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Imperfections in thermoplastics welded joints — Quality levels

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National foreword

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Unregelmäßigkeiten an Schweißverbindungen von thermoplastischen Kunststoffen - Qualitätsstufen

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Foreword

This document (EN 16296:2012) has been prepared by Technical Committee CEN/TC 249 “Plastics”, the secretariat of which is held by NBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2013, and conflicting national standards shall be withdrawn at the latest by April 2013.

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Introduction

This European Standard should be used as a reference in drafting of application codes and/or other application standards. It contains a simplified selection of imperfections based on the designations given in EN 14728, *Imperfections in thermoplastic welds — Classification*.

Some imperfections according to EN 14728 have been used directly and some have been grouped together. The basic numerical referencing system from EN 14728 has been used.

The purpose of this standard is to define quality levels based on typical imperfections, which might occur in normal fabrication. It may be used within a quality system for the production of factory welded 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 should be defined by the application standard or the fabricator in conjunction with the user and/or other parties concerned. The level should be prescribed before the start of production, preferably at the enquiry or order stage.

The quality levels given in this standard are intended to provide basic reference data and are not specifically related to any particular application. They refer to the types of welded joints in a fabrication and not to the complete product or component itself. It is possible, therefore, that different quality levels are applied to individual welded joints in the same product or component.

The choice of quality level for any application should take account of design considerations, subsequent processing, mode of stressing (e.g. static, dynamic), service conditions (e.g. pressure, temperature, environment) and consequences of failure. Economic factors are also important and should include not only the cost of welding but also of inspection, test and repair.

Although this European Standard includes types of imperfections relevant to the processes given in Clause 1, only those which are applicable to the process and application in question need to be considered.

Imperfections are quoted in terms of their actual dimensions. However their detection and evaluation may require the use of one or more methods of non-destructive testing. It should be noted that the detection and sizing of imperfections is dependent on the inspection methods and the extent of testing specified in the application standard or contract.

The need for detection is not the subject of this standard.

This European Standard is directly applicable to visual examination of welds or test specimens. It does not include details of recommended methods of detection and sizing. The indication provided by non-destructive testing should not be used directly for the evaluation of quality levels. Therefore, it needs to be supplemented by requirements for examinations, inspection and testing.

1 Scope

This European Standard provides quality levels for imperfections in thermoplastics welded joints. It applies to material thickness above 2,0 mm.

Three quality levels are given in order to permit application for a wide range of welded fabrication. 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 3.2) of the manufactured product.

This European Standard applies to the following thermoplastic materials:

Table 1

Abbreviation	Material description
ABS	Acrylonitrile-butadiene-styrene plastic
ECTFE	Ethylene-chlorotrifluoroethylene copolymer
FEP	Fluorinated ethylene propylene
PB	Polybutylene
PE	Polyethylene
PFA	Perfluoroalkoxy
PP-B	Polypropylene block copolymer
PP-H	Polypropylene homopolymer
PP-R	Polypropylene random copolymer
PVC-C	Chlorinated polyvinyl chloride
PVC-U	Unplasticised polyvinyl chloride (rigid PVC)
PVDF	Polyvinylidene fluoride

and to the following welding processes:

— Heated tool welding;

— Electrofusion welding;

— Hot gas welding using filler rod only;

— Extrusion welding;

— Solvent welding of pipes.

2 Normative reference

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.

EN 14728, *Imperfections in thermoplastic welds — Classification*

3 Terms and definitions

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

3.1
quality level
description of the qualities of a weld on the basis of type and size of selected imperfections

3.2
fitness-for-purpose
ability of a product, process or service to serve a defined purpose under specific conditions

4 Quality levels

4.1 Classification

Three quality levels are defined as B, C and D in order to permit application for a wide range of welded fabrications (see Table 2).

Table 2 — Quality levels for weld imperfections

Symbol	Requirement
B	Stringent
C	Intermediate
D	Moderate

The purpose of this standard is to define quality levels based on typical imperfections, which might occur in normal fabrications and are classified in EN 14728. It may be used within a quality system for the production of factory welded 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 should be defined by the application standard or the fabricator in conjunction with the user and/or other parties concerned. The level should be prescribed before the start of production, preferably at the enquiry or order stage.

For specific applications, additional requirements not covered by this standard may need to be prescribed. These additional requirements shall be defined as quality level A.

4.2 Choice of quality level

For the choice of the quality level, the following factors, among others, shall be taken into account:

— mechanical loading (static, dynamic);

— environment (media, temperature);

— material properties (ductile, brittle);

— manufacturing conditions (workshop, construction site, welding in constrained condition);

— operating conditions;

— potential danger in the event of failure.

5 Requirements for welded joints

The requirements for the above mentioned quality levels (B, C and D) are listed as follows:

— Heated tool butt welds: Table 3;

— Heated tool socket welds: Table 4;

— Electrofusion welds: Table 5;

— Hot gas welds: Table 6;

— Extrusion welds: Table 7;

— Solvent welds in pipes: Table 8.

Different types of imperfection occurring simultaneously at any cross-section of the joint may need special consideration and advice should 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.

In certain circumstances, it is necessary to machine the completed weld. In this case, the weld shall be examined both before and after machining.

Table 3 — Definition of quality levels for heated tool butt welds

Number	Designations	Level B	Level C	Level D
1AAAA	Cracks	Not permissible	Not permissible	Not permissible
2BAAA	Gas cavity	Isolated cavities permissible if diameter ≤ 5 % of wall thickness	Permissible if diameter of largest cavity ≤ 10 % of wall thickness	Permissible if diameter of largest cavity ≤ 15 % of wall thickness
2CAAA	Shrinkage cavity	Isolated cavities permissible if diameter ≤ 5 % of wall thickness	Permissible if diameter of largest cavity ≤ 10 % of wall thickness	Permissible if diameter of largest cavity ≤ 15 % of wall thickness
2DAAA	Craze	Not permissible	Not permissible	Not permissible
3AAAA	Inclusion	Isolated inclusion permissible if maximum dimension ≤ 5 % of wall thickness	Isolated and rows of inclusions permissible if maximum dimension ≤ 10 % of wall thickness	Isolated and rows of inclusions permissible if maximum dimension ≤ 15 % of wall thickness
3KAAA	Degraded polymer	Not permissible	Not permissible	Not permissible
4BAAA	Lack of fusion	Not permissible	Not permissible	Not permissible
5AAAA	Imperfect shape	Mechanical testing of sample welds is recommended	Mechanical testing of sample welds is recommended	Mechanical testing of sample welds is recommended
5EJAA	Linear misalignment	Permissible if misalignment is not greater than 10 % of the wall thickness	Permissible if misalignment is not greater than 15 % of the wall thickness	Permissible if misalignment is not greater than 20 % of the wall thickness
5EKAA	Angular misalignment	Permissible if misalignment is not greater than 0,2°	Permissible if misalignment is not greater than 0,4°	Permissible if misalignment is not greater than 0,8°
5HAAA	Irregular surface	Not permissible	Not permissible	Not permissible
6EAAA	Excessive upset	Not permissible	Not permissible	Not permissible
6HAAA 6HAAC	Excessive asymmetry of welds	Permissible if smaller half of weld bead is not less than 70 % of	Permissible if smaller half of weld bead is not less than 60 % of	Permissible if smaller half of weld bead is not less than 50 % of

Number	Designations	Level B	Level C	Level D
		larger half of weld bead around the whole circumference	larger half of weld bead around the whole circumference	larger half of weld bead around the whole circumference
7BAAA	Thermal damage	Not permissible	Not permissible	Not permissible
9CAAA	Tool mark	Locally permissible if bottom of notch is not acute and the notch depth is less than 10 % of the wall thickness and not greater than 0,5 mm	Locally permissible if bottom of notch is not acute and the notch depth is less than 10 % of the wall thickness and not greater than 1,0 mm	Locally permissible if bottom of notch is not acute and the notch depth is less than 15 % of the wall thickness and not greater than 2,0 mm
NOTE The data in this table can also be found in DVS 2202-1 [1].				

Table 4 — Definition of quality levels for heated tool socket welds

Number	Designations	Level B	Level C	Level D
2BAAA	Gas cavity	Isolated cavities permissible if diameter ≤ 5 % of insertion length	Permissible if diameter of largest cavity ≤ 10 % of wall thickness	Permissible if diameter of largest cavity ≤ 15 % of wall thickness
2DAAA	Craze	Not permissible	Not permissible	Not permissible
3AAAA	Inclusion	Isolated inclusion permissible if maximum dimension ≤ 5 % of fusion length	Isolated and rows of inclusions permissible if maximum dimension ≤ 10 % of fusion length	Isolated and rows of inclusions permissible if maximum dimension ≤ 15 % of fusion length
3KAAA	Degraded polymer	Not permissible	Not permissible	Not permissible
4BAAA	Lack of fusion	Not permissible	Not permissible	Not permissible
4RAAA	Compressed pipe ends	Not permissible	Not permissible	Not permissible
4SAAA	Insufficient penetration	Permissible if inserted length is no more than 10 % less than the specified insertion length	Permissible if inserted length is no more than 15 % less than the specified insertion length	Permissible if inserted length is no more than 20 % less than the specified insertion length
5AAAA	Imperfect shape of weld flash	Mechanical testing of sample welds is recommended	Mechanical testing of sample welds is recommended	Mechanical testing of sample welds is recommended
5EKAA	Angular misalignment	Permissible if misalignment is not greater than 0,2°	Permissible if misalignment is not greater than 0,4°	Permissible if misalignment is not greater than 0,8°
6EAAA	Excessive upset	Not permissible	Not permissible	Not permissible
6HAAA 6HAAC	Excessive asymmetry of welds	Not permissible	Not permissible	Not permissible
7BAAA	Thermal damage	Not permissible	Not permissible	Not permissible

NOTE The data in this table can also be found in DVS 2202-1 [1].

Table 5 — Definition of quality levels for electrofusion welds

Number	Designations	Level B	Level C	Level D
3AAAA	Inclusion	Isolated inclusion permissible if maximum dimension ≤ 5 % of fusion length	Isolated and rows of inclusions permissible if maximum dimension ≤ 10 % of fusion length	Isolated and rows of inclusions permissible if maximum dimension ≤ 15 % of fusion length
3KAAA	Degraded polymer	Not permissible	Not permissible	Not permissible
4BAAA	Lack of fusion	Not permissible	Not permissible	Not permissible
4SAAA	Insufficient penetration	Permissible if inserted length is not less than the specified insertion length minus 10 % of the length of the internal cold zone	Permissible if inserted length is not less than the specified insertion length minus 10 % of the length of the internal cold zone	Permissible if inserted length is not less than the specified insertion length minus 15 % of the length of the internal cold zone
4TAAA	Displaced filament	Not permissible	Not permissible	Not permissible
4UAAA	Failure of welding indicator	Not permissible	Not permissible	Not permissible
5EKAA	Angular misalignment	Permissible if misalignment is not greater than 0,2°	Permissible if misalignment is not greater than 0,4°	Permissible if misalignment is not greater than 0,8°
6EAAA	Excessive upset (molten material exuding between pipe and fitting)	Not permissible	Not permissible	Not permissible
7BAAA	Thermal damage	Not permissible	Not permissible	Not permissible
9CAAA	Tool mark	Locally permissible if bottom of notch is not acute and the notch depth is less than 10 % of the wall thickness of the pipe or fitting at the location of the notch	Locally permissible if bottom of notch is not acute and the notch depth is less than 10 % of the wall thickness of the pipe or fitting at the location of the notch	Locally permissible if bottom of notch is not acute and the notch depth is less than 15 % of the wall thickness of the pipe or fitting at the location of the notch
NOTE The data in this table can also be found in DVS 2202-1 [1].				

Table 6 — Definition of quality levels for hot gas welds

Number	Designations	Level B	Level C	Level D
1AAAA	Cracks	Not permissible	Not permissible	Not permissible
2BAAA	Gas cavity	Isolated cavities permissible if diameter ≤ 5 % of wall thickness	Permissible if diameter of largest cavity ≤ 10 % of wall thickness	Permissible if diameter of largest cavity ≤ 15 % of wall thickness
2DAAA	Craze	Not permissible	Not permissible	Not permissible
3AAAA	Inclusion	Isolated inclusion permissible if maximum dimension ≤ 5 % of wall thickness	Isolated and rows of inclusions permissible if maximum dimension ≤ 10 % of wall thickness	Isolated and rows of inclusions permissible if maximum dimension ≤ 15 % of wall thickness
3KAAA	Degraded polymer	Not permissible	Not permissible	Not permissible
4BAAA	Lack of fusion	Not permissible	Not permissible	Not permissible
4CAAG	Incomplete penetration	Not permissible	Not permissible	Not permissible
4DAAG	Excessive penetration	Locally permissible if less than (<) 15 % of the wall thickness but not greater than 2 mm	Permissible if less than 20 % of the wall thickness, but not greater than 3 mm	Permissible if less than 25 % of the wall thickness, but not greater than 4 mm
4EAAA	Undercut	Not permissible	Locally permissible if no sharp edges and undercut is less than 10 % of the wall thickness, but not greater than 1 mm	Locally permissible if no sharp edges and undercut is less than 10 % of the wall thickness, but not greater than1 mm
4QAAA	Groove in upset or reinforcement	Locally permissible if bottom of groove above the plate surface	Locally permissible if bottom of groove above the plate surface	Locally permissible if bottom of groove above the plate surface
5EJAA	Linear misalignment	Permissible if misalignment is not greater than 10 % of the wall thickness	Permissible if misalignment is not greater than 15 % of the wall thickness.	Permissible if misalignment is not greater than 20 % of the wall thickness.

Number	Designations	Level B	Level C	Level D
5EKAA	Angular misalignment	Permissible if misalignment is not greater than 0,6°	Permissible if misalignment is not greater than 1,0°	Permissible if misalignment is not greater than 1,5°
5HAAA	Irregular surface	Not permissible	Only isolated occurrences permissible	Only isolated occurrences permissible
6BAAA	Excess weld material	Permissible if weld height between 10 % and 40 % of wall thickness	Permissible if weld height between 5 % and 50 % of wall thickness	Permissible if weld height between 5 % and 60 % of wall thickness
6FAAA	Incompletely filled groove	Not permissible	Not permissible	Not permissible
6HAAA	Excessive asymmetry of welds	Not permissible	Not permissible	Not permissible
7BAAA	Thermal damage	Not permissible	Only isolated occurrences permissible	Only isolated occurrences permissible
7GAAA	Poor restart	Not permissible	Small cross-section reductions permissible if there are no sharp transitions	Small cross-section reductions permissible if there are no sharp transitions
7VAAA	Weld intersections	Not permissible	Not permissible	Not permissible
9CAAA	Tool mark	Locally permissible if bottom of notch is not acute and the notch depth is less than 10 % of the wall thickness and not greater than 0,5 mm	Locally permissible if bottom of notch is not acute and the notch depth is less than 10 % of the wall thickness and not greater than 1,0 mm	Locally permissible if bottom of notch is not acute and the notch depth is less than 15 % of the wall thickness and not greater than 2,0 mm
NOTE The data in this table can also be found in DVS 2202-1 [1].				

Table 7 — Definition of quality levels for extrusion welds

Number	Designations	Level B	Level C	Level D
1AAAA	Cracks	Not permissible	Not permissible	Not permissible
2BAAA	Gas cavity	Isolated cavities permissible if diameter ≤ 10 % of wall thickness	Permissible if diameter of largest cavity ≤ 15 % of wall thickness	Permissible if diameter of largest cavity ≤ 20 % of wall thickness
2CAAA	Shrinkage cavity	Isolated cavities permissible if diameter ≤ 10 % of wall thickness	Permissible if diameter of largest cavity ≤ 15 % of wall thickness	Permissible if diameter of largest cavity ≤ 20 % of wall thickness
2DAAA	Craze	Not permissible	Not permissible	Not permissible
3AAAA	Inclusion	Isolated inclusion permissible if maximum dimension ≤ 5 % of wall thickness	Isolated and rows of inclusions permissible if maximum dimension ≤ 10 % of wall thickness	Isolated and rows of inclusions permissible if maximum dimension ≤ 15 % of wall thickness
3KAAA	Degraded polymer	Not permissible	Not permissible	Not permissible
4BAAA	Lack of fusion	Not permissible	Not permissible	Not permissible
4CAAG	Incomplete penetration	Not permissible	Not permissible	Permissible if difference between actual and specified penetration less than 10 % of wall thickness, but not greater than 1 mm
4DAAG	Excessive penetration	Permissible (PE and PP only) if between 10 % and 25 % of the wall thickness	Permissible (PE and PP only) if between 5 % and 30 % of the wall thickness	Permissible (PE and PP only) if between 0 % and 40 % of the wall thickness
4EAAA	Undercut	Locally permissible if no sharp edges and undercut is less than 10 % of the wall thickness, but not greater than 1 mm	Permissible if no sharp edges and undercut is less than 10 % of the wall thickness, but not greater than 2 mm	Permissible if no sharp edges and undercut is less than 20 % of the wall thickness, but not greater than 3 mm

Number	Designations	Level B	Level C	Level D
4QAAA	Groove in upset or reinforcement	Locally permissible if bottom of groove above the plate surface	Locally permissible if bottom of groove above the plate surface	Locally permissible if bottom of groove above the plate surface
5AAAA	Imperfect shape	Mechanical testing of sample welds is recommended	Mechanical testing of sample welds is recommended	Mechanical testing of sample welds is recommended
5DAAA	Overlap	Not permissible	Locally permissible if unfused overlap length is less than 5 mm	Locally permissible if unfused overlap length is less than 10 mm
5EJAA	Linear misalignment	Permissible if misalignment is not greater than 10 % of the wall thickness	Permissible if misalignment is not greater than 20 % of the wall thickness	Permissible if misalignment is not greater than 30 % of the wall thickness
5EKAA	Angular misalignment	Permissible if misalignment is not greater than 0,6°	Permissible if misalignment is not greater than 1,0°	Permissible if misalignment is not greater than 1,5°
5GAAA	Irregular width	Permissible if only occurring in isolated sections	Permissible	Permissible
5HAAA	Irregular surface	Not permissible	Not permissible	Not permissible
6BAAA	Excess weld material	Permissible if weld height is between 10 % and 30 % of the wall thickness, but not greater than 6 mm	Permissible if weld height is between 5 % and 40 % of the wall thickness, but not greater than 8 mm	Permissible if weld height is between 0 % and 50 % of the wall thickness, but not greater than 10 mm
6FAAA	Incompletely filled groove	Not permissible	Not permissible	Not permissible
7BAAA	Thermal damage	Not permissible	Not permissible	Not permissible
7GAAA	Poor restart	Not permissible	Small cross-section reductions permissible if there are no sharp transitions	Small cross-section reductions permissible if there are no sharp transitions
7VAAA	Weld intersections	Not permissible	Not permissible	Not permissible

Number	Designations	Level B	Level C	Level D
8VAAA	Transverse ripple	Permissible if only in isolated sections	Permissible	Permissible
9CAAA	Tool mark	Locally permissible if bottom of notch is not acute and the notch depth is less than 10 % of the wall thickness and not greater than 0,5 mm	Locally permissible if bottom of notch is not acute and the notch depth is less than 10 % of the wall thickness and not greater than 1,0 mm	Locally permissible if bottom of notch is not acute and the notch depth is less than 15 % of the wall thickness and not greater than 2,0 mm
NOTE The data in this table can also be found in DVS 2202-1 [1].				

Table 8 — Definition of quality levels for solvent welds in pipes

Number	Designations	Level B	Level C	Level D
1AAAA	Cracks	Not permissible	Not permissible	Not permissible
2BAAA	Gas / air cavity	Isolated cavities permissible if diameter ≤ 5 % of insertion length	Permissible if diameter of largest cavity ≤ 10 % of insertion length	Permissible if diameter of largest cavity ≤ 15 % of insertion length
3AAAA	Inclusion	Not permissible	Not permissible	Isolated inclusion permissible if maximum dimension is ≤ 5 % of insertion length
4RAAA	Compressed pipe ends (over penetration of pipe into socket)	Not permissible	Not permissible	Not permissible
4SAAA	Insufficient penetration	Permissible if inserted length is no more than 10 % less than the specified insertion length	Permissible if inserted length is no more than 10 % less than the specified insertion length	Permissible if inserted length is no more than 15 % less than the specified insertion length
5EKAA	Angular misalignment	Permissible if misalignment is not greater than 0,2°	Permissible if misalignment is not greater than 0,4°	Permissible if misalignment is not greater than 0,8°
6BAAA	Excess weld material (solvent cement)	Not permissible	Not permissible	Not permissible
6FAAA	Incompletely filled groove	Not permissible	Not permissible	Not permissible

Bibliography

[1] DVS 2202-1, *Imperfections in thermoplastic welded joints — Features, descriptions, evaluation*

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