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Steel structures —

Part 2:
Fabrication and erection

Structures en acier —

Part 2: Fabrication et montage

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10721-2 was prepared by Technical Committee ISO/TC 167, *Steel and aluminium structures*, Subcommittee SC 2, *Steel: Fabrication and erection*.

ISO 10721 consists of the following parts, under the general title *Steel structures*:

— *Part 1: Materials and design*

— *Part 2: Fabrication and erection*

Annexes A to D are for information only.

Introduction

This part of ISO 10721 establishes a common basis for drafting national standards for the fabrication and erection of steel structures, in order to ensure an adequate and consistent treatment of safety and serviceability compatible with ISO 10721-1. The specific and numerate requirements for the achievement of structures which are optimal with respect to the state of the economy, development and general values of a nation are given in the appropriate national standard.

NOTE Those concerned with a construction project may need to take into account the safety and health of the construction workers in accordance with national laws, regulations and practice. Thus, fabricators, clients, designers, constructors, employers, self-employed persons and employees may be concerned with this matter.

Steel structures —

Part 2:
Fabrication and erection

1 Scope

This part of ISO 10721 specifies the requirements for the fabrication, erection and inspection of structural steelwork in buildings designed in accordance with ISO 10721-1, including steelwork in composite steel and concrete structures.

This part of ISO 10721 is also applicable to bridges, off-shore and other civil engineering and related structures, but for such structures it may be necessary to consider other requirements.

NOTE For welded connections and for structures subject to fatigue, special considerations regarding scope and field of application are presented in 8.9 and 10.1 respectively of ISO 10721-1.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10721. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10721 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO R615, *Methods for determining the mechanical properties of the weld metal deposited by electrodes 3,15 mm or more in diameter.*

ISO 630, *Structural steel — Plates, wide flats, bars, sections and profiles.*

ISO 657 (all parts), *Dimensions of hot rolled steel sections.*

ISO 700, *Power sources for manual metal arc welding with covered electrodes and for the TIG process.*

ISO 1461, *Metallic coatings — Hot dip galvanized coatings on fabricated ferrous products — Requirements.*

ISO 2063, *Metallic coatings — Protection of iron and steel structures against corrosion — Metal spraying of zinc and aluminium.*

ISO 2081, *Metallic coatings — Electroplated coatings of zinc on iron or steel.*

ISO 2082, *Metallic coatings — Electroplated coatings of cadmium on iron or steel.*

ISO 2400, *Welds in steel — Reference block for the calibration of equipment for ultrasonic examination.*

ISO 2553, *Welded, brazed and soldered joints — Symbolic representation on drawings.*

ISO 3690, *Welding — Determination of hydrogen in deposited weld metal arising from the use of covered electrodes for welding mild and low alloy steels.*

ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers.*

ISO 7415, *Plain washers for high-strength and structural bolting, hardened and tempered.*

ISO 7963, *Welds in steel — Calibration block No. 2 for ultrasonic examination of welds.*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.*

ISO 8501-2, *Preparation of steel substrates before the application of paints and related products — Visual assessment of surface cleanliness — Part 2: Preparation grades of previously coated steel substrates after localized removal of previous coatings.*

ISO 8503-1, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces.*

ISO 8503-2, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 2: Method for the grading of surface profile of abrasive blast-cleaned steel — Comparator procedure.*

ISO 9000 (all parts), *Quality management and quality assurance standards.*

ISO 9002, *Quality systems — Model for quality assurance in production and installation.*

ISO 9606-1, *Approval testing of welders — Fusion welding — Part 1: Steels.*

ISO 9692, *Metal-arc welding with covered electrode, gas-shielded metal-arc welding and gas welding — Joint preparations for steel.*

ISO 9956-1, *Specification and approval of welding procedures for metallic materials — Part 1: General rules for fusion welding.*

ISO 9956-2, *Specification and approval of welding procedures for metallic materials — Part 2: Welding procedure specification for arc welding.*

ISO 9956-3, *Specification and approval of welding procedures for metallic materials — Part 3: Welding procedure tests for the arc welding of steels.*

ISO 10721-1:1997, *Steel structures — Part 1: Materials and design.*

ISO 12944-4, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 4: Types of surface and surface preparation.*

ISO 14713, *Protection against corrosion of iron and steel in structures — Zinc and aluminium coatings guidelines.*

3 Materials

All materials should comply with the requirements of 6.3 of ISO 10721-1:1997.

For steels not complying with 6.3 of ISO 10721-1:1997, other requirements may be necessary.

Where no suitable International Standard exists, reference shall be made to appropriate national standards, certification schemes and agreements.

Unless stated otherwise, the national standards to be adopted are those of the country in which the structure is to be built.

Where no standards exist, the proprietary manufacturer's recommendations shall be adopted.

4 Fabrication workmanship

4.1 Material identification

The fabricator shall demonstrate the means used to effectively identify steel materials prior to fabrication and assembly of members. Hard stamping may be used except where otherwise specified by the designer, such as for elements subject to sudden impact or fatigue criteria or in regions where plastic hinges may occur.

4.2 Bending and pressing

Steel may be bent or pressed to the required shape by either the hot or the cold process, provided the properties of the material are not affected beyond the limits specified in the relevant steel standard.

For cold bending of plates and flats, the internal radius of bends shall be within tolerances given in the design documents and shall not be less than the bend testing radius specified for the material thickness in the relevant steel standard.

For hot bending, the temperature, timing and cooling rate shall be appropriate to the particular type of steel. Bending in the blue heat range (290 °C to 380 °C) shall be avoided.

4.3 Straightening and flattening

Straightening and flattening shall be carried out by the application of heat or by the slow application of mechanical pressure; hammering is not permitted.

When straightening and flattening by the application of localized heat, the recommendations of clause B.4 in annex B should be followed.

4.4 Forging

Forging shall be carried out in such a manner that it will not impair the properties of the material.

4.5 Preparation of edges, ends and surfaces

4.5.1 General

Cutting shall be by sawing, shearing and machine thermal or laser cutting. Unguided flame cutting shall only be used for notching or the completion of the formation of slotted holes. Re-entrant corners shall be rounded by grinding and be free of overcutting.

4.5.2 Preparation of material

The preparation of the material shall be in accordance with the following requirements:

a) parent metal surfaces within 25 mm of the weld shall be smooth, uniform and free from cracks, loose or thick scale and other contaminants which would adversely affect the strength or quality of the weld;

b) where small notches or irregularities in gas-cut edges occur on otherwise satisfactory surfaces, they shall be removed by grinding or machining to a smooth profile.

   Notches in excess of 5 mm in depth or other discontinuities considered unacceptable shall be repaired by welding to an approved welding procedure. Subsequently, they shall be ground smooth and flush with the adjacent surface to produce an acceptable finish;

c) re-entrant corners shall be filleted to a radius of not less than 10 mm;

NOTE A re-entrant corner is a corner in which the open angle between the cut faces is less than 180°.

d) methods other than those given in 4.5 may be used for joint preparation, back-gouging or for the removal of unacceptable material except that thermal gouging shall not be used on quenched and tempered steels;

e) edges of built-up beam and girder webs shall be cut to the prescribed camber with suitable allowance for shrinkage due to cutting and welding. Deviations from the specified camber tolerance may be corrected by the use of an appropriate heating procedure;

f) steel surfaces shall:

1) **on rolled surfaces**, be no worse than Grade C in accordance with ISO 8501-1 and be free from surface defects in accordance with ISO 630,

2) **on cut surfaces**, have a suitable surface roughness and be free from sharp arrises which prevent the attainment of the surface conditions required for the painting system specified.

4.5.3 Flame cutting and shearing

Flame cutting and shearing shall be permitted for elements subject to consideration of the following:

a) where a fatigue quality is specified (see D.5.2 in annex D);

b) the cut edge is completely incorporated in the weld;

c) when specified, the maximum hardness of the cut edge does not exceed the levels given in the appropriate national standard;

d) the roughness of the cut edge does not exceed the value specified in the appropriate national standard.

4.5.4 Machining butted joints

Joint surfaces dependent on contact for the transmission of load shall be within the tolerances specified (see 8.6). No machining need be carried out on a bearing face which is to be grouted directly to a foundation.

Compression joints which depend on contact bearing shall have the bearing surfaces of individual fabricated pieces prepared to a common plane by sawing or machining.

4.5.5 Contact surfaces for slip-resistant connections

All contact surfaces shall, at the time of assembly, be as specified and free of any contaminant.

When the joint is assembled, the contact surfaces shall be free from dust, oil, paint or other deleterious materials, except for a planned slip-resistant coating. Spots of oil which cannot be removed by flame cleaning without leaving harmful residues shall be removed by suitable chemical means. If rust forms on the contact surfaces before they have been assembled, it will be sufficient to remove any thin films of rust or other loose material by brushing with a steel brush. During this process the roughened surface shall not be damaged or made smooth.

4.6 Holes for bolts and pins

4.6.1 Forming holes

Round holes for bolts shall be formed either by drilling or punching. Slotted holes shall be either punched in one operation or incrementally punched, or formed by drilling or punching two holes and completing by hand flame cutting. Countersinking shall be carried out by drilling. All holes shall be free from significant burrs.

Where holes are drilled in one operation through parts clamped together which would not otherwise be separated after drilling, they need not be separated to remove the burrs.

Holes through more than one plate should be punched in the same direction. Punching is allowed for a material up to 25 mm in thickness provided that the hole diameter is not less than the thickness of the material, and distortion of the hole is within 10 % of its specified diameter.

Anchor bolt holes in baseplates may be formed by thermal cutting.

Holes in elements subject to fatigue, or where specified, shall either be drilled or subpunched 2 mm undersize in diameter for preloaded bolts and 4 mm undersize for ordinary bolts and reamed.

4.6.2 Holes for general purpose and structural bolts

Except as permitted by 4.6.3, the diameter of the hole shall not exceed the nominal diameter of the bolt by more than:

a) 1 mm for bolts up to and including 14 mm in diameter;

b) 2 mm for bolts over 14 mm but less than 27 mm in diameter;

c) 3 mm for bolts 27 mm in diameter and larger.

4.6.3 Oversize and slotted holes

In accordance with A.8.8.2.2 in ISO 10721-1:1997, the hole dimensions given in Table 1 should apply.

In the case of oversize holes, greater attention shall be taken to ensure resistance to shear and tension when applicable.

4.6.4 Holes for pins

Pin holes shall be bored smooth, straight and true to gauge and at right angles to the axis of the member. Boring shall be undertaken only after the member is finally bolted or welded, unless otherwise permitted.

For pins up to and including 250 mm diameter, the diameter of the pins shall be within a tolerance of – 0,25 mm to – 0,40 mm and the diameter of the pin hole shall be within a tolerance of 0 mm to + 0,15 mm.

For pins exceeding 250 mm diameter, the clearance between the pin and the pin hole shall be not less than 0,40 mm and not more than 0,75 mm.

Table 1 — Dimensions for oversize and slotted holes

Hole type	Hole dimension for bolt diameter d of		
	⩾ 16 mm and ⩽ 22 mm	24 mm	⩾ 27 mm
a) Oversize			
Maximum dia.	d + 4 mm	d + 6 mm	d + 8 mm
b) Short slotted			
Width	d + 2 mm	26 mm	d + 3 mm
Length (maximum)	d + 6 mm	32 mm	d + 10 mm
c) Long slotted			
Width	d + 2 mm	26 mm	d + 3 mm
Length (maximum)	2,5 d	60 mm	2,5 d

4.7 Bolts, nuts and washers

4.7.1 General purpose and non-preloaded structural bolts

The connected parts shall be firmly drawn together. All bolted splices shall be provided with steel packing plates in order to ensure that the total remaining step between adjacent plates does not exceed 2 mm.

The tip of the bolt shall be flush with or outside the face of the nut when installed. The thread may be included in the shear plane.

4.7.2 Countersunk bolts

Countersunk bolts shall comply with the requirements of the appropriate national standard.

4.7.3 Preloaded structural bolts

The tip of the bolt shall be flush with or outside the face of the nut when installed. The thread is permitted to be included in the shear plane unless otherwise stated.

4.7.4 Washers

4.7.4.1 Washers for preloaded bolts

Hardened washers for preloaded high-strength bolts shall be in accordance with the requirements of ISO 7415 as follows:

a) when bolts with a nominal f_u greater than 830 N/mm^2 and a diameter greater than 27 mm are used, hardened washers at least 8 mm in thickness shall be used;

b) when preloaded bolts are to be installed in an oversize hole or in a short slotted hole in an outer ply, a hardened washer shall be used. In outer plies of a joint for long slotted holes, structural plate washers or continuous bars at least 8 mm thick with standard holes shall be used to completely cover the slot;

c) when the inspection or installation procedure involves the use of a calibrated wrench or torque spanner, a hardened washer shall be used under the turned element.

In all joints using material having a nominal f_y less than 280 N/mm^2 and bolts having a nominal f_u greater than 830 N/mm^2, hardened washers shall be used;

d) to compensate for the lack of parallelism for bolts with an f_u greater than 830 N/mm^2, where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, a tapered washer shall be used.

4.7.4.2 Washers for ordinary bolts

a) When the nut would otherwise bind on the thread run-out, a washer shall be used.

b) A suitable washer shall be used under the head and nut when assembling components with oversize or slotted holes.

c) Washers shall be used under the bolt head and nut when used on metal-sprayed or galvanized steelwork.

d) Washers shall be used under the turned element when the surface is painted.

4.7.5 Nuts

4.7.5.1 Non-preloaded structural bolts

Nuts on non-preloaded structural bolts and ordinary bolts shall be tightened to an amount corresponding to the full effort of using a hand wrench. When so specified, nuts shall be prevented from working loose by the use of lock washers, lock nuts, jam nuts, defacing of the threads, welding or other methods approved by the designer.

4.7.5.2 Preloaded structural bolts

Nuts on preloaded structural bolts shall be installed in accordance with 4.7.7.

4.7.6 Galvanized bolts, nuts and washers

When specified, bolts, nuts and washers shall be galvanized with suitable quality control to avoid mismatch of nut and bolt threads. In the case of bolts with f_u minimum greater than 830 N/mm^2 and for all washers, suitable measures shall also be taken to avoid hydrogen embrittlement. Bolts of property class 12.9 should not be galvanized. In all cases, when bolts are installed in a connection they shall:

a) have three to five threads in the grip;

b) be capable of producing a tensile-type fracture of the bolt; and

c) be capable of rotating one full turn from snug before failure when properly lubricated.

4.7.7 Installation of preloaded structural bolts

Preloaded structural bolts shall be tightened as follows. However if necessary tightening may be undertaken by turning the bolt while holding the nut against rotation.

The permitted methods of tightening are:

a) turn-of-nut tightening;

After aligning the holes of the joint, the bolts shall be placed and brought to a “snug-tight” condition to ensure that the parts of the joint are brought into firm contact with one another. “Snug-tight” is defined as the tightness attained by full effort of using a hand wrench or by a few impacts of an impact wrench. Following the initial snugging operation, bolts shall be placed in any remaining holes and brought to snug-tightness. Re-snugging of bolts may be necessary in large joints. When all bolts are snug-tight, each bolt in the joint shall then be additionally tightened by the applicable amount of nut rotation given in Table 2. Tightening should proceed systematically from the most rigid part of the joint to its free edges.

Table 2 — Nut rotation from snug-tight condition

Bolt length [a]	Turn	Tolerance mm
⩽ 4 bolt diameters	1/3	± 30°
> 4 bolt diameters and ⩽ 8 bolt diameters or 200 mm	1/2	± 30°
> 8 bolt diameters or 200 mm	2/3	± 45°

[a] Bolt length is measured from underside of head to expected location of outer face of nut.

b) direct tension indicator;

Tightening of bolts using direct tension indicator devices is permitted provided the suitability of the device can be demonstrated by testing a representative sample of not less than three indicator devices for each diameter and grade of fastener in a calibration device capable of indicating bolt tension. The test assembly shall include flat hardened washers, if required in the actual connection, arranged similar to those in the actual connections to be tensioned. The calibration test shall demonstrate that the device indicates a tension not less than 5 % greater than that required by 8.8.2.3 of ISO 10721-1:1997.

c) any other method that can be demonstrated to meet the requirements of 8.8.2.3 of ISO 10721-1:1997.

Manufacturers' installation procedures shall be followed for installation of bolts in the calibration device and in all connections. Special attention shall be given to proper installation of flat hardened washers when load-indicating devices are used with bolts installed in oversize or slotted holes and when the load-indicating devices are used under the turned element. When the direct tension indicator involves an irreversible mechanism such as yielding or fracture of an element, bolts shall be installed in all holes of the connection and brought to snug-tight condition. All fasteners shall then be fully tightened, progressing systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners prior to final twist-off or yielding of the control or indicator element of the individual devices. In some cases, proper tensioning of the bolts may require more than a single cycle of systematic tightening.

4.7.8 Reuse of bolts

Bolts with a nominal f_u greater than 830 N/mm^2 and galvanized bolts shall not be reused. Other bolts may be reused, provided f_u is not greater than 830 N/mm^2, if approved by the designer. Retightening previously partially tightened bolts which may have been loosened by the tightening of adjacent bolts shall not be considered as reuse.

4.7.9 Pins

Pins shall be parallel throughout and shall have a smooth surface free from flaws. They shall be of sufficient length to ensure that all parts connected thereby will bear fully on them. Where the ends are threaded they shall be turned to a smaller diameter and protection for the thread shall be provided.

4.8 Welding

4.8.1 General requirements

4.8.1.1 Welding processes

The welding process shall be selected from the following:

a) shielded metal arc (111);

b) gas metal arc (131, 135);

c) flux-cored arc (114, 136, 137);

d) submerged arc (121);

e) stud welding (781, 782).

NOTE Parentheses indicate process reference according to ISO 4063.

Any welding process not listed above but which gives equivalent results to those specified herein is not necessarily precluded. Such processes are acceptable when allowed by appropriate national standards, the welding procedures have been qualified as required by those standards, and use of the process is acceptable to the responsible authority.

Power sources for manual metal arc and TIG welding shall be in accordance with ISO 700. For other processes, the power sources shall be in accordance with appropriate national standards.

4.8.1.2 Filler metals

Electrodes, electrode-gas and electrode-flux combinations shall be as specified in the appropriate International Standards or appropriate national standards.

Where filler metal, electrode-gas or electrode-flux combinations are to be used which are not covered in the requirements of the appropriate International Standard, they shall be permitted provided they are in accordance with the approved welding procedures. The extent of the validity of such qualification shall be limited to the steel, the type of weld and the essential variables used in procedure qualification.

Methods for determining the mechanical properties of the weld metal from electrodes 3,15 mm or more in diameter shall be in accordance with ISO R615. For other electrodes, appropriate national standards may be used.

Hydrogen content of covered electrodes shall be determined in accordance with ISO 3690.

4.8.1.3 Weld symbols on drawings

Weld types, sizes and lengths shall be designated on the drawing in accordance with ISO 2553.

4.8.2 Workmanship

4.8.2.1 General welding requirements

Where the contract requires the use of approved welding procedures, these shall be approved in accordance with ISO 9956-1, ISO 9956-2 and ISO 9956-3 or appropriate national standards. For guidance on factors to be considered, see ISO 3088.

Where the contract requires the use of approved welders, they shall be approved to ISO 9606-1.

Welders and the associated weld joint shall be adequately protected against the direct effect of wind, rain and snow and other elements that could prevent acceptable results.

Welding shall not be undertaken when the steel temperature is lower than specified in accordance with the national standard, except with the express consent of the responsible authority.

This shall also apply to stud welding. However, if required in accordance with appropriate national standards, stud welding, when done below 0 °C, shall be permitted only if an additional number of studs beyond that normally required is successfully tested (refer to ISO 10721-1).

The sizes and lengths of welds shall be not less than those specified by design requirements and detail drawings, nor shall they be in excess of the requirements beyond the tolerances prescribed by national acceptance standards without approval. The location of welds shall not be changed without reference to the designer.

Depending upon the carbon equivalent of the steels, the combined thicknesses and the hydrogen level of the welding consumables, it may be necessary to preheat the steel before welding (refer to EN 1011-1 and EN 1011-2). In order to confirm preheat requirements, it may be necessary to carry out a welding procedure test in accordance with ISO 9956-1, ISO 9956-2 and ISO 9956-3.

Back-gouging shall produce a contour of a single U-groove with its fusion faces readily accessible for welding and its depth adequate to ensure penetration into the previously deposited weld metal.

4.8.2.2 Storage and conditioning of electrodes

After welding consumables have been removed from their original packages, they shall be protected or stored in accordance with the requirements of the appropriate national standard. Where the latter is unavailable, the manufacturer's recommendations shall be adhered to.

4.8.2.3 Assembly and fit-up tolerances

4.8.2.3.1 General

Joint preparation and fit-up dimensions for steels under this part of ISO 10721 shall be selected so as not to exceed the appropriate geometrical tolerances in ISO 9692.

4.8.2.3.2 Fillet-welded joint

The parts to be joined by fillet welds shall be brought into as close a contact as practicable. Where an occasional non-uniformity in the fit-up occurs, the local gap as related to the total length of the parts in the joint shall not exceed:

a) 2 mm for joints of maximum 600 mm in length;

b) 3 mm for joints over 600 mm in length and maximum 3 m in length;

c) 5 mm for joints over 3 m in length.

For parts 75 mm and greater in thickness, the gap shall not exceed 8 mm. However, for any gap greater than 3 mm, a sealing weld, with suitable backing material, shall be used to prevent melt-through and the final weld shall attain the required throat size.

In all cases where there is a local separation of 2 mm or greater over more than 10 % of the weld length, the leg of the fillet weld shall be increased to ensure that the design throat is maintained.

NOTE Backing to prevent burn-through may be of flux, glass tape, iron powder, or similar material, or it may be provided by means of root passes deposited by basic electrodes or other low hydrogen arc welding processes.

4.8.2.3.3 Lap joints

The separation between surfaces of lap joints shall not exceed 2 mm. The use of filler packs is prohibited unless otherwise specified.