
SERIES 1800
STRUCTURAL STEELWORK

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STRUCTURAL STEELWORK

1800 (08/14) General

1800.1 (08/14) Introduction and Basis of Execution

- 1 (08/14) This Series is part of the Specification for Highway Works. Whilst this Series is particularly relevant to the subject matter in its title it must be read in conjunction with the general requirements in Series 000 and 100 and with all other Series relevant to the specification for the particular Works to be undertaken.
- 2 (08/14) The Contractor shall supply and install all structural steelwork in accordance with this Series. Any requirement to be fulfilled by the constructor in this Series and Appendix 18/1 is a requirement on the Contractor.
- 3 (08/14) The terms 'execution' and 'constructor' have been used throughout this Series to be compatible with the terms used in BS EN 1090-2:2008+A1:2011.
- 4 (08/14) The basis for the execution of structural steelwork in this Series shall be BS EN 1090-2:2008+A1:2011, with options and requirements described in this Series (see 1800.3).

1800.2 (08/14) Clause Numbering

- 1 (08/14) The clause and sub-clause numbering and headings in Clauses 1801 to 1812 in this Series adopt those in BS EN 1090-2:2008+A1:2011, Clauses 1 to 12 respectively except that the clause numbers are pre-fixed by '180' for Clauses 1 to 9 and '18' for Clauses 10, 11 and 12.
- 2 (08/14) The numbering of paragraphs in this Series bears no specific relationship to the order of paragraphs presented in BS EN 1090-2:2008+A1:2011.
- 3 (08/14) Cross reference to a specific paragraph within this Series is by sub-clause number followed by the paragraph number in brackets where appropriate.

1800.3 (08/14) Options and Requirements

- 1 (08/14) Where the requirements specified in BS EN 1090-2:2008+A1:2011 are to apply to this Series without amendment, the heading of the related sub-clause in this Series is followed by the abbreviation (AEN) (i.e. as in BS EN 1090-2:2008+A1:2011).
- 2 (08/14) Where there is a choice between two or more different requirements in a sub clause in BS EN 1090-2:2008+A1:2011 the selected requirement(s) shall be as described in this Series. All other requirements in that sub-clause in BS EN 1090-2:2008+A1:2011 shall apply to this Series unless otherwise described in this Series.
- 3 (08/14) Where requirements are described in this Series, the requirements in the related sub-clause in BS EN 1090-2:2008+A1:2011 shall also apply to this Series unless otherwise described in this Series.
- 4 (08/14) Where Appendix 18/1 shall be referred to for any contract specific requirements, the heading of the sub-clause in this Series is followed by the abbreviation (18/1).
- 5 (08/14) Where a requirement in BS EN 1090-2:2008+A1:2011 is qualified in that standard by the words 'unless otherwise specified', the requirement shall not be amended unless it is described otherwise in this Series or in Appendix 18/1.

1800.4 (08/14) Qualification of Constructors

- 1 (08/14) In order to satisfy the general assumptions stated in BS EN 1990:2002+A1:2005, 1.3(2) relating to the execution of structures designed to the Eurocodes, all structural steelwork executed in accordance with this Series shall be undertaken by a constructor which has the necessary technical capability and competence for the type and value of work to be undertaken. These requirements will be satisfied by registration and audit through a registration scheme such as the Register of Qualified Steelwork Contractors Scheme for Bridgeworks (RQSC, see www.steelconstruction.org) to the levels appropriate for the value and technical complexity of the structural steelwork.

2 (08/14) The constructor shall undertake a review to confirm that their technical capability and competence is sufficient for the execution of the works described in Appendix 18/1. The review shall be documented and shall be submitted for the approval of the Overseeing Organisation in advance of execution. The documented review shall be treated as an execution record and shall form part of the execution documentation (see 1804.2.2 and 1804.2.4). The review shall include supporting evidence that shall include but not be limited to:

- details demonstrating compliance with 1800.4 (1) and 1800.5.1 (1)
- type and size of construction works;
- product forms and thicknesses;
- material grades;
- execution processes;
- level of welding control in accordance with the relevant part of BS EN ISO 3834:2005; and
- quantified service categories.

1800.5 (08/14) Quality management schemes

1800.5.1 (08/14) Execution of steelwork

1 (08/14) In order to satisfy the requirements stated in BS EN 1990:2002+A1:2005, 2.5 relating to quality management measures in the execution of structures designed to the Eurocodes, the constructor shall have an independently certified quality management system complying with EN ISO 9001 in place for all structural steelwork executed in accordance with this Series. This requirement will be satisfied by the constructor being registered to National Highway Sector Scheme 20 'The Execution of Steelwork in Transportation Infrastructure Assets', as described in Appendix A.

1800.5.2 (08/14) Supply of mechanical fasteners

1 (08/14) The requirements described in 1812.2.1 (2) for the verification of mechanical fasteners will be satisfied through mechanical fasteners being supplied by an Organisation registered to National Highway Sector Scheme 3 'Stocking and Distribution Activities for Mechanical Fasteners', as described in Appendix A.

1800.6 (08/14) CE Marking

1800.6.1 (08/14) General

1 (08/14) Conformity assessment of structural steel components shall be undertaken in accordance with BS EN 1090-1:2009+A1:2011. A declaration of performance under a CE mark in accordance with the Construction Products Regulations shall be provided for all structural steel components. The declaration of performance shall include a declaration of Structural Characteristics in accordance with 1800.6.2 (1).

1800.6.2 (08/14) Declaration of structural characteristics

1 (08/14) In the property declaration for 'Structural Characteristics' of a structural steel component, the entry for 'Manufacturing' shall read as follows:

'According to component specification "X", which specifies the relevant EN 1090-2 requirements and execution class(es).

where:

"X" is the component specification reference defined in 1800.6.3(1).

1800.6.3 (08/14) Component specification reference (18/1)

1 (08/14) The component specification reference to be adopted for the conformity assessment of a structural steel component shall be as identified in Appendix 18/1.

1800.6.4 (08/14) Component specification

- 1 (08/14) The component specification for a structural steel component shall comprise the following:
- this Series,
 - Appendix 18/1.

1801 (08/14) Scope

- 1 (08/14) This Series shall apply to the execution of all permanent structural steelwork, and to all temporary structural steelwork required for the execution of the permanent structural steelwork.

1802 (08/14) Normative References

1802.1 (08/14) General

- 1 (08/14) For normative references not given in BS EN 1090-2:2008+A1:2011 see Appendix F.

1802.2 (08/14) Constituent products

1802.2.1 (08/14) Steels (AEN)

1802.2.2 (08/14) Steel castings (AEN)

1802.2.3 (08/14) Welding consumables (AEN)

1802.2.4 (08/14) Mechanical fasteners

- 1 (08/14) For normative references not given in BS EN 1090-2:2008+A1:2011 see Appendix F.

1802.2.5 (08/14) High strength cables (AEN)

1802.2.6 (08/14) Structural bearings

- 1 (08/14) For normative references not given in BS EN 1090-2:2008+A1:2011 see Appendix F.

1802.3 (08/14) Preparation (AEN)

1802.4 (08/14) Welding

- 1 (08/14) For normative references not given in BS EN 1090-2:2008+A1:2011 see Appendix F.

1802.5 (08/14) Testing

- 1 (08/14) For normative references not given in BS EN 1090-2:2008+A1:2011 see Appendix F.

1802.6 (08/14) Erection (AEN)

1802.7 (08/14) Corrosion protection (AEN)

1802.8 (08/14) Tolerances (AEN)

1802.9 (08/14) Miscellaneous (AEN)

1803 (08/14) Terms and Definitions

- 1 (08/14) Quantified service category: Category that characterises a component or structure (or part thereof) in terms of the circumstances of its use within specified limits of static and cyclic stressing. Quantified service category is designated by one of the symbols F36, F56, F71, F90, F112 or F140. (See also 1804.1.1(2) and 1804.1.1 (3))
- 2 (08/14) Factory production control: (Abbreviated to FPC in this Series) The documented, permanent and internal control of production in a factory, in accordance with BS EN 1090-1:2009+A1:2011, 6.3.
- 3 (08/14) Inspection lot (for mechanical fasteners): As defined in BS EN ISO 3269:2001

1804 (08/14) Specifications and Documentation

1804.1 (08/14) Execution specification

1804.1.1 (08/14) General (18/1)

- 1 (08/14) The execution specification for structural steelwork shall comprise the following:
 - this Series,
 - Appendix 18/1.
- 2 (08/14) Certain requirements in this Series are differentiated on the basis of quantified service category (see 1803 (1)). These are given in the following sub-clauses:
 - 1805.3.3 Surface conditions of steel products
 - 1805.3.4 Special properties of steel products
 - 1806.2 Identification marks
 - 1806.4.4 Free edge hardness
 - 1806.6.3 Execution of holing
 - 1806.7 Cut outs
 - 1807.4.1.2 Qualification of welding procedures
 - 1807.5.6 Temporary attachments
 - 1807.5.9.2 Single side weld permanent backing
 - 1807.5.17 Execution of welding
 - 1807.6 Acceptance criteria for FPC
 - 1812.4.2.2 Scope of specific weld inspection
 - 1812.4.2.3 Final visual acceptance criteria for welds
 - 1812.4.2.4 Final MT, PT, UT and RT acceptance criteria for welds
 - 1812.4.4 Production tests on welding
- 3 (08/14) Where requirements are differentiated on the basis of quantified service category, the quantified service category for a component or structure (or part thereof) is identified in Appendix 18/1.

1804.1.2 (08/14) Execution classes

- 1 (08/14) Certain technical requirements in BS EN 1090-2:2008+A1:2011 are differentiated on the basis of execution class. Where this Series, including Appendix 18/1, specifies a requirement which is common to more than one execution class all relevant execution classes are indicated. For example, if the specified requirement is the same for EXC2, EXC3 and EXC4 this is designated EXC2/3/4.

1804.1.3 (08/14) **Preparation grades (AEN)**

1804.1.4 (08/14) **Geometrical tolerances (AEN)**

1804.2 (08/14) **Constructor's documentation**

1804.2.1 (08/14) **Quality documentation**

1 (08/14) Quality documentation shall conform to the requirements for EXC2/3/4.

1804.2.2 (08/14) **Quality plan**

1 (08/14) A quality plan for the execution of the works is required and shall include the items recommended in BS EN 1090-2:2008+A1:2011, Annex C and 1809.4.1(1).

2 (08/14) The execution records shall include the constructor's drawings (including electronic files) for the execution of all components.

3 (08/14) The constructor's drawings (including electronic files) shall include the quantified service category and unique component mark information.

4 (08/14) Constructor's drawings in this Series shall be treated as fabrication drawings in accordance with Series 100.

5 (08/14) Execution records described in this Series shall be treated as quality records in accordance with Series 100.

1804.2.3 (08/14) **Safety of erection works (AEN)**

1804.2.4 (08/14) **Execution documentation (AEN)**

1805 (08/14) **Constituent Products**

1805.1 (08/14) **General (AEN) (18/1)**

1805.2 (08/14) **Identification, inspection documents and traceability**

1 (08/14) Inspection documents for steel grades S355 JR and JO shall conform to the requirements for EXC2/3/4 in BS EN 1090-2:2008+A1:2011, Table 1, note a.

2 (08/14) Stages of traceability shall conform to the requirements for EXC3/4.

3 (08/14) Specialist proprietary and/or bespoke products incorporating non-standardised features, components or methods of manufacture, eg castings, forgings, cables and their terminations, energy absorbing devices, mechanical components such as movement joints and major bearings shall be uniquely traceable.

4 (08/14) The identification of different grades and/or qualities of constituent products shall conform to the requirements for EXC2/3/4.

1805.3 (08/14) **Structural steel products**

1805.3.1 (08/14) **General (18/1)**

1 (08/14) Option 3 in BS EN 10025-1:2004, 7.3.2.2 allowing Charpy quality to be verified at a temperature above the lowest test temperature shall not be adopted.

1805.3.2 (08/14) **Thickness tolerances**

1 (08/14) Thickness tolerance Class A shall be used.

1805.3.3 (08/14) Surface conditions (18/1)

1 (08/14) For plates and wide flats, EXC3/4 shall apply and more stringent surface conditions shall be required as follows. Class A3 and class B3 to BS EN 10163-2 shall apply in all circumstances, except that class A2 and class B2 may be adopted where:

- steels are not specified to BS EN 10025-6;
- the quantified service category is F90 or less;
- reports on weld repairs are submitted;
- UT and MPI are used for inspection of weld repairs; and
- weld repairs are rechecked on delivery for quantified service categories F71 and above.

2 (08/14) For sections, the special restrictions on surface imperfections and repair shall conform to BS EN 10163-3 as follows:

- cracks, shells and seams in sections shall be repaired in all circumstances;
- class C3 and class D3 require no special restrictions;
- class C2 and class D2 shall have the same restrictions in use as for plates to class A2 and class B2, in 1805.3.3(1);
- class C1 and class D1 shall be restricted to quantified service category F36.

3 (08/14) Steel with pitted surfaces, ie rust grades C and D according to BS EN ISO 8501-1:2007 shall not be used.

1805.3.4 (08/14) Special properties (18/1)

1 (08/14) The following requirements shall apply to cross plates in welded cruciform and welded tee joints transmitting primary stresses through the plate thickness on a band of width four times the thickness of the plate each side of the proposed attachment.

- for quantified service category F56, the internal discontinuity quality class shall conform to the requirements for EXC3/4;
- for quantified service category F71 and above, BS EN 10160 internal discontinuity class S₂ shall be used;

2 (08/14) Flange or web plates close to bearing diaphragms and /or single sided bearing stiffeners, where attached by welding, shall be checked for conformance to BS EN 10160 internal discontinuity quality class S₁ in the areas defined in BS EN 1090-2:2008+A1:2011, 5.3.4.

3 (08/14) The precautions necessary to avoid lamellar tearing in tee, cruciform and corner joints shall be decided by the constructor, whether or not improved deformation properties have been specified for the through plates.

1805.4 (08/14) Steel castings (AEN) (18/1)

1805.5 (08/14) Welding consumables

1 (08/14) As an alternative to the consumables in BS EN 1090-2:2008+A1:2011, Table 18/6, C-Mn consumables may be used for welding steels supplied to EN 10025-5, but only for:

- single run fillet welds not exceeding 8mm leg length using processes 135 and 121;
- butt welds using one run only per side;
- the body of multi-pass butt welds except for the outer 3mm thick surface zones of the cap, root and ends (excluding any overfill). The surface zones shall be deposited using consumable conforming to options 1, 2 or 3 of BS EN 1090-2:2008+A1:2011, Table 18/6. (See also BS EN 1090-2:2008+A1:2011, 7.5.10).

1805.6 (08/14) Mechanical fasteners

1805.6.1 (08/14) General (AEN)

1805.6.2 (08/14) Terminology

1 (08/14) The 'part-turn' method of tightening of preloaded fasteners is similar to the 'combined method' in BS EN 1090-2:2008+A1:2011. However it is restricted to Grade 8.8 assemblies, but class K_o assemblies may also be used. It has reduced torque values in the first step and higher nut rotations in the second step (see 1808.5.1(5)).

1805.6.3 (08/14) Structural bolting assemblies for non-preloaded applications (AEN) (18/1)

1805.6.4 (08/14) Structural bolting assemblies for preloading (18/1)

1 (08/14) The following products shall be used for preloaded bolt assemblies using all tightening methods, except the HRC method:

- bolt assemblies conforming to BS EN 14399-3 (HR type);
- nuts lubricated by the manufacturer after the nuts have been tapped (and, if relevant, after any coating passivation process has been completed).

2 (08/14) Electroplated property class 10.9 bolt assemblies shall not be used.

3 (08/14) Cleaning of property class 10.9 bolts prior to hot dip galvanising shall be by blast cleaning and not by pickling.

4 (08/14) Nuts of property class 10 shall be used with bolts of property class 8.8.

5 (08/14) Bolts of property class 10.9 shall not be used for assemblies tightened by the part turn method (see 1808.5.1 (4) and (5)).

1805.6.5 (08/14) Direct tension indicators (AEN)

1805.6.6 (08/14) Weather resistant assemblies

1 (08/14) The chemical composition of weather resistant assemblies shall comply with the requirements for Type 3 fasteners to ASTM standard A325, Grade A, or equivalent.

1805.6.7 (08/14) Foundation bolts (18/1)

1 (08/14) Reinforcing steels shall not be used for foundation bolts carrying applied tension forces.

1805.6.8 (08/14) Locking devices (AEN) (18/1)

1805.6.9 (08/14) Washers (AEN)

1805.6.9.1 (08/14) Plain washers (AEN)

1805.6.9.2 (08/14) Taper washers (AEN)

1805.6.10 (08/14) Hot rivets (AEN)

1805.6.11 (08/14) Fasteners for thin gauge components (AEN) (18/1)

1805.6.12 (08/14) Special fasteners (AEN) (18/1)

1805.6.13 (08/14) Delivery and identification

1 (08/14) See 1800.5.2 (1).

1805.7 (08/14) Studs and shear connectors

1 (08/14) Headed stud connectors shall be Type SD1 in accordance with BS EN ISO 13918:2008.

1805.8 (08/14) Grouting materials (18/1)

1 (08/14) Bedding mortars shall conform to the requirements of Series 2600, Clause 2601.

1805.9 (08/14) Expansion joints for bridges

1 (08/14) Expansion joints shall conform to the requirements of Series 2300, Clause 2301 and contract specific Appendix 23/1.

1805.10 (08/14) High strength cables, rods and terminations (AEN) (18/1)

1805.11 (08/14) Structural bearings (18/1)

1 (08/14) The guidance given in PD 6703:2009 on the execution of bearings shall be followed, where relevant.

1806 (08/14) Preparation and Assembly

1806.1 (08/14) General (AEN)

1806.2 (08/14) Identification (18/1)

1 (08/14) Identification of components shall conform to the requirements for EXC3/4.

2 (08/14) Hard stamps, punched or drilled marks shall not be used for zones with a quantified service category of F71 and above.

3 (08/14) Soft or low stress stamps may be used for zones with a quantified service category of F90 and below.

4 (08/14) No method of marking involving deformation or removal of metal shall be used for zones with a quantified service category of F112 and above.

1806.3 (08/14) Handling and storage (AEN)

1806.4 (08/14) Cutting

1806.4.1 (08/14) General (AEN)

1806.4.2 (08/14) Shearing and nibbling (AEN)

1806.4.3 (08/14) Thermal cutting

1 (08/14) The quality of cut surfaces shall conform to the requirements for EXC2/3.

1806.4.4 (08/14) Hardness of free edge surfaces (18/1)

1 (08/14) Free edge surfaces with hardnesses exceeding 380HV10 values shall be ground, finished or machined until sufficient material has been removed such that the 380HV10 limit is not exceeded, subject to the exceptions in 1806.4.4(2).

2 (08/14) Unless prohibited in Appendix 18/1, the hardness limit described in 1806.4.4(1) need not apply to machine plasma cut edges where:

- a) the steel grade does not exceed S420;
- b) plain edge surfaces are not subject to a quantified service category exceeding F71 [subject to c)];
- c) edge surfaces within 25mm of stress raising features such as re-entrant corners, openings, weld terminations on the edge that are not subject to a quantified service category exceeding F36;

- d) edge surfaces are not subject to subsequent cold forming (unless fully fused over the full length and width by subsequent welding); and
- e) procedure tests have been carried out to verify that the proposed method of surface preparation of the plasma cut edge can readily achieve the cleanliness and profile described in Series 1900, where corrosion protection of the edges is required.

1806.5 (08/14) Shaping (AEN)

1806.5.1 (08/14) General (AEN)

1806.5.2 (08/14) Hot forming (AEN)

1806.5.3 (08/14) Flame straightening

1 (08/14) A suitable procedure shall be developed in accordance with the requirements for EXC3/4 and shall include the following:

- the materials being used for procedure approval purposes shall be of a higher grade and subgrade than that used in the component being straightened;
- for destructive tests, any reduction in tensile strength shall not exceed 5% of the original value and any reduction in Charpy energy shall not exceed 10% of the original value at the same test temperature.

1806.5.4 (08/14) Cold forming (AEN) (18/1)

1806.6 (08/14) Holing

1806.6.1 (08/14) Dimensions of holes (AEN) (18/1)

1806.6.2 (08/14) Tolerances on hole diameter for bolts and pins (AEN)

1806.6.3 (08/14) Execution of holing

1 (08/14) For material 3mm thick or less with a quantified service category of less than F71, round holes for fasteners or pins may be formed by punching without reaming as permitted for EXC1/2. For material 3mm thick or less with a quantified service category of F71 and above, round holes for fasteners or pins shall be drilled or be punched at least 2mm undersize in diameter and reamed after punching.

2 (08/14) For material thicker than 3mm, round holes for fasteners or pins shall be drilled or be punched at least 2mm undersize in diameter and reamed after punching in accordance with the requirements for EXC3/4.

3 (08/14) For slotted holes the methods given in Table 18/1 may be used up to the maximum quantified service categories and thicknesses given in Table 18/1.

(08/14) **Table 18/1 Method for slotted holes**

| Method | Maximum quantified service category | Maximum thickness, mm |
|--|-------------------------------------|-----------------------|
| Punching and hand thermal cutting | F36 | - |
| Punching in a single operation Thermal cutting by machine | F56 | 15 |
| Drilling and/or milling | F112 | - |

1806.7 (08/14) Cut outs (18/1)

- 1 (08/14) The minimum radius for re-entrant corners and notches in all thicknesses of material shall conform to the requirements for EXC2/3, except for quantified service category F71 and above when the requirement for EXC4 shall apply (when the stress direction is in the plane of the radius), subject to a smaller radius not being described in Appendix 18/1. If Form B in BS EN 1090-2:2008+A1:2011, 6.7 is to be used, the design shall be verified for the loss of section.
- 2 (08/14) The restriction on the use of punched cut outs required for EXC4 shall apply where:
 - quantified service categories F56 and above are required;
 - materials conforming to BS EN 10025-6 are used.

1806.8 (08/14) Full contact bearing surfaces (AEN) (18/1)

1806.9 (08/14) Assembly (18/1)

- 1 (08/14) Elongations of holes by drifting shall be limited according to the tolerance class for EXC1/2 when applied to non-preloaded connected parts. The tolerance class for EXC3/4 shall apply to preloaded connected parts.
- 2 (08/14) All connections for temporary components shall be executed in accordance with the requirements of this Series including those described in Appendix 18/1, according to the quantified service category appropriate to the connection location. (See also 1807.5.6)
- 3 (08/14) Connections for temporary components shall not result in the removal or addition of permanent material, or introduce permanent notches unless permitted by Appendix 18/1.

1806.10 (08/14) Assembly check (18/1)

- 1 (08/14) Where a full or staged trial assembly is undertaken 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 shall be carried out at that time.
- 2 (08/14) The following shall be taken into account:
 - support of the assembly parts to minimise dead weight deflections;
 - correct re-establishment of the alignment of assembly parts in staged trial assembly;
 - control of, or allowance for, differential temperature distributions throughout the steelwork if exposed to direct sunlight when surveys are made;
 - unique marking for identification and orientation of individual members.

1807 (08/14) Welding

1807.1 (08/14) General (18/1)

- 1 (08/14) The BS EN ISO 3834 quality requirements shall conform to the requirements for EXC3/4, unless EXC2 is required by Appendix 18/1.
- 2 (08/14) Permanent welds that are not described in Appendix 18/1 shall not be permitted.

1807.2 (08/14) Welding plan

1807.2.1 (08/14) Requirements for a welding plan (AEN)

1807.2.2 (08/14) Content of a welding plan (AEN)

1807.3 (08/14) Welding processes (AEN)

1807.4 (08/14) Qualification of welding procedures and welding personnel

1807.4.1 (08/14) Qualification of welding procedures

1807.4.1.1 (08/14) General

- 1 (08/14) Where tack welds are used in the root of a preparation, a weld procedure specification (WPS) shall be produced for this specific condition. The tolerances on size and length of the tack weld and any subsequent profiling requirements shall be specified in the WPS. The WPS shall state whether the tack weld is intended to be fully re-melted by the root run or not.
- 2 (08/14) If the tack weld is to be removed prior to welding of the joint, the minimum permitted size of tack weld shall be subject to a welding procedure test in accordance with BS EN ISO 15614-1.
- 3 (08/14) If the tack weld is to be left in the joint, the maximum cross section of tack weld shall be used and the root and subsequent passes shall be deposited until such time as the root pass is fully covered. The full length of the tack weld location shall be subjected to a welding procedure test in accordance with BS EN ISO 15614-1 (see Table 18/11, footnote A).
- 4 (08/14) The tack weld shall be assumed to be a fillet weld for the purposes of qualification.

1807.4.1.2 (08/14) Qualification of welding procedures for processes 111, 114, 12, 13 and 14

- 1 (08/14) Methods of qualification shall be in accordance with those permitted for EXC3/4 in BS EN 1090-2:2008+A1:2011, Table 12.
- 2 (08/14) The weld procedure qualification acceptance levels in BS EN ISO 15614-1 are less stringent in some respects than those required for FPC for EXC3/4 (see BS EN 1090-2:2008+A1:2011, 7.6). Also, for the highest quantified service categories, the acceptance limits for certain imperfection types are more stringent than for EXC4 (see 1812.4.2.3 and 1812.4.2.4). If either of these criteria are being used for FPC the relevant weld procedure qualification acceptance levels shall be amended. Existing procedures qualified to BS EN ISO 15614-1 shall be re-qualified accordingly by reference to the original test results, if possible. If this cannot be done, or the original results do not conform to the more stringent requirements, the relevant qualification tests for evaluation of imperfections shall be repeated.
- 3 (08/14) Joints with restricted access for welding (eg slot and plug welds, shallow angle branch connections), shall be subject to procedure testing in accordance with BS EN ISO 15613.

1807.4.1.3 (08/14) Qualification of welding procedures for other welding processes (processes 21, 22, 23, 24, 42, 52, 783 and 784)

- 1 (08/14) Welding procedure qualification for welding process reference numbers 783 and 784 shall conform to the requirements for EXC3/4 in BS EN 1090-2:2008+A1:2011, Table 13, note a.

1807.4.1.4 (08/14) Validity of a welding procedure qualification

- 1 (08/14) Welding production tests shall be carried out in accordance with the qualification standard for the process concerned.

1807.4.2 (08/14) Welders and welding operators

- 1 (08/14) Welders shall be qualified by specific test for welding of joints with restricted access (see 1807.4.1.2 (3)).

1807.4.3 (08/14) Welding co-ordination

- 1 (08/14) Welding co-ordination shall conform to the requirements for EXC2/3/4.

1807.5 (08/14) Preparation and execution of welding

1807.5.1 (08/14) Joint preparation

1807.5.1.1 (08/14) General

1 (08/14) Where prefabrication primers are to be left on fusion faces, the weld procedures shall be tested in accordance with the requirements for EXC3/4.

1807.5.1.2 (08/14) Hollow sections (AEN)

1807.5.2 (08/14) Storage and handling of welding consumables (AEN)

1807.5.3 (08/14) Weather protection (AEN)

1807.5.4 (08/14) Assembly for welding

1 (08/14) The guidance on preparation, assembly and welding of joints in hollow sections given in BS EN 1090-2:2008+A1:2011, Annex E shall be applied. In addition for the assembly of hollow sections the following shall apply:

- In the case of a full penetration butt weld where access is restricted, a pre-production welding test conforming to BS EN ISO 15613 shall be conducted to demonstrate that the full penetration butt weld can be achieved,
- In the case of fillet welded joints with root gaps, compensation shall be made for loss of throat and leg length (see BS EN 1090-2:2008+A1:2011, 7.5.8.1).

1807.5.5 (08/14) Preheating (AEN)

1807.5.6 (08/14) Temporary attachments (18/1)

1 (08/14) Temporary welded attachments shall not be permitted in zones of quantified service categories F112 and above, or within 25mm of an edge, or where described in Appendix 18/1.

2 (08/14) The use of temporary welded attachments shall be specified as required for EXC3/4.

3 (08/14) Restrictions on the removal of temporary welded attachments shall be in accordance with the requirements for EXC3/4 for thermal cutting and chipping, except that thermal cutting may be used provided that the finished cut surface is at least 3mm proud of the permanent member surface. Remnants of temporary materials proud of the permanent member surface shall be removed by grinding parallel to the member axis and the ground surface checked for freedom from cracking using magnetic particle testing.

1807.5.7 (08/14) Tack welds

(08/14) Tack welds shall be made using qualified welding procedures as required for EXC2/3/4 (see 1807.4.1.1).

1807.5.8 (08/14) Fillet welds (AEN)

1807.5.8.1 (08/14) General (AEN)

1807.5.8.2 (08/14) Fillet welds for thin gauge components (AEN)

1807.5.9 (08/14) Butt welds

1807.5.9.1 (08/14) General (18/1)

1 (08/14) Run-on and run-off pieces shall be used on all butt welds and shall conform to the requirements for EXC3/4, where access allows.

2 (08/14) Where a weld surface is required to be ground or machined flush, this shall be executed prior to non-destructive testing.

1807.5.9.2 (08/14) Single sided welds (18/1)

1 (08/14) Permanent steel backing shall only be used if described in Appendix 18/1. The continuity of permanent steel backing shall conform to the requirements for EXC3/4. The execution of the continuity weld shall depend upon the quantified service category related to stresses parallel to the axis of the backing component, as follows:

- F36: no additional requirements;
- F56 to F90: make continuous by full penetration butt weld at any stage, followed by surface crack detection;
- F112 to F140: make continuous by full penetration butt weld, followed by flush grinding and surface crack detection before assembly.

1807.5.9.3 (08/14) Back gouging (AEN)

1807.5.10 (08/14) Welds on steels with improved atmospheric corrosion resistance

1 (08/14) The requirements for the consumables to be used for welds on steels with improved atmospheric corrosion resistance are given in 1805.5.

1807.5.11 (08/14) Branch connections (AEN)

1807.5.12 (08/14) Stud welding

1 (08/14) With reference to BS EN ISO 14555:2006, Annex B Table B.1, the comprehensive quality requirements in accordance with ISO 3834-2 shall be adopted.

1807.5.13 (08/14) Slot and plug welds (18/1)

1 (08/14) The depth-to-minimum width ratio of the slot or plug hole shall not exceed that used for the weld procedure qualification test.

1807.5.14 (08/14) Spot welds for thin gauge components

1807.5.14.1 (08/14) Arc spot welds (AEN) (18/1)

1807.5.14.2 (08/14) Resistance spot welds (AEN)

1807.5.15 (08/14) Other weld types (AEN) (18/1)

1807.5.16 (08/14) Post weld heat treatment (AEN)

1807.5.17 (08/14) Execution of welding (18/1)

1 (08/14) The requirements for removal of weld spatter shall conform to the requirements for EXC3/4 except where permitted in Tables 18/7 and 18/8. The requirements for EXC3/4 shall apply to exposed steels to BS EN 10025-5 and BS EN 10088-1.

2 (08/14) The direction of grinding of the surfaces of completed welds shall be parallel to the stress direction for welds with a quantified service category of F90 and above.

1807.5.18 (08/14) Welding of bridge decks (AEN)

1807.6 (08/14) Acceptance criteria

1 (08/14) Acceptance criteria for FPC shall not be to a lower standard than that required for specific testing of the work, taking into account the method of testing and maximum quantified service category required for the work (See 1812.4.2.3 and 1812.4.2.4 for acceptance levels for specific testing).

1807.7 (08/14) Welding of stainless steels

1807.7.1 (08/14) Amendments to EN 1011-1 requirements (AEN)

1807.7.2 (08/14) Amendments to EN 1011-3 requirements (18/1)

1 (08/14) Coloured oxide films shall be removed.

2 (08/14) Copper backing shall be nickel or chromium plated and when high heat input is used it shall be water cooled.

1807.7.3 (08/14) Welding dissimilar steels (AEN) (18/1)

1808 (08/14) Mechanical Fastening

1808.1 (08/14) General (AEN)

1808.2 (08/14) Use of bolting assemblies

1808.2.1 (08/14) General (18/1)

1 (08/14) Welding of nuts, bolts or washers shall not be used on bolt assemblies above property class 4.6. Welding of property class 4.6 nuts, bolts and washers shall only be undertaken where described in Appendix 18/1 and shall be subject to the requirements in 1807, 1812.4 and BS EN 1090-2:2008+A1:2011, 7.

1808.2.2 (08/14) Bolts (AEN) (18/1)

1808.2.3 (08/14) Nuts (AEN)

1808.2.4 (08/14) Washers (18/1)

1 (08/14) Washers shall be placed under the nut or head of the bolt in non-preloaded assemblies whichever is rotated.

1808.3 (08/14) Tightening of non-preloaded bolts (AEN) (18/1)

1808.4 (08/14) Preparation of contact surfaces in slip resistant connections (18/1)

1 (08/14) All surfaces which overlap each other in the final assembled connection excluding any painted edge strip around the perimeter of the connection described in Series 1900, 1906 shall be deemed to be 'contact surfaces'.

2 (08/14) The specified surface treatment applied to the friction surfaces shall be maintained until the surfaces are brought together and the connection assembled.

1808.5 (08/14) Tightening of preloaded bolts

1808.5.1 (08/14) General (18/1)

1 (08/14) At the snug tight stage, the exposed surfaces of the components being connected shall be aligned within 1mm where they emerge from beneath the cover plate(s) at the joint plane. This is subject to the tolerances of thickness difference between the two components (including any packing plates) in BS EN 1090-2:2008+A1:2011, 8.1 also being met. If this is exceeded, steel packing plates shall be used.

2 (08/14) In the case of preloaded lap joints subject to axial load only in the plane of the friction surfaces, the out of plane bending stiffness of cover plates may need to be limited to achieve adequate contact between friction surfaces. Measures to limit the out-of-plane bending stiffness of cover plates shall be as described in Appendix 18/1. Additional contact surfaces shall be treated as contact surfaces in slip resistant connections.

3 (08/14) Where a connection is designed to transfer applied tensile forces through a flanged and bolted end plate, as a minimum, the area of the mating surfaces in direct line with the tension member cross section shall be in contact when all bolts are snug tight. Any remaining gaps in this zone shall be filled by steel shims prior to the application of the remaining preload. If necessary, bolts can be partially slackened to enable shims to be inserted. The shims shall not be loose in the final snug tight stage. In the event of a tapering gap, a purpose machined tapered steel shim may be used. As an alternative, flat (parallel) steel shims of not less than 0.1mm and of not more than 0.2mm thick shall be inserted to refusal in steps until the gap in the contact zone is filled, followed by retightening to the snug tight stage.

4 (08/14) The part turn method may be used for tightening preloaded bolts if:

- the bolts are property class 8.8 and assemblies conform to 1805.6.4;
- the required nominal minimum preloading force is not in excess of the values specified in BS EN 1090-2:2008+A1:2011, Table 19; and
- the joint fit-up conforms to 1808.5.1(1) or 1808.5.1(3) above, whichever is applicable.

5 (08/14) The part turn method is the same as the combined method in BS EN 1090-2:2008+A1:2011, 8.5.4, except that:

- K_o bolt assemblies may be used;
- In the first tightening step the nut shall be tightened to a specified torque, as given in Table 18/2 of this Series;
- In the second tightening step the nut shall be tightened to a specified turn as given in Table 18/3 of this Series.

(08/14) **Table 18/2 Torque values for the part turn method – step one**

| | | | | | | |
|----------------------------|-----------|------------|------------|------------|------------|------------|
| Bolt diameter d, mm | 16 | 20 | 22 | 24 | 27 | 30 |
| Torque value M, Nm | 80 | 160 | 210 | 270 | 340 | 460 |

(08/14) **Table 18/3 Rotation values for the part turn method – step two**

| Bolt diameters, mm | Grip length^{A)}, mm | Rotation, ° |
|---------------------------|-------------------------------------|--------------------|
| 16 to 22 | $t \leq 115$ | 180 (½ turn) |
| | $115 < t \leq 275$ | 270 (¾ turn) |
| 24 to 30 | $t \leq 160$ | 180 (½ turn) |
| | $160 < t \leq 350$ | 270 (¾ turn) |

^{A)} Equal to nominal thickness, t , in BS EN 1090-2:2008+A1:2011, Table 21

6 (08/14) The torque method shall not be used for the tightening of preloaded bolts unless described in Appendix 18/1.

1808.5.2 (08/14) Torque reference values (AEN)

1808.5.3 (08/14) Torque method

1 (08/14) The k value shall be checked daily with torque wrenches in accordance with BS EN 1090-2:2008+A1:2011, Annex H and the torque for both tightening steps adjusted accordingly. Any assembly lots that fail to conform to this test shall be discarded.

1808.5.4 (08/14) Combined method

1 (08/14) For property classes 8.8 and 10.9 bolt assemblies to BS EN 14399-3 (see 1805.6.4), the further rotation values in BS EN 1090-2:2008+A1:2011, Table 21 shall be amended as follows for the same thickness ranges:

- replace 60° by 90° (¼ turn);
- replace 90° by 120° (1/3 turn);
- replace 120° by 180° (½ turn).

2 (08/14) The k value shall be checked daily with the torque wrenches in accordance with BS EN 1090-2:2008+A1:2011, Annex H and the torque for the first tightening step adjusted accordingly. Any assembly lots that fail to conform to this test shall be discarded.

3 (08/14) The simplified value of $M_{r,1} = 0.13dF_{p,C}$ shall not be used.

1808.5.5 (08/14) HRC method

1 (08/14) The preload shall be checked on sample assemblies for each assembly lot within seven days prior to use, in accordance with BS EN 1090-2:2008+A1:2011, Annex H. Any assembly lots showing values of preload below the minimum specified value shall be discarded.

2 (08/14) The pre-tightening step shall be repeated until the shear wrench outer socket has stopped turning on all assemblies in a joint.

1808.5.6 (08/14) Direct tension indicator method (AEN)

1808.6 (08/14) Fit bolts (AEN)

1808.7 (08/14) Hot riveting

1808.7.1 (08/14) Rivets (AEN)

1808.7.2 (08/14) Installation of rivets (AEN) (18/1)

1808.7.3 (08/14) Acceptance criteria (AEN) (18/1)

1808.8 (08/14) Fastening of thin gauge components

1808.8.1 (08/14) General (AEN)

1808.8.2 (08/14) Use of self-tapping and self-drilling screws (AEN)

1808.8.3 (08/14) Use of blind rivets (AEN)

1808.8.4 (08/14) Fastening sidelaps (AEN) (18/1)

1808.9 (08/14) Use of special fasteners and fastening methods (AEN) (18/1)

1808.10 (08/14) Galling and seizure of stainless steels (AEN)

1809 (08/14) Erection

1809.1 (08/14) General (AEN)

1809.2 (08/14) Site conditions (AEN)

1809.3 (08/14) Erection method

1809.3.1 (08/14) Design basis for the erection method (AEN)

1809.3.2 (08/14) Constructor's erection method (AEN)

1809.4 (08/14) Survey

1809.4.1 (08/14) Reference system (18/1)

1 (08/14) The reference temperature shall be 15°C, unless otherwise described in Appendix 18/1. The reference temperature shall be recorded in the quality plan.

1809.4.2 (08/14) Position points (AEN)

1809.5 (08/14) Supports, anchors and bearings

1809.5.1 (08/14) Inspection of supports (AEN)

1809.5.2 (08/14) Setting out and suitability of supports (AEN)

1809.5.3 (08/14) Maintaining suitability of supports (AEN) (18/1)

1809.5.4 (08/14) Temporary supports (18/1)

1 (08/14) Levelling nuts or other devices providing temporary support shall be slackened off before final tensioning of foundation bolts where a post-tensioning force is specified, to allow the post-tensioning force to be transferred to the foundations.

2 (08/14) In the case of exposed steelwork and irrespective of bedding material, the minimum finished cover to steel packings or other steel temporary support devices left in position shall be 50mm.

1809.5.5 (08/14) Grouting and sealing (18/1)

1 (08/14) Unless otherwise described in Appendix 18/1, the surfaces of steelwork and bearings that are to be in contact with grout or bedding mortar shall be treated in accordance with 1810.7.

1809.5.6 (08/14) Anchoring (AEN)

1809.6 (08/14) Erection and work at site

1809.6.1 (08/14) Erection drawings (AEN)

1809.6.2 (08/14) Marking (AEN)

1809.6.3 (08/14) Handling and storage on site

1 (08/14) The defined procedure for restoration of damaged steelwork shall conform to the requirements for EXC2/3/4, and shall be approved by the Overseeing Organisation in advance of implementation.

2 (08/14) The processes used for the restoration of damaged steelwork shall be in accordance with the requirements of this Series.

1809.6.4 (08/14) Trial erection (AEN)

1809.6.5 (08/14) Erection methods

1809.6.5.1 (08/14) General (AEN)

1809.6.5.2 (08/14) Temporary works (AEN)

1809.6.5.3 (08/14) Fit-up and alignment

1 (08/14) The use of shims shall be avoided where possible by suitable controls on preparation, assembly and weld distortion and, if necessary, by machining.

2 (08/14) If welding is required for securing shims, it shall be carried out in accordance with BS EN 1090-2:2008+A1:2011, 7 as required for EXC3/4. The requirements of Clause 1807 and 1812.4 shall also apply.

3 (08/14) Where steel shims are needed to correct the fit between members, particularly in preloaded tension joints (see 1808.5.1), and where gaps are variable across the interface, flat (parallel) steel shims may be used as an alternative to a purpose machined tapered steel shim. The gap shall be filled by insertion of shims of not less than 0.1mm and not more than 0.2mm thick from the widest gap position until refusal. The excess material shall be cut off on completion.

1810 (08/14) Surface Treatment

1810.1 (08/14) General (18/1)

- 1 (08/14) Treatment of surfaces to receive corrosion protection shall be in accordance with Series 1900.
- 2 (08/14) The requirements for the execution of corrosion protection in BS EN 1090-2:2008+A1:2011, Appendix F shall be supplemented by those in Series 1900.
- 3 (08/14) The performance specification required by BS EN 1090-2:2008+A1:2011, F.1.2 shall be as given in Appendix 19/1.
- 4 (08/14) The prescriptive requirements for corrosion protection required by BS EN 1090-2:2008+A1:2011, F.1.3 shall be as given in Series 1900.
- 5 (08/14) With reference to BS EN 1090-2:2008+A1:2011, F.4, the requirements for friction surfaces and class of treatment or tests required for surfaces in slip resistant connections shall be as described in Appendix 18/1.
- 6 (08/14) With reference to BS EN 1090-2:2008+A1:2011, F.4, where corrosion protection is specified, the requirements for corrosion protection and extent of surfaces to be painted at preloaded connections shall be as given in Series 1900, Clause 1906 and Appendix 19/5.
- 7 (08/14) With reference to BS EN 1090-2:2008+A1:2011, F.4, the extent of surfaces affected by preloaded bolts in connections that are not required to be slip resistant shall be as given in Appendix 18/1.
- 8 (08/14) The requirements for the protection of the lower embedded part of foundation bolts shall be as described in BS EN 1090-2:2008+A1:2011, F.5, unless otherwise described in Appendix 18/1.
- 9 (08/14) With reference to BS EN 1090-2:2008+A1:2011, F.6.3, for components that are to be galvanized after manufacture, the requirements for procedure qualification of the dipping process shall be as given in Appendix 18/1.
- 10 (08/14) With reference to BS EN 1090-2:2008+A1:2011, F.6.3, the requirements for the inspection, checking and qualification of the preparation to be carried out before subsequent overcoating of galvanized components shall be as given in Appendix 18/1.
- 11 (08/14) With reference to BS EN 1090-2:2008+A1:2011, F.7.3, reference areas shall be as required by Series 1900, Clause 1915.

1810.2 (08/14) Preparation of steel substrates for paints and related products (18/1)

- 1 (08/14) All surfaces shall meet the requirements of BS EN ISO 8501-3:2007 preparation grade P3, unless otherwise described in Appendix 18/1.
- 2 (08/14) All edges requiring preparation grade P3 shall be rounded to a constant radius of not less than 2mm, the radius being tangential to the original surfaces (see BS EN ISO 12944-3:1998, 5.4 and Fig. D.5).

1810.3 (08/14) Weather resistance steels (18/1)

- 1 (08/14) Exposed surfaces of uncoated weather resistant steel shall be blast cleaned to grade Sa2 to BS EN ISO 8501-1 to achieve a uniform surface. Any surfaces that are subsequently marked or contaminated shall be cleaned to a similar standard.
- 2 (08/14) Uncoated weather resistant steel shall be kept free of contamination such as oil, grease, paint, concrete and asphalt.

1810.4 (08/14) Galvanic coupling (AEN)

1810.5 (08/14) Galvanizing (AEN) (18/1)

1810.6 (08/14) Sealing of spaces (18/1)

1 (08/14) The internal treatment system to be provided to enclosed spaces that are to be sealed by welding or provided with internal protective treatment shall be as described in Series 1900.

2 (08/14) All internal spaces which have been identified as being hermetically sealed in Appendix 18/1 shall have all joints, whether welded, mechanically fastened or bonded, leak tested prior to application of the external protective coating (see BS EN 1779). The bubble emission technique in accordance with BS EN 1593 shall be used.

1810.7 (08/14) Surfaces in contact with concrete (18/1)

1 (08/14) When formwork is in contact with the outer surfaces of the steelwork the embedded length shall be measured from the junction between the concrete, the formwork and the steelwork.

1810.8 (08/14) Inaccessible surfaces

1 (08/14) Faying surfaces and surfaces beneath washers in connections other than slip resistant connections that are to be painted shall be treated in accordance with Series 1900.

2 (08/14) In uncoated weather resisting steels, faying surfaces and surfaces beneath washers in connections other than slip resistant connections shall be cleaned to grade St2 to BS EN ISO 8501-1 immediately prior to the connection being made.

1810.9 (08/14) Repairs after cutting or welding (18/1)

1 (08/14) Protective treatment on edges and adjacent surfaces which have been damaged by cutting shall be restored in accordance with the original specification.

2 (08/14) Coatings on precoated constituent products that have been damaged by welding shall be restored in accordance with Appendix 18/1

1810.10 (08/14) Cleaning after erection

1810.10.1 (08/14) Cleaning of thin gauge components (AEN)

1810.10.2 (08/14) Cleaning of stainless steel components (AEN) (18/1)

1811 (08/14) Geometrical Tolerances

1811.1 (08/14) Tolerance types (18/1)

1 (08/14) Where full contact end bearing is specified (see BS EN 1090-2:2008+A1:2011, D.1.13) special tolerances are required. The maximum gap between the two surfaces shall be limited to 0.5mm. In the case of fitted web stiffeners, the gap shall also be limited to a maximum of 0.25mm over 60% of the fitted area.

1811.2 (08/14) Essential tolerances

1811.2.1 (08/14) General (AEN)

1811.2.2 (08/14) Manufacturing tolerances

1811.2.2.1 (08/14) Rolled sections (AEN)

1811.2.2.2 (08/14) **Welded sections**(AEN)

1811.2.2.3 (08/14) **Cold formed sections** (AEN)

1811.2.2.4 (08/14) **Stiffened plating** (AEN)

1811.2.2.5 (08/14) **Profiled sheets** (AEN)

1811.2.2.6 (08/14) **Shells** (AEN)

1811.2.3 (08/14) **Erection tolerances**

1811.2.3.1 (08/14) **Reference system** (AEN)

1811.2.3.2 (08/14) **Foundation bolts and other supports** (AEN)

1811.2.3.3 (08/14) **Column bases** (AEN)

1811.2.3.4 (08/14) **Columns** (AEN)

1811.2.3.5 (08/14) **Full contact bearing** (AEN)

1811.3 (08/14) **Functional tolerances**

1811.3.1 (08/14) **General** (AEN)

1811.3.2 (08/14) **Tabulated values**

1 (08/14) Functional tolerance class 1 shall be adopted except in the following cases from BS EN 1090-2:2008+A1:2011 where class 2 shall be adopted:

- D.2.1 (1 to 6) at bearing and bearing stiffener locations;
- D.2.3 (3);
- D.2.7 (3 and 4).

1811.3.3 (08/14) **Alternative criteria** (AEN) (18/1)

1812 (08/14) **Inspection, Testing and Correction**

1812.1 (08/14) **General** (AEN)

1812.2 (08/14) **Constituent products and components**

1812.2.1 (08/14) **Constituent products** (18/1)

1 (08/14) Specific testing of products not covered by the European or International standards references in BS EN 1090-2:2008+A1:2011 shall be as described in Appendix 18/1.

2 (08/14) The Constructor shall verify that mechanical fasteners conform to the requirements of the product standard to which the mechanical fasteners have been manufactured (see 1800.5.2(1)). Reports of the verification undertaken shall be prepared. The reports shall be treated as execution records and shall form part of the execution documentation (see 1804.2.2 and 1804.2.4). The verification shall include:

- Obtaining evidence of certification of the quality of the mechanical fasteners such as the manufacturer's declaration of performance under a CE mark, manufacturer's certificates and test reports from manufacturer's or suppliers.

- Review of the mechanical fastener documentation to confirm authenticity, relevance, accuracy and completeness.
- Inspection and sample testing of the mechanical fasteners to be used in the works in accordance with BS EN ISO 3269:2001, to confirm that the dimensional and mechanical properties comply with the product standard to which the mechanical fasteners have been manufactured. The inspection and sample testing shall use an AQL of 0.65 for non-destructive tests, an AQL of 1.5 for destructive tests, and an Ac Level of 0 (zero).

3 (08/14) In addition to the requirements of 1812.2.1(2) or 1800.5.2(1) as appropriate, the Constructor shall undertake suitability testing of mechanical fasteners supplied for use in the works in accordance with a relevant standard. For each inspection lot of mechanical fasteners, three fasteners shall be drawn at random and tested in accordance with the suitability test related to the product standard to which the mechanical fasteners have been manufactured. The mechanical fasteners that are subjected to the suitability testing shall be discarded following testing. In the event of a mechanical fastener not meeting the requirements of the suitability test, all mechanical fasteners in the associated inspection lot shall be discarded. The suitability testing shall be reported in accordance with the relevant standard. The reports shall be treated as execution records and shall form part of the execution documentation (see 1804.2.2 and 1804.2.4).

1812.2.2 (08/14) Components (AEN)

1812.2.3 (08/14) Non-conforming products

1 (08/14) Records of testing undertaken to prove product conformity shall be treated as execution records and shall form part of the execution documentation (see 1804.2.2 and 1804.2.4).

1812.3 (08/14) Manufacturing: geometrical dimensions of manufactured components

1 (08/14) The inspection plan shall identify all dimensions which could be at risk of non-conformity. Checks shall be made during execution and action taken to ensure that any non-conformity is corrected at the earliest opportunity. All such dimensions shall be checked before the steelwork is dispatched to site. Components in the neighbourhood of site connections shall be re-checked once the connections are complete.

2 (08/14) If the correction of a nonconformity is not practicable, proposed modifications to the steel structure to compensate for the nonconformity shall be approved by the Overseeing Organisation in advance of implementation.

3 (08/14) Repair of local dents in hollow sections by means of welded cover plates shall only be undertaken if approved by the Overseeing Organisation in advance of implementation.

1812.4 (08/14) Welding

1812.4.1 (08/14) Inspection before and during welding (AEN)

1812.4.2 (08/14) Inspection after welding (AEN)

1812.4.2.1 (08/14) Timing (AEN)

1812.4.2.2 (08/14) Scope of inspection

1 (08/14) All welded joints shall be subject to specific inspection. The scope of specific inspection for each joint shall be 100% visual and in accordance with the extent and methods of supplementary non destructive testing (NDT) given in Table 18/4, Table 18/5 and Table 18/6 of this Series.

2 (08/14) Table 18/4 specifies the minimum proportions of welded joints subjected to specific supplementary NDT for shop welds in steel grades up to and including S355 and quantified service category F56, which represent the most common conditions. The percentages in Table 18/4 shall be applied to the number of joints tested up to weld lengths of one metre in any joint. For joints with weld lengths exceeding one metre, the percentage shall be applied to the proportion of weld in every joint.

3 (08/14) Where other conditions than those assumed in Table 18/4 apply, the minimum proportion of welded joints to be subjected to specific supplementary NDT shall be increased (or decreased) by one or more levels in accordance with Table 18/5. This shall be done by applying the next highest (or lowest) proportion using the following sequence of seven increasing levels of proportion: 0%, 2%, 5%, 10%, 20%, 50%, 100%.

NOTE: For example, if the proportion in Table 18/4 is 20%, an increase of one level changes the requirement to 50% and a decrease of one level to 10%.

4 (08/14) If adjustments are made according to more than one condition in Table 18/5, the net number of levels shall be used, after adding and/or subtracting the number of levels given in each note.

NOTE: For example, if the proportion in Table 18/4 is 100% and the adjustments according to Table 18/5 are -1, -1 and +1 level respectively, the net adjustment would be -1 level, which would result in a proportion of 50%.

5 (08/14) For quantified service category F71 and above for shop welds in steel grades up to and including S355, the minimum proportions of welded joints which shall be subjected to supplementary NDT are specified in Table 18/6. For other conditions, the proportion tested in Table 18/6 shall be adjusted in accordance with Table 18/5 as described in 1812.4.2.2 (3) and (4) for Table 18/4.

6 (08/14) The selection of EXC in BS EN 1090-2:2008+A1:2011, Table 24 for scope of routine FPC inspection shall be determined by the manufacturer according to the nature of the work in normal production. It shall be not less than the specific inspections required in 1812.4.2.2(1) to (5), whichever is the greater.

NOTE: Any FPC inspections undertaken on a specific structure which conform to Table 18/4 in this Series, providing that the acceptance criteria in 1812.4.2.3 and 1812.4.2.4 are fully met, can be regarded and documented as part of the specific inspection required in 1812.4.2.2(1) to (5).

1812.4.2.3 (08/14) Visual inspection of welds

1 (08/14) The criteria for final acceptance without the need for repair shall be in accordance with Table 18/7 and Table 18/8 in this Series. These criteria shall apply irrespective of those adopted for FPC.

2 (08/14) The selection of EXC in BS EN 1090-2:2008+A1:2011, 7.6 for the purposes of routine FPC of visual weld quality shall be determined by the manufacturer, according to the nature of the work in normal production.

1812.4.2.4 (08/14) Additional NDT methods

1 (08/14) The criteria for final acceptance without the need for repair shall be in accordance with Table 18/9 for magnetic particle and penetrant testing and Table 18/10 for ultrasonic and radiographic testing. These criteria shall apply irrespective of those used for FPC.

2 (08/14) The selection of the EXC in BS EN 1090-2:2008+A1:2011, 7.6 for the purposes of routine FPC of NDT based weld quality shall be determined by the manufacturer, according to the nature of the work in normal production.

NOTE: The capability of proving that some of the criteria are met can depend on the method of testing.

1812.4.2.5 (08/14) Correction of welds

1 (08/14) Repairs shall be carried out as required for EXC2/3/4.

1812.4.3 (08/14) Inspection and testing of welded shear studs for composite steel and concrete structures

1 (08/14) Production tests in accordance with BS EN ISO 14555:2006, 14.2 shall be performed before the beginning of welding operations and repeated after every 5000 welds for each combination of stud diameter, parent material and type of equipment that is used.

2 (08/14) Every stud on a production piece of steelwork shall be tested by striking the side of the head of the stud with a 2kg hammer. The weld shall be considered acceptable if there is a clear ring tone due to the striking. Any stud considered to be unacceptable as a result of this test shall be tested as part of the testing described in 1812.4.3 (3).

3 (08/14) Simplified production tests shall be carried out as required by BS EN ISO 14555:2006, 14.3, and at a minimum rate of 1 test (comprising 3 studs) after every 100 welds on each piece of steelwork, with a minimum of 1 test (comprising 3 studs) per piece. The bend test shall be carried out in accordance with BS EN ISO 14555:2006, 11.3 a). The direction of the bend test shall be such that the bent stud shall not interfere with other elements of the works. Studs shall not be bent back after testing.

4 (08/14) The documented results of the production and simplified production tests shall be treated as execution records and shall form part of the execution documentation (see 1804.2.2 and 1804.2.4).

1812.4.4 (08/14) Production tests on welding

1 (08/14) Production tests conforming to the requirements for EXC3/4 are required.

2 (08/14) Specific production testing shall be conducted on run-off coupon plates in accordance with Table 18/11, and shall apply to all parts of the structure.

1812.5 (08/14) Mechanical fastening

1812.5.1 (08/14) Inspection of non-preloaded bolted connections (AEN) (18/1)

1812.5.2 (08/14) Inspection and testing of preloaded bolted connections

1812.5.2.1 (08/14) Inspection of friction surfaces (AEN) (18/1)

1812.5.2.2 (08/14) Inspection before tightening

1 (08/14) The tightening procedure shall be checked as required for EXC2/3/4.

1812.5.2.3 (08/14) Inspection during and after tightening

1 (08/14) Inspection during and after tightening shall be as required for EXC2/3/4.

2 (08/14) In BS EN 1090-2:2008+A1:2011, 12.5.2.3c), the number of bolt assemblies inspected overall in a structure shall conform to the requirements for EXC3/4.

3 (08/14) The part turn method shall conform to the requirements of BS EN 1090-2:2008+A1:2011, 12.5.2.3c)i.

4 (08/14) In BS EN 1090-2:2008+A1:2011, 12.5.2.3d) the sampling plan shall conform to the requirements for EXC2/3.

5 (08/14) For the final tightening inspection the bolt assembly shall be checked for overtightening.

6 (08/14) For the part turn method, the inspection and testing requirements of BS EN 1090-2:2008+A1:2011, 12.5.2.5 shall apply except as follows:

- the first step shall be checked as required for EXC3/4 but using the same torque conditions as given in Table 18/2 of this Series.
- for inspection after the second step, rotation angle values given for the combined method shall be replaced with:
 - a) 0° (in lieu of 15°)
 - b) 60° (in lieu of 30°).

1812.5.2.4 (08/14) Torque method

1 (08/14) Inspection of tightening by the torque method shall conform to the requirements for EXC3/4 in BS EN 1090-2:2008+A1:2011, Table 25.

1812.5.2.5 (08/14) Combined method

1 (08/14) For the combined method, checking of the first step shall conform to the requirements for EXC3/4.

1812.5.2.6 (08/14) HRC method (AEN)

1812.5.2.7 (08/14) Direction tension indicator method (AEN)

1812.5.3 (08/14) Inspection, testing and repairs of hot rivets

1812.5.3.1 (08/14) Inspection

1 (08/14) The sampling plan shall conform to the requirements for EXC2/3.

1812.5.3.2 (08/14) Repairs (AEN)

1812.5.4 (08/14) Inspection of cold formed components and sheeting fastening

1812.5.4.1 (08/14) Self-tapping and self-drilling screws (AEN)

1812.5.4.2 (08/14) Blind rivets (AEN)

1812.5.5 (08/14) Special fasteners and fastening methods

1812.5.5.1 (08/14) General (AEN) (18/1)

1812.5.5.2 (08/14) Cartridge fired and air driven pins (AEN)

1812.5.5.3 (08/14) Other mechanical fasteners (AEN)

1812.6 (08/14) Surface treatment and corrosion protection (AEN)

1812.7 (08/14) Erection

1812.7.1 (08/14) Inspection of trial erection (18/1)

1 (08/14) The following checks shall be carried out during trial erection, where applicable, in addition to those that may be described in Appendix 18/1:

- dimensions critical to assembly to other parts of the structure;
- overall horizontal and vertical alignment and twist;
- evidence of correct re-establishment of alignment of units in staged trial erection;
- temperature differentials in box girders;
- fit-up of bolted joints and site welding preparations;
- alignment of bolt holes;
- identification marks of members and their orientation, including packer plates.

1812.7.2 (08/14) Inspection of the erected structure (AEN)

1812.7.3 (08/14) Survey of geometrical position of connection nodes

1812.7.3.1 (08/14) Survey methods and accuracy

1 (08/14) The survey of the completed structure shall conform to the requirements for EXC3/4. This shall include recording of dimensional checks at acceptance of the structure.

1812.7.3.2 (08/14) System of measurement (AEN)

1812.7.3.3 (08/14) Reference points and levels (AEN)

1812.7.3.4 (08/14) Location and frequency (18/1)

1 (08/14) Account shall be taken of the deflection effects due to temporary equipment supported by, or supporting, the erected structure and any non-steelwork dead weight which is in place at the time of measurement of the positional accuracy of the steelwork.

1812.7.3.5 (08/14) Acceptance criteria (AEN)

1812.7.3.6 (08/14) Definition of nonconformity (AEN) (18/1)

1812.7.3.7 (08/14) Action on nonconformity (AEN)

1812.7.4 (08/14) Other acceptance tests (AEN) (18/1)

SUPERSEDED

(08/14) **Table 18/4 Minimum extent of supplementary NDT of shop welds in steel grades up to and including S355 and quantified service category F56**

| Weld type | Orientation ^{A)} | Thickness (t) or throat (a) ^{B)} mm | Proportion of joints tested % | |
|--------------------------|---------------------------|--|--|---------------------------------------|
| | | | Magnetic particle (MT) or penetrant testing (PT) | Ultrasonic testing (UT) ^{C)} |
| Butt | Transverse | $t < 8$ | 100 | Not applicable |
| | | $8 \leq t < 20$ | 20 | 50 ^{D)} |
| $t > 20$ | | 50 | 100 | |
| Fillet | Longitudinal | $t < 8$ | 50 | Not applicable |
| | | $8 \leq t \leq 20$ | 5 | 0 |
| | $t > 20$ | 10 | 10 | |
| | Transverse | $t \leq 20$ | 5 | No requirement |
| $t > 20, a \leq 10$ | | 10 | No requirement | |
| $t > 50, 10 < a \leq 15$ | | 20 | 0 | |
| $t > 20, a > 15$ | | 20 | 10 | |
| | Longitudinal | As per transverse fillet but reduced by 2 levels ^{E)} | | |

^{A)} Transverse applies to all welds orientated within 60° of the longitudinal axis of members, except for connection zones where all orientations are deemed to be transverse. Connection zones are all locations within 200 mm of a main structural connection, loading point or support position.

^{B)} t = the nominal maximum parent metal thickness in the joint;
a = the nominal fillet weld throat dimension (including any specified penetration).

^{C)} Testing conditions to BS EN ISO 17640:2010 shall be as follows: Level B, evaluation level DAC -14 dB.

^{D)} 100% for single sided butt where there is no access to root side.

^{E)} See 1812.4.2.2 for definition of change in level.

(08/14) **Table 18/5 Adjustments in proportions of supplementary NDT for conditions other than those covered by Table 18/4 and Table 18/6**

| Condition | Change in level ^{A)} |
|---|--|
| Site welded joints | +1 |
| Automatic and robotic welded joints ^{B)} | -1 |
| Standard proprietary products manufactured on a mass production basis ^{B)} | -1 |
| Steel grades above S355 and below S500 | +1 |
| Steel grades S500 and above | +2 |
| Quantified service category F36 (relative to F56) | -1 |
| After a non-conformance with acceptance criteria in Table 18/9 or Table 18/10, applicable to all joints of similar type tested in the same production batch; to be maintained until the cause has been identified and rectified and defects eliminated. | +2 (minimum, depending on degree of severity of non-conformance) |

^{A)} See 1812.4.2.2.

^{B)} Not applicable to transverse butt welds of F90 and above.

(08/14) Table 18/6 Minimum extent of supplementary NDT of shop welds in steel grades up to and including S355 and quantified service categories F71 to F140

| Weld type | Orientation ^{A)} | Thickness (t) ^{B)} or throat (a) mm | Magnetic particle (MT) or penetrant testing (PT) | | | Proportion of joints tested % | | | Radiographic testing (RT) ^{D)} | | |
|--------------|-------------------------------|--|--|-----|---------------|-------------------------------|----------------|----------------|---|----------------|-------------------|
| | | | F71 | F90 | F112 and F140 | F71 | F90 | F112 and F140 | F90 | F112 | F140 |
| Butt | Transverse | t < 8 | 100 | 100 | 100 | Not applicable | Not applicable | Not applicable | 20 | 100 | 100 ^{E)} |
| | | 8 ≤ t ≤ 20 | 50 | 100 | 100 | 100 | 100 | 100 | 0 | 20 | 100 ^{E)} |
| | | t > 20 | 100 | 100 | 100 | 100 | 100 | 100 | 0 | 50 | 100 ^{E)} |
| Fillet | Transverse | t < 8 | 100 | 100 | 100 | Not applicable | Not applicable | Not applicable | 10 | 50 | 100 |
| | | 8 ≤ t ≤ 20 | 20 | 50 | 100 | 10 | 20 | 100 | 0 | 10 | 100 |
| | | t > 20 | 20 | 50 | 100 | 10 | 20 | 100 | 0 | 10 | 100 |
| Longitudinal | As per longitudinal butt weld | t ≤ 20 | 20 | 100 | 100 | No requirement | No requirement | No requirement | No requirement | No requirement | No requirement |
| | | t > 20, a ≤ 10 | 50 | 100 | 100 | 10 | 20 | 20 | 20 | 50 | 100 |
| | | t > 20, 10 < a ≤ 15 | 100 | 100 | 100 | 20 | 50 | 50 | 50 | 100 | 100 |
| Longitudinal | As per longitudinal butt weld | t > 20, a > 15 | 100 | 100 | 100 | 50 | 100 | 100 | 100 | 100 | 100 |
| | | No requirement | | | | | | | | | |
| | | No requirement | | | | | | | | | |

^{A)} and ^{B)} As per Table 18/4, footnotes ^{A)} and ^{B)}.^{C)} Testing conditions to BS EN ISO 17640:2010 shall be as follows:

- quantified service categories F71 and F90: testing level B, evaluation level DAC -14dB;
- quantified service category F112: testing level C, evaluation level DAC -17dB;
- quantified service categories F140: testing level C, evaluation level DAC -20dB;
- transverse indication scans required for longitudinal welds.

^{D)} Applies to in-line butt welds only. BS EN 1435 test class B, shall be used.^{E)} Not relevant for designs based on Table 8.3 in BS EN 1993-1-9:2005

(08/14) Table 18/7 Weld acceptance criteria for visual inspection (all dimensions in mm)

| Main criterion | Imperfection type ^{A)} | | Dimensional parameter ^{B)} | | Joint type | Weld type | Acceptance limits ^{B),C)} to quantified service category | | Remedial action in event of non-conformance ^{E)} | |
|------------------------|---------------------------------|-------------------------------|-------------------------------------|-----------------------------|--------------|-----------|---|-----------------------------------|---|---|
| | Description | BS EN ISO 6520-1:2007 ref no. | Symbol | BS EN ISO 5817:2007 ref no. | | | [] applies to longitudinal welds only ^{D)} | F56 (For F36, see ^{F)}) | | |
| Overall joint geometry | Weld location error | — | Dr | — | All | Fillet | Dr ± 10 | [±10] | As per F56 | Refer to welding coordinator for remedial action |
| | Incorrect weld type | — | Dr | — | All | All | NP | [NP] | As per F56 | Refer to welding coordinator for remedial action |
| | Inadequate weld length | — | Dr | — | All | All | Dr -0 | [-5] | As per F56 | Add extra weld length |
| | Linear misalignment | 5071, 5072 | h | 3.1 | In line butt | Butt | h ≤ 0.2t | [0.3t] | See Table 18/8 | Remove existing weld, realign joint, remake preparations and check with MT or PT, reweld to AWPS, check with UT |
| | | | | | | | h ≤ 4 | [5] | | |
| | Angular misalignment | 508 | β | — | In line butt | Butt | h ≤ 0.4t | [0.4t] | See Table 18/8 | Correct using approved procedure, check with MT or PT |
| | | | | | | | h ≤ 6 | [6] | | |
| Root gap ^{G)} | 617 | h | 3.2 | Lap, tee, cruciform | Fillet | β ≤ 2° | [3°] | See Table 18/8 | Refer to welding coordinator for remedial action | |
| | | | | | | h ≤ 2 | [3] | | | |

(08/14) Table 18/7 Weld acceptance criteria for visual inspection (all dimensions in mm) (continued)

| Main criterion | Imperfection type ^{A)} | | Dimensional parameter ^{B)} | Joint type | Weld type | Acceptance limits ^{B), C)} to quantified service category ^{D)} | | Remedial action in event of non-conformance ^{E)} | | |
|---|---|-------------------------------|-------------------------------------|---------------------|---------------------|--|--|--|---|-------------------------------|
| | Description | BS EN ISO 6520-1:2007 ref no. | | | | Symbol | BS EN ISO 5817:2007 ref no. | | F56 | F71 to F140 |
| Surface notches | Crack | 100 to 106 | — | All | All | NP | [NP] | Remove imperfections by grinding to approved excavation shape, check with PT, reweld to AWPS, refer to welding co-ordinator for establishment of cause | | |
| | Lack of fusion | 401, 506 | — | All | All | NP | [NP] | | | |
| | Lack of penetration (unspecified) | 402 | — | h | All | Single sided butt | NP | | [h ≤ 0.1t] | |
| | | | | | | | | | [h ≤ 1] | |
| | Large cavities | 2015, 2016, 202, 510 | — | — | All | Butt | NP | | [NP] | |
| As per F56 | | | | | | | | | | |
| Undercut, under fill etc. | 501, 509, 511, 515, 517 | h | 1.7, 1.8, 1.14, 1.17, 1.19 | All | All | h ≤ 0.5 | [1] | | | |
| | | | | | | | See Table 18/8 | | | |
| | | | | | | | Remove by grinding, repair to AWPS | | | |
| Pore | 2017 | d | 1.3 | All | All | d ≤ 2 | [2] | Remove to depth of 3 mm, repair to AWPS | | |
| Toe angle | 5051 | α | 1.12 | All | All | α ≥ 90° | [90°] | Correct with high speed rotary burr or reweld to AWPS | | |
| Loss of cross-section | Damage | 601, 603 to 606 | — | All | All | NP | [NP] | As per F56 | Grind out to smooth profile, repair by AWPS if h > 1 | |
| | | | | | | | Remove imperfections by grinding to approved excavation shape, check with PT, reweld to AWPS, refer to welding co-ordinator for establishment of cause | | | |
| | Insufficient weld throat, ^{a H)} | 5213 | h | 1.20 | Tee, lap, cruciform | Fillet | NP ^{G)} | [h ≤ 0.1a] | As per F56 | Increase size using same AWPS |
| | | | | | | | | [h ≤ 1] ^{G)} | | |
| Insufficient leg length, ^{z H)} | 521 | h | — | Tee, lap, cruciform | Fillet | NP ^{G)} | [h ≤ 0.1z] ^{G)} | As per F56 | Increase cross sectional area using methods above, depending on imperfection type | |
| | | | | | | | [h ≤ 2] ^{G)} | | | |
| Multiple conforming surface imperfections | 201, 202, 501, 509, 511, 515, 5213 | h, l, d, l _p | 4.2, 4.1 | All | All | See I) | [See I)] | As per F56 | Increase cross sectional area using methods above, depending on imperfection type | |

(08/14) Table 18/7 Weld acceptance criteria for visual inspection (all dimensions in mm) (continued)

| Main criterion | Imperfection type ^{A)} | | Dimensional parameter ^{B)} | Joint type | Weld type | Acceptance limits ^{B), C)} to quantified service category | | Remedial action in event of non-conformance ^{E)} | | | | | | | | | | | | | | | | | |
|---|---------------------------------|-------------------------------|-------------------------------------|------------|-----------|--|--|---|--|--|------|------|-----|-----|-----|-----|------------------------|-----|-----|------|------|------|------|------|------|
| | Description | BS EN ISO 6520-1:2007 ref no. | | | | Symbol | BS EN ISO 5817:2007 ref no. | | [] applies to longitudinal welds only ^{D)} | F71 to F140 (For F36, see ^{F)}) | | | | | | | | | | | | | | | |
| Surface condition | Deposits | 602, 613, 614, 615 | — | 1.23 | All | All | Not permitted if surface to receive corrosion protection | See Table 18/8 Remove by grinding or blast cleaning | | | | | | | | | | | | | | | | | |
| <p>^{A)} The three digit BS EN ISO 6520-1 designation is deemed to include all four digit sub-categories.</p> <p>^{B)} Symbols are as defined by BS EN ISO 5817 or BS EN ISO 6520-1.</p> <p>^{C)} Dr = the dimension (or weld type) specified on the drawings. NP = not permitted.</p> <p>^{D)} Where more than one limit is given for an imperfection for a given quantified service category and weld orientation, all limits shall apply.</p> <p>^{E)} Longitudinal welds are those not deemed to be "transverse", see Table 18/4 footnote^{A)}.</p> <p>^{F)} AWPS = approved welding procedure specification for repair, qualified in accordance with 1807.4.1</p> <p>^{G)} For joints in any orientation to F36, the imperfection limits given for longitudinal welds [] for F56 are applicable.</p> <p>Where a root gap h has been observed in a tee, cruciform or corner joint, the nominal required fillet weld dimensions, as measured with a weld gauge, shall be increased as follows, unless compensating penetration beyond the root has been proven: minimum required throat size $a + 0.7h$; minimum required leg length $z + h$ (on affected leg only). See also^{H)}.</p> <p>^{H)} Both a and z measurements shall be checked, irrespective of which has been specified on the drawings. They are related as follows:</p> | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr> <td>Angle between fusion faces</td> <td>120°</td> <td>110°</td> <td>100°</td> <td>90°</td> <td>80°</td> <td>70°</td> <td>60°</td> <td rowspan="2">See also^{G)}</td> </tr> <tr> <td>z/a</td> <td>2.0</td> <td>1.74</td> <td>1.56</td> <td>1.41</td> <td>1.31</td> <td>1.22</td> <td>1.15</td> </tr> </table> | | | | | | | | | Angle between fusion faces | 120° | 110° | 100° | 90° | 80° | 70° | 60° | See also ^{G)} | z/a | 2.0 | 1.74 | 1.56 | 1.41 | 1.31 | 1.22 | 1.15 |
| Angle between fusion faces | 120° | 110° | 100° | 90° | 80° | 70° | 60° | See also ^{G)} | | | | | | | | | | | | | | | | | |
| z/a | 2.0 | 1.74 | 1.56 | 1.41 | 1.31 | 1.22 | 1.15 | | | | | | | | | | | | | | | | | | |
| <p>^{I)} All permitted imperfections resulting in loss of cross-section shall be summed and assessed as follows: $\Sigma hl + \Sigma 0,5dt \leq 4,5t$ or $[\leq 9t]$. Σhl shall include subsurface imperfections assuming $h = 3$; see Table 18/10, footnote^{K)}. Measurement length $l_p = 100$ mm. For fillet welds "a", shall be substituted for "t".</p> | | | | | | | | | | | | | | | | | | | | | | | | | |

(08/14) Table 18/8 Weld acceptance criteria for visual inspection for quantified service categories F71 to F140 where limits differ from those for F56 in Table 18/7 (all dimensions in mm)

| Imperfection type ^{A)} | Acceptance limits according to quantified service category ^{B), C)} [] applies to longitudinal welds only ^{D)} | | | | | | Remedial action in event of non-conformance |
|---|--|---|---|---|---|---|---|
| | F71 | F90 | F112 | F140 | | | |
| Linear misalignment | In-line butt | $h \leq 0.15t$ [5] | $h \leq 0.1t$ [4] | $h \leq 0.05t$ [4] | $h \leq 0.05t$ [4] | $h \leq 0.05t$ [4] | As per Table 18/7 |
| | Cruciform | $h \leq 0.3t$ [6] | $h \leq 0.2t$ [6] | $h \leq 0.1t$ [5] | $h \leq 0.1t$ [3] | $h \leq 0.1t$ [3] | |
| Angular misalignment | $\beta \leq 2^\circ$ [3] | $\beta \leq 1.5^\circ$ [2] | $\beta \leq 1^\circ$ [2] | $\beta \leq 1^\circ$ [2] | $\beta \leq 0.5^\circ$ [2] | $\beta \leq 0.5^\circ$ [2] | As per Table 18/7 |
| Root gap ^{E)} | $h \leq 2$ [2] | $h \leq 2$ [2] | $h \leq 1$ [1] | $h \leq 1$ [1] | $h \leq 0.5$ [0.5] | $h \leq 0.5$ [0.5] | As per Table 18/7 |
| Undercut, underfill | $h \leq 0.3$ [h ≤ 1] | NP | NP | NP | NP | NP | As per Table 18/7 |
| Porosity | $d \leq 1.5$ [1.5] | $d \leq 1$ [1] | NP | NP | NP | NP | As per Table 18/7 |
| Toe angle | $\alpha \geq 110^\circ$ [90°] | $\alpha \geq 150^\circ$ [90°] | $\alpha \geq 165^\circ$ [110°] | $\alpha \geq 165^\circ$ [110°] | $\alpha \geq 175^\circ$ [110°] | $\alpha \geq 175^\circ$ [110°] | As per Table 18/7 |
| Deposits | Not permitted if surface to receive corrosion protection | NP | NP | NP | NP | NP | See ^{F)} |
| Variation in root or cap longitudinal profile ^{B)} | $\Delta h \leq 3$ ^{G)} [Δh ≤ 3] | $\Delta h \leq 2$ ^{G)} [Δh ≤ 2] | $\Delta h \leq 1$ ^{G)} [Δh ≤ 1] | $\Delta h \leq 1$ ^{G)} [Δh ≤ 1] | $\Delta h \leq 0.5$ ^{G)} [Δh ≤ 0.5] | $\Delta h \leq 0.5$ ^{G)} [Δh ≤ 0.5] | See ^{H)} |

A) Imperfection types as designated in Table 18/7, footnote^{A)}.

B) Symbols are as defined by BS EN ISO 5817 or BS EN ISO 6520-1.

NP = not permitted. Δh = the maximum variation in cap or root profile measured along weld axis over any length of 3 mm.

C) Where more than one limit is given for an imperfection for a given quantified service category and weld orientation, all limits shall apply.

D) Longitudinal welds are those not deemed to be "transverse"; see Table 18/4, footnote^{A)}.E) Correct fillet weld sizes as per Table 18/7, footnote^{G)}.

F) For F112 and above, remove with high speed rotary burr.

G) Transverse welds outside connection zones are exempt from this restriction (see Table 18/4, footnote^{A)}).

H) Correct by tapering slope to shallower angle or repair to AWPS.

(08/14) Table 18/9 Weld acceptance criteria for magnetic particle and penetrant testing

| Imperfection type | Acceptance standards | Indication pattern | Acceptance limits according to quantified service category ^{A)} [] applies to longitudinal welds with longitudinal linear indications only ^{B)} | | | Remedial actions in event of non-conformance ^{C)} |
|---|-------------------------------------|-----------------------|---|-------------------|-------------|--|
| | | | F56 (For F36, see ^{D)}) | F71 | F90 to F140 | |
| Surface notches identified in Table 18/7 and Table 18/8 | BS EN ISO 23278 and BS EN ISO 23277 | Isolated | Level 2 [Level 3] | Level 1 [Level 2] | NP [NP] | Remove by high speed burr machining with machining marks in longitudinal direction. Repair to AWPS if non-conformance with Table 18/7 and Table 18/8 depth requirements (h). |
| | | Grouped ^{E)} | NP [NP] | NP [NP] | NP [NP] | |

^{A)} NP = not permitted.

^{B)} Longitudinal welds are those not deemed to be "transverse"; see Table 18/4, footnote ^{A)}.

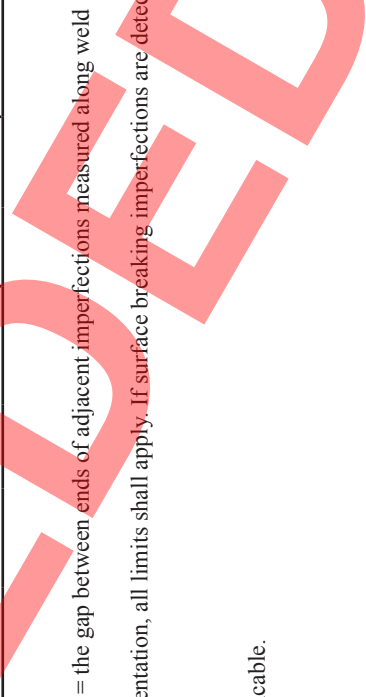
^{C)} Approved welding procedure specification (AWPS) for repair, qualified in accordance with 1807.4.1.

^{D)} For joints in any orientation to F36, the imperfection limits given for longitudinal welds [] for F56 are applicable.

^{E)} "Grouped" shall be deemed to apply to any indications separated by less than 2.5 mm.

(08/14) Table 18/10 Weld acceptance criteria for ultrasonic testing with limited optional radiographic testing (all dimensions in mm)

| Imperfection type ^{A)} | Dimensional parameter ^{B)} | Location in cross-section or throat | Acceptance limits according to quantified service category ^{B),C)} [] applies to longitudinal welds only ^{D)} | | | | | Remedial action in event of non-conformance ^{E)} |
|---|-------------------------------------|-------------------------------------|---|---|---|--|--|---|
| | | | F56 (For F36, see ^{B)}) | F71 | F90 | F112 | F140 | |
| Description | BS EN ISO 6520-1, ref no. | | | | | | | |
| Cracks | — | Full depth | [NP] ^{H)} | [NP] ^{H)} | [NP] ^{H)} | [NP] ^{D)} | [NP] ^{D)} | Refer to welding co-ordinator to determine cause. Remove by grinding to approved excavation shape. Check with MT or PT. Reweld to AWPS. |
| Pores ^{G)} , inclusions ^{G)} , cavities ^{G)} , lack of fusion, lack of penetration | h, 1 | Within 6 mm of any surface | h ≤ 3 [3] | h ≤ 3 [3] | NP ^{H)} [h ≤ 3] | NP ^{D)} [NP] ^{D)} | NP ^{D)} [NP] ^{D)} | |
| | 2.1, 2.2 | Deeper than 6 mm from any surface | h ≤ 3 [3] | h ≤ 3 [3] | h ≤ 3 [3] | NP ^{H)} [h ≤ 3] | NP ^{D)} [NP] ^{D)} | |
| Uniformly distributed or clustered porosity | h, 1, l _p , H, L | Full depth | ∑ ≤ 1.5t ^{J)} [3t] ^{D)} 1.5t ^{B)} | ∑ ≤ [3t] ^{K)} 1.5t ^{K)} | ∑ ≤ [3t] ^{K)} 1.5t ^{K)} | NP | NP | |
| | — | Full depth | l _p = 100 [100] H ≥ 6 [6] L ≥ 10 [10] | l _p = 100 [100] H ≥ 6 [6] L ≥ 10 [10] | ∑ ≤ [3t] ^{K)} 1.5t ^{K)} l _p = 100 [100] H ≥ 6 [6] L ≥ 10 [10] | NP | NP | |



^{A)} Imperfection types as designated in Table 18/7, footnote^{A)}.
^{B)} Symbols are as defined by BS EN ISO 5817.
 NP = not permitted. H = the clear gap between adjacent imperfections measured in through thickness direction. L = the gap between ends of adjacent imperfections measured along weld axis.
^{C)} Where more than one limit is given for an imperfection for a given quantified service category and weld orientation, all limits shall apply. If surface breaking imperfections are detected by UT, the criteria given in Table 18/7, Table 18/8 and Table 18/9 apply.
^{D)} Longitudinal welds are those not deemed to be “transverse”; see Table 18/4, footnote^{A)}.
^{E)} Approved welding procedure specification (AWPS) for repair, qualified in accordance with 1807.4.1.
^{F)} For joints in any orientation to F36, the imperfection limits given for longitudinal welds [] for F56 are applicable.
^{G)} Radiographic testing may be used to assist in interpretation of these imperfections.
^{H)} Rejection level DAC -14dB.
^{I)} Rejection level DAC -17dB.
^{J)} Rejection level DAC -20dB.
^{K)} If permitted surface imperfections resulting in loss of cross-section also exist, the criteria in Table 18/7, footnote^{D)} also apply.
^{L)} Also, not permitted when checked by radiographic testing.

(08/14) Table 18/11 Production tests on run off coupon plates

| Weld type | Quantified service categories | Material grades | Test type | Testing rate |
|---|-------------------------------|--|--------------------------------|------------------|
| In-line transverse butt weld in tension | F90 and above | All | UT+3 macros | 1 in 5 |
| | F56 and above | S355 to S460 ML, NL | Charpys | 1 in 10 |
| | | S460 to S690 Q S420 to S690 QL, QL1 | Tensile Tensile and Charpys | 1 in 5 1 in 5 |
| Longitudinal butt or fillet | F90 | All | UT + 3 macros ^{A)} | 1 in 20 |
| | F112 and above | All | UT + 3 macros ^{A)} | 1 in 5 |

^{A)} A tack weld shall be included in the coupon plate if used in production and at least one macro shall be taken at each end of the tack weld.