



BSI Standards Publication

Structural use of steel and aluminium

Part 2: Execution of steel bridges conforming to
BS EN 1090-2 – Guide

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Foreword

Publishing information

This part of PD 6705 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 June 2020. It was prepared by Subcommittee B/525/10, *Bridges*, under the authority of Technical Committee B/525, *Building and civil engineering structures*. A list of organizations represented on these committees can be obtained on request to their secretary.

Supersession

PD 6705-2:2020 supersedes PD 6705-2:2010+A1:2013, which is withdrawn.

Relationship with other publications

This Published Document gives guidance on the use of BS EN 1090-2:2018 for the execution of steel bridges in the UK.

[BS EN 1993](#) requires compliance with BS EN 1090 as the key reference standard for fabrication and erection which is necessary for the design assumptions in BS EN 1993 to be valid.

Information about this document

The guidance given in this Published Document consists of non-contradictory complementary information (NCCI) to enable the user to apply BS EN 1090-2:2018 in a safe and economical manner, with particular reference to the following:

- selection of options where they are defined in BS EN 1090-2:2018;
- selection of service categories in terms of quantified performance requirements, for use in choosing execution requirements, where applicable; and
- additional information where permitted in BS EN 1090-2:2018.

This revision takes account of changes to BS EN 1090-2 made in the 2018 revision and comments arising from its application in the drafting and use of specifications based on BS EN 1090-2:2008+A1:2011.

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

Use of this document

As a guide, this Publish Document takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice.

This publication is not to be regarded as a British Standard.

Presentational conventions

The provisions in this Published Document are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

The word “may” is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word “can” is used to express possibility, e.g. a consequence of an action or an event.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

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

Compliance with a Published Document cannot confer immunity from legal obligations.

1 Scope

This part of PD 6705 gives guidance on the use of BS EN 1090-2:2018 for the execution of all types of steel bridges designed to [BS EN 1993](#).

NOTE As BS EN 1090-2:2018 contains many clauses which have multiple options or requires additional information, guidance is given in this Published Document to ensure that technically sound choices are made.

This part of PD 6705 specifies appropriate controls on management systems, procedure approval, personnel qualification, process selection, quality of materials and workmanship, inspection, testing and recording.

This part of PD 6705 is applicable to the same scope of application as BS EN 1090-2:2018 with the following exceptions:

- a) resistance welding; and
- b) matters not related to structural integrity, e.g. visual appearance.

The recommendations given in this Published Document are only applicable when the design requirements and recommendations in the following documents have been adopted, where relevant:

- BS EN 1990, *Eurocode – Basis of structural design*;
- [BS EN 1991](#), *Eurocode 1 – Actions on structures*;
- BS EN 1993-2, *Eurocode 3 – Design of steel structures – Part 2: Steel bridges*;
- BS EN 1994-2, *Eurocode 4 – Design of composite steel and concrete structures – Part 2: General rules and rules for bridges*; and
- any UK National Annexes and Published Documents referenced normatively or informatively in the above standards.

This Published Document is prepared for personnel involved in the regulation, design, procurement, fabrication, erection and certification of steel bridges when BS EN 1090-2:2018 is used as the basis for specifying the execution.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies¹⁾. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 1090-2:2018, *Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures*

BS EN 1593, *Non-destructive testing – Leak testing – Bubble emission techniques*

BS EN 1990, *Eurocode 0 – Basis of structural design*

[BS EN 1991](#), *Eurocode 1 – Actions on structures*

[BS EN 1993](#), *Eurocode 3 – Design of steel structures*

BS EN 1993-1-9, *Eurocode 3 – Design of steel structures – Part 1-9: Fatigue*

BS EN 1993-2, *Eurocode 3 – Design of steel structures – Part 2: Steel bridges*

BS EN 1994-2, *Eurocode 4 – Design of composite steel and concrete structures – Part 2: General rules and rules for bridges*

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

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

BS EN 10025-5:2004, *Hot rolled products of structural steels – Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance*

BS 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*

BS EN 10088-1, *Stainless Steels – Part 1: List of stainless steels*

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

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

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

[BS EN 14399](#), *High-strength structural bolting assemblies for preloading*

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

BS EN ISO 3834-2, *Quality requirements for fusion welding of metallic materials – Part 2: Comprehensive quality requirements*

BS EN ISO 5817, *Welding – Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections*

BS EN ISO 6520-1, *Welding and allied processes – Classification of geometric imperfections in metallic materials – Part 1: Fusion welding*

[BS EN ISO 14555:2017](#), *Welding – Arc stud welding of metallic materials*

BS EN ISO 15613, *Specification and qualification of welding procedures for metallic materials – Qualification based on pre-production welding test*

BS 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*

BS EN ISO 23277, *Non-destructive testing of welds – Penetrant testing – Acceptance levels*

BS EN ISO 23278, *Non-destructive testing of welds – Magnetic particle testing – Acceptance levels*

[PD 6695-1-9](#), *Recommendations for the design of structures to BS EN 1993-1-9*

[PD 6695-1-10](#), *Recommendations for the design of structures to BS EN 1993-1-10*

[PD 6702-1](#), *Structural use of aluminium – Part 1: Recommendations for the design of aluminium structures to BS EN 1999*

[PD 6705-3](#), *Structural use of steel and aluminium – Part 3: Recommendations for the execution of aluminium structures to BS EN 1090-3*

ISO 10721-1, *Steel structures – Part 1: Materials and design*

ISO 10721-2, *Steel structures – Part 2: Fabrication and erection*

3 Terms and definitions

For the purposes of this part of PD 6705, the terms and definitions given in BS EN 1090-2:2018 and the following applies.

3.1 quantified service category (QSC)

category that characterizes a detail, component or structure (or part thereof), in terms of the circumstances of its use within specified limits of static and cyclic stressing

NOTE See [Annex B](#).

4 General

BS EN 1090-2 superseded [BS 5400-6](#) in March 2010 and represented a substantial change in practice for specifying the execution of steelwork applied to bridges in the UK.

[Annex A](#) sets out the background to the main developments in the preparation of BS EN 1090-2, and also identifies the main differences in the scope and technical bases of BS EN 1090-2 as compared to [BS 5400-6](#). This is to assist the user in adapting to the changes in practice necessary when using BS EN 1090-2:2018.

BS EN 1090-2:2018 enables persons responsible for preparing the execution specification for steel bridges to incorporate appropriate requirements relating to those clauses in order to comply with BS EN 1993-2. This applies whether the specification is intended to cover steel bridges in general, particular types of steel bridge, parts of a steel bridge, or a bridge for an individual project.

The recommendations given in this Published Document represent the minimum requirements needed to ensure that the design conforms to BS EN 1993-2. Not all recommendations given in this Published Document are relevant if the scope of the execution specification is limited. The recommendations do not preclude the addition of further requirements in an execution specification, provided they do not lower the level of a recommended minimum requirement.

The purpose of this Published Document is to ensure that steel bridges are executed with the same level of assurance of reliability as that provided in [BS 5400-6](#).

5 Basis for the recommended selections of choice permitted by BS EN 1090-2:2018

5.1 Objectives

The objective of this Published Document is to ensure that, when using BS EN 1090-2:2018 for specifying the execution of steelwork in bridges, the design resistance values assumed in [BS EN 1993](#) are realized in the final bridge construction to the level of reliability in accordance with BS EN 1990, [BS EN 1991](#) and [BS EN 1993](#).

BS EN 1090-2:2018 contains multiple options and requirements for further information. Many of these involve decisions on specialist technical matters which users might not feel qualified to make. Use of this Published Document should ensure that technically sound choices are made, resulting in bridges being executed economically whilst maintaining the level of reliability defined above.

This is achieved by specifying appropriate controls on:

- a) management systems;
- b) procedure approval;
- c) personnel qualification;

- d) process selection;
- e) quality of materials and workmanship;
- f) inspection;
- g) testing; and
- h) recording.

[Annex B](#) sets out a method of determining QSC and guidance for its use in drafting specifications. [Annex C](#) gives explanatory notes which detail the background to selected recommendations for additional specification material, selection of options and choice of execution class, where the issues involved are of a specialist nature. [Annex D](#) gives a list of references of individual Parts of normative standards which are referenced in BS EN 1090-2:2018, Clause 2, but where the Part references are not given.

5.2 Reliability level

The partial factors for actions and material properties chosen by the UK and specified in the NA to BS EN 1990, NA to [BS EN 1991](#) and NA to BS EN 1993-2 are based on achieving the same notional safety margins used for general structural applications.

NOTE In BS EN 1990:2002+A1:2005 this generally aligns with reliability class (RC) 2 which is consistent with the basis of the safety factors used for most British Standard limit state structural design codes.

BS EN 1990:2002+A1:2005, [Annex B](#) recommends that RC2 may be associated with consequence class (CC) 2.

The partial factor Y_M is necessary to allow for inherent deviations in chemical, mechanical and geometrical properties of the members and joints in the final structure, including execution-induced stresses and notch-like imperfections. These inherent deviations are set at maximum limits which are not considered to be economical to reduce further and are defined by the relevant specified quality levels. The recommendations in this Published Document control these inherent deviations so that the values of Y_M for use in the UK are valid for all steel bridge applications.

A further factor in achieving reliability is the elimination of gross deviations due to human error. These are not common occurrences but, if they do occur, can result in serious loss of reliability, which cannot be economically mitigated against by increasing the values of Y_M . Mitigation against such deviations is the prime function of quality control measures which provide assurance that the required quality levels have been met.

In cases where a higher level of reliability is deemed to be necessary (e.g. class RC3 in BS EN 1990:2002+A1:2005, [Annex B](#)), it might be appropriate to increase the scope of testing and inspection to levels above that recommended in this Published Document.

5.3 Types of choice in BS EN 1090-2:2018

There are three types of choice available to the user of BS EN 1090-2:2018.

- a) Execution class: BS EN 1090-2:2018, **A.3** lists 27 technical requirements where choices can be made by selection of execution class. Twenty one of these are related to assurance matters, including quality documentation, identification, inspection documents, traceability, welding management, qualification of weld procedures, welders and welding coordinators and inspection of welding and bolting. The remaining six relate to the physical quality required for thermal

cutting, temporary attachments, butt weld terminations, continuity of weld backing and weld acceptance criteria.

- b) Options: BS EN 1090-2:2018, **A.2** lists nearly 130 requirements which can be subject to variation by the specifier.
- c) Additional information: BS EN 1090-2:2018, **A.1** lists over 80 requirements which, if relevant to the structure, require further information to be provided by the specifier.

5.4 Basis for selection of execution class

BS EN 1090-2:2008+A1:2011, Annex B gave informative guidelines on selection of execution class in Table B.3 in terms of consequences class (CC), service category (SC) and production category (PC). This information has been removed in BS EN 1090-2:2018.

BS EN 1090-2:2018, **4.1.2**, Note refers to BS EN 1993-1-1:2005+A1:2014, Annex C for the basis for the selection of execution classes. This normative annex re-confirms that execution class can be applied either to the works as a whole, an individual component or a detail of a component. It also contains an optional Table C.1, which is not dissimilar in principle to BS EN 1090-2:2008+A1:2011, Table B.3. In Table C.1, however, the recommended choice of execution class is now dependent on reliability class (RC) or CC. The dependence of execution class on SC is now given directly in terms of the type of applied loading (static, quasi-static, fatigue or seismic), but without reference to specific structural applications. Dependence on type of component (referred to as “production category” in BS EN 1090-2:2008+A1:2011, Table B.2) is still only applicable to EXC1.

The NA+A1:2014 to BS EN 1993-1-1:2005+A1:2014, **NA.2.27.3**, Table NA.4 gives general, but not specific, guidelines for selection of execution class in terms of which design standards apply (BS EN 1993-1-9, BS EN 1993-1-12 and [BS EN 1998](#) in particular). **NA.2.27.3**, Note 1 advises that certain execution classes might need to be enhanced to ensure full compatibility with the design resistance values in [BS EN 1993](#) and reference is made to the guidance in this Published Document for that purpose.

The main unresolved issue resulting in the UK’s original negative vote on FprEN 1090-2:2008, which was the technical basis of the guidelines and their perceived incompatibility with BS EN 1990, remains. This particularly applies to the quality related items, as opposed to the assurance related items [see [5.3a](#)], which in BS EN 1090-2:2018 are still linked directly to the reliability level instead of quantitatively defined service categories. The UK was able to implement BS EN 1090-2:2018 due to the flexibility provided in BS EN 1993-1-1, Annex C.

In BS EN 1090-2:2018, where there is a choice of execution class in a particular clause, this Published Document considers each case separately. In certain clauses the requirements can be the same for more than one execution class. In these cases, the recommendation is given by the execution class number(s). For example, if the preferred option is the same for execution class 2, 3 and 4, the choice is indicated as EXC2/3/4.

The recommendation for selecting a particular execution class (or classes) does not imply any change in reliability level (see [5.2](#)).

NOTE Where the execution class has been used to differentiate a quality requirement, there might be more than one recommended class, the distinction being dependent on QSC (see [5.5](#)).

5.5 Quantified service category

The fatigue design rules specified in BS EN 1993-1-9 permit high levels of cyclic stressing for certain categories of detail. These levels are acceptable provided a high quality of execution can be assured, free from all but very small notches. This demands a high degree of control of execution, particularly for welding, and inspection procedures for detection and assessment. Such stress levels are usually

only found in limited parts of certain bridges. However, when they do occur, extra controls should be applied to achieve the correct level of reliability.

[BS 5400](#) (withdrawn), ISO 10721, [BS 8118](#) (withdrawn), [PD 6702-1](#) and [PD 6705-3](#) provide simple means of identifying the higher risk areas. [Annex B](#) provides means of calculating and designating the various levels of fatigue stressing and static stressing. These are compatible with the design rules in BS EN 1993-1-9 and BS EN 1993-1-10 including their National Annexes, [PD 6695-1-9](#) and [PD 6695-1-10](#). For this purpose, six levels of QSC are defined. They are designated F36, F56, F71, F90, F112 and F140 in increasing severity of quality requirement.

QSC has effect on the recommended requirements in the following clauses:

- [7.2.3](#) Surface conditions;
- [7.2.4.1](#) Internal discontinuity quality class;
- [8.2](#) Marking methods;
- [8.4](#) Hardness of free edges;
- [8.6.1](#) Round holes for fasteners or pins;
- [8.6.2](#) Slotted holes;
- [8.7.1](#) Minimum radii of cut outs;
- [8.7.2](#) Punched cut outs;
- [9.1](#) Weld quality management;
- [9.2.2](#) Methods of weld procedure qualification;
- [9.4.3](#) Temporary welded attachments;
- [9.4.5](#) Permanent steel backing;
- [9.4.7](#) Stray arcing and spatter;
- [14.1.2](#) Inspection and testing of steel castings;
- [14.3.1](#) Project specific scope of weld inspection;
- [14.3.3](#) Project specific weld acceptance criteria; and
- [14.3.6](#) Production weld tests.

[Annex B](#) gives guidance on how QSC can be used in the drafting of an execution specification.

5.6 Options

Guidance on selection of any BS EN 1090-2:2018, **A.2** options which could affect the structural reliability level in a bridge are given in Clause **6** to Clause **14**, where relevant. If no guidance is given, the stated requirement should be assumed to be acceptable for UK bridges.

5.7 Additional information

Guidance on any BS EN 1090-2:2018, **A.1** items of required additional information considered necessary to control the structural reliability level of a bridge are given in Clause **6** to Clause **14**, where relevant.

6 Specifications and documentation (see BS EN 1090-2:2018, Clause 4)

6.1 Execution class (see BS EN 1090-2:2018, 4.1.2)

Execution class is used in Clause 6 to Clause 14 of this Published Document for the purposes of recommending the appropriate requirement where options based on this parameter are given in BS EN 1090-2:2018 (see [5.4](#)). In some cases, the applicable recommended requirement might depend on the QSC (see [5.5](#)).

6.2 Quality documentation (see BS EN 1090-2:2018, 4.2.1)

Quality documentation should conform to the requirements for EXC2/3/4.

6.3 Quality plan (see BS EN 1090-2:2018, 4.2.2 and [Annex C](#))

A quality plan for execution of the works should be provided and include the items recommended in BS EN 1090-2:2018, Annex C, if applicable.

7 Constituent steel products (see BS EN 1090-2:2018, Clause 5)

7.1 Identification, inspection documents and traceability (see BS EN 1090-2:2018, 5.2)

7.1.1 Stages of traceability (see BS EN 1090-2:2018, 5.2)

Stages of traceability should conform to the requirements for EXC3/4.

7.1.2 Traceability of individual products (see BS EN 1090-2:2018, 5.2)

Specialist proprietary and/or bespoke products incorporating non-standardized features, components or methods of manufacture should be individually traceable.

NOTE For example, castings, forgings, cables and their terminations, energy absorbing devices, mechanical components such as movement joints and major bearings etc.

Small identical bespoke products such as special fasteners should be traceable to their individual manufacturing lot.

7.1.3 Marking of different grades and/or qualities (see BS EN 1090-2:2018, 5.2)

The identification of different grades and/or qualities of each individual constituent product should conform to the requirements for EXC2/3/4.

7.2 Structural steel products (see BS EN 1090-2:2018, 5.3)

7.2.1 Options (see BS EN 1090-2:2018, 5.3.1)

7.2.1.1 Standards for steel products

Wrought steel product forms identified in BS EN 1090-2:2018, [Table 2](#) to [Table 4](#) should be specified in accordance with the product standards listed in these tables.

7.2.1.2 Options in product standards

The only options usually needed are those covered by [7.2.1.3](#) to [7.2.1.5](#), and [7.2.2](#) to [7.2.5](#). In particular, caution should be exercised in the use of optional variations to chemical composition. The reason for specifying such an option should be given and it should be verified that no adverse effect on mechanical properties, weldability or other property could result.

7.2.1.3 Options for impact properties

The following options for impact property verification should apply:

- a) Option 3 in BS EN 10025-1:2004, **7.3.2.2**: the lowest test temperature should be adopted; and
- b) Option 3 in BS EN 10025-5:2004, **7.3.2.2** and **8.4.2**: the impact properties of steel grade S355WP should be verified.

7.2.1.4 Options for suitability for hot dip galvanising

The following options for steel that is to be hot dip galvanized should apply:

- a) Option 5 in BS EN 10025-1:2004, **7.4.3**: the product should be suitable for hot dip zinc coating;
- b) Option 1.4 in BS EN 10210-1:2006, **6.7.2**: the product should be suitable for hot dip galvanizing; and
- c) Option 1.4 in BS EN 10219-1:2006, **6.8.2**: the product should be suitable for hot dip galvanizing.

7.2.1.5 Options for weld repair of hollow sections

The following options for weld repair of hollow sections in zones of QSC F112 and F140 should apply:

- a) Option 1.5 in BS EN 10210-1:2006, **6.8.4**: repair of the body by welding should not be permitted; and
- b) Option 1.5 in BS EN 10219-1:2006, **6.9.4**: repair of the body by welding should not be permitted.

7.2.2 Thickness tolerances (see BS EN 1090-2:2018, 5.3.2)

For thickness tolerance, thickness tolerance class A should be used.

NOTE See [Annex C, C.1](#).

7.2.3 Surface conditions (see BS EN 1090-2:2018, 5.3.3)

7.2.3.1 Plates and wide flats

For plates and wide flats, the limits on surface discontinuities and ground areas should conform to BS EN 10163-2, class A or class B. Repair by welding should not be carried out (subclass 3) on steels conforming to BS EN 10025-6 or where QSC F112 or F140 applies. Where repairs by welding are required, they should conform to subclass 2 with the following additional requirements:

- a) reports on weld repairs should be submitted;
- b) UT and MT should be used for inspection of weld repairs; and
- c) weld repairs on components with a QSC of F71 or F90 should be re-checked on delivery.

NOTE See [Annex C, C.2](#).

7.2.3.2 Sections

For sections, excluding hollow sections which are covered by [7.2.3.3](#), the limits on surface discontinuities and ground areas should conform to BS EN 10163-3, class C or class D. Repair by welding should not be carried out (subclass 3) for steels to BS EN 10025-6 or where QSC F112 or F140 applies. Imperfections such as cracks, shells and seams should be repaired if a permissible repair method is available; otherwise the affected product should be treated as non-conforming.

Where repairs by welding are required, they should conform to subclass 2 with the following additional requirements:

- a) reports on weld repairs should be submitted;
- b) UT and MT should be used for inspection of weld repairs; and
- c) weld repairs on components with a QSC of F71 or F90 should be re-checked on delivery.

NOTE See [Annex C, C.2](#).

7.2.3.3 Hollow sections

For hot finished and cold formed hollow sections, surface defects in the body of the section should be repaired in accordance with BS EN 10210-1 and BS EN 10219-1 respectively, subject to the restrictions in [7.2.1.5](#). Where repairs by welding are required, the following additional requirements should apply:

- a) reports on weld repairs should be submitted;
- b) UT and MT should be used for inspection of weld repairs; and
- c) weld repairs on components with a QSC of F71 or F90 should be re-checked on delivery.

NOTE See [Annex C, C.2](#).

7.2.4 Additional properties (see BS EN 1090-2:2018, 5.3.4)

7.2.4.1 Cross plates in welded cruciform and welded tee joints – transmitting primary stresses through the plate thickness

For QSC F56, the internal discontinuity quality class S1 of BS EN 10160 should apply.

For QSC F71 and above, the internal discontinuity quality class S2 of BS EN 10160 should apply.

NOTE See [Annex C, C.3](#).

7.2.4.2 Flange or web plates close to bearing diaphragms and/or single-sided bearing stiffeners

Flange or web plates close to bearing diaphragms and/or single-sided bearing stiffeners, where attached by welding, should conform to BS EN 10160 internal discontinuity quality class S1 in the areas defined in BS EN 1090-2:2018, [5.3.4](#).

NOTE See [Annex C, C.3](#).

7.2.5 Improved deformation properties (Z testing) perpendicular to the surface (see BS EN 1090-2:2018, 5.3.4)

The constructor should decide what precautions are needed to avoid lamellar tearing in tee, cruciform and corner joints. This should be done whether or not improved deformation properties to BS EN 10164 have been specified for the through plates.

NOTE See [Annex C, C.4](#).

7.3 Steel castings (see BS EN 1090-2:2018, 5.4)

The specification of grades and qualities and selection of options permitted by the product standard is a specialist matter requiring expert knowledge and practical experience of casting technology.

Only general guidance and principles are given in this Published Document.

In the case of castings used for proprietary products, such as bearings, cable terminations etc., the casting designer's calculations and the manufacturer's quality and testing requirements should be reviewed prior to acceptance by the bridge designer.

In the case of castings designed by the bridge designer, expert advice should be sought at the design concept stage so that the quality and testing requirements are consistent with the design requirements. This should include:

- a) selection of material designation in accordance with BS EN 10340;
- b) review of geometry with regard to castability and inspectability;
- c) selection of appropriate quality control options from BS EN 1559-2, Annex A;
- d) weldability (when applicable); and
- e) methods and scope of testing and inspection.

In selection of casting designation for satisfying the ULS requirements in [BS EN 1993](#), the mechanical properties specified for the various grades of wrought products should be the basis of selection for castings for the same stressing conditions. This should include the proof stress (see BS EN 10340:2007, [7.2.2.2](#)), the minimum tensile strength and the charpy impact properties (see BS EN 1993-1-10 and its National Annex). In the latter case, the lowest test temperature should be used (see BS EN 10340:2007, [7.2.2.3](#)).

The chemical composition limits for the selected casting designation in BS EN 10340:2007, Table 1 should be taken into account if castings are to be welded. These should be taken into account when developing and qualifying weld procedures for cast steels (e.g. carbon equivalent values, sulphur limits, etc.).

Recommendations for the scope of testing and NDT acceptance levels are given in [14.1.2](#).

NOTE See [Annex C, C.5](#).

7.4 Welding consumables for weathering steels (see BS EN 1090-2:2018, Table 6 and 7.5.10)

Options 1, 2 and 3 in BS EN 1090-2:2018, Table 6 are suitable for the purposes of weather resistance and weldability.

C-Mn consumables may be used, but only for:

- a) single run fillet welds not exceeding 8 mm leg length using processes 135 and 121;
- b) butt welds using one run only per side; and
- c) the body of multi-pass fillet or butt welds except for the outer 3 mm thick surface zones of the cap, root and ends (excluding any overfill). The surface zones should be deposited using consumables conforming to options 1, 2 or 3.

NOTE See [Annex C, C.6](#).

7.5 Bolt assemblies (see BS EN 1090-2:2018, 5.6)

7.5.1 Preloaded bolting assemblies (see BS EN 1090-2:2018, 5.6.4)

The following products should be used for preloaded bolting assemblies using all tightening methods, except the HRC method:

- a) bolting assemblies conforming to BS EN 14399-3 (HR type); and
- b) nuts fully lubricated by the manufacturer after the nuts have been tapped (and, if relevant, after any coating passivation process has been completed). Lubricant coatings which are permanently liquid and could risk contamination of faying surfaces should not be used (lubricants such as dip spin applied dry film friction control fluid would be suitable, for example).

Bolts of property class 10.9 should not be used for assemblies tightened by the part turn method (see [10.2.6](#)).

Electroplated property class 10.9 bolting assemblies should not be used.

Cleaning of property class 10.9 bolting assemblies prior to hot dip galvanizing should be by blast cleaning and not by pickling.

Nuts of property class 10 may be used with bolts of property class 8.8.

NOTE See [Annex C, C.7](#).

7.5.2 Foundation bolts (see BS EN 1090-2:2018, 5.6.7)

Reinforcing steels should not be used for foundation bolts subject to applied tension forces.

7.5.3 Locking devices (see BS EN 1090-2:2018, 5.6.8 and 8.2.1)

Prevailing torque type nuts should not be used as a substitute for nuts conforming to [BS EN 14399](#) when used with bolts conforming to [BS EN 14399](#) in preloaded joints.

NOTE Preloaded assemblies installed and tightened in accordance with BS EN 1090-2:2018 are resistant to loosening.

7.5.4 Solid rivets for hot riveting (see BS EN 1090-2:2018, 5.6.10)

Solid rivets for hot riveting should conform to [BS 4620](#).

8 Preparation and assembly (see BS EN 1090-2: 2008+A1:2011, Clause 6)

8.1 Identification of components (see BS EN 1090-2:2018, 6.2)

A suitable identification system should identify each finished component to the documentation supplied for its constituent product(s).

NOTE Examples of types of documentation are given in BS EN 1090-2:2018, **12.2.1**, Note 1.

8.2 Marking methods (see BS EN 1090-2:2018, 6.2)

Hard stamps, punched or drilled marks may only be used for zones with a QSC of F56 and below.

Soft or low stress stamps may be used for zones with a QSC of F90 and below.

No type of marking process involving deformation of or removal of metal from the surface should be used for zones with a QSC of F112 and above.

Markings should be visible when steelwork is assembled and erected.

8.3 Quality of thermally cut surfaces (see BS EN 1090-2:2018, 6.4.3)

The quality of cut surfaces should conform to the requirements for EXC3/4.

8.4 Hardness of free edge surfaces (see BS EN 1090-2:2018, 6.4.4)

Free edge surfaces with hardnesses exceeding 380 (HV10) values should be ground, finished or machined until sufficient material has been removed such that the 380 (HV10) limit is not exceeded, subject to the following exceptions.

The hardness limit of 380 (HV10) is not applicable to machine plasma cut edges where all the following conditions are met:

- a) the steel grade does not exceed S420;
- b) plain edge surfaces are not subject to a QSC exceeding F71 [subject to c)];

- c) edge surfaces within 25 mm of stress raising features, such as re-entrant corners, openings, weld terminations on the edge not subject to a QSC exceeding F36; and
- d) edge surfaces are not subject to subsequent cold forming (unless fully fused over the full length and width by subsequent welding).

NOTE See [Annex C, C.8](#).

8.5 Flame straightening (see BS EN 1090-2:2018, 6.5.3.1 and 6.5.3.2)

Documented procedures for correction of distortion using flame straightening should be developed for all steel grades and for the following typical modes of distortion:

- a) an out-of-plane bow of a flat element;
- b) an in-plane bow of a flat element or a bow about the minor axis of an open section; and
- c) a bow about either axis of a hollow section or about the major axis of an open section.

The method of heating should be by oxy-fuel gas (acetylene recommended) using equipment with purpose made heating nozzles. The fuel gas mixture, nozzle size and arrangement, flame distance, heat zones and sequence of heating should be specified.

The surface temperature of the heated zones should be measured and controlled using a contact pyrometer or temperature sensitive crayons.

Maximum surface temperatures, according to the following material groups and delivery conditions, should not be greater than:

- 1) 625 °C for steels conforming to BS EN 10025-2, BS EN 10025-3, BS EN 10025-5 and [BS EN 10210](#), but excluding those supplied in the “+M” delivery condition [see [2](#)]; or
- 2) 550 °C for steels conforming to BS EN 10025-4, BS EN 10025-6 and [BS EN 10219](#), including any other steels supplied in the “+M” delivery condition.

The temperatures in [1](#)) and [2](#)) are irrespective of the temperatures reached during any flame straightening procedure trials.

The cooling phase down to 350 °C should be unassisted. Below this temperature, cooling may be assisted by an air blast. Quenching by water should not be used except where permitted for stainless steels [see BS EN 1090-2:2018, 6.5.3.2c)].

Passive restraints may be used during the heating cycle. Active application of force during the heating cycle, for example by jacking, should not be used.

For steel grades greater than S355, procedures should be qualified by applying the method to a test piece of appropriate form and known rolling direction, thickness and material grade.

Following completion of the qualification test and cooling to ambient temperature, a set of longitudinal tensile, impact and hardness tests should be taken from 2 mm below the material surface of the heated zone where the maximum specified temperature had been sustained for the longest period. The results, as tested in accordance with BS EN 10025-1, should demonstrate that the specified mechanical properties of the product have been maintained.

A conforming procedure qualification test should qualify procedures within the following limits:

- i) all material grades and subgrades up to and including those tested;
- ii) all element thicknesses up to and including that tested; and
- iii) the number of full thermal cycles per heat zone up to and including the number applied in the test.

Operators should be assessed and approved by the welding coordinator to ensure satisfactory understanding and capability of implementing the documented instruction for correction.

NOTE See [Annex C, C.9](#).

8.6 Execution of holing (see BS EN 1090-2:2018, 6.6.3)

8.6.1 Round holes for fasteners or pins

Round holes for fasteners or pins should be drilled, or be punched at least 2 mm undersize in diameter and reamed after punching, where any of the following conditions apply:

- a) the material thickness is greater than 3 mm;
- b) the QSC is F71 or higher;
- c) the joint is designed to be slip resistant; or
- d) the joint is designed to be preloaded.

NOTE See [Annex C, C.10](#).

8.6.2 Slotted holes

The restrictions on forming slotted holes should be as for round holes as set out in [8.6.1](#), except that:

- a) machining (e.g. reaming, milling) should be used to complete slotted holes formed by drilling or punching;
- b) hand thermal cutting of slotted holes should not be permitted in any material thickness; and
- c) slotted holes should not be permitted in zones with a QSC above F112.

8.7 Cut outs (see BS EN 1090-2:2018, 6.7)

8.7.1 Minimum radii

The minimum radius for re-entrant corners and notches should be 5 mm for QSC F56 and 10 mm for QSC F71 and above, subject to a smaller radius not being specified.

8.7.2 Punched cut outs

Punched cut outs should not be permitted where a QSC of F56 or above is required.

8.8 Assembly – Connections for temporary assembly components (see BS EN 1090-2:2018, 6.9)

Connections for temporary components which can affect the works in service, including the reinstatement or sealing of holes and the removal or otherwise of welded attachments, should be agreed with the designer before execution starts (see [9.4.3](#)).

8.9 Trial assembly (see BS EN 1090-2:2018, 6.10)

A full or staged trial assembly should be undertaken, where it is necessary to prove fit-up between components and critical dimensions especially where tolerances on overall geometry or joint fit-up are small. This applies particularly to bolted joints with butting faces.

A full or staged trial assembly of the superstructure should be undertaken where:

- a) erection operations are to be undertaken within restricted possession times;
- b) the vertical camber is critical to the correct dead weight stress distribution in continuous main girders, particularly in cable stayed or suspension bridges; and/or
- c) fit-up tolerances are small in latticed structures which contain heavy members and rigid joints.

The correction of hole alignment by reaming of bolted splices, selection of pack thicknesses, correction of weld preparation fit-up and correct positioning of temporary alignment cleats can be carried out during trial assembly.

The following factors should be taken into account:

- 1) support of the assembly parts should minimize self-weight stresses, where the unstressed camber profile is being checked;
- 2) correct alignment of assembly parts should be re-established in staged trial assembly;
- 3) differential temperature distributions throughout the steelwork should be controlled or allowed for if exposed to direct sunlight when surveys are made;
- 4) unique marking for identification and orientation of individual members should be used;
- 5) all shop welding should be complete;
- 6) all shop bolting should be complete; and
- 7) lack of fit between components should not be corrected by bolt tensioning.

These measures ensure that long range locked-in forces, beyond those allowed for in the design, are controlled within acceptable limits, e.g. incorrect dead load bending moment distribution in continuous girders.

9 Welding (see BS EN 1090-2:2018, Clause 7)

9.1 Quality management (see BS EN 1090-2:2018, 7.1, 7.2.2 and 7.3)

The quality requirements given in [BS EN ISO 3834](#) should conform to the requirements for EXC3/4. The exception to this is where quality requirements for EXC2 might be suitable for simple bridges of limited span using steel grades of S355 or below, provided a QSC of no more than F56 is required.

The quality requirements given in [BS EN ISO 3834](#) for EXC1 should not be applied to bridges.

The constructor should ensure that the range of bridge types for which their welding management systems have been approved are clearly defined on a schedule. The schedule should support any certification in terms of type and size of construction, material grades, product forms and thicknesses, execution processes and QSC.

NOTE See [Annex C, C.11](#).

When applying the conditions for welding cold formed zones in accordance with BS EN 1993-1-8:2005, **4.14**, Table 4.2, the “predominantly static loading” condition should be deemed to apply to a QSC of F56 and the “fatigue predominates” condition to QSCs of F71 and above.

Attention is drawn to the change in BS EN 1090-2:2018, **7.3**, which now states that any welding process listed in BS EN ISO 4063 may be used for structural steelwork. In BS EN 1090-2:2008+A1:2011, **7.3**, welding processes were restricted to those for which standards for weld procedure qualification were listed in Table 12 and Table 13 of that standard. There are at least 20 other basic types of welding process listed in BS EN 4063 which are capable of welding steel and for which the standards listed in BS EN 1090-2:2018 do not adequately cover key quality management activities. These include activities such as weld procedure specification, weld and welder procedure qualification, welding process control, testing, inspection and acceptance criteria. If such welding processes are to be used, the proposed welding facilities and personnel should undergo a review by a specialist in the process concerned prior to the selection of that process for the work.

9.2 Qualification of welding procedures (see BS EN 1090-2:2018, 7.4.1)

9.2.1 Tack welds (see BS EN 1090-2:2018, 7.4.1.1 and 7.5.7)

Tack welding procedures should be qualified as required by EXC2/3/4 in BS EN 1090-2:2018, 7.5.7. The welding procedure specification (WPS) should include the special deposition conditions and the tests described below.

The tolerances on cross section and length of the tack weld and any subsequent profiling requirements, such as feathering of ends, should be specified in the WPS.

To qualify the procedure for a tack weld where it is to be incorporated in the joint, the maximum permitted cross section of tack weld should be used in the qualification test. The positions of the ends of the tack weld should be marked on the test piece.

Macroscopic examination and hardness testing should be carried out within the tack weld length. This test should not be required if the original test for qualifying the complete weld includes the tack weld tested as described in this paragraph.

NOTE See [Annex C, C.12](#).

9.2.2 Methods of qualification (see BS EN 1090-2:2018, 7.4.1.2 and 7.4.1.3)

Methods of qualification should be in accordance with those permitted for EXC3/4 in BS EN 1090-2:2018, Table 12. Qualification by means of a standard welding procedure should not be permitted. For method of qualification of tack welds, see [9.2.1](#).

The welding coordinator should take account of the fact that some of the imperfection acceptance limits in BS EN 15614-1 are less restrictive than are required for factory production control (FPC) given in BS EN 1090-2:2018, 7.6, particularly for the higher EXCs. The limits given in BS EN 15614-1 might also be less restrictive than are required for fitness for purpose (FFP) given in [14.3.3](#), particularly for higher QSCs. In the latter case, the relevant WPS should be reviewed, together with the associated WPQR test record (where available), in order to establish whether any additional controls need to be added to the WPS to ensure that the FFP limits have an adequate probability of being met in production; for example, restrictions on tolerances for joint preparation/fit-up and welding parameters, and limitations on welding position. In cases of doubt that the FFP limits might not be met, a pre-production test of the joint concerned should be carried out, followed by a non-destructive and/or destructive examination, as appropriate, to provide the necessary assurance.

NOTE See [Annex C, C.13](#).

Alternatives to the cruciform tensile test to BS EN ISO 9018 for fillet welds on steel grades $\geq$ S460 should not be permitted.

Welding procedure qualification for welding process numbers 783, 784 and 786 should be carried out by a welding procedure test in accordance with [BS EN ISO 14555:2017, 10.2](#). For process 783, the examination and testing of test pieces should be carried out in accordance with [BS EN ISO 14555:2017, Table 1](#) for comprehensive quality requirements according to BS EN ISO 3834-2.

Fillet, partial penetration and full penetration tee joint welds should be qualified by a supplementary in-line butt weld procedure qualification record to demonstrate mechanical properties in accordance with [BS EN ISO 15614-1:2017, Table 2 footnote f](#).

9.2.3 Welded joints in reinforcing steel

Qualification testing for welded joints involving reinforcing steel should be carried out in accordance with BS EN ISO 17660-1, irrespective of whether a joint is nominally classified as “load” or “non-load” bearing.

NOTE See NA to BS EN 17660-1:2006, 3.2 and NA to BS EN ISO 17660-2:2006, 3.2.

9.3 Welding co-ordination (see BS EN 1090-2:2018, 7.4.3)

Welding co-ordination should conform to the requirements for EXC2/3/4. This Published Document gives no specific guidance on selection of execution class from BS EN 1090-2:2018, Table 14 and Table 15. This is because the level of technical knowledge of welding co-ordination personnel is decided by the certification body responsible for determining the conditions of certification of the constructor. This is in accordance with [BS EN ISO 3834](#) (see 9.1).

NOTE See [Annex C, C.14](#).

9.4 Preparation and execution of welding (see BS EN 1090-2:2018, 7.5)

9.4.1 Prefabrication primers: weld procedure tests (see BS EN 1090-2:2018, 7.5.1.1)

Where prefabrication primers are to be left on fusion faces or heat affected zones, the weld procedures should be tested in accordance with the requirements for EXC2/3/4.

9.4.2 Welded joints in hollow sections (see BS EN 1090-2:2018, 7.5.4, 7.5.8.1, 7.5.11 and Annex E)

The guidance on preparation, assembly and welding given in BS EN 1090-2:2018, Annex E should be applied. With regards to the assembly of hollow sections, attention should be paid to the following points.

- a) Adequate access for penetration to the root in the case of full penetration butt welds. Where access is restricted, a pre-production welding test conforming to BS EN ISO 15613 should be conducted using the tolerances on preparation and fit-up that give the most restricted access, to demonstrate that the required penetration can be achieved.
- b) Compensation for loss of throat and leg length in the case of fillet welded joints with root gaps (see also BS EN 1090-2:2018, 7.5.8.1).

9.4.3 Temporary attachments: use and removal (see BS EN 1090-2:2018, 7.5.6)

In accordance with EXC3/4, restrictions on the use of temporary attachments should conform to a) to c).

- a) Temporary welded attachments should not be used in zones of QSCs F112 and above.
- b) Except where excluded in c), removal of temporary welded attachments by thermal cutting, gouging and chipping may be used provided that the finished cut surface of the remainder of the attachment is at least 3 mm from the permanent member surface prior to grinding smooth. Remnants of temporary materials proud of the original member surface should be removed by grinding parallel to the member axis and the ground surface checked for freedom from cracking using magnetic particle testing.

NOTE See [Annex C, C.15](#).

- c) Gouging and chipping should not be used on steel grades $\geq$ S460 or where a QSC of F71 or above applies.

9.4.4 Butt weld run-on/run-off pieces (see BS EN 1090-2:2018, 7.5.9.1)

Run-on and run-off pieces should be used on all butt welds and should conform to the requirements for EXC2/3/4, where access allows.