8.1);
- 3.13 Inspection certificate 3.2.

5.3 Example of an order

10 t cold formed welded square hollow sections in accordance with EN 10219-2 with specified outside dimensions 100 mm × 100 mm and wall thickness of 8 mm of 12 m approximate lengths, grade S460QH according to this document and chemical composition for hot-dip zinc coating (Option 3.8) and supplied with inspection certificate 3.1:

EXAMPLE 10 t – CFRHS – EN 10219-2 — 100 × 100 × 8 – approximate length 12 m
EN 10219-3 — S460QH – Option 3.8

6 Manufacturing process

6.1 General

Structural welded cold formed hollow sections of normalized/normalized rolled, thermomechanical rolled and quenched and tempered steels shall conform to Annexes B to D and steels with improved atmospheric corrosion resistance shall conform to the requirements of Annex E.

In addition, the general technical delivery requirements specified in EN 10021 shall apply.

6.2 Steel manufacturing process

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

6.2.2 The method of deoxidation shall be as specified in Tables B.1, C.1, D.1 and E.1.

6.3 Grain structure

The steel grades given in Annexes B to D shall have a ferritic grain size equal to or finer than 6 when measured in accordance with EN ISO 643 (see 7.2.4).

6.4 Condition of feedstock material

According to the designation given in the order the following delivery conditions apply for the feedstock material used for the manufacture of cold formed hollow sections:

- normalized/normalized rolled for steels of qualities N and NL according to Annex B;
- thermomechanical rolled for steels of quality M and ML according to Annex C;
- quenched and tempered for steels of qualities Q, QL and QL1 according to Annex D;
- as rolled or normalized/normalized rolled or thermomechanical formed for steels with improved atmospheric corrosion resistance W according to Annex E.

6.5 Structural hollow section manufacturing process

6.5.1 Structural hollow sections shall be manufactured by electric welding or submerged arc welding without subsequent heat treatment (see 6.6). Hollow sections manufactured by a continuous process shall not include the welds used to join the lengths of strip prior to forming the hollow section, except

that for helically welded submerged arc-welded (SAW) hollow sections, such welds shall be permitted when tested in accordance with 10.4.3.

6.5.2 Electric welded hollow sections shall be supplied with the external weld bead trimmed to an essentially flush condition. Trimming of the internal weld bead is at the discretion of the manufacturer unless Option 1.1 is specified.

Option 3.1 Electric welded hollow sections shall be supplied with the internal weld bead trimmed, the maximum height of the internal weld bead after trimming shall be agreed at the time of enquiry and order.

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

The qualification shall be in accordance with ISO 11484 or SNT TC-1A or EN ISO 9712.

It is recommended that the level 3 personnel be certified in accordance with EN ISO 9712 or ASNT.

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.

6.6 Delivery condition

The hollow sections shall be delivered cold formed without subsequent heat treatment except that the weld seam may be in the as welded or heat treated condition.

NOTE For SAW hollow sections, it could be necessary to perform a warm shaping operation, which does not affect the mechanical properties, in order to meet the out-of-roundness tolerance requirements.

The surface of the hollow sections shall be typical of the feedstock employed and manufacturing method used.

Option 3.2 Other possible surface conditions are:

- a) S2 pickled feedstock;
- b) S3 pickled hollow section;
- c) S4 hot-dip-zinc coated feedstock;
- d) S5 hot-dip-zinc coated hollow section (There shall also be an agreement on the coating of the weld seam).

7 Requirements

7.1 Chemical composition

7.1.1 The chemical composition determined by the cast analysis and reported by the steel producer shall comply with the requirements given in Tables B.1, C.1, D.1 or E.1.

The maximum carbon equivalent value (CEV) for all grades, based on the cast analyses, given in Tables B.2, C.2, D.2 or E.2 shall apply.

When determining the CEV, the following formula of the International Institute of Welding (IIW) shall be used:

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

In addition to the cast analysis, the following option can be specified by the purchaser at the time of enquiry and order:

Option 3.3 For products supplied with specific inspection and testing, a product analysis shall be reported.

Deviations of the product analysis from the specified limits of the cast analysis shall be in accordance with Table 1.

7.1.2 When products are supplied with a control on Si e.g. for hot-dip zinc-coating there could be a need, for certain grades and thicknesses, to increase the content of other elements such as C and Mn, to achieve the required mechanical properties. In such cases, the maximum carbon equivalent values of Table B.2 to Table E.2 may be increased as follows:

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

Table 1 — Permissible deviations of the product analysis from the specified limits of the cast analysis given in Tables B.1, C.1, D.1 and E.1

Element	Permissible maximum content in the cast analysis % by mass	Permissible deviation of the product analysis from specified limits for the cast analysis % by mass
C	$\leq 0,20$	+ 0,02
	$> 0,20$	+ 0,03
Si	$\leq 0,60$	+ 0,05
	$> 0,60$	+ 0,06
Mn	normalized $\leq 1,70$	- 0,05 / + 0,10
	thermomechanical rolled $\leq 2,20$	+ 0,10
	quenched and tempered $\leq 1,70$	+ 0,10
	weather $\leq 1,50$	- 0,05 / + 0,10
P	normalized/thermomechanical rolled $\leq 0,030$, quenched and tempered $\leq 0,025$	+ 0,005
	weather $\leq 0,035$	+ 0,010
S	normalized/ thermomechanical rolled $\leq 0,025$	+ 0,005
	quenched and tempered $\leq 0,015$	+ 0,002
	weather $\leq 0,035$	+ 0,010
Nb	$\leq 0,060$	+ 0,010
V	$\leq 0,20$	+ 0,02
Ti	$\leq 0,03$	+ 0,01
	$> 0,03$	+ 0,02
Cr	$\leq 0,30$	+ 0,05
	$> 0,30$	+ 0,10
Ni	$\leq 0,80$	+ 0,05
	$> 0,80$	+ 0,10
Mo	$\leq 0,10$	+ 0,03
	$> 0,10$	+ 0,04
Cu	normalized/thermomechanical rolled, weather $\leq 0,35$	$\pm 0,04$
	normalized/thermomechanical rolled, weather $0,35 < Cu \leq 0,55$	+ 0,07
	quenched and tempered $\leq 0,50$	+ 0,05
N	normalized/thermomechanical rolled, weather $\leq 0,025$	+ 0,002
	quenched and tempered $\leq 0,020$	+ 0,001
Al _{total}	$\geq 0,020$	- 0,005
B	$\leq 0,005$	+ 0,000 5
Zr	$\leq 0,15$	+ 0,02

7.2 Mechanical properties

7.2.1 Under the inspection and testing conditions as specified in Clause 8 and in the delivery condition as specified in 6.5, the mechanical properties of the finished hollow section shall conform to the relevant requirements of Tables B.3, B.4, C.3, C.4, D.3, D.4 or E.3.

Any heat treatment at more than 580 °C and any heat treatment not processed in the normalizing temperature range could result in a reduction in the mechanical properties and is therefore not recommended.

NOTE Flame straightening can be applied in accordance with CEN/TR 10347.

The following option can be specified by the purchaser at the time of enquiry and order:

Option 3.5 Longitudinal test pieces for the tensile test shall be taken from the centre of the corner, but remote from the weld (see Annex F).

7.2.2 Another temperature as given in the Tables B.4, C.4, D.4 and E.3 may be agreed at the time of the order.

If a Charpy test is performed at a lower temperature than specified in the document and the impact energy values obtained meet the requirements at the higher temperature, then the material is deemed to conform to the document.

The following option can be specified by the purchaser at the time of enquiry and order:

Option 3.6 Longitudinal test pieces for the impact test shall be taken from the centre of the corner but remote from the weld with the notch orientated through the material thickness.

7.2.3 Subject to limitations to 7.2.2:

- a) the impact properties of structural hollow sections of steel qualities J2, K2, N, NL, M, ML, Q, QL and QL1 shall be verified;
- b) the impact properties of structural hollow sections of steel quality J0 need not be verified unless Option 3.7 is specified by the purchaser at the time of enquiry and order.

Option 3.7 For products in quality J0 supplied with specific inspection and testing (see Options 3.12 and 3.13), the verification of the impact properties is specified.

7.2.4 The following requirement for fine grain steel hollow sections can be specified:

- For fine grain steel hollow sections in thicknesses which do not permit impact test pieces of width ≥ 5 mm to be taken, the ferritic grain size (see 6.3) shall be verified by the method as described in EN ISO 643.
- When aluminium is used as the grain refining element, the grain size requirement shall be deemed to be fulfilled if the cast analysis shows the aluminium content to be $\geq 0,020$ % total aluminium or alternatively $\geq 0,015$ % soluble aluminium. In these cases, verification of the grain size is not required.

7.3 Technological properties

7.3.1 Weldability

The steels specified in this document are weldable as given in Annexes B to E. General requirements for welding the products in accordance with this document are given in EN 1011-1 and EN 1011-2.

NOTE 1 When welding hollow sections, as product thickness, strength level and CEV increase, the occurrence of cold cracking in the welded zone forms the main risk. Cold cracking is caused by a combination of the following factors:

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

NOTE 2 By using guidelines, specified for example in EN 1011-1, EN 1011-2 or any other relevant welding standard, the recommended welding conditions and the various welding ranges for the steel grades can be determined. These will vary depending on the product thickness, the applied welding energy, the design requirements, the electrode efficiency, the welding process and the weld metal properties.

Care should be taken when welding in corner regions of cold formed hollow sections. Eurocode 3 (EN 1993-1-8:2005, Table 4.2) includes conditions and restrictions for welding within 5t of the corner of cold formed square and rectangular hollow sections. For steel qualities J2H, K2H, MH, MLH, NH, NLH, where these limits are not satisfied, welding within 5t of the corner may be permitted, for products of nominal thickness not exceeding 12,5 mm, subject to their meeting specific analysis of $C \leq 0,18 \%$, $P \leq 0,020 \%$ and $S \leq 0,012 \%$. For more information, refer to EN 1993-1-8:2005, Table 4.2 and see below.

7.3.2 Hot-dip-zinc coating

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

Option 3.8 can be used to order steels with a chemical composition required for hot-dip-zinc coating. When Option 3.8 is implemented, the purchaser and manufacturer shall agree a steel composition (cast analysis) of silicon and phosphorous according to either:

- Category A (or steels satisfying the formula $Si \leq 0,03 \%$ and $Si + 2,5 P \leq 0,09 \%$); or
- Category B (limited to $0,14 \% \leq Si \leq 0,25 \%$); or
- Category D (limited to $0,25 \% < Si \leq 0,35 \%$);

with required values as cited by the ranges given in EN ISO 14713-2:2009, Table 1, column 2.

Option 3.8 The chemical composition shall be suitable for hot dip zinc coating. If no additional information is given, the delivered category is at the discretion of the manufacturer.

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

The maximum carbon equivalent shall be increased by 0,02 or by 0,01 (see 7.1.2).

7.4 Product supply condition

7.4.1 The hollow sections shall have a smooth surface corresponding to the manufacturing method used; bumps, cavities or shallow longitudinal grooves resulting from the manufacturing process are permissible, provided the remaining thickness is within tolerance, see EN 10219-2.

Surface imperfections may be removed by the manufacturer by grinding, provided that the thickness of the hollow section after the repair is not less than the minimum permissible thickness in accordance with EN 10219-2.

7.4.2 The ends of the hollow section shall be cut nominally square to the axis of the product.

7.4.3 Repair of the weld shall not be permitted for cold formed hollow sections except in the case of submerged arc welds.

7.4.4 For hollow sections repair of the body by welding shall not be permitted unless otherwise specified. The conditions under which, and the extent to which, welding repair to the body may be carried out shall be agreed between the manufacturer and the purchaser.

Option 3.9 Weld repairs to the body of structural steel hollow sections are permitted.

7.4.5 Any permitted weld repairs shall be carried out by operators qualified in accordance with EN ISO 9606-1. Welding repair procedures shall be issued in a written form and qualified in accordance with EN ISO 15607, EN ISO 15609-1 and EN ISO 15614-1.

A hollow section repaired in this way shall be considered to meet all the requirements of this document.

7.4.6 For SAW helical hollow sections where strip/plate was joined together these butt welds shall be carried out by operators qualified in accordance with EN ISO 9606-1. Welding procedures shall be issued in a written form and qualified in accordance with EN ISO 15614-1.

7.5 Non-destructive testing

The seam weld of all welded hollow sections supplied with specific inspection and testing shall be subjected to an applicable non-destructive test in accordance with 10.4.1 to 10.4.3.

Option 3.10 If agreed at the time of enquiry and order, every circular hollow section shall be full peripheral NDT-tested for imperfections according to one of the following standards: EN ISO 10893-2, EN ISO 10893-3 or EN ISO 10893-10 (see 10.4.4).

NOTE Full peripheral NDT is not possible for elliptical, square and rectangular SAW hollow sections.

Option 3.11 If agreed at the time of enquiry and order, every circular hollow section shall be tested for laminar imperfections according to EN ISO 10893-8 or testing is also possible prior to welding according to EN ISO 10893-9 or EN 10160 (see 10.4.5).

7.6 Tolerances and mass

7.6.1 Tolerances of dimensions and shape shall be as specified in EN 10219-2.

7.6.2 A density value of $7,85 \text{ kg/dm}^3$ shall be used in mass calculations.

NOTE Dimensions, sectional properties and mass per unit length for a limited range of sizes of cold formed structural hollow sections are given in EN 10219-2. The purchaser will preferably select hollow section dimensions from this limited range of sizes.

8 Inspection

8.1 Types of inspection

Products complying with this document shall in accordance with EN 10021 be ordered and delivered with an inspection document 2.2, 3.1 or 3.2 as specified in EN 10204. A test report 2.2 for steel grade S355J0WH of Annex E and an inspection certificate 3.1 for all other steel grades of Annexes B to E shall be issued.

Option 3.12 An inspection certificate 3.1 for steel grade S355J0WH of Annex E shall be issued if agreed at the time of enquiry and order.

Option 3.13 An inspection certificate 3.2 shall be issued if agreed at the time of enquiry and order.

8.2 Types and contents of inspection documents

8.2.1 For products supplied with non-specific inspection a test report 2.2 in accordance with EN 10204 shall be provided. The test report shall contain the following codes and relevant information in accordance with EN 10168:

- A — Commercial transactions and parties involved;
- B — Description of products to which the test report applies;
- C10-C13 — Tensile test;
- C71-C92 — Cast analysis;
- Z — Validation.

8.2.2 For products supplied with an inspection certificate 3.1 or 3.2, the following codes and relevant information in accordance with EN 10168 shall be provided:

- 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;
- C71-C92 — Cast analysis and, if applicable, product analysis (as a minimum all the elements referred to in Tables B.1, C.1, D.1 and E.1 as applicable and the CEV shall be reported);
- D02-D50 — if applicable, statement confirming that the NDT has been carried out and that the test results are satisfactory;
- Z — Validation.

If an inspection certificate 3.2 is specified, 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.

8.3 Summary of inspection

The requirements for inspection are given in Tables 2 and 3.

Table 2 — Non-specific inspection for welded cold formed hollow sections for steel grade S355J0WH of Annex E

Inspection requirements				Inspection programme
Type of test		Subclause reference(s)		Non-specific inspection
Mandatory tests	1	Cast analysis	7.1 10.1	One result per delivery item
	2	Tensile test	7.2 10.2.2	One representative result per delivery item
	3	Impact test for quality J0 only	7.2 10.2.3	Not applicable
	4	Surface condition and dimensions	7.4 7.6 10.3	See 10.3
	5	NDT of the weld	7.5 10.4.2, 10.4.3	Not applicable
Optional tests	6	Tensile test in corner region (Option 3.5)	7.2.1 10.2	One representative result per delivery item
	7	All other optional tests		Not applicable

Table 3 — Specific inspection for welded cold formed hollow sections

Inspection requirements				Inspection programme
	Type of test		Subclause reference(s)	Specific inspection
Mandatory tests	1	Cast analysis	7.1 10.1	One per cast
	2	Tensile test	7.2 10.2.2	One test per test unit a, b
	3	Impact test (not for quality J0)	7.2.2 10.2.3	One set of tests per test unit a, b
	4	Surface condition and dimensions	7.4, 7.6 10.3	see 10.3
	5	NDT of the weld	7.5 10.4.2, 10.4.3	Full length
Optional tests	6	Product analysis (Option 3.3)	7.1 10.1	One per cast
	7	Cast analysis additional elements only for non-alloy steels according to Annex A (Option 3.4)	7.1 10.1	One per cast
	8	Tensile test in corner region (Option 3.5)	7.2.1	One test per test unit ^a
	9	Impact test in corner region (Option 3.6)	7.2.2	One set of tests per test unit ^a
	10	Impact test verification for quality J0 (Option 3.7)	7.2.3 10.2	One set of tests per test unit a, b
	11	Full peripheral NDT of the tube (Option 3.10)	7.5 10.4.4	Circular products, full length
	12	Ultrasonic inspection for laminar imperfections (Option 3.11)	7.5 10.4.5	Circular products, full length
^a For test unit see, 9.1. ^b Longitudinal or transverse samples at the discretion of the manufacturer.				

9 Frequency of testing and preparation of samples and test pieces

9.1 Frequency of tests

The verification of the mechanical properties and product analysis, if applicable, shall be carried out by a test unit. A test unit is defined as a quantity of hollow sections from one manufacturing lot of same grade and sectional dimensions including hollow sections from one or more coils or bars or ingots

originating from one or more casts and, if applicable, in the same heat treatment condition, submitted for acceptance at the same time.

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

- 1 for tensile testing;
- 1 sufficient for 2 sets of 3 impact test pieces.

The mass of a test unit shall not exceed the maximum tonnage of sections specified in Table 4.

Table 4 — Test units

Type of hollow section		Test unit
Circular Outside diameter D mm	Square, rectangular or elliptical External perimeter mm	max. mass t
$\leq 114,3$	≤ 400	40
$> 114,3 \leq 323,9$	$> 400 \leq 800$	50
$> 323,9$	> 800	75

9.2 Selection and preparation of samples for product analysis

Samples for product analysis, when required shall be taken from the sample product or alternatively from samples used for mechanical testing or from the full thickness of the hollow section 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 and orientation of samples for mechanical tests

9.3.1 Tensile test pieces

The test pieces for tensile testing shall conform to the following:

- a) the test piece may be the full section of the product;
- b) for circular or elliptical sections, not tested in full section, the test pieces shall be taken either longitudinally or transversely, at the discretion of the manufacturer, at a point remote from the weld (see Annex F);
- c) for square or rectangular sections, not tested in full section, the test pieces shall be taken either longitudinally or transversely, at the discretion of the manufacturer, midway between the corners, from one of the sides not containing the weld (see Annex F).

9.3.2 Impact test pieces

Test pieces for impact testing shall conform to the following:

- a) for circular or elliptical sections, the test pieces shall be taken either longitudinally or transversely, at the discretion of the manufacturer and at a point remote from the weld (see Annex F);
- b) for square or rectangular sections the test pieces shall be taken either longitudinally or transversely, at the discretion of the manufacturer, midway between the corners and from one of the sides not containing the weld (see Annex F).

9.4 Preparation of test pieces for mechanical tests

9.4.1 General

The requirements of EN ISO 377 shall apply in conjunction with the test piece location specified in 9.3.

9.4.2 Tensile test pieces

The requirements of EN ISO 6892-1, as appropriate, shall apply.

Test pieces may be non-proportional, but in cases of dispute proportional test pieces having a gauge length $L_0 = 5,65\sqrt{S_0}$ shall be used (see 10.2.2). For thicknesses less than 3 mm, a gauge length of $L_0 = 80$ mm shall be used provided a test piece width of 20 mm can be achieved, otherwise a gauge length of 50 mm shall be used with a test piece width of 12,5 mm.

9.4.3 Impact test pieces

Impact Charpy-V-notch test pieces shall be machined and prepared in accordance with EN ISO 148-1.

For impact tests, standard Charpy-V-notch test pieces shall be used. If the nominal product thickness is not sufficient for the preparation of standard test pieces, the test shall be carried out using test pieces of width less than 10 mm, but not less than 5 mm. The minimum average values given in Tables B.4, C.4, D.4 and E.3 shall be reduced in direct proportion to the actual width of the test piece compared to that of the standard test piece.

In addition, the following requirements shall apply:

- a) the orientation of the notch is perpendicular to the rolled surface;
- b) for specified thicknesses > 12 mm, standard test pieces shall be machined in such a way that one side is not further away than 2 mm from the outside surface;
- c) for specified thicknesses ≤ 12 mm, when test pieces with reduced sections are used, the width shall be ≥ 5 mm; the largest obtainable width shall be used. If test pieces of width 5 mm cannot be obtained, then the material need not be submitted to impact testing;
- d) Impact tests are not required for specified thicknesses $< 6,0$ mm.

Test piece size is dependent on the actual thickness of the sample and, for circular or elliptical hollow sections, allowance also needs to be made for the curvature of the section.

10 Test methods

10.1 Chemical analysis

The elements to be determined and reported shall be those given in Tables B.1, C.1, D.1 or E.1 for the cast analysis, as applicable and those for determining the carbon equivalent value. 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 temperature

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 B.4, C.4, D.4 or E.3 for the steel grades.

10.2.2 Tensile test

The tensile test shall be carried out in accordance with EN ISO 6892-1.

For the specified yield strengths in Tables B.3, C.3, D.3 and E.3, the upper yield strength (R_{eH}) shall be determined.

If a distinct yield phenomenon is not present, either the 0,2 % proof strength non-proportional extension ($R_{p0,2}$) or the 0,5 % proof strength total extension ($R_{t0,5}$) shall be determined at the discretion of the manufacturer. In cases of dispute, the 0,2 % proof strength ($R_{p0,2}$) shall apply.

If a non-proportional test piece is used, the percentage elongation value obtained after fracture (A) shall be converted to the value for a gauge length $L_0 = 5,65 \sqrt{S_0}$ using the conversion tables given in EN ISO 2566-1.

For thicknesses less than 3 mm, the percentage elongation may be reported for a gauge length of 80 mm or 50 mm.

10.2.3 Impact test

The impact test shall be carried out in accordance with EN ISO 148-1 on Charpy-V-notch specimens using the 2 mm 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 taken, 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 specified value;
 - 2) Not more than two of the six individual values may be lower than the minimum specified value;
 - 3) Not more than one of the six individual values may be lower than 70 % of the minimum 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 (see 9.1).

10.3 Visual inspection and dimensional check

The hollow sections shall be visually inspected for compliance with the requirements of 7.4.

Verification checks on dimensions and shape to ensure compliance with EN 10219-2 shall be carried out.

10.4 Non-destructive testing

10.4.1 General

When the welds of structural hollow sections are to be subjected to non-destructive testing, the method shall be in accordance with 10.4.2 or 10.4.3. At the manufacturer's discretion, the non-destructive testing may be carried out either on the circular shape prior to final forming or on the circular, elliptical, square or rectangular hollow sections after final forming.

10.4.2 Weld seams of electric welded sections

The weld seam of electric welded hollow sections shall be tested in accordance with one of the following European Standards. The standard to be applied is at the discretion of the manufacturer.

- a) EN ISO 10893-2 to acceptance level E4H with the exception that the rotating tube/pancake coil technique shall not be permitted;
- b) EN ISO 10893-3 to acceptance level F5;
- c) EN ISO 10893-11 to acceptance level U5.

When EN ISO 10893-3 or EN ISO 10893-11 are used, calibration shall be carried out using an external reference notch.

Where the manufacturer applies a higher acceptance level than specified above, this is deemed to be in accordance with this document.

10.4.3 Weld seams of submerged arc welded sections

The weld seam of submerged arc welded hollow sections shall be tested either by an automated/semi-automated process in accordance with EN ISO 10893-11 or by a suitable manual method to acceptance level U4 or equivalent. Alternatively, radiography in accordance with EN ISO 10893-6/image quality class R2 or digital radiography in accordance with EN ISO 10893-7/image quality class A shall be used.

Butt welds, used to join lengths of strip/plate together in the spiral submerged arc weld process, shall be permitted, provided that the butt weld is tested to the same type of procedure and meets the same acceptance level as the main weld seam.

10.4.4 Full peripheral NDT

Full peripheral NDT shall be performed in accordance with EN ISO 10893-2 to acceptance level E4/E4H, EN ISO 10893-3 to acceptance level F5 or EN ISO 10893-10, acceptance level U4D.

10.4.5 Ultrasonic testing for laminar imperfections

Ultrasonic testing for laminar imperfections shall be performed in accordance with EN ISO 10893-8 to acceptance level U3 utilizing either an automated/semi-automated system or manual methods as specified in Annex A of that standard.

It is also permissible to test the strip or plate prior to production. In such cases, either testing in accordance with EN ISO 10893-9 to acceptance level U3 or testing to EN 10160, acceptance level S1/E1 shall be carried out.

10.5 Retests, sorting and reprocessing

For retests, sorting and reprocessing, EN 10021 shall apply.

11 Marking

11.1 Except as provided for in 11.2 for hollow sections which are bundled, each hollow section shall be marked by suitable and durable methods such as ink marking, paint stencilling, stamping, adhesive labels or bundle tags containing the following:

- the steel designation e.g. EN 10219-3 — S460QH;
- the manufacturer's name or trademark or product brandname;

- an identification number, e.g. order number, which permits the correlation of the product or delivery unit to the related document;
- in the case of an inspection certificate 3.2, the mark of the external inspection representative (if agreed).

Where Option 3.8 (chemical composition for hot dip zinc coating) is specified, the marking methods and materials used can be agreed in order to avoid interference with the preparation for hot-dip zinc coating (see EN ISO 14713-2).

11.2 Where the products are supplied bundled, the marking required in 11.1 shall be on a label, which shall be securely attached to the bundle.

Annex A (informative)

Structural hollow sections of non-alloy quality steels - Chemical composition and mechanical properties

Theses steel grades are to be found in EN 10219-1.

EN 10219-3:2020 (E)

Annex B

(normative)

Structural hollow sections of normalized/normalized rolled steels - Chemical composition and mechanical properties

For information, steel grades S275NH, S275NLH, S355NH, S355NLH, S460NH, S460NLH are to be found in EN 10219-1.

Table B.1 — Chemical composition — Cast analyses for product thicknesses ≤ 40 mm, feedstock condition N

Steel grade		Type of deoxidation ^a	% by mass													
Steel name	Steel number		C max.	Si max.	Mn	P max.	S max.	Cr max.	Mo max.	Ni max.	Al total ^b min.	Cu max. ^c	Nb max.	Ti max.	V max.	N max.
S420NH	1.8750	FF	0,22	0,60	1,00 to 1,70	0,030	0,025	0,30	0,10	0,80	0,020	0,55	0,050	0,050	0,20	0,025
S420NLH	1.8751					0,025	0,020									

^a The deoxidation method is designated as follows: FF = fully killed steel containing nitrogen binding elements in amounts sufficient to bind the available nitrogen and having a fine grain structure.

^b If sufficient N-binding elements are present, the minimum total Al content does not apply.

^c If the copper content is greater than 0,30 % then the nickel content shall be at least half of the copper content.

Table B.2 — Maximum carbon equivalent value based on cast analysis

Steel grade		Maximum CEV (%) for specified thicknesses	
Steel name	Steel number	$t \leq 16$ mm	$16 \text{ mm} < t \leq 40$ mm
S420NH	1.8750	0,50	0,52
S420NLH	1.8751		

Table B.3 — Mechanical properties of hollow sections in thicknesses ≤ 40 mm made from feedstock material condition N

Steel grade		Minimum yield strength R_{eH} MPa		Tensile strength R_m MPa	Minimum elongation A % a, b	
Steel name	Steel number	For specified thickness mm		for specified thickness mm	for specified thickness ≤ 40 mm	
		≤ 16	$> 16 \leq 40$	≤ 40	Longitudinal	Transverse
S420NH	1.8750	420	400	520 to 680	19	17
S420NLH	1.8751					

a For thicknesses ≥ 3 mm; for section sizes $D/T < 10$ (circular) and $(B+H)/2T < 10$ (square and rectangular) the minimum elongation is reduced by 4. For section sizes $D/T > 10$ to < 15 (circular) and $(B+H)/2T > 10$ to $< 12,5$ (square and rectangular) the minimum elongation is reduced by 2.

b For thicknesses < 3 mm, see 10.2.2. In this case, the values to be achieved shall be agreed between the purchaser and the manufacturer.

Table B.4 — Minimum values of impact energy for impact tests on V-notch test pieces of hollow sections made from feedstock material condition N

Steel grade		Minimum values of impact energy KV_2 in J a, b at test temperature in °C of			
Steel name	Steel number	-50		-20	
		Longitudinal	Transverse	Longitudinal	Transverse
S420NH	1.8750	—	—	40 ^c	20
S420NLH	1.8751	27	16	—	—

If a Charpy test is performed at a lower temperature than specified in the standard and the impact energy values obtained meet the requirements at the higher temperature, then the material is deemed to conform to the standard and the test need not be repeated at the higher temperature.

a For impact properties for reduced section test pieces see 9.4.3.

b The testing is performed for grades NH at -20 °C and for grades NLH at -50 °C.

c This value corresponds to 27J at -30 °C (see EN 1993-1-10).

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Annex C (normative)

Structural hollow sections of thermomechanical formed steels - Chemical composition and mechanical properties

For information, steel grades S275MH, S275MLH, S355MH, S355MLH, S420MH, S420MLH, S460MH, S460MLH are to be found in EN 10219-1.

Table C.1 — Chemical composition - Cast analysis for product thicknesses ≤ 40 mm, feedstock condition M

Steel grade		Type of deoxidation a	% by mass													
Steel name	Steel number		C max.	Si max.	Mn max.	P max.	S max.	Cr max.	Mo max.	Ni max.	Al total ^c min.	Cu max.	Nb max.	Ti max.	V max.	N max.
S500MH	1.8601	FF	0,16	0,60	1,70 ^b	0,030	0,020	0,30	0,20	0,80	0,020	0,55	0,090	0,060	0,12	0,025
S500MLH	1.8602					0,025	0,015									
S550MH	1.8610	FF	0,16	0,60	1,80	0,020	0,015	0,30	0,50	0,80	0,015	0,55	0,090	0,15	0,20	0,025
S550MLH	1.8611					0,020	0,012									
S600MH	1.8613	FF	0,16	0,60	1,90	0,020	0,015	0,30	0,50	0,80	0,015	0,55	0,090	0,22	0,20	0,025
S600MLH	1.8614					0,020	0,012									
S650MH	1.8615	FF	0,16	0,60	2,00	0,020	0,015	0,30	0,50	0,80	0,015	0,55	0,090	0,22	0,20	0,025
S650MLH	1.8617					0,020	0,012									
S700MH	1.8632	FF	0,16	0,60	2,10	0,020	0,015	0,30	0,50	0,80	0,015	0,55	0,090	0,22	0,20	0,025
S700MLH	1.8633					0,020	0,012									
S900MH	1.8619	FF	0,20	0,60	2,20	0,020	0,012	1,60	1,00	0,80	0,015	0,55	0,090	0,25	0,20	0,025
						0,020	0,010									

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Steel grade		Type of deoxidation a	% by mass													
Steel name	Steel number		C max.	Si max.	Mn max.	P max.	S max.	Cr max.	Mo max.	Ni max.	Al total ^c min.	Cu max.	Nb max.	Ti max.	V max.	N max.
S960MH	1.8623	FF	0,20	0,60	2,20	0,020	0,012	1,60	1,00	0,80	0,015	0,55	0,090	0,25	0,20	0,025
						0,020	0,010									
a The deoxidation method is designated as follows: FF = Fully killed steel containing nitrogen binding elements in amounts sufficient to bind the available nitrogen and having a fine grain structure.																
b The maximum Mn-content is allowed to be increased providing the C max is reduced as follows: Cmax 0,16 and Mn max 1,70, C max 0,14 and Mn max 1,80, Cmax 0,12 and Mn max 1,90, Cmax 0,10 and Mn max 2,00, C max 0,08 and Mn max 2,10.																
c If sufficient N-binding elements are present, the minimum total Al content does not apply.																

Table C.2 — Maximum carbon equivalent value based on cast analysis

Steel grade		Maximum CEV (%) for specified thicknesses	
Steel name	Steel number	$t \leq 16 \text{ mm}$	$16 \text{ mm} < t \leq 40 \text{ mm}$
S500MH	1.8601	0,47	0,47
S500MLH	1.8602		
S550MH	1.8610	0,47	0,47
S550MLH	1.8611		
S600MH	1.8613	0,47	0,47
S600MLH	1.8614		
S650MH	1.8615	0,47	0,47
S650MLH	1.8617		
S700MH	1.8632	0,47	0,47
S700MLH	1.8633		
S900MH	1.8619	0,60	0,60
S960MH	1.8623	0,62	0,62

Table C.3 — Mechanical properties of hollow sections in thicknesses ≤ 40 mm made from feedstock material condition M

Steel grade		Minimum yield strength R_{eH} MPa		Tensile strength R_m MPa	Minimum elongation A % a, b, c	
Steel name	Steel number	For specified thickness mm		for specified thickness mm	for specified thickness ≤ 40 mm	
		≤ 16	$> 16 \leq 40$	≤ 40	Longitudinal	Transverse
S500MH	1.8601	500	480	580 to 760	11	9
S500MLH	1.8602					
S550MH	1.8610	550	530	600 to 760	10	8
S550MLH	1.8611					
S600MH	1.8613	600	580	650 to 820	9	7
S600MLH	1.8614					
S650MH	1.8615	650	630	700 to 880	8	6
S650MLH	1.8617					
S700MH	1.8632	700	680	750 to 950	7	5
S700MLH	1.8633					
S900MH	1.8619	900	880	930 to 1200	5	4
S960MH	1.8623	960	940	980 to 1250	4	–
^a For thicknesses ≥ 3 mm; for section sizes $D/T \leq 10$ (circular) and $(B+H)/2T \leq 10$ (square and rectangular) the minimum elongation is reduced by 4 and the maximum tensile strength increased by 50 MPa. For section sizes $D/T > 10$ to < 15 (circular) and $(B+H)/2T > 10$ to < 15 (square and rectangular) the minimum elongation is reduced by 2 and the maximum tensile strength increased by 50 MPa. ^b For thicknesses < 3 mm, see 10.2.2. In this case the values to be achieved shall be agreed between the purchaser and the manufacturer. ^c For applications according to Eurocode 1993-1-1, see Eurocode 1993-1-1, clause 'Materials'						

Table C.4 — Minimum values of impact energy for impact tests on V-notch test pieces of hollow sections made from feedstock material condition M

Steel grade		Minimum values of impact energy KV2 in J ^{a, b} at test temperature in °C of			
		-50		-20	
		Longitudinal	Transverse	Longitudinal	Transverse
Steel name	Steel number				
S500MH	1.8601	—	—	40 ^c	20
S550MH	1.8602			27	16
S600MH	1.8610				
S650MH	1.8615				
S700MH	1.8632				
S900MH	1.8619				
S960MH	1.8623				
S500MLH	1.8611	27	16	—	—
S550MLH	1.8613				
S600MLH	1.8614				
S650MLH	1.8617				
S700MLH	1.8633				
If a Charpy test is performed at a lower temperature than specified in the standard and the impact energy values obtained meet the requirements at the higher temperature, then the material is deemed to conform to the standard and the test need not be repeated at the higher temperature.					
^a For impact properties for reduced section test pieces, see 9.4.3.					
^b The testing is performed for grades MH at -20 °C and for grades MLH at -50 °C.					
^c This value corresponds to 27J at -30 °C (see EN 1993-1-10).					

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Annex D

(normative)

Structural hollow sections of quenched and tempered steels — Chemical composition and mechanical properties

Table D.1 — Chemical composition — Cast analyses for product thickness ≤ 40 mm

Steel grade		Type of deoxidation ^b	% by mass ^a															
Steel name	Steel number		C max.	Si max.	Mn max.	P max.	S max.	Cr max.	Mo max.	Ni max.	Cu max.	Nb max _c	Ti max _c	V max _c	W max	Zr max _c	N max	B max.
S460QH	1.8608	FF	0,25	0,80	1,70	0,025	0,015	1,50	0,70	2,00	0,50	0,06	0,05	0,16	1,50	0,15	0,020	0,0050
S460QLH	1.8606					0,020	0,010											
S460QL1H	1.8616					0,020	0,010											
S500QH	1.8603	FF	0,25	0,80	1,70	0,025	0,015	1,50	0,70	2,00	0,50	0,06	0,05	0,16	1,50	0,15	0,020	0,0050
S500QLH	1.8605					0,020	0,010											
S500QL1H	1.8607					0,020	0,010											
S550QH	1.8604	FF	0,25	0,80	1,70	0,025	0,015	1,50	0,70	2,00	0,50	0,06	0,05	0,16	1,50	0,15	0,020	0,0050
S550QLH	1.8626					0,020	0,010											
S550QL1H	1.8686					0,020	0,010											
S620QH	1.8620	FF	0,25	0,80	1,70	0,025	0,015	1,50	0,70	2,00	0,50	0,06	0,05	0,16	1,50	0,15	0,020	0,0050
S620QLH	1.8622					0,020	0,010											
S620QL1H	1.8684					0,020	0,010											

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Steel grade		Type of deoxidation ^b	% by mass ^a															
Steel name	Steel number		C max.	Si max.	Mn max.	P max.	S max.	Cr max.	Mo max.	Ni max.	Cu max.	Nb max _c	Ti max _c	V max _c	W max	Zr max _c	N max	B max.
S690QH	1.8631	FF	0,25	0,80	1,70	0,025	0,015	1,50	0,70	2,00	0,50	0,06	0,05	0,16	1,50	0,15	0,020	0,0050
S690QLH	1.8628					0,020	0,010											
S690QL1H	1.8688					0,020	0,010											
S770QH	1.8635	FF	0,25	0,80	1,70	0,025	0,015	1,50	1,50	2,00	0,50	0,06	0,06	0,16	1,50	0,15	0,020	0,0050
S770QLH	1.8636					0,020	0,010											
S770QL1H	1.8689					0,020	0,010											
S890QH	1.8637	FF	0,25	0,80	1,70	0,025	0,015	1,50	1,50	2,00	0,50	0,06	0,06	0,16	1,50	0,15	0,020	0,0050
S890QLH	1.8638					0,020	0,010											
S890QL1H	1.8690					0,020	0,010											
S960QH	1.8639	FF	0,25	0,80	1,70	0,025	0,015	1,50	1,50	2,00	0,50	0,06	0,06	0,16	1,50	0,15	0,020	0,0050
S960QLH	1.8640					0,020	0,010											
S960QL1H	1.8691					0,020	0,010											

^a Depending on thickness of the product and the manufacturing conditions, the manufacturer may, in order to obtain the specified properties, add one or several alloying elements up to the maximum values given.

^b The deoxidation method is designated as follows: FF = fully killed steel containing nitrogen binding elements in amounts sufficient to bind the available nitrogen and having a fine grain structure.

^c There shall be at least 0,015 % of a grain-refining element present. Aluminium is one of these elements. The minimum content of 0,015 % applies to soluble aluminium, this value is regarded as attained if the total aluminium content is at least 0,018 %; in case of dispute the soluble aluminium content shall be determined.

Table D.2 — Maximum carbon equivalent value (CEV) based on cast analysis

Steel grade		Maximum CEV (%) for specified thicknesses
Steel name	Steel number	
S460QH	1.8608	0,47
S460QLH	1.8606	
S460QL1H	1.8616	
S500QH	1.8603	0,47
S500QLH	1.8605	
S500QL1H	1.8607	
S550QH	1.8604	0,65
S550QLH	1.8626	
S550QL1H	1.8686	
S620QH	1.8620	0,65
S620QLH	1.8622	
S620QL1H	1.8684	
S690QH	1.8631	0,65
S690QLH	1.8628	
S690QL1H	1.8688	
S770QH	1.8635	0,65
S770QLH	1.8636	
S770QL1H	1.8689	
S890QH	1.8637	0,72
S890QLH	1.8638	
S890QL1H	1.8690	
S960QH	1.8639	0,82
S960QLH	1.8640	
S960QL1H	1.8691	

Table D.3 — Mechanical properties of hollow section in thicknesses ≤ 40 mm made from feedstock material condition QT

Steel grade		Minimum yield strength ReH MPa		Tensile strength Rm MPa		Minimum elongation A % a, b, c	
Steel name	Steel number	For specified thickness mm		for specified thickness mm		for specified thickness ≤ 40 mm	
		≤ 16	> 16 ≤ 40	≤ 16	> 16 ≤ 40	Longitudinal	Transverse
S460QH	1.8608	460	440	550 to 720	550 to 720	17	15
S460QLH	1.8606						
S460QL1H	1.8616						
S500QH	1.8603	500	480	590 to 770	590 to 770	17	15
S500QLH	1.8605						
S500QL1H	1.8607						
S550QH	1.8604	550	530	640 to 820	640 to 820	16	14
S550QLH	1.8626						
S550QL1H	1.8686						
S620QH	1.8620	620	580	700 to 890	700 to 890	14	12
S620QLH	1.8622						
S620QL1H	1.8684						
S690QH	1.8631	690	650	770 to 940	720 to 930	12	10
S690QLH	1.8628						
S690QL1H	1.8688						
S770QH	1.8635	770	710	850 to 1020	770 to 950	11	9
S770QLH	1.8636						
S770QL1H	1.8689						
S890QH	1.8637	890	830	940 to 1120	880 to 1100	9	7
S890QLH	1.8638						
S890QL1H	1.8690						
S960QH	1.8639	960	850	980 to 1170	900 to 1100	8	6
S960QLH	1.8640						
S960QL1H	1.8691						
a For thicknesses ≥ 3 mm; for section sizes D/T < 10 (circular) and (B+H)/2T < 10 (square and rectangular) the minimum elongation is reduced by 4. For section sizes D/T > 10 to < 15 (circular) and (B+H)/2T > 10 to < 12,5 (square and rectangular) the minimum elongation is reduced by 2. b For thicknesses < 3 mm, see 10.2.2. In this case the values to be achieved shall be agreed between the purchaser and the manufacturer. c For applications according to Eurocode 1993–1-1, see Eurocode 1993–1-1, clause ‘Materials’							

Table D.4 — Minimum values of impact energy for impact tests on V-notch test pieces of hollow sections made from feedstock material condition QT

Steel grade		Minimum values of impact energy KV2 in J ^{a, b, c} at test temperature in °C of					
		-50		-40		-20	
		Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
S460QH	1.8608	—	—	—	—	30	27
S500QH	1.8603						
S550QH	1.8604						
S620QH	1.8620						
S690QH	1.8631						
S770QH	1.8635						
S890QH	1.8637						
S960QH	1.8639						
S460QLH	1.8606	—	—	30	27	—	—
S500QLH	1.8605						
S550QLH	1.8626						
S620QLH	1.8622						
S690QLH	1.8628						
S770QLH	1.8636						
S890QLH	1.8638						
S960QLH	1.8640						
S460QL1H	1.8616	35	27	—	—	—	—
S500QL1H	1.8607						
S550QL1H	1.8686						
S620QL1H	1.8684						
S690QL1H	1.8688						
S770QL1H	1.8689						
S890QL1H	1.8690						
S960QL1H	1.8691						
If a Charpy test is performed at a lower temperature than specified in the standard and the impact energy values obtained meet the requirements at the higher temperature, then the material is deemed to conform to the standard and the test need not be repeated at the higher temperature.							
^a For impact properties for reduced section test pieces, see 9.4.3.							
^b The testing is performed for grades QH at -20 °C, for grades QLH at -40 °C and for grades QL1H at -50 °C.							
^c For correlation to other temperatures see EN 1993-1-10.							

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Annex E (normative)

Structural hollow sections of steels with improved atmospheric corrosion resistance — Chemical composition and mechanical properties

Table E.1 — Chemical composition – Cast analysis for product thicknesses ≤ 40 mm

Steel grade		Type of deoxidation a	% by mass									
Steel name	Steel number		C max.	Si max.	Mn max.	P max.	S max.	Cr	Mo max.	Ni max.	Al total ^{b, c} min.	Cu
S355J0WH	1.8644	FF	0,16	0,50	0,50 to 1,50	0,035	0,035	0,30 to 1,25	0,30	0,65	0,020	0,25 to 0,55
S355J2WH	1.8645	FF				0,030	0,030				0,020	
S355K2WH	1.8646	FF				0,030	0,030	0,40 to 0,80			0,020	
S420K2WH	1.8647	FF	0,20	0,65	0,50 to 1,50	0,030	0,030	0,40 to 0,80	0,30	0,65	0,020	0,25 to 0,55
S460K2WH	1.8648	FF	0,20	0,65	0,50 to 1,50	0,030	0,030	0,40 to 0,80	0,30	0,65	0,020	0,25 to 0,55
S500K2WH	1.8649	FF	0,20	0,65	0,50 to 1,50	0,030	0,030	0,40 to 0,80	0,30	0,65	0,020	0,25 to 0,55
^a The deoxidation method is designated as follows: FF = Fully killed steel containing nitrogen binding elements in amounts sufficient to bind the available nitrogen and having a fine grained structure. ^b If sufficient N-binding elements are present, the minimum total Al content does not apply. The nitrogen binding elements shall be reported in the inspection document. ^c The steels shall contain at least one of the following elements: Al total ≥ 0,020 %, Nb: 0,015 - 0,060 %, V: 0,02 - 0,12 %, Ti: 0,02 - 0,10 %. If these elements are used in combination, at least one of them shall be present with the minimum content indicated.												

Table E.2 — Maximum carbon equivalent value (CEV) based on cast analysis

Steel grade		Maximum CEV (%) for specified thicknesses
Steel name	Steel number	$t \leq 40$ mm
S355J0WH	1.8644	0,52
S355J2WH	1.8645	
S355K2WH	1.8646	
S420K2WH	1.8647	0,52
S460K2WH	1.8648	0,52
S500K2WH	1.8649	0,52

Table E.3 — Mechanical properties of hollow sections in thicknesses ≤ 40 mm made from feedstock material condition W

Steel grade		Minimum yield strength R_{eH} MPa		Tensile strength R_m MPa		Minimum elongation A % ^{a, b}	Minimum values of impact energy KV_2 in J ^c	
Steel name	Steel number	For specified thickness mm		for specified thickness mm		for specified thickness mm	at a test temperature of	
		≤ 16	> 16 ≤ 40	≤ 3	> 3 ≤ 40	≤ 40	- 20 °C	0 °C
S355J0WH	1.8644	355	345	510 to 680	470 to 630	20	–	27
S355J2WH	1.8645						27	–
S355K2WH	1.8646						40 ^d	–
S420K2WH	1.8647	420	400	520 to 680	520 to 680	17	40 ^d	–
S460K2WH	1.8648	460	440	540 to 720	530 to 710	15		
S500K2WH	1.8649	500	480	590 to 770	580 to 760	14		

^a For thicknesses ≥ 3 mm; for section sizes D/T < 10 (circular) and (B+H)/2T < 10 (square and rectangular) the minimum elongation is reduced by 4. For section sizes D/T > 10 to < 15 (circular) and (B+H)/2T > 10 to < 12,5 (square and rectangular) the minimum elongation is reduced by 2.

^b For thicknesses < 3 mm see 10.2.2. In this case the values to be achieved shall be agreed between the purchaser and the manufacturer.

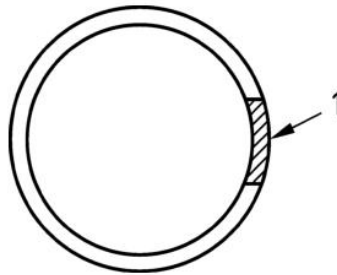
^c For impact properties for reduced section test pieces, see 9.4.3.

^d This value corresponds to 27J at –30 °C (see EN 1993-1-10).

Annex F (normative)

Location of samples and test pieces

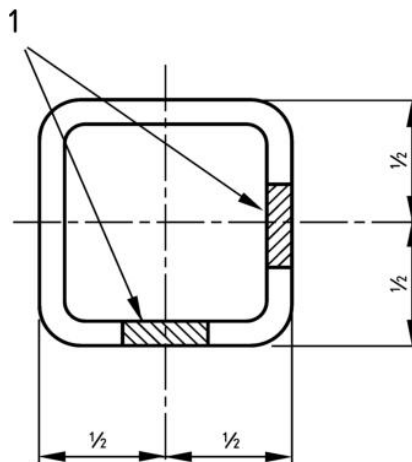
Figures F.1 to F.4 give information on the location of samples and test pieces for hollow sections (see 9.3).



Key

- 1 At any point on circumference but remote from the weld

Figure F.1 — Circular and elliptical sections



Key

- 1 Alternative positions (on any side except a side containing the weld)

Figure F.2 — Square and rectangular sections

Figures F.3 and F.4 give additional information on the location of samples and test pieces for hollow sections (see 9.3).

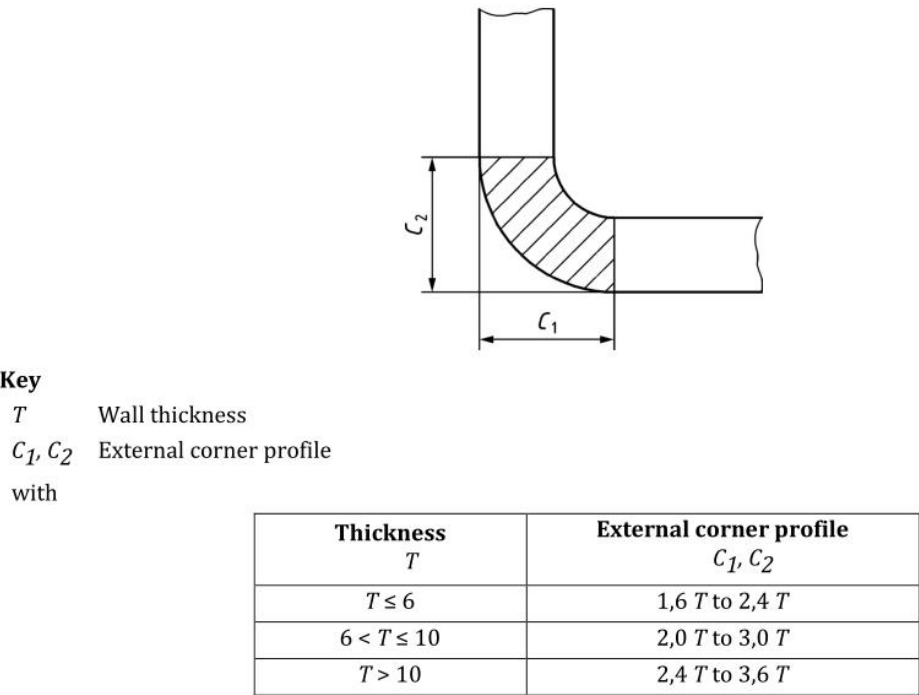


Figure F.3 — Location of samples and test pieces for the tensile test for square and rectangular hollow sections in the corner region

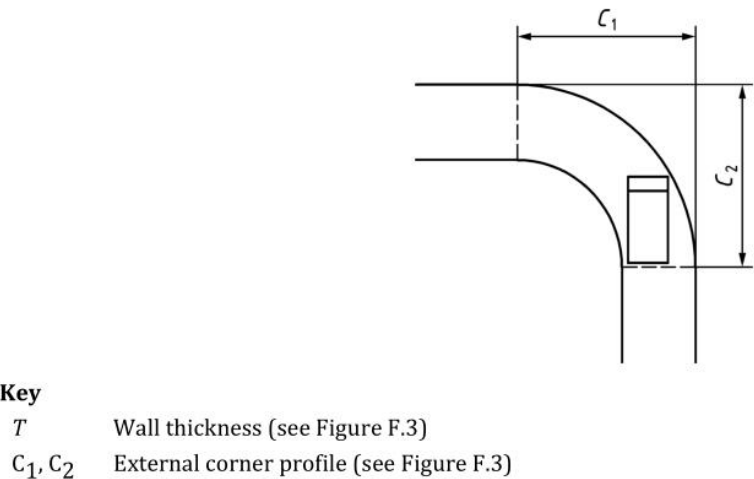


Figure F.4 — Location of test pieces (subsized) for the impact test for square and rectangular hollow sections in the corner region

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- [1] EN 1993-1-10, *Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties*
- [2] EN 10025-3, *Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels*
- [3] EN 10025-4, *Hot rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels*
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- [9] EN ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods (ISO 1461)*

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