

# MIG welding —

## Part 1: Specification for MIG welding of aluminium and aluminium alloys

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- Aluminium Federation
- British Non-ferrous Metals Federation
- Electricity Supply Industry in England and Wales
- Engineering Equipment and Materials Users' Association
- Magnesium Industry Council
- Ministry of Defence
- Society of British Aerospace Companies Limited
- Welding Institute
- Welding Manufacturers' Association

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## Foreword

This British Standard forms one of the process standards in the comprehensive series prepared under the direction of the Welding Standards Committee. It is a revision of BS 3571-1:1962, which is withdrawn. The standard was first published in 1962 as “*General recommendations for manual inert-gas metal-arc welding, Part 1: Aluminium and aluminium alloys*”. This revision takes account of development and more widespread use of the process and sets out requirements for manual and mechanized inert-gas metal-arc welding of wrought and cast aluminium and aluminium alloys.

Although only argon is specified as the shielding gas it is not intended that this standard should inhibit development in the use of helium and helium/argon mixtures. Similarly although welding conditions recommended are for spray transfer welding it is not intended to exclude pulsed arc welding.

Weld acceptance levels are not specified since this British Standard would normally be used in conjunction with other standards. Where no such other standard is available, this British Standard can itself be used, provided that such additional requirements as are necessary are agreed between the contracting parties.

For wrought aluminium and aluminium alloys the material designations used are those in the International Alloy Designation System for Wrought Aluminium and Wrought Aluminium Alloys, which has been adopted in the United Kingdom and is now used in other British Standards.

This system is administered by the Aluminum Association Inc., who issue the “Registration Record of International Alloy Designations and Chemical Composition Limits for Wrought Aluminum Alloys”.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

**Compliance with a British Standard does not of itself confer immunity from legal obligations.**

### Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.



## 1 Scope

This Part of BS 3571 specifies requirements for the manual and mechanized MIG welding of the wrought and cast forms of aluminium and aluminium alloys listed in Table 1 (clause 5).

In addition to the definitive requirements, this standard also requires the items detailed in clause 3 to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

**NOTE** The titles of the publications referred to in this standard are listed on the inside back cover.

## 2 Definitions

For the purposes of this Part of BS 3571, the definitions given in BS 499-1 apply.

## 3 Information and requirements to be agreed and documented

### 3.1 Information to be supplied by the purchaser

The following information to be supplied by the purchaser shall be documented. Both the definitive requirements specified throughout the standard and the documented items shall be satisfied before a claim of compliance with the standard can be made and verified:

- a) whether written welding procedures are required (see clause 4);
- b) whether welding procedure approval tests are required (see clause 19);
- c) the application standard or code of practice to be applied together with any supplementary requirements;
- d) locations, dimensions and details, i.e. form and size of joint, angle between fusion faces, gaps between parts, etc., of all welds. Symbols conforming to BS 499-2 shall be used for standard weld forms, but details shall be given for any non-standard welds;
- e) whether the welds are to be made on the manufacturer's premises or in situ;
- f) whether means of identification is required to enable welds to be traced to the welder who made them (see clause 21);
- g) surface finish of weld profile (see 8.1.3);
- h) whether full penetration welds are required when access to the reverse side is not possible (see 8.1.6);
- i) surface treatment;
- j) quality control arrangements.

### 3.2 Requirements to be agreed

The following items, which are specified in the clauses referred to, to be agreed between the contracting parties, shall be documented. Both the definitive requirements specified throughout the standard and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified:

- a) specification of the parent metal (see clause 5);
- b) specification of the filler wire (see 6.1);
- c) specification of the inert gas mixture [see 6.2 b)];
- d) welding current to be used (see 6.3);
- e) the use of other than run-on/run-off plates to obtain full section thickness (see 8.1.2);
- f) when dressing is not to be carried out, the permissible weld profile if it is not specified in the application standard [see 8.1.3 a)];
- g) the use of a special method to achieve full penetration without the use of backing when access to the reverse side is not possible [see 8.1.6 b)];
- h) the material for permanently backing butt welds when this is not part of the structure [see 8.1.6 2)];
- i) the material for permanently backing welds in hollow sections when this is not of similar composition to the parent metal (see 8.3.3);
- j) the dressing of material prepared by grinding [see 9.2 b)];
- k) the use of chemical treatment to remove surface oxide [see 9.6 b)];
- l) the tolerances on fit-up of parts joined by filled welds (see 12.2);
- m) the action to be taken on any areas of stray arcing (see 17.2);
- n) the peening of welds (see clause 22);
- o) the method and extent of inspection and testing in the absence of a relevant application standard (see clause 24);
- p) the acceptance requirements for welded joints in the absence of a relevant application standard (see clause 25);
- q) the use of local repair welding (see clause 26);
- r) the use of stress-relieving heat treatment (see 27.1);
- s) when post-weld heat treatment is required to improve properties but there is no application standard, the details of the heat treatment to be applied (see 27.2).

## 4 Details of welding procedure

When written welding procedures are required by the purchaser [see 3.1 a)], they shall include such of the following items as are relevant:

- a) welders' identification;
- b) welding procedure serial number;
- c) welding process or processes when more than one is used in making a complete joint;
- d) parent metal specification, thickness and for pipe<sup>1)</sup> the outside diameter or dimension;
- e) whether shop or in situ welding;
- f) weld preparation (sketch);
- g) pre-weld cleaning, degreasing;
- h) fit-up (sketch);
- i) jiggling or tacking;
- j) permanent or temporary backing with details of groove;
- k) welding position (including direction for vertical position);
- l) filler metal specification and size;
- m) pre-heating and interpass temperature, if required, including method and control;
- n) welding speed (mechanized welding);
- o) shielding gas composition and flow rate;
- p) nozzle diameter;
- q) power source characteristic, e.g. constant voltage or constant current;
- r) current range or wire feed speed;
- s) arc voltage range;
- t) electrode extension (mechanized welding);
- u) for pulsed welding, the pulse and background times, currents and voltages;
- v) welding head position and gun angle (mechanized welding);
- w) approximate number and arrangement of runs and weld dimensions (sketch);
- x) welding sequence;
- y) details of oscillation or weaving, if any;
- z) back gouging;
- aa) post-weld heat treatment if required, including method and control;
- bb) any special features.

Welders shall be provided with sufficient information to enable the welding procedure to be carried out satisfactorily.

## 5 Parent metal

The parent metal shall be as specified in either a) or b):

- a) one of the materials listed in Table 1;
- b) when agreed between the contracting parties, materials made from the use of alloys of similar types to those listed in Table 1 [see 3.2 a)].

**Table 1 — Parent metals**

| British Standard                                                                                                                             | Material designation                                                            |
|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| <i>Wrought products</i>                                                                                                                      |                                                                                 |
| BS 1470–75                                                                                                                                   | 1080A<br>1050A<br>1200<br>3103<br>5251<br>5154A<br>5083<br>6061<br>6063<br>6082 |
| BS 2898                                                                                                                                      | 1350<br>6101A                                                                   |
| BS 4300/6–15                                                                                                                                 | 3105<br>5005<br>5454<br>7020                                                    |
| <i>Cast products</i><br>(Sand and permanent<br>mould castings)                                                                               |                                                                                 |
| BS 1490                                                                                                                                      | LM2<br>LM4<br>LM5<br>LM6<br>LM9<br>LM10<br>LM20<br>LM25<br>LM27                 |
| NOTE A cross-reference table between the new and the old BS designations and the nearest equivalent ISO designations is given in Appendix A. |                                                                                 |

## 6 Welding consumables

### 6.1 Filler wires

The types of filler wire given in Table 2 and complying with the requirements of BS 2901-4 shall be used.

NOTE Guidance on the selection of filler metals is given in Appendix B which should be followed unless otherwise agreed between the contracting parties [see 3.2 b)].

<sup>1)</sup> In this standard the word “pipe”, alone or in combination, is used to mean “pipe” or “tube” or “structural hollow section” (circular or rectangular), although these terms are often used for different categories of product by different industries.

**Table 2 — Filler wires**

| Type  | Nominal composition %          |
|-------|--------------------------------|
| 1050A | 99.5 Al                        |
| 1080A | 99.8 Al                        |
| 3103  | Al-1.2 Mn                      |
| 4043A | Al-5.2 Si                      |
| 4047A | Al-12 Si                       |
| 5154A | Al-3.5 Mg-0.3 Mn               |
| 5554  | Al-2.7 Mg-0.8 Mn-0.1 Cr-0.1 Ti |
| 5056A | Al-5 Mg-0.4 Mn                 |
| 5356  | Al-5 Mg-0.1 Mn-0.1 Cr-0.1 Ti   |
| 5556A | Al-5.2 Mg-0.8 Mn-0.1 Cr-0.1 Ti |
| 5183  | Al-4.8 Mg-0.8 Mn-0.1 Cr        |

## 6.2 Shielding gas

The shielding gas shall be as specified in either a) or b).

- a) Argon or an argon/helium mixture. Only argon complying with the requirements of BS 4365 shall be used. The rate of flow of shielding gas shall be sufficient to ensure stable arc conditions and clean welds, i.e. generally in the range 15 L/min to 35 L/min for argon.

NOTE Mechanized welding may require higher flow rates.

- b) When agreed between the contracting parties, other inert gas mixtures provided the weld quality is not adversely affected [see 3.2 c)].

## 6.3 Welding current

The welding current shall be appropriate to the diameter of the filler wire used.

NOTE Guidance on the selection of welding current is given in Appendix C and should be followed unless otherwise agreed between the contracting parties [see 3.2 d)].

## 6.4 Storage and handling

Filler wires shall be stored and handled with care and in accordance with the supplier's recommendations. They shall be stored in their original packaging, in a dry store room. Filler wires that show signs of deterioration, e.g. dirtiness or corrosion, shall not be used.

# 7 Equipment

## 7.1 Plant

Welding plant, instruments, cables and accessories shall comply with the appropriate British Standard. The contractor shall be responsible for ensuring that their capacity is adequate for the welding procedures to be used and for maintaining all welding plant and ancillary equipment in good working order.

NOTE 1 Guidance on the use and maintenance of welding equipment is given in Appendix D.

NOTE 2 Attention is drawn to the advice on safety precautions contained in the Health and Safety at Work Booklet No. 38 "Electric arc welding" issued by the Health and Safety Executive and published by HM Stationery Office.

## 7.2 Earthing

All electrical plant in connection with the welding operation shall be adequately earthed. The welding return lead shall be of the same or greater current rating than the welding lead.

## 7.3 Instrumentation

Adequate means for measuring the gas flow, voltage, current or wire feed speed shall be available either as part of the welding equipment or by the use of portable instruments. When means for measuring true arc voltage, i.e. between workpiece and gun, are not available, allowance shall be made for voltage drop between the workpiece and power source resulting from, for example, length of welding leads or contacts.

In the case of mechanized welding, means shall be provided for measuring the welding speed.

# 8 Welding details

## 8.1 Butt welds

8.1.1 Joint details and approximate spray transfer conditions for manual welding differing from those given in E.2 shall be permitted subject to welding procedure approval.

NOTE 1 For mechanized welding, similar edge preparations may be used but higher currents, gas flows and welding speeds may be utilized.

NOTE 2 Recommended joint details, welding conditions and joint preparation are given in Appendix E.

8.1.2 The ends of butt welds in plate shall be welded so as to provide the full throat thickness. This shall be done by either:

- a) the use of run-on/run-off plates, or  
b) other means agreed between the contracting parties [see 3.2 e)].

8.1.3 The weld face shall be as specified in either a) or b).

- a) In the as-welded condition. The weld face shall be proud of the surface of parent metal and the weld profile shall be as specified in the application standard where this exists. If no application standard exists the weld profile shall be agreed between the contracting parties [see 3.2 f)].
- b) Dressed where a flush surface is required.

8.1.4 Where full penetration butt welds are to be welded from both sides, the back of the first run shall be gouged out to clean weld metal before welding is commenced on the second side, unless in the case of mechanized welding this can be shown by procedure testing to be unnecessary.

NOTE Guidance on back gouging is given in Appendix F.

8.1.5 When temporary backing is specified this may be of freshly cleaned carbon steel, but for high quantity production stainless steel is preferred. If the temporary backing is ungrooved, the back of the first run shall be gouged out to sound metal before welding is commenced on the second side. Dimensions for temporary backing material shall be as given in Figure 1.

8.1.6 Where access to the reverse side is not possible and full penetration welds are required, either:

- a) permanent backing shall be used, or
- b) by agreement between the contracting parties [see 3.2 g)] either:
  - i) an approved special method of welding that gives full penetration without the use of backing shall be adopted, or

- ii) a TIG welding procedure shall be applied to the root of the weld to provide controlled penetration (see BS 3019-1).

Where permanent backing material is used, this shall consist of either:

- 1) part of the parent metal structure, or
- 2) a separate component of a material agreed between the contracting parties as having compatible weldability and having a thickness at least that of the parent metal when this is less than 5 mm [see 3.2 h)].

8.1.7 Where permanent backing material is employed it shall be tack, intermittently or fully welded and the joint shall be arranged in such a way as to ensure that complete fusion of the parts to be joined including the backing, is readily obtained.

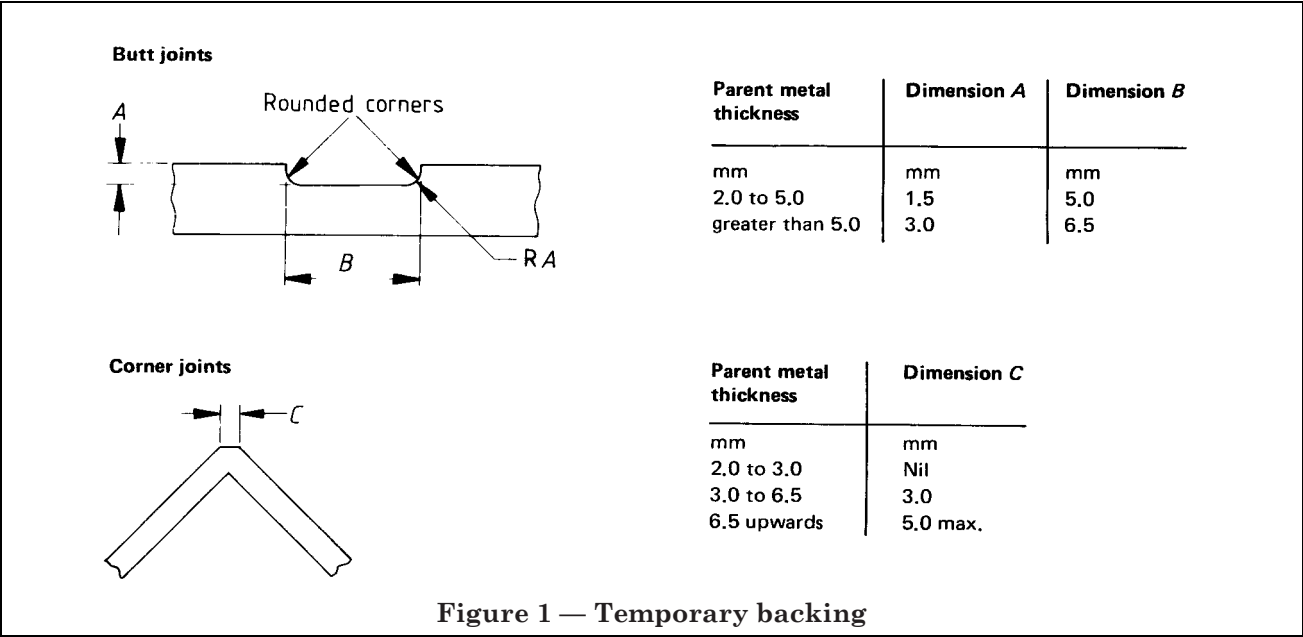
NOTE Under certain conditions, e.g. fatigue and corrosion, permanent backing material may be undesirable.

8.1.8 Where a butt joint is made between two members differing in thickness by:

- a) less than 3 mm, or
- b) one fifth of the thickness of the thinner of the two members,

whichever is the lesser, a gradual transition shall be obtained by deposition of weld metal [see Figure 2(a) and Figure 2(b)]. For greater differences in thicknesses, the thicker shall be tapered on one or both sides [see Figure 2(c) to Figure 2(f)], to a slope of no greater than 1 in 5, so that the weld is made between members of equal thickness.

NOTE The choice of method may be dictated by the application requirements.



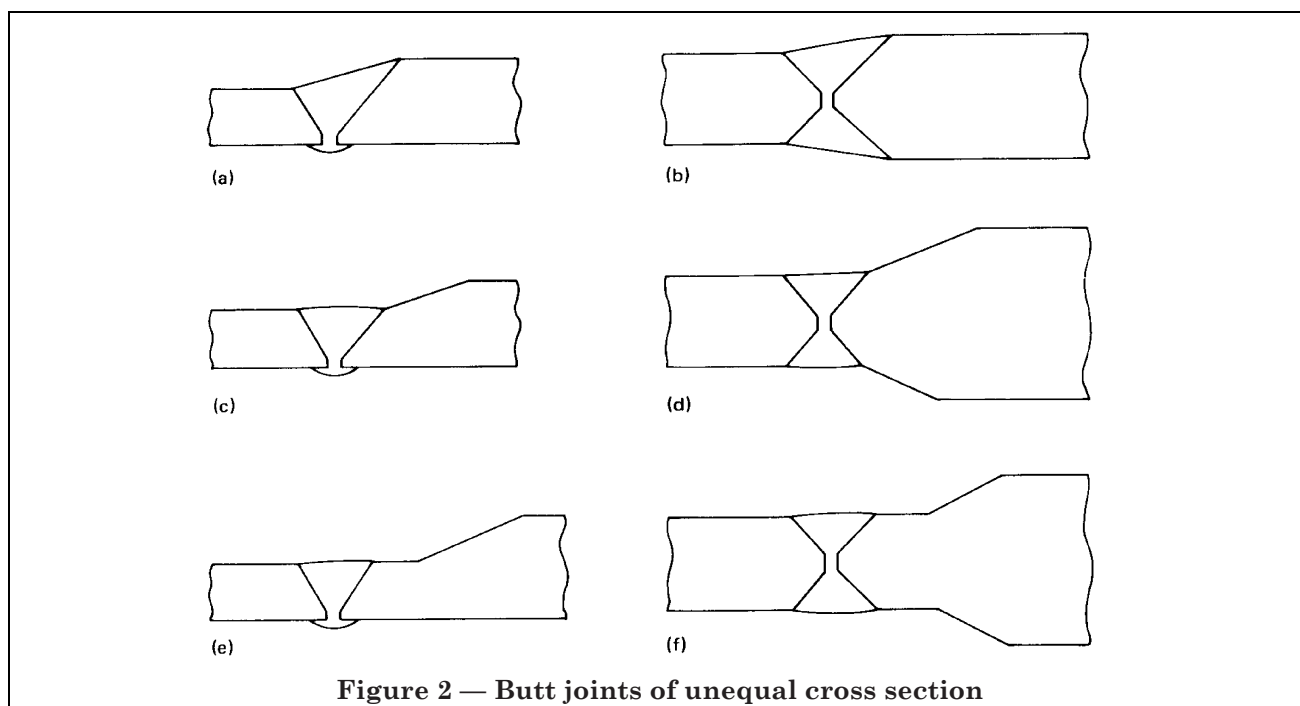


Figure 2 — Butt joints of unequal cross section

## 8.2 Fillet welds

**8.2.1** Joint details and approximate spray transfer conditions for manual welding differing from those given in E.3 shall be permitted subject to welding procedure approval.

NOTE For mechanized welding similar edge preparations may be used and higher currents, gas flow and welding speeds may be utilized.

**8.2.2** A fillet weld, as deposited, shall be not less than the specified dimensions which shall be clearly indicated as throat thickness and/or leg length as appropriate. (See Table 9 and Table 10.)

**8.2.3** For fillet welds having their fusion faces at right angles, the actual throat thickness shall be not less than 0.7 times the design leg length.

## 8.3 Welds in pipe and hollow sections

**8.3.1** Joint details differing from those given in E.4 shall be permitted subject to welding procedure approval.

**8.3.2** Wherever possible, temporary internal alignment and back-up tools shall be used and should be of stainless steel (see 8.1.5).

**8.3.3** Where permanent backing is used it shall be material either:

- a) of similar composition to the parent metal, or
- b) agreed between the contracting parties as having compatible weldability [see 3.2 i)].

## 9 Preparation of joint faces

**9.1** Preparation or cutting of the material shall be done by shearing, sawing, grinding, machining or gouging.

**9.2** Material prepared by grinding shall be either:

- a) dressed with a file to smooth the surface and to remove any debris which may have become embedded in the metal surface, or
- b) by agreement between the contracting parties, left undressed [see 3.2 j)].

**9.3** The preparation of fusion faces, angle of bevel, root radius and root face shall be such that the limits of accuracy required by the appropriate application standard can be achieved.

When, however, no appropriate application standard exists and this standard is itself to be used, the tolerances for manual welding on the limits of gap, root face and the included angle shall be as recommended in Table 6 to Table 11.

NOTE For mechanized welding, closer limits may be necessary and particular requirements depend on the characteristics of the process and the joint configuration.

**9.4** Fusion faces and adjacent surfaces shall be smooth and free from cracks, notches or other irregularities, e.g. overlap which might be the cause of defects or would interfere with the deposition of the weld.

NOTE Removal of sharp corners and burrs on the root faces of single-sided butt welds is recommended.