
**Plastics — Joining of thermoplastic
moulded components — Specification
for quality levels for imperfections**

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is intended to be used as a reference in the drafting of application specifications. It contains a simplified selection of thermal joining process imperfections in thermoplastics based on the designations given in EN 14728.

The purpose of this document is to define dimensions of typical imperfections which might be expected in normal fabrication. It may be used within a quality system for the production of joints. It provides three sets of dimensional values from which a selection can be made for a particular application. The quality level necessary in each case is intended to be defined by the application specification or the responsible designer, in conjunction with the manufacturer, user and/or other parties concerned.

The quality levels are expected to be prescribed before the start of production, preferably at the enquiry or order stage. They provide basic reference data and are not specifically related to any particular application. They refer to types of joint in fabrication and not to the complete product or component itself. It is possible, therefore, for different quality levels to be applied to individual joints in the same product or component.

It is normally expected that, for a particular joint, the dimensional limits for imperfections can all be covered by specifying one quality level. In some cases, it may be necessary to specify different quality levels for different imperfections in the same joint.

The choice of quality level for any application is expected to take account of design considerations, subsequent processing, mode of stressing (e.g. static, dynamic), service conditions (e.g. temperature, environment) and consequences of failure. Economic factors are also important and include not only the cost of joining process but also of inspection and testing.

Imperfections are quoted in terms of their actual dimensions, and their detection and evaluation may require the use of one or more methods of destructive and/or non-destructive testing. The detection and sizing of imperfections are dependent on the inspection methods and the extent of testing specified.

This document is directly applicable to visual testing of thermal joints and does not include details of recommended methods of detection or sizing by non-destructive means. These limits are not necessarily applicable to non-destructive testing methods and might need to be supplemented by requirements for inspection, examination and testing.

The values given for imperfections are for thermal joints produced using normal joining process practice.

Plastics — Joining of thermoplastic moulded components — Specification for quality levels for imperfections

1 Scope

This document specifies quality levels for imperfections in joints in thermoplastic moulded components due to the joining process.

This document does not describe imperfections that can be generated either during service or present before joining, such as poor fit up. The correct preparation before joining is described in the relevant thermal joining process specification (TJPS), as defined in ISO 23512.

Three quality levels are specified in order to permit application for a wide range of the following joining processes:

- a) ultrasonic welding;
- b) ultrasonic spot welding;
- c) infrared welding;
- d) hot gas convection welding;
- e) vibration welding;
- f) spin welding;
- g) laser welding;
- h) hot plate welding; and
- i) heat staking: hot air; electrical, infrared and ultrasonic.

They are designated by symbols B, C and D, where B is the most stringent. The quality levels refer to production quality and not to the fitness for purpose of the manufactured product.

NOTE Standards on joining of plastic pipes, fittings, valves and/or auxiliary equipment, and the assessment of the properties of the resulting joints are developed and maintained by ISO/TC 138.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60812, *Failure modes and effects analysis (FMEA and FMECA)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 design failure mode effect analysis DFMEA

application of the failure modes and effects analysis (FMEA) method specifically to product/service design

3.2 failure modes and effects analysis FMEA

step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service

3.3 fitness for purpose

ability of a product, process or service to serve a defined purpose under specific conditions

3.4 quality level

description of the qualities of a weld on the basis of type and size of selected imperfections

4 Quality levels and requirements

The quality level necessary in each case shall be defined as set out in [Table 1](#). The level shall be prescribed before the start of production, preferably at the enquiry or order stage. The DFMEA severity classes in [Table 1](#) shall be determined in accordance with IEC 60812.

NOTE [Table 1](#) defines three quality levels as B, C and D in order to permit application for a wide range of thermoplastic components.

Table 1 — Quality levels for weld imperfections

Symbol	Requirement
B (DFMEA Severity Class 9–10)	Stringent
C (DFMEA Severity Class 6–8)	Intermediate
D (DFMEA Severity Class 0–5)	Moderate

Where additional requirements not covered by this document need to be prescribed for specific applications, these additional requirements shall be defined as Quality Level A.

The quality level (B, C or D) selected from [Table 1](#) shall be used to define the limits of imperfections given in:

- [Table 2](#) for ultrasonic welding;
- [Table 3](#) for ultrasonic spot welding;
- [Table 4](#) for infrared welding;
- [Table 5](#) for hot gas convection welding;
- [Table 6](#) for vibration welding;
- [Table 7](#) for spin welding;
- [Table 8](#) for laser welding;
- [Table 9](#) for hot plate welding.
- [Table 10](#) for staking: hot air, electrical, infrared and ultrasonic.

Different types of imperfection occurring simultaneously at any cross-section of the joint might need special consideration and agreement should be sought between the contracting parties.

Any two adjacent imperfections separated by a distance less than the major dimension of the smaller imperfection shall be considered as a single imperfection.

Measurements of imperfections can be carried out in accordance with EN 12814-5, EN 13100-1, EN 13100-2 or EN 13100-3, as applicable. Other methods, such as computed tomography, active thermography, terahertz spectroscopy and laser scanning, may also be suitable.

Where it is necessary to machine the completed weld, the weld shall be examined both before and after machining.

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Table 2 — Quality levels for ultrasonic welding

Number	Imperfection designation	Description	Quality level		
			B	C	D
1AAAA	Cracks	Break in continuity of the material either on surface or embedded	Not permissible	Not permissible	Permissible: metric to be agreed with customer
2BAAA	Gas cavities	Cavity formed by evolution or entrapment of gas(es)	Permissible if sum of cavity diameter(s) ≤ 5 % of component wall thickness	Permissible if sum of cavity diameter(s) ≤ 10 % of component wall thickness	Permissible if sum of cavity diameter(s) ≤ 15 % of component wall thickness
3KAAA	Degraded polymer	Inclusion of decomposition products within the weld	Not permissible	Not permissible	Not permissible
4BAAA	Lack of fusion	No fusion across parts of weld interface	Not permissible	Not permissible	Not permissible
4CAAA	Lack of penetration or incomplete penetration	Weld displacement is less than specified minimum value	Not permissible	Not permissible	Permissible: dimension to be agreed with customer
4DAAA	Excessive penetration	Weld displacement is greater than specified maximum value	Not permissible	Not permissible	Permissible: dimension to be agreed with customer
4WAAA	Cold fusion	Incomplete fusion across weld interface	Not permissible	Not permissible	Not permissible
5EIAA	Misalignment	The joint faces are not aligned	Permissible if ≤ 10 % of component wall thickness	Permissible if ≤ 15 % of component wall thickness	Permissible if ≤ 20 % of component wall thickness
5MAAA	“Belled” joint	Excessive deformation of the female part of a shear joint	Not permissible	Not permissible	Not permissible
6BAAA	Excess weld material	Overflow of melt/flash from the joint	Not permissible	Not permissible	Permissible: metric to be agreed with customer
6MAAA	Insufficient flash/upset material	Upset material smaller than the specified value	Not permissible	Not permissible	Not permissible
7BAAE	Thermal damage outside of welding	Thermal damage to the component outside specification	Not permissible	Not permissible	Permissible: requirement to be agreed with customer
9MAAA	Diaphragming	Mechanical damage to the component due to the oscillation energy	Not permissible	Not permissible	Not permissible
9CAAA	Tool mark	Mechanical damage to the component due to tool or fixture contact	Not permissible	Permissible: requirement to be agreed with customer	Permissible: requirement to be agreed with customer

NOTE The numbering system corresponds to that defined in EN 14728.

Table 3 — Quality levels for ultrasonic spot welding

Number	Imperfection designation	Description	Quality level		
			B	C	D
1AAAA	Crack	Break in continuity of the material either on surface or embedded	Not permissible	Not permissible	Permissible: metric to be agreed with customer
2BAAA	Gas cavity	Cavity formed by evolution or entrapment of gas(es)	Permissible if sum of cavity diameter(s) \leq 5 % of component wall thickness	Permissible if sum of cavity diameter(s) \leq 10 % of component wall thickness	Permissible if sum of cavity diameter(s) \leq 15 % of component wall thickness
2DAAA	Craze	Crack-like regions of micro-cavitated material, caused by stress, producing a local whitening of the material	Not permissible	Not permissible	Permissible: metric to be agreed with customer
3AAAA	Solid inclusion	Foreign material trapped in the weld	Inclusions permissible if sum of max. dimension(s) \leq 5 % of component wall thickness	Inclusions permissible if sum of max. dimension(s) \leq 10 % of component wall thickness	Inclusions permissible if sum of max. dimension(s) \leq 15 % of component wall thickness
3KAAA	Degraded polymer	Inclusion of decomposition products within the weld	Not permissible	Not permissible	Not permissible
4BAAA	Lack of fusion	No fusion across parts of weld interface	Not permissible	Not permissible	Not permissible
4CAAA	Incomplete penetration	Weld displacement is less than specified minimum value	Not permissible	Not permissible	Permissible: dimension to be agreed with customer
4DAAA	Excessive penetration	Weld displacement is greater than specified maximum value	Not permissible	Not permissible	Permissible: dimension to be agreed with customer
4WAAA	Cold fusion	Incomplete fusion across weld interface	Not permissible	Not permissible	Not permissible
5AAAA	Imperfect shape	Deviation from the specified geometry of the weld	Not permissible	Not permissible	Permissible: dimension to be agreed with customer
6BAAA	Excess weld material	Overflow of melt/flash from the joint	Not permissible	Not permissible	Permissible: metric to be agreed with customer
6MAAA	Insufficient upset material	Upset material/flash smaller than the specified value	Not permissible	Not permissible	Not permissible
7BAAE	Thermal damage outside of welding	Thermal damage to the component outside specification	Not permissible	Not permissible	Permissible: requirement to be agreed with customer

NOTE The numbering system corresponds to that defined in EN 14728.