



BSI Standards Publication

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

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Published by BSI Standards Limited 2019

ISBN 978 0 580 96534 0

ICS 83.080.01, 83.080.20

The following BSI references relate to the work on this document:

Committee reference WEE/3

Draft for comment 18/30352115 DC

Amendments/corrigenda issued since publication

Date	Text affected

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Summary of pages

This document comprises a front cover, and inside front cover, pages i to ii, pages 1 to 29, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 28 February 2019. It was prepared by Technical Committee WEE/3, *Welding of Thermoplastic Moulded Components*. A list of organizations represented on this committee can be obtained on request to its secretary.

Information about this document

This British Standard has been developed to help organizations better understand quality levels for imperfections in the following thermal joining processes:

- ultrasonic welding;
- ultrasonic spot welding;
- infrared welding;
- hot gas convection welding;
- linear vibration welding;
- orbital vibration welding;
- spin welding;
- laser welding;
- hot plate welding; and
- heat staking: hot air, electrical, infrared and ultrasonic.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

0 Introduction

This British Standard 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 BS EN 14728.

The purpose of this British Standard 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 would normally be expected that for a particular joint the dimensional limits for imperfections could all be covered by specifying one quality level. In some cases, it might 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, testing and repair.

Imperfections are quoted in terms of their actual dimensions, and their detection and evaluation might 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 British Standard 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.

1 Scope

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

This British Standard 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 [BS 89100](#). It is not applicable to onsite joining processes.

Three quality levels are specified in order to permit application for a wide range of joining processes set out in a) to j) below. 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 (see [3.4](#)) of the manufactured product.

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 12814-5, *Testing of welded joints of thermoplastics semi-finished products — Part 5: Macroscopic examination*

BS EN 13100-1, *Non destructive testing of welded joints of thermoplastics semi-finished products — Part 1: Visual examination*

BS EN 13100-2, *Non-destructive testing of welded joints in thermoplastics semi-finished products — Part 2: X-ray radiographic testing*

BS EN 13100-3, *Non destructive testing of welded joints in thermoplastics semi-finished products — Part 3: Ultrasonic testing*

BS EN 14728, *Imperfections in thermoplastic welds — Classification*

BS EN 60812, *Analysis techniques for system reliability — Procedure for failure mode and effects analysis (FMEA)*

[BS 89100](#), *Plastics — Joining of thermoplastic moulded components — Specification of variables for thermal joining processes*

3 Terms and definitions

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

3.1 component

joined sub-components

3.2 design failure mode effect analysis (DFMEA)

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

3.3 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

3.4 fitness for purpose

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

3.5 heat affected zone (HAZ)

area of a welded joint that has not been melted but has had its microstructure and properties altered by the welding process

3.6 quality level

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

3.7 sub-component

part to be joined

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 BS EN 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 standard 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 linear vibration welding;
- [Table 7](#) for orbital vibration welding;
- [Table 8](#) for spin welding;
- [Table 9](#) for laser welding;
- [Table 10](#) for hot plate welding; and
- [Table 11](#) 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 advice shall be sought from the product manufacturer.

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

Measurements of imperfections shall be carried out in accordance with BS EN 12814-5 (macroscopic examination), BS EN 13100-1 (visual examination), BS EN 13100-2 (X-ray testing) or BS EN 13100-3 (ultrasonic testing) as applicable.

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

Table 2 — *Quality levels for ultrasonic welding*

BS EN 14728 number	Imperfection designation	Description	Quality levels			
			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) $\leq$ 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	
2MAAA	Surface bubble	Surface-breaking gas cavity	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	
3KAAA	Degraded polymer	Inclusion of decomposition products	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 value	Not permissible	Not permissible	Permissible: dimension to be agreed with customer	
4DAAA	Excessive penetration	Weld displacement is greater than specified value	Not permissible	Not permissible	Permissible: dimension to be agreed with customer	
4FAAA	No weld	Parts not coming together	Not permissible	Not permissible	Not permissible	

Table 2 (continued)

BS EN 14728 number	Imperfection designation	Description	Quality levels			
			B	C	D	
4WAAA	Cold fusion	Incomplete fusion across weld interface	Not permissible	Not permissible	Not permissible	
5EIAA	Misalignment	The joint faces are not aligned	Permissible if $\leq 10\%$ of component wall thickness	Permissible if $\leq 15\%$ of component wall thickness	Permissible if $\leq 20\%$ 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	

Table 2 (continued)

BS EN 14728 number	Imperfection designation	Description	Quality levels		
			B	C	D
9CAAA	Tool mark	Mechanical damage to the component due to the tool or fixture contact	Not permissible	Permissible: requirement to be agreed with customer	Permissible: requirement to be agreed with customer