
**Welding — Recommendations for welding
of metallic materials —**

Part 4:

**Arc welding of aluminium and aluminium
alloys**

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*Soudage — Recommandations pour le soudage des matériaux
métalliques*

Partie 4: Soudage à l'arc de l'aluminium et des alliages d'aluminium

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this part of ISO/TR 17671 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 17671-4 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

ISO/TR 17671 consists of the following parts, under the general title *Welding — Recommendations for welding of metallic materials*:

- *Part 1: General guidance for arc welding*
- *Part 2: Arc welding of ferritic steels*
- *Part 3: Arc welding of stainless steels*
- *Part 4: Arc welding of aluminium and aluminium alloys*

Introduction

This part of ISO/TR 17671 has been issued with two annexes in order to cover aluminium and the different types of its alloys in all forms which will be produced to the relevant International Standards.

In this part of ISO/TR 17671 the term aluminium stands for aluminium and its alloys.

This part of ISO/TR 17671 gives general guidance for the satisfactory design, production and control of welding and details the possible detrimental effects which may occur, together with advice on methods by which they may be avoided. Generally it is applicable to all types of aluminium materials and is appropriate regardless of the type of fabrication involved, although the application standard/contract may have additional requirements.

Permissible design stresses in welds, methods of testing and acceptance levels are not included because they depend on the service conditions of the fabrication. These details should be obtained from the design specification.

Informative annexes give information on detrimental effects (see annex A) and choice of consumables (see annex B).

This part of ISO/TR 17671 details only welding-related matters and does not give any details of mechanical properties of the welded joint.

This part of ISO/TR 17671 identifies the main factors that affect the welding of aluminium. This will be influenced by parent metal, consumables, design, welding procedure, welding equipment, joint preparation, etc.

General requirements for fusion welding of metallic materials are detailed in ISO/TR 17671-1, in particular:

- tack welds;
- temporary attachments;
- arcing;
- inter-run cleaning and treatment;
- welding procedures;
- identification;
- inspection and testing;
- quality requirements;
- correction of non-conformity;
- distortion;
- post-weld heat treatment;
- abbreviations and symbols;
- run-on/ run-off plates.

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Welding — Recommendations for welding of metallic materials —

Part 4:

Arc welding of aluminium and aluminium alloys

1 Scope

This part of ISO/TR 17671 gives general recommendations for the manual, mechanized and automatic fusion welding of wrought and cast aluminium alloys and combinations thereof.

For general guidelines, see ISO/TR 17671-1.

In this part of ISO/TR 17671 the word “pipe” alone, or in combinations, is used to mean “tube” or “hollow section”, although these terms are often used by different industries for different categories of product.

2 References

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ISO 3834-2, *Quality requirements for welding — Fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

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ISO 3834-3, *Quality requirements for welding — Fusion welding of metallic materials — Part 3: Standards quality requirements*

ISO 4063:1998, *Welding and allied processes — Nomenclature of processes and reference numbers.*

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

ISO 6947:1990, *Welds — Working positions — Definitions of angles of slope and rotation*

ISO 9606-2, *Approval testing of welders — Fusion welding — Part 2: Aluminium and aluminium alloys.*

ISO 9692-3, *Welding and allied processes — Recommendations for joint preparation — Part 3: Metal inert gas welding and tungsten inert gas welding of aluminium and its alloys*

ISO 9956-1, *Specification and approval of welding procedures for metallic materials — Part 1: General rules for fusion welding*

ISO 9956-2, *Specification and approval of welding procedures for metallic materials — Part 2: Welding procedure specification for arc welding*

ISO 9956-4, *Specification and approval of welding procedures for metallic materials — Part 4: Welding procedure tests for the arc welding of aluminium and its alloys*

ISO 10042, *Arc-welded joints in aluminium and its weldable alloys — Guidance on quality levels for imperfections*

ISO 14175:1997, *Welding consumables — Shielding gases for arc welding and cutting*

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ISO 14731, *Welding coordination — Tasks and responsibilities*

ISO 14732, *Welding personnel — Approval testing of welding operators for fusion welding and of resistance weld setters for fully mechanized and automatic welding of metallic materials*

ISO/TR 15608, *Welding — Guidelines for a metallic materials grouping system*

ISO 15614-4, *Specification and approval of welding procedures for metallic materials — Welding procedure test — Part 4: Arc welding of aluminium castings*

ISO/TR 17671-1:—, *Welding — Recommendations for welding of metallic materials — Part 1: General guidance for arc welding*

EN 573-1, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 1: Numerical designation system*

EN 573-2, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 2: Chemical symbol based designation system*

EN 573-3, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 3: Chemical composition*

EN 573-4, *Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 4: Forms of products*

EN 1289, *Non-destructive examination of welds — Penetrant testing of welds — Acceptance levels*

EN 1706, *Aluminium and aluminium alloys — Castings — Chemical composition and mechanical properties*

EN 1780-1, *Aluminium and aluminium alloys — Designation of unalloyed and alloyed aluminium ingots for remelting, master alloys and castings — Part 1: Numerical designation system*

EN 1780-2, *Aluminium and aluminium alloys — Designation of unalloyed and alloyed aluminium ingots for remelting, master alloys and casting — Part 2: Chemical symbol based designation system*

EN 1780-3, *Aluminium and aluminium alloys — Designation of unalloyed and alloyed aluminium ingots for remelting, master alloys and castings — Part 3: Writing rules for chemical composition*

3 Terms and definitions

For the purposes of this part of ISO/TR 17671, the terms and definitions of ISO/TR 17671-1 apply.

4 Provision of quality requirements

In order to ensure the quality of work, it should be performed by approved personnel in accordance with e.g. ISO 9606-2, ISO 14732 and ISO 14731 using approved procedures, e.g. ISO 9956-1, ISO 9956-2, ISO 9956-4 and ISO 15614-4.

5 Parent metal

5.1 General

This part of ISO/TR 17671 applies to wrought, cast and combinations of aluminium, e.g. in accordance with ISO 9606-2, ISO 14732, ISO 9956-4 and ISO 15614-4. The principles of this part of ISO/TR 17671 can be applied to other non-standard or proprietary aluminium alloys, which can include the advanced superplastic alloys and

metal matrix composites, provided the composition of the alloy falls within the parent metal groups listed in annex B. In such cases, the use of this part of ISO/TR 17671 shall be in accordance with the design specification.

Material standards do not fully take into account welding requirements. For this reason, it is sometimes necessary to specify additional requirements for the material when placing the order. This can include selection/restriction of composition/mechanical properties (within certain additional limits to the basic standard requirements) and additional cleanliness of the components.

Permanent backing material and temporary attachments should be compatible with the parent metal.

5.2 Storage and handling

Contact with ferritic materials and copper should be avoided, in order to prevent corrosion.

To avoid the use of incorrect materials, they should be stored so that the alloy type is known (see warning on hard stamping in ISO/TR 17671-1:—).

6 Factors affecting properties of welded structures and assemblies

A short list of possible detrimental effects that can occur as a result of welding, is given in annex A. The list is not exhaustive but features those metallurgical and technological influences that are specific to, or more prevalent with, aluminium. Potential causes and counter measures are also listed.

Consideration shall be given, e.g. in the design of welded structures, to the mechanical properties of the heat affected zone (HAZ) and the weld deposit which can be influenced by the welding procedure. For instance, the weld deposit and the HAZ can have lower mechanical properties than the parent material.

Care should be taken to avoid the creation of any HAZ that has not been considered in the design, e.g. the welding of a temporary attachment.

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7 Fusion welding processes

This part of ISO/TR 17671 applies to the following processes in accordance with ISO 4063:1998, and may be used singly or in combination.

- 131 Metal arc inert gas welding (MIG);
- 141 Tungsten inert gas arc welding (TIG);
- 15 Plasma arc welding.

Other fusion welding processes may be considered by agreement.

8 Welding consumables

8.1 Filler metal

The filler metal should be compatible with the parent metal, see annex B.

Filler metals should be stored in their original packaging in a dry place adequately protected from the effects of the weather and in accordance with relevant standards and/or the supplier's recommendation.

Particular attention shall be paid to the storage and identification of partly used reels of wire and packages of rods located in fabricating shops or on site. This is necessary to ensure that they do not become moist or contaminated, e.g. by dust or oil.

8.2 Shielding gases and gas backing

Argon is most commonly used for MIG, TIG and plasma arc welding of aluminium, but some advantage can be obtained by the use of helium and helium/argon mixtures. They produce improved penetration and/or an increase in the welding speed. They can also reduce imperfections. Shielding gases and gas backing of the following categories in accordance with ISO 14175:1997 shall normally be used.

- I1 (argon);
- I2 (helium);
- I3 (argon/helium mixtures).

Other gas mixtures should only be used in accordance with the design specification (see annex B).

9 Equipment

Further information is given in ISO 3834-2 and ISO 3834-3. Return cables should be of the same or greater cross-sectional area as the welding leads. When quality assurance in accordance with ISO 3834-2 is required, monitoring systems should be calibrated and welding equipment should be validated.

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10 Joint types

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10.1 General

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General guidance is given in ISO 9692-3. Gaps between fusion faces can cause problems, e.g. burn-through, distortion and imperfections. Attempts should therefore be made to minimize them.

10.2 Butt joints

10.2.1 General

Butt joints includes all joints between plates, pipes or combinations including “T” butt joints.

10.2.2 Full penetration

10.2.2.1 Single-sided welding

The following methods should be used for welding the joint:

- a) without backing;
- b) with temporary backing;
- c) with permanent backing;
- d) other suitable method.

10.2.2.2 Double-sided welding

The following methods should be used for welding the joint:

- a) fully weld the first side, then complete the weld from the second side;
- b) partially weld from both sides, completing the weld in a balanced sequence. This method will minimize distortion;
- c) root run placed from the first side (instead of backing), then complete the weld from the second side;
- d) other suitable method.

10.2.3 Partial penetration

10.2.3.1 Single-sided welding

The following methods should be used for welding the joint:

- a) weld to achieve the required weld depth without penetrating to the second side;
- b) other suitable method.

10.2.3.2 Double-sided welding

The following methods should be used for welding the joint:

- a) weld to achieve the required weld depth, then weld from the second side to achieve that required weld depth;
- b) partially weld from both sides, completing welds to the required weld depths utilizing a balanced sequence. This method will minimize distortion;
- c) weld to achieve the required weld depth then finish the weld from the second side by placement of a sealing run;
- d) other suitable method.

10.3 Fillet welds

The root gap between contacting surfaces should be as small as possible.

11 Backing material

11.1 Permanent backing material

For further information on material types see ISO/TR 15608.

11.2 Temporary backing material

Stainless steel, aluminium, copper or ceramics can be used. Precautions should be taken to avoid copper or other material pick-up or overheating of backing material. For the purposes of this part of ISO/TR 17671 stainless steel refers only to austenitic stainless steel.