

Execution of steel structures and aluminium structures

Part 2: Technical requirements for steel structures

ICS 91.080.10

National Foreword

This British Standard is the UK implementation of BS EN 1090-2:2008+A1:2011. It supersedes BS EN 1090-2:2008, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted to Technical Committee CB/203, Design & execution of steel structures.

A list of organizations represented on this committee can be obtained on request to its secretary.

Additional information

BSI, as a member of CEN, is obliged to publish EN 1090-2:2008 as a British Standard. However, attention is drawn to the fact that during the development of this European Standard, the UK committee voted against its approval as a European Standard.

The reason for the UK committee vote was because of concerns about possible misspecification in terms of execution classes and weld quality levels in particular. If realized, these concerns about the range and the basis of some of the choices could lead either to under-specification and inadequate safety or to over-specification and possible barriers to trade. These issues are described more fully below, together with suggestions that should avoid these risks.

This standard gives the technical requirements for the execution (fabrication and erection) of steel structures and is a supporting standard for the harmonized standard BS EN 1090-1, *Execution of steel structures and aluminium structures – Part 1: Requirements for conformity assessment of structural components*. Conformity assessment to BS EN 1090-1 requires that the manufacturer operates a certified factory production control system. The quality management requirements for factory production control include, for instance, levels of traceability and welding quality management which are defined by reference to BS EN 1090-2.

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This standard supersedes several existing standards and hence has a very wide scope. Therefore, it requires specifiers to make a series of project- or application-specific decisions before execution commences on each part of the works. Annex A itemizes the additional and optional information required.

Execution classes

This standard introduces the concept of execution class (EXC) as a classified set of requirements specified for the execution of the works as a whole, of an individual component, or of a detail of a component. Annex A.3 itemizes those requirements in the standard which depend on the choice of execution class.

It is a design decision for the specifier to select the execution class required for the works as a whole, an individual component, or a particular detail of a component. Annex B of BS EN 1090-2 provides some informative guidance on the factors that might be relevant to that decision. The primary reason to differentiate is to provide a level of reliability against failure or malfunction of the structure/component/detail that is matched to the consequences (see BS EN 1990, *Eurocode – Basis of structural design*, for further information). Hence, execution class is widely used in this standard as a reliability differentiator for providing choice of quality, testing and qualification requirements, although the relationship between this new differentiator and those recommended by BS EN 1990 is not fully defined.

Annex B of BS EN 1090-2 recommends that the choice of execution class should also depend on the ‘service category’ (SC) that characterizes a component in terms of the circumstances of its designed use, and the ‘production category’ (PC) that characterizes a component in terms of the methods used for its execution. These latter two types of category imply that, for a given structure/component/detail, the execution class specified should be increased in line with more onerous demands in service and/or if it is more difficult to produce.

From Annex B it appears likely that most steel structures in the UK will include components in both PC1 and PC2, but most will be SC1 unless they are designed for fatigue actions (in which case they will be SC2). Thus, as a default basis, EXC2 could be specified for structures/components/details used in buildings, and EXC3 could be specified for structures/components/details used in bridges.

Weld quality levels

For structures/components/details designed for fatigue additional requirements should be adopted because the simple choice between design for quasi-static (SC1) and fatigue (SC2) applications does not sufficiently discriminate the required weld quality levels in terms of fatigue classes.

In these circumstances, as the choice of appropriate requirements requires a level of design and construction knowledge that many potential users of this standard may not possess, reference should be made to the advice given in PD 6695-1-9, *Recommendations for the design of structures to BS EN 1993-1-9*, which explains the relationship between design and execution with respect to fatigue classes (FAT classes), and PD 6705-2, *Recommendations for the execution of steel bridges to BS EN 1090-2*, which gives acceptance criteria for welds designed for fatigue. These acceptance criteria have been developed for structural welds on a fitness-for-purpose basis and are consistent with those used in the British Standards that are superseded by BS EN 1090-2.

BS EN 1090-2 relates the execution classes to weld quality levels in BS EN ISO 5817, *Welding – Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections*, as follows:

- EXC1: Quality level D;
- EXC2: Quality level C generally;
- EXC3: Quality level B (i.e. as required for welder qualification tests and welding procedure qualification records);
- EXC4: Quality level B+.

These levels may generally be appropriate to establish, prequalify and certificate the routine quality level of the manufacturer's welding operations. However, although EXC4 can be used to specify the extent of supplementary non-destructive testing, the associated quality level B+ is not practically achievable in routine production as it requires the manufacturer to demonstrate a capability of meeting a quality level which is more stringent than that for which the manufacturer's welders and welding procedures are qualified. Thus, if a quality level of B or higher is required, it is more practical to specify this for each relevant joint detail and not for routine production, using the acceptance criteria given in PD 6705-2 for evaluating imperfections on an individual basis, as permitted by BS EN 1090-2.

Tolerances

BS EN 1090-2 is more complicated than the British Standards that it supersedes in its approach to specifying permitted geometrical deviations as systems of tolerances. Three types of geometrical tolerance are defined:

1. essential tolerances that are essential for the mechanical resistance and stability of the completed structure and which are used to support conformity assessment to BS EN 1090-1;
2. functional tolerances required to fulfil other criteria such as fit-up and appearance;
3. special tolerances that may be specified for project-specific reasons, and which would need to be clearly defined in the execution specification.

Functional tolerances are defined for two classes, of which the less onerous tolerance class 1 is the default specification for routine execution. Tolerance class 2 is likely to require special and more expensive measures in fabrication and erection.

As an alternative, the standard allows BS EN ISO 13920, *Welding – General tolerances for welded constructions – Dimensions for lengths and angles – Shape and position*, to be used as the basis for specifying functional tolerances. BS EN ISO 13920 is suitable for those weldments and more heavily welded structural components where potential distortion from welding is the dominant factor in determining the dimensions and shape of the completed component and its fit-up to other components. BS EN 1090-2 selects the class relevant to the function of structural components from the four tolerance classes defined in BS EN ISO 13920.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

English Version

Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures

Exécution des structures en acier et des structures en
aluminium - Partie 2: Exigences techniques pour les
structures en acier

Ausführung von Stahltragwerken und Aluminiumtragwerken
- Teil 2: Technische Regeln für die Ausführung von
Stahltragwerken

This European Standard was approved by CEN on 11 April 2008 and includes Amendment 1 approved by CEN on 25 June 2011.

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

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Foreword

This document (EN 1090-2:2008+A1:2011) has been prepared by Technical Committee CEN/TC 135 “Execution of steel structures and aluminium structures”, the secretariat of which is held by SN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2012, and conflicting national standards shall be withdrawn at the latest by February 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document includes Amendment 1, approved by CEN on 2011-06-25.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**.

This document supersedes **A1** EN 1090-2:2008 **A1**.

EN 1090, *Execution of steel structures and aluminium structures* consists of the following parts:

Part 1: Requirements for conformity assessment of structural components

Part 2: Technical requirements for steel structures

Part 3: Technical requirements for aluminium structures

According to the CEN/CENELEC Internal Regulations, the national standards organizations 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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

This European Standard specifies requirements for execution of steel structures, in order to ensure adequate levels of mechanical resistance and stability, serviceability and durability.

This European Standard specifies requirements for execution of steel structures in particular those that are designed according to all parts of EN 1993 and the steel parts of composite steel and concrete structures designed according to all parts of EN 1994.

This European Standard presupposes that the work is carried out with the necessary skill and adequate equipment and resources to perform the work in accordance with the execution specification and the requirements of this European Standard.

1 Scope

This European Standard specifies requirements for execution of structural steelwork as structures or as manufactured components, produced from:

- hot rolled, structural steel products up to and including grade S690;
- cold formed components and sheeting up to and including grades S700 A1 *deleted text* A1;
- hot finished and cold formed austenitic, austenitic-ferritic and ferritic stainless steel products;
- hot finished and cold formed structural hollow sections, including standard range and custom-made rolled products and hollow sections manufactured by welding.

This European Standard may also be used for structural steel grades up to and including S960, provided that conditions for execution are verified against reliability criteria and any necessary additional requirements are specified.

This European Standard specifies requirements independent of the type and shape of the steel structure (e.g. buildings, bridges, plated or latticed components) including structures subjected to fatigue or seismic actions. The requirements are expressed in terms of execution classes

This European Standard applies to structures designed according to the relevant part of EN 1993.

This European Standard applies to structural components and sheeting as defined in EN 1993-1-3.

This European Standard applies to steel components in composite steel and concrete structures designed according to the relevant part of EN 1994.

This European Standard may be used for structures designed according to other design rules provided that conditions for execution comply with them and any necessary additional requirements are specified.

This European Standard does not cover requirements for watertightness or air permeability resistance of sheeting.

2 Normative references

2.1 General

The following referenced documents are indispensable for the application 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.

2.2 Constituent products

2.2.1 Steels

EN 10017, *Steel rod for drawing and/or cold rolling — Dimensions and tolerances*

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

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

EN 10025-1:2004, *Hot rolled products of structural steels — Part 1: General technical delivery conditions*

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

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

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

EN 10025-5, *Hot rolled products of structural steels — Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance*

EN 10025-6, *Hot rolled products of structural steels — Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition*

EN 10029, *Hot rolled steel plates 3 mm thick or above — A1 Tolerances on dimensions and shape A1*

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

EN 10048, *Hot rolled narrow steel strip — Tolerances on dimensions and shape*

EN 10051, A1 *Continuously hot-rolled strip and plate/sheet cut from wide strip of non-alloy and alloy steels A1 — Tolerances on dimensions and shape*

EN 10055, *Hot rolled steel equal flange tees with radiused root and toes — Dimensions and tolerances on shape and dimensions*

EN 10056-1, *Structural steel equal and unequal leg angles — Part 1: Dimensions*

EN 10056-2, *Structural steel equal and unequal leg angles — Part 2: Tolerances on shape and dimensions*

EN 10058, *Hot rolled flat steel bars for general purpose — Dimensions and tolerances on shape and dimensions*

EN 10059, *Hot rolled square steel bars for general purposes — Dimensions and tolerances on shape and dimensions*

EN 10060, *Hot rolled round steel bars for general purposes — Dimensions and tolerances on shape and dimensions*

EN 10061, *Hot rolled hexagon steel bars for general purposes — Dimensions and tolerances on shape and dimensions*

EN 10080, *Steel for the reinforcement of concrete — Weldable reinforcing steel — General*

EN 10088-1, *Stainless steels — Part 1: List of stainless steels*

EN 10088-2:2005, *Stainless steels — Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes*

EN 10088-3:2005, *Stainless steels — Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes*

EN 10131, *Cold rolled uncoated and zinc or zinc-nickel electrolytically coated low carbon and high yield strength steel flat products for cold forming — Tolerances on dimensions and shape*

EN 10139, *Cold rolled uncoated mild steel narrow strip for cold forming — Technical delivery conditions*

EN 10140, *Cold rolled narrow steel strip — Tolerances on dimensions and shape*

EN 10143, *Continuously hot-dip coated steel sheet and strip — Tolerances on dimensions and shape*

EN 10149-1, *Hot-rolled flat products made of high yield strength steels for cold forming — Part 1: General delivery conditions*

EN 10149-2, *Hot-rolled flat products made of high yield strength steels for cold forming — Part 2: Delivery conditions for thermomechanically rolled steels*

EN 10149-3, *Hot-rolled flat products made of high yield strength steels for cold forming — Part 3: Delivery conditions for normalized or normalized rolled steels*

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

EN 10163-2, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 2: Plate and wide flats*

EN 10163-3, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 3: Sections*

EN 10164, *Steel products with improved deformation properties perpendicular to the surface of the product — Technical delivery conditions*

A1 EN 10169, *Continuously organic coated (coil coated) steel flat products — Technical delivery conditions* **A1**

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

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

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

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

EN 10268, *Cold rolled steel flat products with high yield strength for cold forming — Technical delivery conditions*

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

A1 deleted text **A1**

EN 10296-2:2005, *Welded circular steel tubes for mechanical and general engineering purposes — Technical delivery conditions — Part 2: Stainless steel*

EN 10297-2:2005, *Seamless circular steel tubes for mechanical and general engineering purposes — Technical delivery conditions — Part 2: Stainless steel*

A1 EN 10346, *Continuously hot-dip coated steel flat products — Technical delivery conditions* **A1**

EN ISO 1127, *Stainless steel tubes — Dimensions, tolerances and conventional masses per unit length (ISO 1127:1992)*

A1 EN ISO 9445-1, *Continuously cold-rolled stainless steel — Tolerances on dimensions and form — Part 1: Narrow strip and cut lengths (ISO 9445-1:2009)*

EN ISO 9445-2, *Continuously cold-rolled stainless steel — Tolerances on dimensions and form — Part 2: Wide strip and plate/sheet (ISO 9445-2:2009)* **A1**

ISO 4997, *Cold-reduced carbon steel sheet of structural quality*

2.2.2 Steel castings

EN 10340:2007, *Steel castings for structural uses*

A1 EN 1559-1, *Founding — Technical conditions of delivery — Part 1: General*

EN 1559-2, *Founding — Technical conditions of delivery — Part 2: Additional requirements for steel castings* **A1**

2.2.3 Welding consumables

EN 756, *Welding consumables — Solid wires, solid wire-flux and tubular cored electrode-flux combinations for submerged arc welding of non alloy and fine grain steels — Classification*

EN 757, *Welding consumables — Covered electrodes for manual metal arc welding of high strength steels — Classification*

EN 760, *Welding consumables — Fluxes for submerged arc welding — Classification*

EN 1600, *Welding consumables — Covered electrodes for manual metal arc welding of stainless and heat resisting steels — Classification*

EN 13479, *Welding consumables — General product standard for filler metals and fluxes for fusion welding of metallic materials*

EN 14295, *Welding consumables — Wire and tubular cored electrodes and electrode-flux combinations for submerged arc welding of high strength steels — Classification*

EN ISO 636, *Welding consumables — Rods, wires and deposits for tungsten inert gas welding of non alloy and fine grain steels — Classification (ISO 636:2004)*

EN ISO 2560, *Welding consumables — Covered electrodes for manual metal arc welding of non-alloy and fine grain steels — Classification* ^[A1] (ISO 2560:2009) ^[A1]

EN ISO 13918, *Welding — Studs and ceramic ferrules for arc stud welding (ISO 13918:2008)*

EN ISO 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes (ISO 14175:2008)*

EN ISO 14341, *Welding consumables — Wire electrodes and deposits for gas shielded metal arc welding of non alloy and fine grain steels — Classification (ISO 14341:2002)*

EN ISO 14343, *Welding consumables — Wires electrodes, strip electrodes, wires and rods for* ^[A1] *arc* ^[A1] *welding of stainless and heat resisting steels — Classification* ^[A1] (ISO 14343:2009) ^[A1]

EN ISO 16834, *Welding consumables — Wire electrodes, wires, rods and deposits for gas-shielded arc welding of high strength steels — Classification (ISO 16834:2006)*

EN ISO 17632, *Welding consumables — Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non alloy and fine grain steels — Classification (ISO 17632:2004)*

EN ISO 17633, *Welding consumables — Tubular cored electrodes and rods for gas shielded and non-gas shielded metal arc welding of stainless and heat-resisting steels — Classification* ^[A1] (ISO 17633:2010) ^[A1]

EN ISO 18276, *Welding consumables — Tubular cored electrodes for gas-shielded and non-gas-shielded metal arc welding of high-strength steels — Classification (ISO 18276:2005)*

2.2.4 Mechanical fasteners

EN 14399-1, *High-strength structural bolting assemblies for preloading — Part 1: General requirements*

EN 14399-2, *High-strength structural bolting assemblies for preloading — Part 2: Suitability test for preloading*

EN 14399-3, *High-strength structural bolting assemblies for preloading — Part 3: System HR — Hexagon bolt and nut assemblies*

EN 14399-4:2005, *High-strength structural bolting assemblies for preloading — Part 4: System HV — Hexagon bolt and nut assemblies*

EN 14399-5, *High-strength structural bolting assemblies for preloading — Part 5: Plain washers*

EN 14399-6, *High-strength structural bolting assemblies for preloading — Part 6: Plain chamfered washers*

EN 14399-7, *High-strength structural bolting assemblies for preloading — Part 7: System HR — Countersunk head bolts and nut assemblies*

EN 14399-8, *High-strength structural bolting assemblies for preloading — Part 8: System HV — Hexagon fit bolt and nut assemblies*

^[A1] EN 14399-9 ^[A1], *High-strength structural bolting assemblies for preloading — Part 9: System HR or HV — Bolt and nut assemblies with direct tension indicators*

^[A1] EN 14399-10 ^[A1], *High-strength structural bolting assemblies for preloading — Part 10: System HRC — Bolt and nut assemblies with calibrated preload*

EN 15048-1, *Non preloaded structural bolting assemblies — Part 1: General requirements*

EN 20898-2, *Mechanical properties of fasteners — Part 2: Nuts with specified proof load values — Coarse thread (ISO 898-2:1992)*

EN ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: ^{A1} Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread (ISO 898-1:2009) ^{A1}*

EN ISO 1479, *Hexagon head tapping screws (ISO 1479:1983)*

EN ISO 1481, *Slotted pan head tapping screws (ISO 1481:1983)*

EN ISO 3506-1, *Mechanical properties of corrosion-resistant stainless-steel fasteners — Part 1: Bolts, screws and studs ^{A1} (ISO 3506-1:2009) ^{A1}*

EN ISO 3506-2, *Mechanical properties of corrosion-resistant stainless-steel fasteners — Part 2: Nuts ^{A1} (ISO 3506-2:2009) ^{A1}*

^{A1} EN ISO 4042, *Fasteners — Electroplated coatings (ISO 4042:1999) ^{A1}*

EN ISO 6789, *Assembly tools for screws and nuts — Hand torque tools — Requirements and test methods for design conformance testing, quality conformance testing and recalibration procedure (ISO 6789:2003)*

EN ISO 7049, *Cross recessed pan head tapping screws (ISO 7049:1983)*

^{A1} EN ISO 7089, *Plain washers — Normal series — Product grade A (ISO 7089:2000)*

EN ISO 7090, *Plain washers, chamfered — Normal series — Product grade A (ISO 7090:2000)*

EN ISO 7091, *Plain washers — Normal series — Product grade C (ISO 7091:2000)*

EN ISO 7092, *Plain washers — Small series — Product grade A (ISO 7092:2000)*

EN ISO 7093-1, *Plain washers — Large series — Part 1: Product grade A (ISO 7093-1:2000)*

EN ISO 7093-2, *Plain washers — Large series — Part 2: Product grade C (ISO 7093-2:2000)*

EN ISO 7094, *Plain washers — Extra large series — Product grade C (ISO 7094:2000) (Corrigendum AC:2002 incorporated) ^{A1}*

EN ISO 10684, *Fasteners — Hot dip galvanized coatings (ISO 10684:2004)*

EN ISO 15480, *Hexagon washer head drilling screws with tapping screw thread (ISO 15480:1999)*

EN ISO 15976, *Closed end blind rivets with break pull mandrel and protruding head — St/St (ISO 15976:2002)*

EN ISO 15979, *Open end blind rivets with break pull mandrel and protruding head — St/St (ISO 15979:2002)*

EN ISO 15980, *Open end blind rivets with break pull mandrel and countersunk head — St/St (ISO 15980:2002)*

EN ISO 15983, *Open end blind rivets with break pull mandrel and protruding head — A2/A2 (ISO 15983:2002)*

EN ISO 15984, *Open end blind rivets with break pull mandrel and countersunk head — A2/A2 (ISO 15984:2002)*

ISO 10509, *Hexagon flange head tapping screws*

2.2.5 High strength cables

prEN 10138-3, *Prestressing steels — Part 3: Strand*

EN 10244-2, *Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 2: Zinc or zinc alloy coatings*

EN 10264-3, *Steel wire and wire products — Steel wire for ropes — Part 3: Round and shaped non alloyed steel wire for high duty applications*

EN 10264-4, *Steel wire and wire products — Steel wire for ropes — Part 4: Stainless steel wire*

EN 12385-1, *Steel wire ropes — Safety — Part 1: General requirements*

EN 12385-10, *Steel wire ropes — Safety — Part 10: Spiral ropes for general structural applications*

EN 13411-4, *Terminations for steel wire ropes — Safety — Part 4: Metal and resin socketing*

2.2.6 Structural bearings

EN 1337-2, *Structural bearings — Part 2: Sliding elements*

EN 1337-3, *Structural bearings — Part 3: Elastomeric bearings*

EN 1337-4, *Structural bearings — Part 4: Roller bearings*

EN 1337-5, *Structural bearings — Part 5: Pot bearings*

EN 1337-6, *Structural bearings — Part 6: Rocker bearings*

EN 1337-7, *Structural bearings — Part 7: Spherical and cylindrical PTFE bearings*

EN 1337-8, *Structural bearings — Part 8: Guide bearings and restraint bearings*

2.3 Preparation

EN ISO 9013, *Thermal cutting — Classification of thermal cuts — Geometrical product specification and quality tolerances (ISO 9013:2002)*

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 *

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

2.4 Welding

EN 287-1, *Qualification test of welders — Fusion welding — Part 1: Steels*

EN 1011-1:1998, *Welding — Recommendations for welding of metallic materials — Part 1: General guidance for arc welding*

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

EN 1011-3, *Welding — Recommendations for welding of metallic materials — Part 3: Arc welding of stainless steels*

EN 1418, *Welding personnel — Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials*

EN ISO 3834 (all parts), *Quality requirements for fusion welding of metallic materials (ISO 3834:2005)*

EN ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers* ^[A1] (ISO 4063: 2009, Corrected version 2010-03-01) ^[A1]

EN ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003, corrected version:2005, including Technical Corrigendum 1:2006)*

EN ISO 9692-1, *Welding and allied processes — Recommendations for joint preparation — Part 1: Manual metal-arc welding, gas-shielded metal-arc welding, gas welding, TIG welding and beam welding of steels (ISO 9692-1:2003)*

EN ISO 9692-2, *Welding and allied processes — Joint preparation — Part 2: Submerged arc welding of steels (ISO 9692-2:1998)*

EN ISO 13916, *Welding — Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature (ISO 13916:1996)*

EN ISO 14373, *Resistance welding — Procedure for spot welding of uncoated and coated low carbon steels (ISO 14373:2006)*

EN ISO 14554 (all parts), *Quality requirements for welding — Resistance welding of metallic materials (ISO 14544-1:2000)*

EN ISO 14555, *Welding — Arc stud welding of metallic materials (ISO 14555:2006)*

EN ISO 14731, *Welding coordination — Tasks and responsibilities (ISO 14731:2006)*

EN ISO 15609-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding (ISO 15609-1:2004)*

EN ISO 15609-4, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 4: Laser beam welding* ^[A1] (ISO 15609-4:2009) ^[A1]

EN ISO 15609-5, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 5: Resistance welding (ISO 15609-5:2004)*

EN ISO 15610, *Specification and qualification of welding procedures for metallic materials — Qualification based on tested welding consumables (ISO 15610:2003)*

EN ISO 15611, *Specification and qualification of welding procedures for metallic materials — Qualification based on previous welding experience (ISO 15611:2003)*

EN ISO 15612, *Specification and qualification of welding procedures for metallic materials — Qualification by adoption of a standard welding procedure (ISO 15612:2004)*

EN ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test (ISO 15613:2004)*

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 15614-1:2004)*

EN ISO 15614-11, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 11: Electron and laser beam welding (ISO 15614-11:2002)*

EN ISO 15614-13, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 13: Resistance butt and flash welding (ISO 15614-13:2005)*

EN ISO 15620, *Welding — Friction welding of metallic materials (ISO 15620:2000)*

EN ISO 16432, *Resistance welding — Procedure for projection welding of uncoated and coated low carbon steels using embossed projection(s) (ISO 16432:2006)*

EN ISO 16433, *Resistance welding — Procedure for seam welding of uncoated and coated low carbon steels (ISO 16433:2006)*

2.5 Testing

EN 473, *Non destructive testing — Qualification and certification of NDT personnel — General principles*

EN 571-1, *Non destructive testing — Penetrant testing — Part 1: General principles*

EN 970, *Non-destructive examination of fusion welds — Visual examination*

EN 1290, *Non-destructive examination of welds — Magnetic particle examination of welds*

EN 1435, *Non-destructive testing of welds — Radiographic testing of welded joints*

EN 1713, *Non-destructive testing of welds — Ultrasonic testing — Characterization of indications in welds*

EN 1714, *Non-destructive testing of welds — Ultrasonic testing of welded joints*

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

EN 12062:1997, *Non-destructive examination of welds — General rules for metallic materials*

EN ISO 6507 (all parts), *Metallic materials — Vickers hardness test (ISO 6507:2005)*

EN ISO 9018, *Destructive tests on welds in metallic materials — Tensile test on cruciform and lapped joints (ISO 9018:2003)*

EN ISO 10447, *Resistance welding - Peel and chisel testing of resistance spot and projection welds (ISO 10447:2006)*

2.6 Erection

EN 1337-11, *Structural bearings — Part 11: Transport, storage and installation*

ISO 4463-1, *Measurement methods for building — Setting-out and measurement — Part 1: Planning and organization, measuring procedures, acceptance criteria*

ISO 7976-1, *Tolerances for building — Methods of measurement of buildings and building products — Part 1: Methods and instruments*

ISO 7976-2, *Tolerances for building — Methods of measurement of buildings and building products — Part 2: Position of measuring points*

ISO 17123 (all parts), *Optics and optical instruments — Field procedures for testing geodetic and surveying instruments*

2.7 Corrosion protection

EN 14616, *Thermal spraying — Recommendations for thermal spraying*

EN 15311, *Thermal spraying — Components with thermally sprayed coatings — Technical supply conditions*

EN ISO 1461:1999, *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods (ISO 1461:1999)*

EN ISO 2063, *Thermal spraying — Metallic and other inorganic coatings — Zinc, aluminium and their alloys (ISO 2063:2005)*

EN ISO 2808, *Paints and varnishes — Determination of film thickness (ISO 2808:2007)*

EN ISO 8501 (all parts), *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness*

EN 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 8503-1:1988)*

EN 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 8503-2:1988)*

EN ISO 12944 (all parts), *Paints and varnishes — Corrosion protection of steel structures by protective paint systems (ISO 12944:1998)*

[A1] EN ISO 14713-1, *Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures — Part 1: General principles of design and corrosion resistance (ISO 14713-1:2009)*

EN ISO 14713-2, *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)* **[A1]**

ISO 19840, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces*

2.8 Tolerances

EN ISO 13920, *Welding — General tolerances for welded constructions — Dimensions for lengths and angles — Shape and position (ISO 13920:1996)*

2.9 Miscellaneous

EN 508-1, *Roofing products from metal sheet — Specification for self-supporting products of steel, aluminium or stainless steel sheet — Part 1: Steel*

EN 508-3, *Roofing products from metal sheet — Specification for self-supporting products of steel, aluminium or stainless steel sheet — Part 3: Stainless steel*

EN 1993-1-6, *Eurocode 3: Design of steel structures — Part 1-6: Strength and Stability of Shell Structures*

EN 1993-1-8, *Eurocode 3: Design of steel structures — Part 1-8: Design of joints*

EN 13670 ^{A1}, *Execution of concrete structures*

ISO 2859-5, *Sampling procedures for inspection by attributes — Part 5: System of sequential sampling plans indexed by acceptance quality limit (ALQ) for lot-by-lot inspection*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

3.1

construction works

everything that is constructed or results from construction operations. This term covers both building and civil engineering works. It refers to the complete construction comprising both structural and non-structural components

3.2

works

parts of construction works that are structural steelwork

3.3

structural steelwork

steel structures or manufactured steel components used in construction works

3.4

constructor

person or organization executing the works (the supplier in EN ISO 9000)

3.5

structure

see EN 1990

3.6

manufacturing

all activities required to produce and deliver a component. As relevant, this comprises e.g. procurement, preparation and assembly, welding, mechanical fastening, transportation, surface treatment and the inspection and documentation thereof

3.7

execution

all activities performed for the physical completion of the works, i.e. procurement, fabrication, welding, mechanical fastening, transportation, erection, surface treatment and the inspection and documentation thereof

3.7.1

execution specification

set of documents covering technical data and requirements for a particular steel structure including those specified to supplement and qualify the rules of this European Standard

NOTE 1 Execution specification includes requirements where this European Standard identifies items to be specified.

NOTE 2 Execution specification can be seen as the complete set of requirements for manufacture and installation of structural steel components with the manufacturing requirements given in a set of component specifications according to EN 1090-1 ^{A1}.

3.7.2

execution class

classified set of requirements specified for the execution of the works as a whole, of an individual component or of a detail of a component

3.8

service category

category that characterises a component in terms of the circumstances of its use

3.9

production category

category that characterises a component in terms of the methods used for its execution

3.10

constituent product

material and product used for manufacturing a component and which remains as part of it, e.g. structural steel product, stainless steel product, mechanical fastener, welding consumable

3.11

component

part of a steel structure, which may itself be an assembly of several smaller components

3.11.1

cold formed component

see EN 10079 and EN 10131

3.12

preparation

all activities performed on the constituent steel products to produce the parts ready for assembly and inclusion in components. As relevant, this comprises e.g. identification, handling and storage, cutting, shaping and holing

3.13

design basis method of erection

outline of a method of erection upon which the design of the structure is based (also known as the design erection sequence)

3.13.1

erection method statement

documentation describing the procedures to be used to erect a structure

3.14

nonconformity

see EN ISO 9000

3.15

additional NDT (non destructive testing)

NDT technique which is additional to visual examination, e.g. magnetic particle, penetrant, eddy current, ultrasonic or radiographic testing

3.16

tolerance

see ISO 1803

3.16.1

essential tolerance

basic limits for a geometrical tolerance necessary to satisfy the design assumptions for structures in terms of mechanical resistance and stability

3.16.2

functional tolerance

geometrical tolerance which might be required to meet a function other than mechanical resistance and stability, e.g. appearance or fit up

3.16.3

special tolerance

geometrical tolerance which is not covered by the tabulated types or values of tolerances given in this European Standard, and which needs to be specified in a particular case

3.16.4

manufacturing tolerance

permitted range in the size of a dimension of a component resulting from component manufacture

4 Specifications and documentation

4.1 Execution Specification

4.1.1 General

The necessary information and technical requirements for execution of each part of the works shall be agreed and complete before commencement of execution of that part of the works. There shall be procedures for making alterations to previously agreed execution specification. Execution specification shall consider such of the following items as are relevant:

- a) additional information, as listed in A.1;
- b) options, as listed in A.2;
- c) execution classes, see 4.1.2;
- d) preparation grades, see 4.1.3;
- e) tolerance classes, see 4.1.4;
- f) technical requirements regarding the safety of the works, see 4.2.3 and 9.2.

4.1.2 Execution classes

Four execution classes 1 to 4, denoted EXC1 to EXC4, are given, for which requirement strictness increases from EXC1 to EXC4.

Execution classes may apply to the whole structure or to a part of the structure or to specific details. A structure can include several execution classes. A detail or group of details will normally be ascribed one execution class. However, the choice of an execution class does not necessarily have to be the same for all requirements.

If no execution class is specified EXC2 shall apply.

The list of requirements related to execution classes is given in A.3.

Guidance for the choice of execution classes is given in Annex B.

NOTE The choice of execution classes is related to production categories and service categories, with links to consequence classes as defined in Annex B of EN 1990:2002.

4.1.3 Preparation grades

Three preparation grades, denoted P1 to P3 according to ISO 8501-3, are given, for which requirement strictness increases from P1 to P3.

NOTE Preparation grades are related to the expected life of the corrosion protection and corrosivity category as defined in Clause 10.

Preparation grades may apply to the whole structure or to a part of the structure or to specific details. A structure can include several preparation grades. A detail or group of details will normally be ascribed one preparation grade.

4.1.4 Geometrical tolerances

Two types of geometrical tolerances are defined in 11.1:

- a) essential tolerances;
- b) functional tolerances, with two classes for which requirement strictness increases from class 1 to class 2.

4.2 Constructor's documentation

4.2.1 Quality documentation

The following points shall be documented for EXC2, EXC3 and EXC4:

A1

- a) organisation chart and managerial staff responsible for each aspect of the execution; **A1**
- b) the procedures, methods and work instructions to be applied;
- c) an inspection plan specific to the works;
- d) a procedure for handling changes and modifications;
- e) a procedure for handling of nonconformities, requests for concessions and quality disputes;
- f) **A1** specified hold-points **A1** or requirement to witness inspections or tests, and any consequent access requirements.

4.2.2 Quality plan

It shall be specified if a quality plan for execution of the works is required.

NOTE EN ISO 9000 gives the definition of a quality plan.

It shall include:

- a) a general management document which shall address the following points:

- 1) review of specification requirements against process capabilities;

A1

- 2) the allocation of tasks and authority during the various phases of the project; **A1**
 - 3) principles and organisation arrangements for inspection including allocation of responsibilities for each inspection task;
- b) quality documentation prior to execution **A1** *deleted text* **A1**. The documents shall be produced before execution of the construction step to which they relate;

- c) execution records which are actual records of inspections and checks carried out, or demonstrate qualification or certification of implemented resources.  Execution records related to specified hold-points shall be produced before the hold-point is released. 

Annex C gives a check-list for the content of a quality plan recommended for the execution of structural steelwork with reference to the general guidelines in ISO 10005.

4.2.3 Safety of the erection works

Method statements giving detailed work instructions shall comply with the technical requirements relating to the safety of the erection works as given in 9.2 and 9.3.

4.2.4 Execution documentation

Sufficient documentation shall be prepared during execution and as a record of the as-built structure to demonstrate that the works have been carried out according to the execution specification.

5 Constituent products

5.1 General

Generally constituent products to be used for the execution of steel structures shall be selected from the relevant European Standards listed in the following clauses. If constituent products that are not covered by the standards listed are to be used, their properties shall be specified.

Definitions and requirements of EN 10021 shall apply together with those of the relevant European product standard.

5.2 Identification, inspection documents and traceability

The properties of supplied constituent products shall be documented in a way that enables them to be compared to the specified properties. Their conformity with the relevant product standard shall be checked in accordance with 12.2.

For metallic products, the inspection documents according to EN 10204 shall be as listed in Table 1.

Table 1 — Inspection documents for metallic products

Constituent product	Inspection documents
Structural steels (Tables 2 and 3)	according to Table B.1 of EN 10025-1:2004 ^{a b}
Stainless steels (Table 4)	3.1
Steel castings	according to Table B.1 of EN 10340:2007
Welding consumables (Table 5)	2.2
Structural bolting assemblies	2.1 ^c
Hot rivets	2.1 ^c
Self-tapping and self-drilling screws and blind rivets	2.1
Studs for arc studs welding	2.1 ^c
Expansion joints for bridges	3.1
High strength cables	3.1
Structural bearings	3.1
^a For structural steel grade S355 JR or JO inspection document 3.1 is required for EXC2, EXC3 and EXC4. ^b EN 10025-1 requires that the elements included in the CEV formula shall be reported in the inspection document. The reporting of other added elements required by EN 10025-2 should include Al, Nb, and Ti. ^c If a 3.1 certificate is required, this may be substituted by a manufacturing lot identification mark.	

For EXC3 and EXC4, constituent products shall be traceable at all stages from receipt to hand over after incorporation in the works.

This traceability may be based on records for batches of product allocated to a common production process, unless traceability for each product is specified.

For EXC2, EXC3 and EXC4, if differing grades and/or qualities of constituent products are in circulation together, each item shall be designated with a mark that identifies its grade.

Methods of marking shall be in accordance with that for components given in 6.2.

If marking is required, unmarked constituent products shall be treated as non conforming product.

5.3 Structural steel products

5.3.1 General

Structural steel products shall conform to the requirements of the relevant European product standards as listed in Tables 2, 3 and 4, unless otherwise specified. Grades, qualities and, if appropriate, coating weights and finishes, shall be specified together with any required options permitted by the product standard, including those related to suitability for hot dip zinc-coating, if relevant.

Steel products to be used in the manufacture of cold formed components shall have properties that conform to the required suitability for cold forming process. Carbon steels suitable for cold forming are listed in Table 3.

Table 2 — Product standards for structural carbon steels

Products	Technical delivery requirements	Dimensions	Tolerances
I and H sections	EN 10025-1 and EN 10025-2 EN 10025-3 EN 10025-4 EN 10025-5 EN 10025-6 As relevant	Not available	EN 10034
Hot-rolled taper flange I sections		Not available	EN 10024
Channels		Not available	EN 10279
Equal and unequal leg angles		EN 10056-1	EN 10056-2
T Sections		EN 10055	EN 10055
Plates, flats, wide flats		Not applicable	EN 10029 EN 10051
Bars and rods		EN 10017, EN 10058, EN 10059, EN 10060, EN 10061	EN 10017, EN 10058, EN 10059, EN 10060, EN 10061
Hot finished hollow sections	EN 10210-1	EN 10210-2	EN 10210-2
Cold formed hollow sections	EN 10219-1	EN 10219-2	EN 10219-2
NOTE EN 10020 gives definitions and classifications of grades of steel. Steel designations by name and number are given in EN 10027-1 and -2 respectively.			

Table 3 — Product standards for sheet and strip suitable for cold forming

Products	Technical delivery requirements	Tolerances
Non-alloy structural steels	EN 10025-2	EN 10051
Weldable fine grain structural steels	EN 10025-3, EN 10025-4	EN 10051
High yield strength steels for cold forming	EN 10149 A1, EN 10268	EN 10029, EN 10048, EN 10051, EN 10131, EN 10140 A1
Cold reduced steels	ISO 4997	EN 10131
Continuously coated hot dip coated steels	EN 10346 A1	EN 10143
Continuously organic coated steel flat products	EN 10169 A1	EN 10169 A1
Narrow strips	EN 10139	EN 10048 EN 10140

Table 4 — Product standards for stainless steels

Products	Technical delivery requirements	Tolerances
Sheets, plates and strips	EN 10088-2	EN 10029, EN 10048, EN 10051, EN ISO 9445
Tubes (welded)	EN 10296-2	EN ISO 1127
Tubes (seamless)	EN 10297-2	
Bars, rods and sections	EN 10088-3	EN 10017, EN 10058, EN 10059, EN 10060, EN 10061
NOTE Steel designations by name and number are given in EN 10088-1.		

5.3.2 Thickness tolerances

Thickness tolerances for structural steel plates shall be as follows in accordance with EN 10029, unless otherwise specified:

EXC4: Class B

For other structural and stainless steel products the thickness class A shall be used unless otherwise specified.

5.3.3 Surface conditions

For carbon steels, surface condition requirements are as follows:

- a) class A2 for plates and wide flats in accordance with the requirements of EN 10163-2;
- b) class C1 for sections in accordance with the requirements of EN 10163-3. Execution specifications shall specify if imperfections such as cracks, shell and seams shall be repaired.

If more stringent surface conditions are required for plates in EXC3 and EXC4, they shall be specified.

For stainless steel the surface finish requirements shall be as follows:

- a) sheet, plate and strip: in accordance with the requirements of EN 10088-2;
- b) bars, rods and sections: in accordance with the requirements of EN 10088-3.

Additional requirements related to the following items: special restrictions on either surface imperfections or repair of surface defects by grinding in accordance with EN 10163, or with EN 10088 for stainless steel, shall be specified.

For other products the surface finish requirements shall be specified in terms of appropriate European or International specifications.

If the relevant specification does not adequately define decorative or specialist surface finishes, the finish shall be specified.

The surface condition of constituent products shall be such that the relevant requirements for surface preparation grade in accordance with 10.2 can be achieved.

5.3.4 Special properties

For EXC3 and EXC4, internal discontinuity quality class S1 of EN 10160 shall be $\boxed{A_1}$ used $\langle A_1 \rangle$ for welded cruciform joints transmitting primary tensile stresses through the plate thickness on a band of width four times the thickness of the plate each side of the proposed attachment.

It shall be specified whether areas close to bearing diaphragms or stiffeners should be checked for the existence of internal discontinuities. In this case quality class S1 of EN 10160 shall apply to a band of flange or web plate of width 25 times the plate thickness each side of a bearing diaphragm or stiffener if attached by welding.

In addition, requirements related to the following items shall be specified if relevant:

- a) testing on constituent products, other than stainless steels, to identify internal discontinuities or cracks in zones to be welded;
- b) improved deformation properties perpendicular to the surface of constituent products, other than stainless steels, in accordance with EN 10164;
- c) special delivery conditions of stainless steels, for example Pitting Resistance Equivalent (Nitrogen) (PRE(N)) or accelerated corrosion testing. The PRE(N) shall be given by $(Cr + 3.3 Mo + 16 N)$, in which the elements are in percent by weight, unless otherwise specified;
- d) processing conditions if constituent products are to be processed before delivery.

NOTE Heat treatment, cambering and bending are examples of such processes.

5.4 Steel castings

Steel castings shall conform to the requirements in EN 10340. Grades, qualities and, if appropriate, finishes shall be specified together with any required options permitted by the $\boxed{A_1}$ product standard including necessary information and options as required in EN 1559-1 and EN 1559-2 $\langle A_1 \rangle$.

5.5 Welding consumables

All welding consumables shall conform to the requirements to EN 13479 and the appropriate product standard as listed in Table 5.

Table 5 — Product standards for welding consumables

Welding consumables	Product standards
Shielding gases for arc welding and cutting	EN ISO 14175
Wire electrodes and deposits for gas-shielded metal arc welding of non-alloy and fine grain steels	EN ISO 14341
Solid wires, solid wire-flux and tubular cored electrode-flux combinations for submerged arc welding of non alloy and fine grain steels	EN 756
Covered electrodes for manual arc welding of high strength steels	EN 757
Tubular cored electrodes for metal arc welding with and without gas shield of non alloy and fine grain steels	EN ISO 17632
Fluxes for submerged arc welding	EN 760
Covered electrodes for manual arc welding of stainless and heat resisting steels	EN 1600
Rods, wires and deposits for tungsten inert gas welding of non alloy and fine grain steels	EN ISO 636
Covered electrodes for manual arc welding of non-alloy and fine grain steels	EN ISO 2560
Wires electrodes, wires and rods for arc welding of stainless and heat-resisting steels	EN ISO 14343
Wire electrodes, wires, rods and deposits for gas-shielded arc welding of high strength steels	EN ISO 16834
Wire and tubular cored electrodes and electrode-flux combinations for submerged arc welding of high strength steels	EN 14295
Tubular cored electrodes for metal arc welding with or without a gas shield of stainless and heat-resisting steels	EN ISO 17633
Tubular cored electrodes for gas shielded metal arc welding of high strength steels	EN ISO 18276

The type of welding consumables shall be appropriate to the welding process, the material to be welded and the welding procedure.

For steel grades higher than S355, the use of consumables and fluxes with medium-high basicity index is recommended for the welding processes: 111, 114, 121, 122, 136, 137 (see 7.3 for definition of welding processes).

If steel according to EN 10025-5 is to be welded, welding consumables shall be used which ensure that the completed welds have a weather resistance at least equivalent to the parent metal. Unless otherwise specified, one of the options given in Table 6 shall be used.

Table 6 — Welding consumables to be used with steels according to EN 10025-5

Process	Option 1	Option 2	Option3
111	Matching	2,5 % Ni	1 % Cr 0,5 % Mo
135	Matching	2,5 % Ni	1 % Cr 0,5 % Mo
121,122	Matching	2 % Ni	1 % Cr 0,5 % Mo
Matching: 0,5 % Cu and other alloy elements			
NOTE See also 7.5.10.			

For stainless steels, welding consumables which give weld deposits of at least equivalent corrosion resistance to the parent metal shall be used.

5.6 Mechanical fasteners

5.6.1 General

The corrosion resistance of the connectors, fasteners and sealing washers shall be comparable to that specified for the fastened components.

Hot dip galvanized coatings of fasteners shall conform to EN ISO 10684.

A1 Electroplated coatings of fasteners shall conform to EN ISO 4042. **A1**

Protective coatings of components for mechanical fasteners shall comply with the requirements of the relevant product standard or, in the absence thereof, with the manufacturer's recommendation.

A1 NOTE Attention is drawn to the risk of hydrogen embrittlement during electroplating or hot dip galvanizing of 10.9 bolts. **A1**

5.6.2 Terminology

In the text the following terms are used:

- a) "washer" meaning: "plain or chamfered washer";
- b) "assembly" meaning: "a bolt with a nut and washer(s) as necessary".

5.6.3 Structural bolting assemblies for non preloaded applications

Carbon and alloy steel and austenitic stainless steel structural bolting assemblies for non preloaded applications shall conform to EN 15048-1.

Assemblies according to EN 14399-1 may also be used for non preloaded applications.

Property classes of bolts and nuts and, if appropriate, surface finishes shall be specified together with any required options permitted by the product standard.

The mechanical properties shall be specified for:

- a) carbon and alloy steel bolting assemblies with larger diameter than those specified in EN ISO 898-1 and EN 20898-2;
- b) austenitic stainless steel bolting assemblies with larger diameter than those specified in EN ISO 3506-1 and EN ISO 3506-2;
- c) austenitic-ferritic **A1** assemblies **A1**.

Fasteners according to EN ISO 898-1 and EN 20898-2 shall not be used to join stainless steels according to EN 10088 unless otherwise specified. If insulation kits are to be used full details of their use shall be specified.

5.6.4 Structural bolting assemblies for preloading

High strength structural bolting assemblies for preloading include system HR, system HV and HRC bolts. They shall conform to the requirements in EN 14399-1 and in the appropriate European Standard as listed in Table 7.

Property classes of bolts and nuts and, if appropriate, surface finishes shall be specified together with any required options permitted by the product standard.

Table 7 — Product standards for high strength structural bolting assemblies for preloading

Bolts and nuts	Washers
EN 14399-3	EN 14399-5 EN 14399-6
EN 14399-4	
EN 14399-7	
EN 14399-8	
EN 14399-10	

Stainless steel bolts shall not be used in preloaded applications unless otherwise specified. If used they shall be treated as special fasteners.

5.6.5 Direct tension indicators

Direct tension indicators and associated hardened nut face and bolt face washers shall be in accordance with EN 14399-9.

Direct tension indicators shall not be used with weather resistant steels or stainless steels.

5.6.6 Weather resistant assemblies

Weather resistant assemblies shall be made of improved atmospheric corrosion resistance material the chemical composition of which shall be specified.

NOTE Type 3 Grade A fasteners to ASTM standard A325 would be suitable [51].

Their mechanical characteristics, performances and delivery conditions shall conform to the requirements in EN 14399-1 or EN 15048-1 as relevant.

5.6.7 Foundation bolts

The mechanical properties of foundation bolts shall be in accordance with EN ISO 898-1 or fabricated from hot-rolled steel conforming to EN 10025-2 to EN 10025-4. If specified, reinforcing steels may be used. In this case they shall conform to EN 10080 and the steel grade shall be specified.

5.6.8 Locking devices

If required the locking devices such as prevailing torque nuts or other types of bolt which effectively prevent loosening of the assembly if subjected to impact or significant vibration shall be specified.

Unless otherwise specified, products from EN ISO 2320, EN ISO 7040, EN ISO 7042, EN ISO 7719, EN ISO 10511, EN ISO 10512 and EN ISO 10513 may be used.

5.6.9 Washers

5.6.9.1 Plain washers

Washers from EN ISO 7089, EN ISO 7090, EN ISO 7091, EN ISO 7092, EN ISO 7093 or EN ISO 7094 may be used for carbon steels. Washers from EN ISO 7089, EN ISO 7090, EN ISO 7092 or EN ISO 7093-1 may be used for stainless steels. Hardness of the washers shall be in accordance with the requirements of EN 15048-1.

5.6.9.2 Taper washers

Taper washers shall comply with the relevant product standard. $\triangle A_1$

5.6.10 Hot rivets

Hot rivets shall comply with the relevant product standard.

5.6.11 Fasteners for thin gauge components

Self-drilling screws shall comply with EN ISO 15480 and self-tapping screws with EN ISO 1481, EN ISO 7049, EN ISO 1479 or ISO 10509.

Blind rivets shall comply with EN ISO 15976, EN ISO 15979, EN ISO 15980, EN ISO 15983 or EN ISO 15984.

Cartridge fired pins, air driven pins shall be classified as special fasteners.

Mechanical fasteners for use in stressed skin applications shall be of a specified type for such application.

5.6.12 Special fasteners

Special fasteners are fasteners that are not covered by European or International Standards. They shall be specified, as well as any tests necessary.

NOTE The use of special fasteners is covered in 8.9.

Hexagon injection bolts shall be classified as special fasteners.

5.6.13 Delivery and identification

Fasteners according to 5.6.3 to 5.6.5 shall be delivered and identified in accordance with the requirements of the relevant product standard.

Fasteners according to 5.6.7 to 5.6.12 shall be delivered and identified as follows:

a) They shall be delivered in an appropriate durable packaging and labelled such that the content is readily identifiable.

b) Labelling or accompanying $\triangle A_1$ documentation shall be in accordance with the requirements of the product standard and should contain $\triangle A_1$ the following information in a legible and durable form:

- manufacturer's identification and, if relevant, lot numbers;
- type of fastener and material and, if appropriate, its assembly;
- protective coating;
- dimensions in mm, as appropriate for nominal diameter and length, and if appropriate, washer diameter, thickness and effective compression range of elastomeric part;
- size of drill bit as appropriate;
- for screws: details of the limiting torque values;
- for cartridge fired and air driven pins: details of the firing charge and driving forces as appropriate.

- c)  marking of fasteners shall be in accordance with the requirements of the product standard. 

5.7 Studs and shear connectors

Studs for arc stud welding including shear connectors for steel/concrete composite construction shall comply with the requirements of EN ISO 13918.

Shear connectors other than the stud type shall be classified as special fasteners and comply with 5.6.12.

5.8 Grouting materials

The grouting materials to be used shall be specified. It shall be cement based grout, special grout or fine concrete.

Cement based grout for use between steel bases or bearing plates and concrete foundations shall be as follows:

- a) for nominal thickness not exceeding 25 mm: Neat Portland cement;
- b) for nominal thickness between 25 and 50 mm: Fluid Portland cement mortar that is not leaner than 1:1 cement to fine aggregate;
- c) for nominal thickness of 50 mm and above: Dry as possible Portland cement mortar that is not leaner than 1:2 cement to fine aggregate.

Special grouts include cement based grouts used with admixtures, expanding grout and resin based grout. Those with low shrinkage characteristics are recommended.

Special grout shall be accompanied by detailed instructions for use that are attested by the manufacturer.

Fine concrete shall only be used between steel bases or bearing plates and concrete foundations that have gaps with nominal thickness of 50 mm and above.

5.9 Expansion joints for bridges

Requirements for type and characteristics of expansion joints shall be specified.

5.10 High strength cables, rods and terminations

Wires for high strength cables shall be cold drawn or cold rolled steel wires and conform to the requirements of EN 10264-3 or EN 10264-4. The tensile strength grade and, if appropriate, coating class according to EN 10244-2 shall be specified.

Strands for high strength cables shall conform to the requirements of prEN 10138-3. The designation and class of the strand shall be specified.

Steel wire ropes shall conform to the requirements of EN 12385-1 and EN 12385-10. The minimum breaking load and diameter of the steel wire rope and, if appropriate, requirements related to corrosion protection shall be specified.

The filling material for the sockets shall conform to the requirements of EN 13411-4. It shall be selected taking into account service temperature and actions such that continued creeping of the loaded strand through the socket is prevented.

5.11 Structural bearings

Structural bearings shall comply with the requirements of EN 1337-2, EN 1337-3, EN 1337-4, EN 1337-5, EN 1337-6, EN 1337-7 or EN 1337-8 as relevant.

6 Preparation and assembly

6.1 General

This clause specifies the requirements for cutting, shaping, holing and assembly of constituent steel components for inclusion into components.

NOTE Welding and mechanical fastening are dealt with in Clauses 7 and 8.

Structural steelwork shall be fabricated considering the requirements in Clause 10 and within the tolerances specified in Clause 11.

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

6.2 Identification

At all stages of manufacturing each piece or package of similar pieces of steel components shall be identifiable by a suitable system. For EXC3 and EXC4 finished components shall be identified to inspection certificates.

Identification may be achieved as appropriate by batching or by the shape and the size of the component or by the use of durable and distinguishing marks applied in a way not producing damage. Chiselled notches are not permitted.

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 are permitted only for steel grades up to and including S355;
- b) they are not permitted for stainless steels;
- c) they are not permitted on coated materials for cold-formed components;
- d) they shall only be used in the specified areas 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.

Soft or low stress stamps may be used for stainless steels unless otherwise specified.

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

6.3 Handling and storage

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

A constituent product shall not be used beyond a shelf life specified by its 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 comply with the relevant product standard.

Structural steel components shall be packed, handled and transported in a safe manner, so that permanent deformation does not occur and surface damage is minimised. Handling and storage preventive measures specified in Table 8 shall be applied as appropriate.

Table 8 — List of handling and storage preventive measures

Lifting	
1	Protection of components from damage at the lifting points
2	Avoidance of single point lifting of long components by use of spreader beams as appropriate
3	Bundling together lightweight components particularly prone to edge damage, twisting and distortion if handled as individual items. Care taken to avoid localized damage where component 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	
4	Stacking of manufactured components stored before transportation or erection clear of the ground to be kept clean
5	Necessary supports to avoid permanent deformations
6	Storage of profiled sheeting, and other materials supplied with pre-finished decorative surfaces according to the requirements of relevant standards
Protection against corrosion	
7	Avoidance of accumulation of water
8	Precautions in order to avoid the penetration of moisture into bundles of sections with metallic pre-coatings NOTE In case of prolonged open storage on site the bundles of sections should be opened and the sections separated to avoid the occurrence of 'black or white rust'.
9	Appropriate corrosion protection treatment of cold formed steel components less than 4 mm thick done before leaving the manufacturing works, sufficient at least to resist the exposure likely to be experienced during transportation, storage and initial erection
Stainless steels	
10	Handling and storage of stainless steel so as to prevent contamination by fixtures or manipulators etc. Careful storage of stainless steel, so that the surfaces are protected from damage or contamination
11	Use of protective film or other coating, to be left on as long as practicable
12	Avoidance of storage in salt-laden humid atmospheres
13	Protection of storage racks by wooden, rubber or plastic battens or sheaths to avoid carbon steel, copper-containing, lead etc. rubbing surfaces
14	Use of markers containing chloride or sulphide prohibited NOTE An alternative is to use protective film and apply all marks only into this film.
15	Protection of stainless steel from direct contact with carbon steel lifting tackle or handling equipment such as chains, hooks, strapping and rollers or the forks of fork lift trucks by use of isolating materials or light plywood or suction cups. Use of appropriate erection tools to ensure that surface contamination does not occur
16	Avoidance of contact with chemicals, including dyes, glues, adhesive tape, undue amounts of oil and grease NOTE If it is necessary to use them, their suitability is to be checked with their manufacturer.
17	Use of segregated manufacturing used for carbon steel and stainless steel to prevent carbon steel pick-up. Use of separate tools dedicated for use with stainless steel only, particularly grinding wheels and wire brushes. Wire brushes and wire wool of stainless steel, preferably an austenitic grade
Transport	
18	Special measures needed for protecting manufactured components in transit

6.4 Cutting

6.4.1 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 European Standard are met.

NOTE Known and recognised cutting methods are sawing, shearing, disc cutting, water jet techniques and thermal cutting. Hand thermal cutting should be used only if it is not practical to use machine thermal cutting. [A1] Some cutting methods can be unsuitable for components subject to fatigue. [A1]

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 the damage on the coating.

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

6.4.2 Shearing and nibbling

The free edge surfaces shall be checked and smoothed as necessary in order to remove significant defects. If grinding or machining is used after shearing or nibbling, the minimum depth of grinding or machining shall be 0,5 mm.

6.4.3 Thermal cutting

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

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

- 1) a straight cut from the thickest constituent product;
- 2) a straight cut from the thinnest constituent product;
- 3) a sharp corner from a representative thickness;
- 4) a curved arc from a representative thickness.

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

The quality of cut surfaces defined in accordance with EN ISO 9013 shall be as follows:

- a) for EXC1 cut edges that are free from significant irregularities are acceptable provided that any dross is removed. For perpendicularity or angularity tolerance, u, range 5 may be used;
- b) Table 9 specifies the requirements for other execution classes.

Table 9 — Quality of the cut surfaces

	Perpendicularity or angularity tolerance, u	Mean height of the profile, Rz5
EXC2	Range 4	Range 4
EXC3	Range 4	Range 4
EXC4	Range 3	Range 3

6.4.4 Hardness of free edge surfaces

For carbon steels, if specified, hardness of free edge surfaces shall be in accordance with Table 10. In this case processes that are likely to produce local hardness (thermal cutting, shearing, punching) shall have their capability checked. In order to achieve the required hardness of free edge surfaces, preheating of material shall be applied as necessary.

Table 10 — Permitted maximum hardness values (HV 10)

Product standards	Steel grades	Hardness values
EN 10025-2 to -5	S235 to S460	380
EN 10210-1, EN 10219-1		
EN 10149-2 and EN 10149-3	S260 to S700	450
EN 10025-6	S460 to S690	
NOTE These values are in accordance with EN ISO 15614-1 applied to steel grades listed in ISO/TR 20172.		

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

- four samples shall be produced from procedure tests on constituent product encompassing the range of constituent products processed that are most susceptible to local hardening;
- four local hardness tests shall be done on each sample in locations likely to be affected. The tests shall be in accordance with EN ISO 6507.

NOTE The requirements for checking of hardness after welding are included in procedure testing (see 7.4.1).

6.5 Shaping

6.5.1 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 worked material.

Requirements and recommendations for hot, cold forming and flame straightening of steels shall be as given in the relevant product standards and in CEN/TR 10347.

Shaping by controlled application of heat may be used under the conditions specified in 6.5.2 and 6.5.3.

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

6.5.2 Hot forming

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

[A1] For steels according to EN 10025-4 and in the delivery condition +M according to EN 10025-2 hot forming is not permitted. **[A1]**

For quenched and tempered steels hot forming is not permitted unless the requirements of EN 10025-6 are fulfilled.

Shaping by hot forming ($T > 580\text{ °C}$) of cold formed thin gauge components and sheeting is not permitted if the nominal yield strength is achieved by cold forming.

For steel grades up to and including S355, the hot forming process shall take place in the **[A1]** red hot (600 °C to 650 °C) state **[A1]** and the temperature, timing and cooling rate shall be appropriate to the particular type of steel. Bending and forming in the blue heat range (250 °C to 380 °C) is not permitted.

For steel grades S450+N (or +AR) according to EN 10025-2, and S420 and S460 according to EN 10025-3, the hot forming process shall take place in the temperature range 960 °C to 750 °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 normalising treatment shall be carried out.

Hot forming is not allowed for S450 according to EN 10025-2 if no delivery condition is indicated.

NOTE If no delivery condition is indicated, steel products S450 could be delivered in the thermomechanical delivery condition.

6.5.3 Flame straightening

If distortion is to be corrected by flame straightening, this shall be undertaken by local application of heat, ensuring that the maximum steel temperature and the cooling procedure are controlled.

For EXC3 and EXC4 a suitable procedure shall be developed. The procedure shall include at least:

- 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 approval;
- e) identification of workers entitled to apply the process.

6.5.4 Cold forming

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.

NOTE Cold forming leads to reduction in the ductility. Furthermore attention is drawn to the risk of hydrogen embrittlement associated with subsequent processes such as acid treatment during coating or hot dip galvanization.

- a) For steel grades higher than S355, if a stress relief treatment is carried out after cold forming, the following two conditions shall be satisfied:
 - 1) temperature range: 530 °C to 580 °C ;

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

Stress relief treatment at more than 580 °C, or for over an hour, may lead to deterioration of the mechanical properties. If it is intended to stress relieve S420 to S700 steels at higher temperatures or for longer times, the required minimum values of the mechanical properties shall be agreed in advance with the product manufacturer.

b) For stainless steels, unless otherwise specified, the minimum inside bend radii to be formed shall be:

1) 2 t for austenitic grades 1.4301, 1.4401, 1.4404, 1.4541 and 1.4571;

2) 2,5 t for austenitic-ferritic grade 1.4462.

where t is the thickness of the material.

c) For other grades of stainless steels, the minimum inside bend radii shall be specified.

Smaller inside bend radii may be permitted if due consideration is given to issues such as steel specification, condition and thickness and the direction of bending in relation to the rolling direction.

In order to counteract the effects of spring-back, stainless steel needs to be over-bent to a slightly higher degree than carbon steel.

NOTE The power requirement for bending stainless steel are higher than for bending geometrically similar carbon steel components, due to work hardening (by about 50% in the case of the austenitic steels or even more in the case of 1.4462 austenitic-ferritic steel).

d) Cold formed sections and sheeting may be shaped by cranking, smooth curving or crimping as appropriate to the materials to be used.

For cold formed components and sheeting used as structural components, shaping by cold forming shall comply with the following two conditions:

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

2) 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. For further information, see EN 508-1 and EN 508-3.

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 may cause alteration of section properties (e.g. concavity, ovality and wall thinning) and increased hardness.

e) For circular tubes bending by cold forming shall comply with the following three conditions, unless otherwise specified:

1) the ratio of the overall diameter of the tube to the wall thickness shall not exceed 15;

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

3) $\overline{A_1}$ the longitudinal seam weld $\overline{A_1}$ in the cross-section shall be positioned close to the neutral axis, in order to reduce the bending stresses at the weld.

6.6 Holing

6.6.1 Dimensions of holes

This clause applies to the making of holes for connections with mechanical fasteners and pins.

The definition of the nominal hole diameter combined with the nominal diameter of the bolt to be used in the hole determines whether the hole is "normal" or "oversize". The terms "short" and "long" applied to slotted holes refer to two types of holes used for the structural design of preloaded bolts. These terms may be used also to designate clearances for non-preloaded bolts. Special dimensions should be specified for movement joints.

The nominal clearances for bolts and for pins not intended to act in fitted conditions shall be as specified in Table 11. The nominal clearance is defined as:

- the difference between the nominal hole diameter and the nominal bolt diameter for round holes;
- the difference between respectively the length or the width of the hole and the nominal bolt diameter for slotted holes.

Table 11 — Nominal clearances for bolts and pins (mm)

Nominal bolt or pin diameter d (mm)	12	14	16	18	20	22	24	27 and over
Normal round holes ^a	1 ^{b c}		2					3
Oversize round holes	3		4				6	8
Short slotted holes (on the length) ^d	4		6				8	10
Long slotted holes (on the length) ^d	1,5 d							
^a For applications such as towers and masts the nominal clearance for normal round holes shall be reduced by 0,5 mm unless otherwise specified.								
^b For coated fasteners, 1 mm nominal clearance can be increased by the coating thickness of the fastener.								
^c Bolts with nominal diameter 12 and 14 mm, or countersunk bolts may also be used in 2 mm clearance holes under conditions given in EN 1993-1-8.								
^d For bolts in slotted holes the nominal clearances across the width shall be the same as the clearances on diameter specified for normal round holes.								

For fit bolts the nominal hole diameter shall be equal to the shank diameter of the bolt.

NOTE 1 For fit bolts to EN 14399-8 the nominal diameter of the shank is 1 mm larger than nominal diameter of the threaded portion.

For hot rivets the nominal hole diameter shall be specified.

For countersunk bolts or hot rivets, nominal dimensions of the countersinking and tolerances on those shall be such that after installation the bolt or rivet shall be flush with the outer face of the outer ply. The dimensions of the countersinking shall be specified accordingly. If countersinking through more than one ply the plies shall be held firmly together during countersinking.

If countersunk bolts are identified as being for use in tension or preloaded applications, the nominal depth of countersinking shall be at least 2 mm less than the nominal thickness of the outer ply.

NOTE 2 The 2 mm is to allow for adverse tolerances.

For blind rivets used for the fixing of profile sheeting, the diameter of the clearance hole (d_h) shall comply with the following according to the standards for rivets given in 5.6.11:

$$d_{\text{nom}} + 0,1 \text{ mm} \leq d_h \leq d_{\text{nom}} + 0,2 \text{ mm} \quad \text{with} \quad d_{\text{nom}} = \text{nominal diameter of the rivet}$$

6.6.2 Tolerances on hole diameter for bolts and pins

Unless otherwise specified, hole diameters shall comply with the following:

- a) holes for fit bolts and fitted pins: class H11 according to ISO 286-2;
- b) other holes: $\pm 0,5 \text{ mm}$, the hole diameter being taken as the average of entry and exit diameters (see Figure 1).

6.6.3 Execution of holing

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

- a) cutting requirements relating to local hardness and quality of cut surface, according to 6.4 are fulfilled;
- b) all matching holes for fasteners or pins register with each other so that fasteners can be inserted freely through the assembled members in a direction at right angles to the faces in contact.

Punching is permitted provided that the nominal thickness of the component is not greater than the nominal diameter of the hole, or for a non-circular hole, its minimum dimension.

For EXC1 and EXC2, holes may be formed by punching without reaming unless otherwise specified.

[A1] For EXC3 and EXC4, punching without reaming is not permitted if the plate thickness is greater than 3 mm. For plate thickness greater than 3 mm, the holes shall be punched at least 2 mm undersize in diameter. For plate or sheet thickness less than or equal to 3 mm (i.e. sheets), holes may be formed by full size punching.

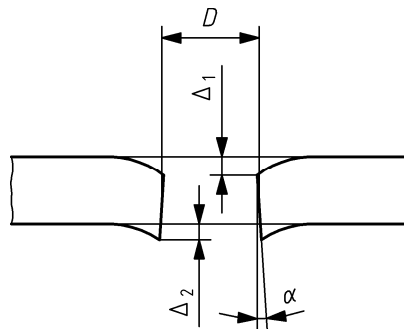
The capability of holing processes shall be checked periodically as follows: **[A1]**

- eight samples shall be produced from procedure tests on constituent product encompassing the range of hole diameters, constituent product thickness and grades processed;
- hole sizes shall be checked at both ends of each hole using go/no go gauges. Holes shall comply with the tolerance class as specified in 6.6.2.

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

Holes shall also conform to the following:

- 1) the taper angle (α) shall not exceed that shown in Figure 1;
- 2) the burrs (Δ) shall not exceed that shown in Figure 1;
- 3) at splices, the holes in mating surfaces shall be punched in one direction in all components.



$$D = \frac{(d_{\max} + d_{\min})}{2}$$

$$\max (\Delta_1 \text{ or } \Delta_2) \leq \frac{A_1}{10} D / 10 \frac{A_1}{10}$$

$$\alpha \leq 4^\circ \text{ (i.e. 7 \%);}$$

Figure 1 — Permitted distortions of punched holes and plasma cuts

Holes for fit bolts and fit pins may be either drilled full size or reamed in situ. If the holes are to be reamed in situ, they shall be made at least 3 mm undersized initially by drilling or punching. If the fastener is to fit through multiple plies they shall be held firmly together during drilling or reaming. The reaming shall be carried out with a fixed spindle device. Acidic lubricant shall not be used.

Countersinking of normal round holes for countersunk bolts or rivets shall be undertaken after holing.

Long slotted holes shall be either punched in one operation or formed by drilling or punching two holes and completed by hand thermal cutting, unless otherwise specified.

For cold formed components and sheeting, slotted holes may be formed by punching in a single operation, consecutive punching, or joining two punched or drilled holes by use of a jig saw.

Burrs shall be removed from holes before assembly. If holes are drilled in one operation through parts clamped together which would not otherwise be separated after drilling, removing of burrs is necessary only from the outside holes.

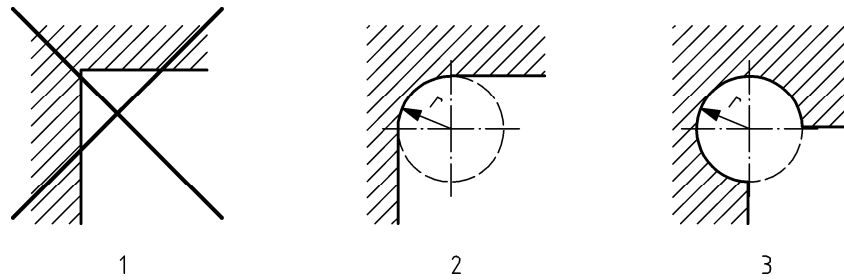
6.7 Cut outs

Over-cutting of re-entrant corners shall not be permitted. Re-entrant corners are those where the open angle between the faces is less than 180°.

Re-entrant corners and notches shall be rounded off with a minimum radius of:

- 5 mm for EXC2 and EXC3.
- 10 mm for EXC4.

Examples are given in Figure 2.



Key

- 1 not permitted
- 2 Form A (recommended for fully mechanised or automatic cutting)
- 3 Form B (permitted)

Figure 2 — Example of cut outs

At punched cut outs in plates over 16 mm in thickness, the deformed materials shall be removed by grinding. Punched cut outs are not permitted for EXC4.

For thin gauge components and sheeting, locations where sharp re-entrant corners are not permitted shall be specified with the minimum acceptable radii.

6.8 Full contact bearing surfaces

If full contact bearing surfaces are specified, the cutting length, squareness of ends and flatness of surface shall comply with the tolerances specified in Clause 11.

6.9 Assembly

Assembly of components shall be carried out so as to fulfil the specified tolerances.

Precautions shall be taken so as to prevent galvanic corrosion produced by contact between different metallic materials.

Contamination of stainless steel by contact with structural steel should be avoided.

Drifting to align holes shall be carried out in such a way that the elongation does not exceed the values given in D.2.8 No 6 as follows:

- EXC1 and EXC2: Class 1;
- EXC3 and EXC4: Class 2.

In case those values are exceeded holes shall be corrected by reaming.

Holes for which elongation is not permitted shall be identified and not be used for alignment (e.g. for fit bolts).

NOTE In such cases specific alignment holes may be provided.

All connections for temporary components provided for manufacturing purposes shall meet the requirements of this European Standard and any special requirements including those related to fatigue which shall be specified.

Requirements for camber or presets in components shall be checked after completion of assembly.

6.10 Assembly check

The fit between manufactured components that are inter-connected at multiple connection interfaces shall be checked using dimensional templates, accurate three-dimensional measurements or by trial assembly. Requirements for whether, and to what extent, trial assembly is to be used shall be specified.

Trial assembly means putting together sufficient components of a whole structure to check that they fit. It should be considered to prove fit-up between components if this is not provable by using templates or measurement.

7 Welding

7.1 General

Welding shall be undertaken in accordance with the requirements of the relevant part of EN ISO 3834 or EN ISO 14554 as applicable.

NOTE Guidelines for implementation of EN ISO 3834 on quality requirements for fusion welding of metallic materials is given in CEN ISO/TR 3834-6.  [31] 

According to the execution class, the following parts of EN ISO 3834 apply:

- EXC1: Part 4 "Elementary quality requirements";
- EXC2: Part 3 "Standard quality requirements";
- EXC3 and EXC4: Part 2 "Comprehensive quality requirements".

Arc welding of ferritic steels and stainless steels should follow the requirements and recommendations of EN 1011-1, EN 1011-2, EN 1011-3 as amended in 7.7.

7.2 Welding plan

7.2.1 Requirements for a welding plan

A welding plan shall be provided as part of the production planning required by the relevant part of EN ISO 3834.

7.2.2 Content of a welding plan

 The  welding plan shall include, as relevant:

- a) the welding procedure specifications including welding consumable, any preheating, interpass temperature and post weld heat treatment requirements;
- b) measures to be taken to avoid distortion during and after welding;
- c) the sequence of welding with any restrictions or acceptable locations for start and stop positions, including intermediate stop and start positions where joint geometry is such that welding cannot be executed continuously;

NOTE Guidance for joints of hollow sections is given in Annex E.

- d) requirements for intermediate checking;
- e) turning of components in the welding process, in connection with the sequence of welding;