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Steel structures — Execution of structural steelwork —

Part 3: **Fabrication**

Structures en acier – Exécution des charpentes et ossatures en acier —
Partie 3: Fabrication

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 167, *Steel and aluminium structures*.

This first edition cancels and replaces ISO 10721-2:1999, which has been technically revised.

A list of all parts in the ISO 17607 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Specific requirements for the achievement of structures that are optimal with respect to safety, the state of the economy, development and general values of a nation are given in the appropriate regional or national standards, if they exist.

Many nations do not have their own standards for structural steelwork. Some reference other national or regional standards. Some permit the project's standard to be selected by the owner, designer or constructor of the structure. Some do not require any standards to be followed.

The ISO 17607 series of standards on the execution of structural steelwork was developed to serve as a means to provide a set of requirements and guidance for projects that are constructed without a governing regional or national standard. The ISO 17607 series can also serve to reduce trade barriers.

Additional requirements to be addressed in the execution of structural steelwork, as structures or as fabricated components, can be found in the other parts of the series:

— ISO 17607-1 (General requirements and terms and definitions)

— ISO 17607-2 (Steels);

— ISO 17607-4 (Erection);

— ISO 17607-5 (Welding);

— ISO 17607-6 (Bolting).

Steel structures — Execution of structural steelwork —

Part 3: Fabrication

1 Scope

This document defines the general requirements for fabrication in the execution of structural steelwork as structures or as fabricated components in conjunction with ISO 17607-1.

Additional requirements to be addressed in the execution of structural steelwork, as structures or as fabricated components, can be found in other parts of the ISO 17607 series.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 286-2, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

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

ISO 9013, *Thermal cutting — Classification of thermal cuts — Geometrical product specification and quality tolerances*

ISO 13920, *Welding — General tolerances for welded constructions — Dimensions for lengths and angles — Shape and position*

ISO/TR 15608, *Welding — Guidelines for a metallic materials grouping system*

ISO 17607-1, *Steel structures — Execution of structural steelwork — Part 1: General requirements and vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17607-1 apply.

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

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

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

4 Execution specification

See ISO 17607-1.

National standards and documents that provide technically equivalent conditions may be used, in whole or in part, in place of referenced ISO standards or requirements of this document. In these cases,

the technically equivalent national standards and documents, and deviations from the requirements of this document shall be referenced in the execution specification.

The necessary information and technical requirements for execution of fabrication shall be agreed on and complete before commencement.

The execution specification shall include the following items as relevant:

a) for additional information, see A.1;

b) for additional information, see A.2;

c) requirements related to execution levels, see A.3;

d) identification and traceability requirements, see ISO 17607-1;

e) geometrical tolerances, see Clause 6.

There shall be procedures for making alterations to a previously agreed on execution specification.

5 Preparation and assembly

5.1 General

This clause specifies the requirements for identification and traceability, handling and storage, cutting, shaping, holing for structural bolting, temporary attachments, and assembly of steel products and sub-components for inclusion into components.

NOTE Provisions for welding and structural bolting are given in ISO 17607-5 and ISO 17607-6.

Structural steelwork shall be fabricated within the tolerances specified in Clause 6.

Equipment used in the fabrication process shall be maintained to ensure that use, wear and failure do not cause nonconformity in the fabrication process.

5.2 Identification and traceability

5.2.1 Identification

For identification, see ISO 17607-1.

Identification is required for execution levels 1 to 4 (EXL1, EXL2, EXL3, and EXL4) or as specified in the execution specification.

At all stages of fabrication, unassembled single items and constituent products shall be identifiable by a suitable method of identification for the purposes of proper assembly.

NOTE Examples of fabrication stages include storage, cutting, holing, fit-up, welding and painting or coating. Depending on the execution class, identification can vary from a visual marking or tag on each piece to designated locations for similar products.

The following requirements apply to hard stamped, punched or drilled marks used for marking single components or packages of similar components, unless otherwise specified:

a) They shall only be used for steel grades up to and including 500 MPa;

b) They shall only be used in areas, as specified in the execution specification, where the marking method would not affect the fatigue life.

If the use of hard stamps, punched or drilled marks is not permitted, it shall be specified whether soft or low stress stamps may be used.

Any zones where identification marks are not permitted or shall not be visible after completion shall be specified in the execution specification.

The assembled component as it moves through the production, shipping and erection processes shall also be identifiable by suitable methods.

Identification documents shall be retained for all constituent products. The retention period shall be specified in the execution specification.

5.2.2 Traceability

For traceability see ISO 17607-1.

5.3 Handling and storage

Constituent products shall be handled and stored in conditions that are in accordance with the product manufacturer's recommendations.

Constituent products shall not be used beyond the shelf life specified by their manufacturer. Products that have been handled or stored in a way or for a length of time that could have led to significant deterioration shall be checked before use to ensure that they still conform with the relevant product standard and execution specification.

Structural steel components shall be packed, handled, and transported safely so that permanent deformation does not occur, and surface damage is minimised. Handling and storage preventive measures specified in Table 1 shall be applied as appropriate.

Table 1 — List of handling and storage preventive measures

Lifting
Protection of components from damage at the lifting points
Avoidance of single point lifting of long components by use of spreader beams
Bundling together lightweight components particularly prone to edge damage, twisting and distortion if handled as individual items. Care taken to avoid localized damage where components touch each other, to unstiffened edges at lifting points or other zones where a significant proportion of the weight of the bundle is imposed on a single unreinforced edge
Storage
Stacking of fabricated components stored before transportation or erection clear of the ground to be kept clean
Necessary supports to avoid permanent deformations
Storage of materials supplied with pre-finished decorative surfaces in accordance with relevant standards
Protection against corrosion
Avoidance of accumulation of water
Transport
Special measures needed for protecting fabricated components in transit

5.4 Cutting

5.4.1 General

Cutting shall be carried out in such a way that the requirements for geometrical tolerances, maximum hardness and smoothness of free edges as specified in this document are met.

NOTE Recognised cutting processes are sawing, shearing, nibbling, disc cutting, water jet techniques and thermal cutting.

Hand thermal cutting shall be used only if it is not practical to use mechanically guided thermal cutting. For some cutting methods, precautions shall be taken if the cut edges are to be free edges (i.e. not to be subsequently welded) for components subject to fatigue, as specified in the execution specification.

If a process does not conform, it shall not be used until corrected and checked again. It may be used on a restricted range of constituent products that do produce conforming results.

If coated materials are to be cut, the method of cutting shall be selected to minimize any damage to the coating.

Burrs that can cause injury or prevent the proper alignment or bedding of sections shall be removed.

5.4.2 Shearing and nibbling

The free edge surfaces shall be checked and smoothed as necessary to remove nonconformities. If grinding or machining is required after shearing or nibbling, the minimum depth of grinding or machining shall be 0,5 mm. The restrictions on punching in 5.6.1.2 also apply to shearing and nibbling.

5.4.3 Thermal cutting

The capability of automated thermal cutting processes shall be checked annually as set out below.

Four samples shall be produced from the constituent product to be cut by the process:

a) a straight cut from the thickest constituent product;

b) a straight cut from the thinnest constituent product;

c) a re-entrant corner from a representative thickness;

d) a curved arc from a representative thickness.

Measurements shall be taken on each straight sample over at least a 200 mm length and checked against the required quality of the cut surface. The corner and curved samples shall be visually inspected to establish that they produce edges of equivalent quality to the straight cuts.

Alternatively, the capability of automated thermal cutting processes may be checked as given in Annex B.

The quality requirements for cut surfaces to be left as free edges (i.e. not to be subsequently incorporated into a weld) shall be according to Table 2 when assessed in accordance with ISO 9013, unless otherwise specified.

Alternatively, the reference for evaluation of cut surfaces may be the surface roughness gauge included in the AWS C4.1-77 set. When used, the roughness of thermal cut surfaces shall be evaluated by visually comparing the cut surface to the roughness represented on the roughness gauge. Surface roughness shall be no greater than that represented by Sample 3, except that for the ends of members not subject to calculated stress, copes in beams with the flange thickness not exceeding 50 mm (2 in), and for materials over 100 mm to 200 mm (4 in to 8 in) thick, surface roughness shall not exceed that represented by Sample 2.

When required by the execution specification, free edges that are to have surface preparation before paint coating shall have the hardened surface removed.

When required by the execution specification, free edges that are to be hot dip galvanized shall have the hardened surface removed.

NOTE Liquid metal assisted cracking (LMAC), or liquid metal embrittlement (LME) can occur where surfaces are thermally cut and receive hot dip galvanizing. See ISO 14713-2 and DASt-Richtlinie 022 [17] for guidance.

Table 2 — Quality of the cut surfaces[a]

Execution level	Perpendicularity or angularity tolerance u	Mean height of the profile R_{z5}
EXL1	Cut edges to be free from significant irregularities and dross shall be removed	
EXL2	Range 5	Range 4
EXL3	Range 4	Range 4
EXL4	Range 4	Range 4

[a] Ranges are specified in ISO 9013

5.4.4 Hardness of free edge surfaces

The hardness of free edge surfaces of carbon steel groups 2.2 and 3, as listed in ISO/TR 15608, shall be no more than 450 (HV10) or 420 Brinell (HB). In this case, processes that are likely to produce local hardness (thermal cutting, shearing, nibbling and punching) shall have their capability checked. To achieve the required hardness of free edge surfaces, preheating of material shall be applied as necessary.

Unless otherwise specified in the execution specification, the check of the capability of the processes shall be as follows:

a) four samples shall be produced from procedure tests on constituent products encompassing the range of constituent products processed that are most susceptible to local hardening;

b) four local hardness tests shall be performed on each sample in locations likely to be affected. The tests shall be in accordance with ISO 6506-1 or ISO 6507-1.

NOTE The requirements for checking hardness after welding are included in procedure testing (see ISO 17607-5).

5.5 Shaping

5.5.1 General

Steel may be bent, pressed or forged to the required shape either by the hot or by the cold forming processes, provided the properties are not reduced below those specified for the material to be worked.

Requirements and recommendations for hot forming, cold forming and flame straightening of steels shall be as given in the relevant product standards or the recommendations of the steel manufacturer.

Cooling rates should be selected to prevent hardening and excessive grain coarsening

NOTE See CEN/TR 10347 for guidance.

If the relevant product standards or steel manufacturer's recommendations are not followed, then the process shall be qualified by procedure testing established in execution specification.

Cambering, straightening or shaping by controlled application of heat may be used under the conditions specified in 5.5.2 and 5.5.3.

Cambered, straightened or shaped components that exhibit cracking, lamellar tearing, or damage to surface coatings shall be treated as non-conforming products.

5.5.2 Hot forming (forging)

Shaping by hot forming (forging) shall conform to the requirements relating to hot forming of the relevant product standard and to the recommendations of the steel manufacturer.

Hot forming of thermo-mechanically rolled or quenched and tempered steels shall not be used.

In the absence of recommendations from the steel manufacturer:

— For steel grades up to and including 360 MPa yield, the hot forming process shall take place in the range 600 °C to 650 °C. The temperature, timing and cooling rate shall be appropriate to the particular type of steel. During cooling, bending and forming in the range of 250 °C to 380 °C is not permitted.

— For steel grades above 360 MPa yield, the hot forming process shall take place in the temperature range 750 °C to 960 °C with subsequent cooling at air temperature. The cooling rate should be such as to prevent hardening as well as excessive grain coarsening. If this is not practicable, a subsequent normalizing treatment shall be carried out.

5.5.3 Flame (heat) straightening, cambering, and curving

If flame (heat) straightening, cambering, or curving is used it shall be performed by the local application of heat, ensuring that the maximum steel temperature recommended by the steel manufacturer is not exceeded.

In the absence of recommendations from the steel manufacturer:

— For steel grades up to and including 420 MPa yield, the maximum temperature for flame straightening shall not exceed 700 °C.

— For steel grades above 420 MPa yield, the maximum temperature for flame straightening shall not exceed 650 °C.

For fine grain and thermo-mechanically controlled processed (TMCP) steels, a documented procedure shall include requirements for:

a) maximum steel temperature and procedure of cooling allowed;

b) method of heating;

c) method used for temperature measurements;

d) results of mechanical tests carried out for the process qualification;

e) identification of workers entitled to apply the process.

NOTE See ISO/TR 15608 for guidance.

For fine grain and the TMCP steels, the procedure shall be qualified based on the results of tensile, impact and hardness tests. With respect to the thermally heated zone, the location used for temperature measurement and the locations and orientation for the test samples shall be specified.

5.5.4 Cold forming

5.5.4.1 General

Shaping by cold forming, produced either by roll forming, pressing or folding shall conform to the requirements for cold formability given in the relevant product standard. Hammering shall not be used.

Unless permitted by the steel manufacturer's recommendations, cold forming shall not be performed when the steel temperature is lower than 15 °C.

NOTE Cold forming leads to a reduction in the ductility. Information on cold forming prior to hot dip galvanizing is given in ISO 14713-2.

5.5.4.2 Steel plates

For steel plates, unless otherwise specified in the execution specification, the minimum inside bend radii to be cold-formed shall be in accordance with Table 3.

Table 3 — Minimum inside bend radii for thickness and grade[a]

Specified minimum yield strength of steel MPa	Bend lines perpendicular to direction of final rolling				Bend lines parallel to direction of final rolling			
	Material thickness t (mm)							
	≤ 15	15 < ≤ 25	25 < ≤ 50	50 <	≤ 15	15 < ≤ 25	25 < ≤ 50	50 <
< 345	1,5t	1,5t	1,5t	2t	2,3t	2,3t	2,3t	3t
345 ≤ < 460			2t	2,5t			3t	4t
460 ≤ < 690			3t	3,5t			4,5t	5t
690 ≤	1,8t	2,3t	4,5t	5,5t	2,7t	3,5t	7t	8t

[a] At locations where plastic deformation capacity is required, the inside bending radius shall be minimum:

— 8t where the direction of the stress is parallel to bend line;

— 4t where the direction of stress is perpendicular to bend line.

5.5.4.3 Steel grades higher than 360 MPa yield

In the absence of recommendations from the steel manufacturer, for steel grades higher than 360 MPa yield, if a stress relief treatment is carried out after cold forming, the following two conditions shall be satisfied:

a) temperature range: 530 °C to 580 °C;

b) holding time: 2 min/mm of material thickness, but with a minimum time of 30 min.

NOTE Stress relief treatment at more than 580 °C, or for over an hour, can lead to deterioration of the mechanical properties.

If it is required to stress relieve steel grades higher than 360 MPa at higher temperatures or for longer times, the required minimum values of the mechanical properties shall be agreed on in advance with the steel manufacturer.

5.5.4.4 Cold-formed components

For cold-formed components, shaping by further cold forming shall conform with the following two conditions:

a) the surface coatings and the accuracy of profile shall not be impaired;

b) it shall be specified if constituent products require protective membranes to be applied before forming.

NOTE 1 Some coatings and finishes are particularly prone to abrasive damage, both during forming and subsequently during erection.

Bending by cold forming of hollow section components may be used provided that hardness and geometry of the as-bent constituent product are checked.

NOTE 2 Bending by cold forming can cause alteration of section properties (e.g. concavity, ovality and wall thinning) and increased hardness.

5.5.4.5 Circular hollow sections

For circular hollow sections, unless process specific capability can be demonstrated in terms of maintaining cross sectional geometry, bending by cold forming shall conform with the following three conditions:

a) the ratio of the overall diameter of the tube to the wall thickness does not exceed 15;

b) the bend radius (at the centreline of the tube) is not less than 1,5d or d+100 mm, whichever is the larger, in which d is the overall diameter of the tube;

c) the longitudinal seam weld in the cross-section is positioned no further than d/5 from the centreline of the bend, measured in the direction of the plane of the bend.

5.6 Holing for structural bolting

5.6.1 Execution of holing

5.6.1.1 Methods

Holes for bolts or pins may be formed by any process (e.g. drilling, punching, water jet, laser, plasma, or other thermal cutting) provided that this leaves a finished hole such that:

— cutting requirements relating to local hardness and quality of cut surface are fulfilled;

— all matching holes for bolts or pins register with each other such that the bolts or pins can be inserted freely through the assembled members in a direction at right angles to the faces in contact.

A round hole for a bolt or pin shall be cut with mechanical guidance, drilled full size, sub-punched 3 mm undersize and reamed to size, or punched full size.

A slotted hole shall be either cut with mechanical guidance, punched in one operation, or formed by punching or drilling two adjacent holes and completed by cutting.

5.6.1.2 Punching

Unless otherwise specified in the execution specification, bolt holes may be formed by punching without reaming except in

— quenched and tempered steel of 690 MPa tensile strength or greater with a thickness greater than 13 mm;

— plastic hinge locations in materials with a thickness greater than 13 mm;

— areas subject to fatigue;

— lap joints where the bolts are above Grade 8.8;

— joints designed to be slip resistant.

The execution specification shall identify areas subject to fatigue, plastic hinge rotation, or with slip-resistant joints.

Where untreated punched bolt holes are not permitted, holes may be punched at least 2 mm less than full size and then reamed or drilled until all trace of the original punched surface has been removed.