Weld preparation

No. 5.01

Scope

This Guidance Note relates to all fusion faces of any elements specified by the designer to be joined by welding, i.e. those for fillet welds as well as butt welds, whether special preparation is required or not.

Relevant clauses in the Standards

The clauses relevant to joint preparation are:

EN 1011 (Ref.1)

Part1:

General: **8.2**

Part 2:

General: **8.1**, **8.2**, Annex **B**

Tolerances: **8.2** (fillet welds)

Preparation: **10**

Assembly: **11**.

EN 1090-2 (Ref.2)

General: **7.5.1**

The latter Standard recommends the use of EN ISO 9692-1 and EN ISO 9692-2 (Ref.3), where there are many examples of joint preparations suitable for use in bridge fabrication. These Standards detail dimensions and ranges of application including recommended welding processes.

In addition, EN 1090-2, 7.5.1.1 also recommends reference to EN 1993-2 (Ref. 4), where there is specific guidance on structural detailing of steel bridge decks including tolerances.

General

The typical forms of weld preparation in EN ISO 9692 are likely to be satisfactory in most applications. Modifications may be necessary to suit the position of welding or to accommodate a difficult access weld. Furthermore, bridge fabricators have approved procedures with particular joint preparations that suit their processes and methods. The 'Introduction' sections of the Standards recognize this by stating that the examples given cannot be regarded as the only solutions for the selection of joint type.

Contract specifications are often written giving only the weld type, size and position, and requiring the fabricator to propose such details to the designer for approval.

EN ISO 15609-1 (Ref.5) is the current specification for the content of welding procedure specifications. Included in the requirements common to all welding procedures is joint design, and it is necessary to prepare a sketch or make reference to standards which provide this information. Standards imply national documents, e.g. EN ISO 9692, or perhaps fabricator preferred details of joint types regularly used.

It is suggested that all welds in structural bridgework are sufficiently important to require detailed sketches and the requirement should be made clear in the contract documentation. However, see comment below about prequalified procedures.

Variability of preparation

Experience has shown that the consistency of the chosen preparation is as important to the performance of a satisfactory welded joint as the actual dimensions chosen in any application.

EN 1011-2 gives guidance on preparation, geometry (including tolerances), assembly, alignment of butt welds and fit-up of fillet welds. Certain of these parameters will fall into the category of "essential variables" for particular processes and applications. This implies that variation outside the permitted range of tolerance may have a significant effect on the performance of the fabrication and hence cannot be permitted.

The achievement of an intended penetration in fillet welds is of particular importance, especially if the fabricator offers a deep penetration process/procedure. The key design parameter is the weld throat dimension, although the weld size is usually specified by leg length in the UK. The effective throat depends on the weld size (leg length), the weld shape (i.e. the ratio of two leg lengths, ideally 1:1) and the penetration into the parent plates. The depth of penetration is not measurable externally and tight procedural control of the process is necessary to ensure success.

Penetration is governed by two main things, the process/ procedure and the root gap (sometimes referred to as the fit-up). EN 1011-2 clause 8.2 gives an absolute upper limit of 3 mm for root gaps in fillet welds, but that is after saying that the edges

and surfaces should be in **as close contact as possible.** It should also be noted that there is a limit for imperfection for quality levels in EN ISO 5817 (Ref.6). For EXC3, quality level B applies and there is a formula to calculate the permissible root gap up to a maximum of 2 mm for material thickness greater than 3 mm.

Both Standards suggest that consideration should be given to increasing the leg length to compensate for a large gap. EN 1090-2 Clause 7.5.8 provides a formula for calculating the increased fillet size necessary to compensate for root gaps based upon the gap and the weld throat thickness.

Preparations for hollow sections

For structures using hollow sections, especially where they meet at an angle, there are potential difficulties achieving satisfactory preparations all around the perimeter. EN 1090-2 Annex E provides weld preparations suitable for executing branch and in-line joints in hollow sections by applying the principles of EN 9692-1 specifically to this type of joint.

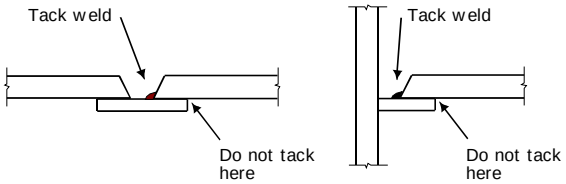
Most fabricators develop their own details for dealing with the transitions. This is usually a combination of varying the preparation locally and turning the elements during welding.

Backing material

EN 1090-2 states that permanent backing material may be used, unless otherwise specified. It shall have a carbon equivalent value not exceeding 0.43 or be the same material as the most weldable of the parent metals to be joined by the weld. Previous welding standards required the material to be metallurgically compatible; that remains sound advice.

EN 1011-2 states that another steel part of the structure may be used as backing material when this is appropriate. Examples where this technique might be used are where closing plates are required to be welded to box girder structures or boxed-in sections within structures, where no alternative access is possible to weld internally. Edges of internal diaphragm plates or stiffeners are frequently used to provide the backing.

There are fatigue design considerations associated with the use of permanent backing strips or flats and the general advice is that these should be avoided if at all possible, by rearranging the joint details to permit welding from both sides. Where this is not possible, the backing material may be tacked onto one of the prepared ends, **in the root of the preparation.** In that position it can be examined for cracking prior to permanent welding; if a tack is intact it can be incorporated into the weld; if not, it should be completely ground out before it is welded over. Only qualified welders, working to a qualified procedure, should be used for the attachment of backing flats, and, because of the small weld size and higher heat sink, it is particularly important to observe the preheating requirements. Figure 1 shows typical plane and T butt weld applications using backing strips.



Note that the backing strip should fit as closely as possible to the plate surfaces and in any event with a gap of not more than 1 mm.

Figure 1 *Attachment of backing flats*

Proprietary ceramic backing strips, either rigid or flexible, are widely available, and, if used correctly by experienced fabricators, can be an advantage for welding difficult joints. Procedure testing or application trials are recommended to confirm the joint integrity.

References

1. EN 1011, Welding. Recommendations for welding of metallic materials.
   Part 1:2009, General guidance for arc welding.
   Part 2:2001, Arc welding of ferritic steels.
2. EN 1090-2:2008+A1:2011, Execution of steel structures and aluminium structures.
   Part 2: Technical requirements for steel structures
3. EN ISO 9692, Welding and allied processes. Types of joint preparation.
   Part 1:2013. Manual metal-arc welding, gas-shielded metal-arc welding, gas welding, TIG welding and beam welding of steels
   Part 2:1998, Submerged arc welding of steels.

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4. EN 1993-2:2006. Eurocode 3- Design of steel structures- Part 2: Steel bridges.
5. EN ISO 15609-1:2004, Specification and qualification of welding procedures for metallic materials. Welding procedure specification. Arc welding.
6. EN ISO 5817:2014. Welding- Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded)- Quality levels for imperfections.