Section 16

Welding

16.1 Welding processes

16.1.1 Manual metal arc (MMA)

This is the most commonly used technique. There is a wide choice of electrodes, metal and fluxes, allowing application to different welding conditions. The gas shield is evolved from the flux, preventing oxidation of the molten metal pool.

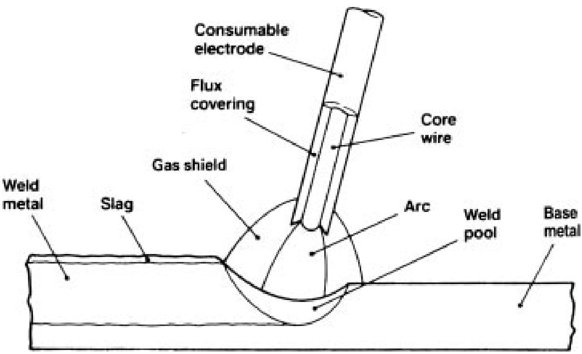

Figure 16.1

16.1.2 Metal inert gas (MIG)

Electrode metal is fused directly into the molten pool. The electrode is therefore consumed rapidly, being fed from a motorized reel down the centre of the welding torch.

Engineers' Data Book, Fourth Edition. Clifford Matthews.

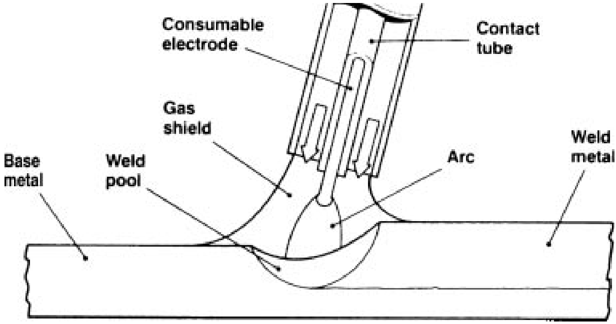

Figure 16.2

16.1.3 Tungsten inert gas (TIG)

This uses a similar inert gas shield to MIG but the tungsten electrode is not consumed. Filler metal is provided from a separate rod fed automatically into the molten pool.

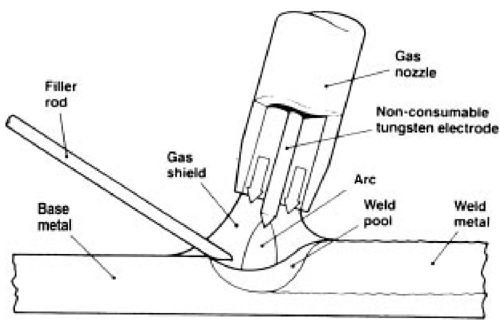

Figure 16.3

16.1.4 Submerged arc welding (SAW)

Instead of using shielding gas, the arc and weld zone are completely submerged under a blanket of granulated flux. A continuous wire electrode is fed into the weld. This is a common process for welding structural carbon or carbon – manganese steelwork. It is usually automatic with the welding head being mounted on a traversing machine. Long continuous welds are possible with this technique.

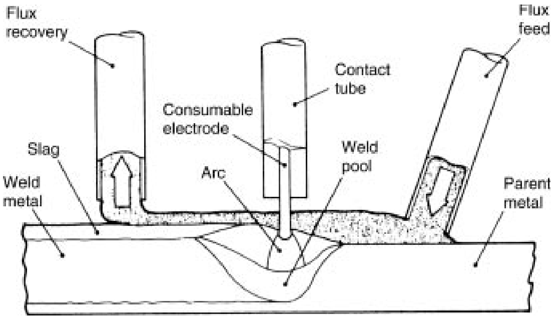

Figure 16.4

16.1.5 Flux-cored arc welding (FCAW)

Similar to the MIG process, but uses a continuous hollow electrode filled with flux, which produces the shielding gas. The advantage of the technique is that it can be used for outdoor welding, as the gas shield is less susceptible to draughts.

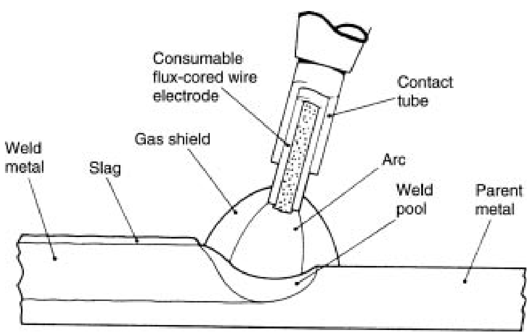

Figure 16.5

16.1.6 Electrogas welding (EGW)

This is a mechanized electrical process using an electric arc generated between a solid electrode and the workpiece. It has similarities to the MIG process.

16.1.7 Plasma welding (PW)

Plasma welding is similar to the TIG process. A needle-like plasma arc is formed through an orifice and fuses the parent metal. Shielding gas is used. Plasma welding is most suited to high-quality and precision welding applications.

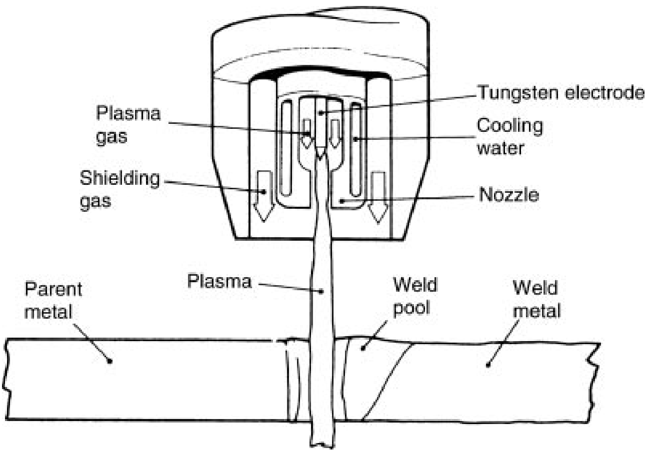

Figure 16.6

16.2 Weld types and orientation

The main *types* are butt and fillet welds – with other specific ones being developed from these.

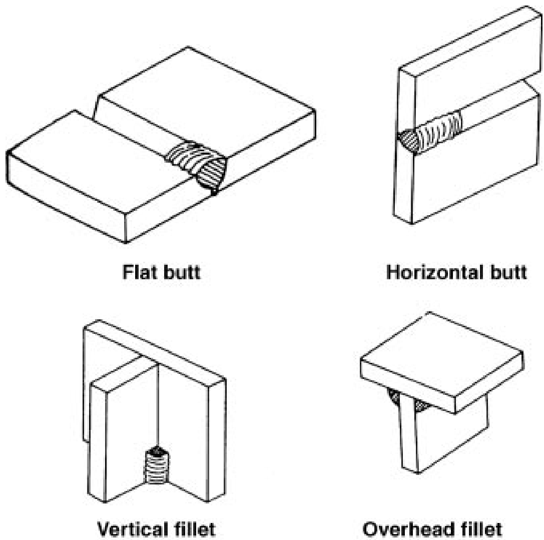

Figure 16.7

Orientation of the weld (i.e. the position in which it was welded) is also an important factor. Weld positions are classified formally in technical standards such as ASME IX, Part QW 461.

16.2.1 Weld terminology

Fillet and butt welds features have specific terminology that is used in technical standards such as BS 499: 2009.

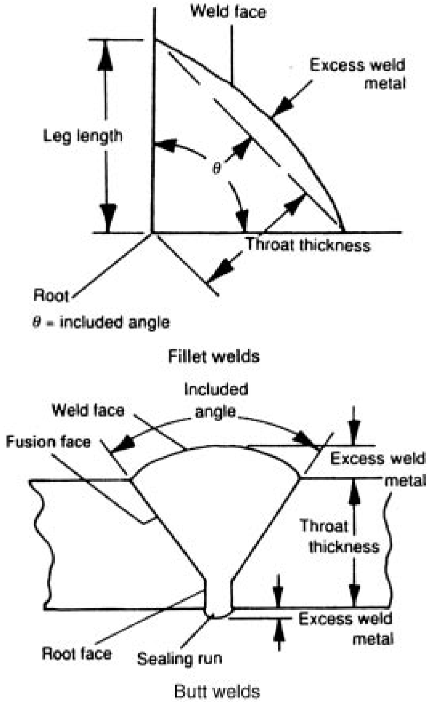
Weld face
Excess weld metal
Leg length
θ
Throat thickness
Root
θ = included angle
Fillet welds
Included angle
Weld face
Fusion face
Excess weld metal
Throat thickness
Excess weld metal
Root face
Sealing run
Butt welds

Figure 16.8

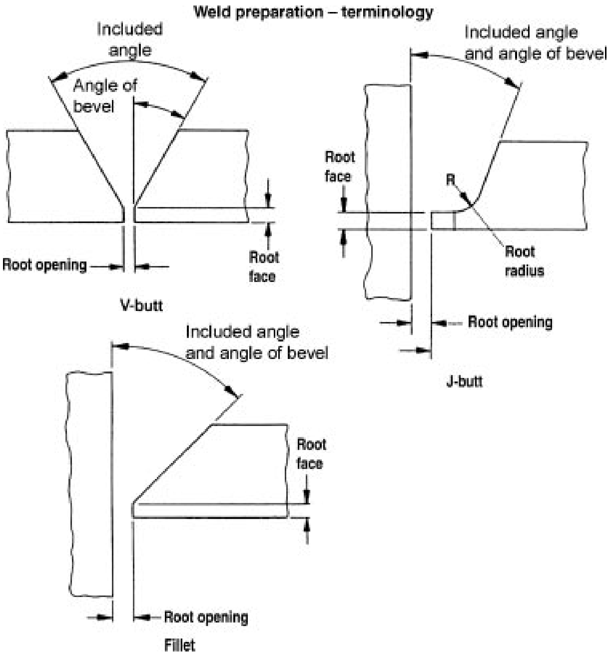

Figure 16.8 (Cont.)

16.3 Welding symbols

Standards such as BS 499, ISO 2553, and AWS A2.4: 2007 contain libraries of symbols to be used on fabrication drawings to denote features of weld preparations and the characteristics of the welds themselves.

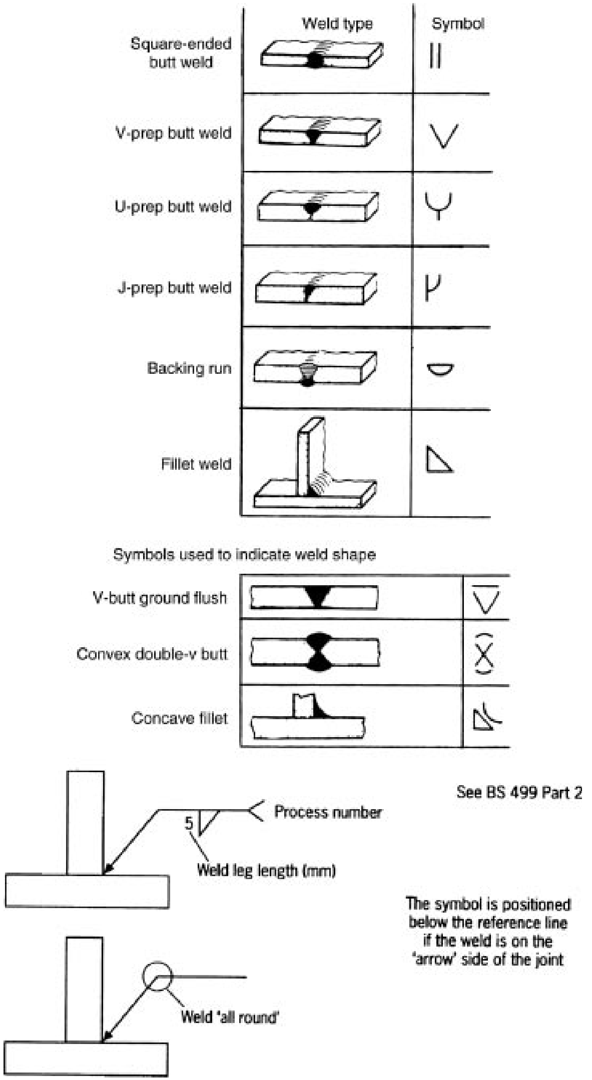
Weld type
Symbol
Square-ended butt weld
V-prep butt weld
U-prep butt weld
J-prep butt weld
Backing run
Fillet weld
Symbols used to indicate weld shape
V-butt ground flush
Convex double-v butt
Concave fillet
See BS 499 Part 2
Process number
5
Weld leg length (mm)
The symbol is positioned below the reference line if the weld is on the 'arrow' side of the joint
Weld 'all round'

Figure 16.9

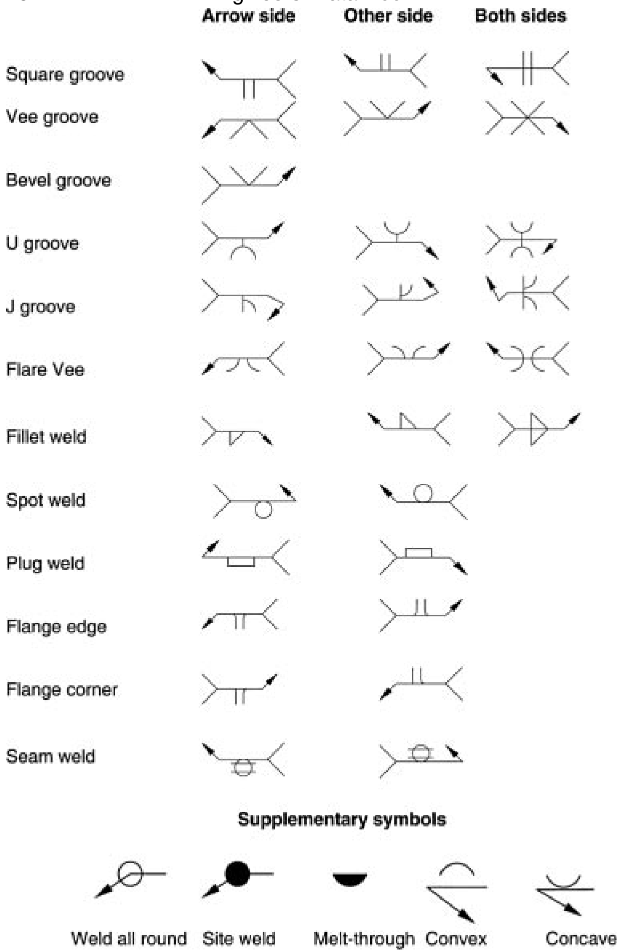
Arrow side
Other side
Both sides
Square groove
Vee groove
Bevel groove
U groove
J groove
Flare Vee
Fillet weld
Spot weld
Plug weld
Flange edge
Flange corner
Seam weld
Supplementary symbols
Weld all round
Site weld
Melt-through
Convex
Concave

Figure 16.10

16.4 Welding defects

All welding processes, particularly the manual ones, can suffer from defects. The causes of these are reasonably predictable.

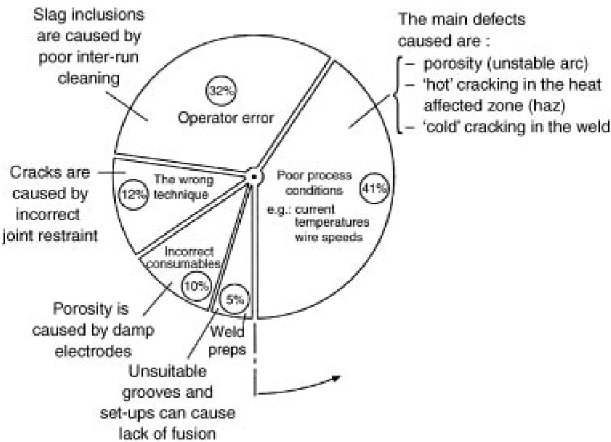

Figure 16.11

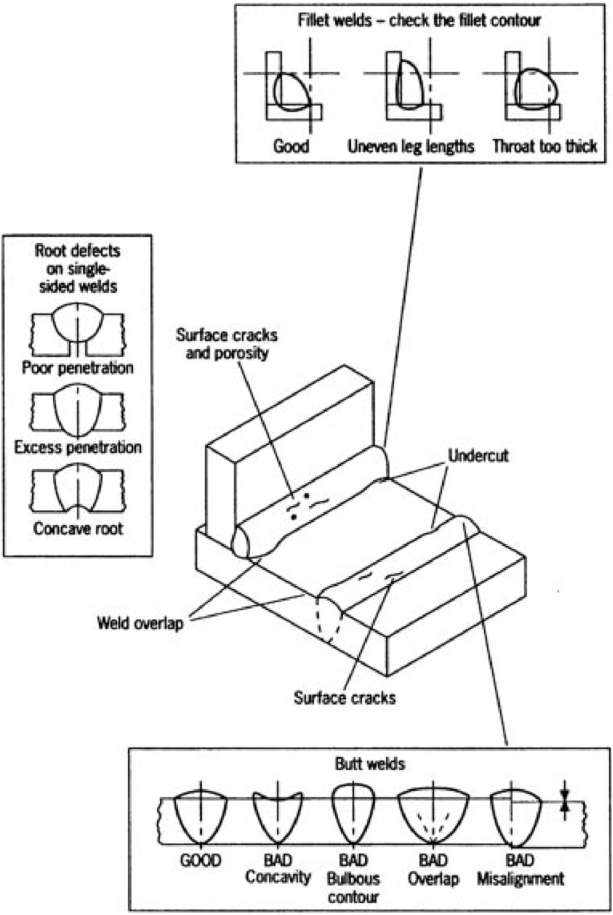

Figure 16.11 (Cont.)

Many weld defects can be detected by close visual inspection backed up by surface non-destructive testing (NDT).

16.5 Welding documentation

Welding is associated with a well-defined set of documentation designed to specify the correct weld method to be used, confirm that this method has been tested, and ensure that the welder performing the process has proven ability. The documents are shown below.

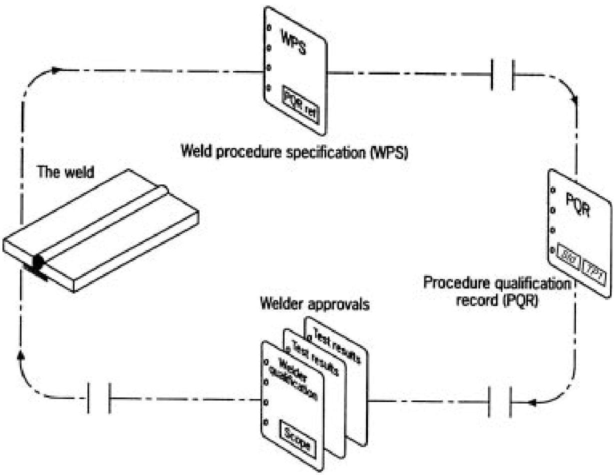

Figure 16.12

16.5.1 Weld procedure specification (WPS)

The WPS describes the weld technique and includes details of:

- parent material;
- filler material;
- weld preparation;
- welding variables; current, orientation, etc.;
- pre- and post-weld heat treatment; and
- the relevant procedure qualification record (PQR).

16.5.2 Procedure qualification record (PQR)

This is sometimes called a weld procedure qualification (WPQ) and is the 'type-test' record of a particular type of weld. The weld is subjected to non-destructive and destructive tests to test its quality.

16.5.3 Welder qualifications

'Coded' welders are tested to a range of specific WPSs to ensure their technique is good enough.

USEFUL STANDARDS

1. BS2633: 1987: Specification for Class I arc welding of ferritic steel pipework for carrying fluids.
2. BS 2971: 1991: Specification for Class II arc welding of carbon steel pipework for carrying fluids.
3. BS 4570: 1985: Specification for fusion welding of steel castings.
4. BS EN 288: Parts 1–8: 1995: Specification and approval of welding procedures for metallic materials.
5. BS EN 287-1: 2004: Approval testing of welders for fusion welding.
6. BS EN 26520: 1992: Classification of imperfections in metallic fusion welds, with explanations. This is an identical standard to ISO 6520.
7. BS EN 25817: 1992: Arc welded joints in steel – guidance on quality levels for imperfections.
8. BS EN 970: 1997: Non-destructive examination of fusion welds.
9. PD 6493: 1991: Guidance on methods for assessing the acceptability of flaws in fusion welded structures.
10. ISO 9692: 2003: Metal arc welding.
11. EN 1011: 2009: Recommendations for welding of metallic materials.
12. ISO EN 3834: 2005: Quality requirements for welding.