DIN EN ISO 17677-1

ICS 01.040.25; 25.160.10

Ersatz für
DIN EN ISO 17677-1:2019-06

Widerstandsschweißen – Begriffe – Teil 1: Punkt-, Buckel- und Rollennahtschweißen (ISO 17677-1:2021); Dreisprachige Fassung EN ISO 17677-1:2021

Resistance welding –
Vocabulary –
Part 1: Spot, projection and seam welding (ISO 17677-1:2021);
Trilingual version EN ISO 17677-1:2021

Soudage par résistance –
Vocabulaire –
Partie 1: Soudage par points, par bossages et à la molette (ISO 17677-1:2021);
Version trilingue EN ISO 17677-1:2021

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Nationales Vorwort

Dieses Dokument (EN ISO 17677-1:2021) wurde vom Technischen Komitee ISO/TC 44 „Welding and allied processes“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 121 „Schweißen und verwandte Verfahren“ erarbeitet, dessen Sekretariat von DIN (Deutschland) gehalten wird.

Das zuständige nationale Normungsgremium ist der Arbeitsausschuss NA 092-00-12 AA „Widerstandsschweißen (DVS AG V 3)“ im DIN-Normenausschuss Schweißen und verwandte Verfahren (NAS).

Hinweis: In der deutschen Übersetzung fehlt der Literaturhinweis [3], ISO/TR 25901-1:2016, *Welding and allied processes — Vocabulary — Part 1: General terms*. Dadurch hat sich die Benummerung der nachfolgenden Literaturhinweise entsprechend verschoben.

Für die in diesem Dokument zitierten Dokumente wird im Folgenden auf die entsprechenden deutschen Dokumente hingewiesen:

ISO 4063	siehe	DIN EN ISO 4063
ISO 17659:2002	siehe	DIN EN ISO 17659:2005-09

Aktuelle Informationen zu diesem Dokument können über die Internetseiten von DIN (www.din.de) durch eine Suche nach der Dokumentennummer aufgerufen werden.

Änderungen

Gegenüber DIN EN ISO 17677-1:2019-06 wurden folgende Änderungen vorgenommen:

a) die Begriffe aus ISO 14329 wurden überführt;

b) redaktionelle Anpassungen.

Frühere Ausgaben

DIN EN ISO 17677-1: 2010-01, 2019-06

Nationaler Anhang NA
(informativ)

Literaturhinweise

DIN EN ISO 4063, *Schweißen und verwandte Prozesse — Liste der Prozesse und Ordnungsnummern*

DIN EN ISO 17659:2005-09, *Schweißen — Mehrsprachige Benennungen für Schweißverbindungen mit bildlichen Darstellungen (ISO 17659:2002); Dreisprachige Fassung EN ISO 17659:2004*

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EUROPEAN STANDARD

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Widerstandsschweißen — Begriffe — Teil 1: Punkt-, Buckel- und Rollennahtschweißen (ISO 17677-1:2021)

Resistance welding — Vocabulary — Part 1: Spot, projection and seam welding (ISO 17677-1:2021)

Soudage par résistance — Vocabulaire — Partie 1: Soudage par points, par bossages et à la molette (ISO 17677-1:2021)

Diese Europäische Norm wurde vom CEN am 28. Februar 2021 angenommen.

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This European Standard was approved by CEN on 28 February 2021.

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La présente Norme européenne a été adoptée par le CEN le 28 février 2021.

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European foreword

This document (EN ISO 17677-1:2021) has been prepared by Technical Committee ISO/TC 44 "Welding and allied processes" in collaboration with Technical Committee CEN/TC 121 “Welding and allied processes” the secretariat of which is held by DIN.

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 September 2021, and conflicting national standards shall be withdrawn at the latest by September 2021.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 17677-1:2019.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 17677-1:2021 has been approved by CEN as EN ISO 17677-1:2021 without any modification.

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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).

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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 44, *Welding and allied processes*, Subcommittee SC 6, *Resistance welding and allied mechanical joining*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 17677-1:2019), of which it constitutes a minor revision. The main changes compared to the previous edition are as follows:

— the terms and definitions of ISO 14329 have been implemented;

— editorial changes have been made.

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.

Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

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Resistance welding — Vocabulary —

Part 1:
Spot, projection and seam welding

1 Scope

This document establishes a vocabulary of terms and definitions for resistance spot welding, projection welding and seam welding.

NOTE In addition to terms used in English and French, two of the three official ISO languages, this document gives the equivalent terms in German; these are published under the responsibility of the member body for Germany (DIN). However, only the terms and definitions given in the official languages can be considered as ISO terms and definitions.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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 http://www.electropedia.org/

3.1 Welding and testing procedures

3.1.1
chisel test
test in which a chisel is driven between the sheets near to adjacent welds until either fracture occurs or until the metal near the weld yields or bends

3.1.2
cross tension test
tensile test of a resistance welded specimen to determine the mechanical properties and failure mode of the weld

3.1.3
cross-wire welding
projection welding (3.1.11) of crossed wires or rods

3.1.4
direct welding
resistance welding secondary circuit variant in which welding current and *electrode force* (3.3.5) are applied to the workpieces by directly opposed *electrodes* (3.2.1) and only one weld is made by one welding operation

Note 1 to entry: See Figure 12 for typical arrangements.

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3.1.5
indirect welding
resistance welding secondary circuit variant in which the welding current flows through the workpieces in locations away from, as well as at, the welds

Note 1 to entry: See Figure 13 for typical arrangements.

3.1.6
multiple impulse welding
welding with more than one impulse

Note 1 to entry: See Figures 4 to 7 for related time and *electrode force* (3.3.5) diagrams.

3.1.7
multiple spot welding
spot welding in which two or more welds are made simultaneously in one welding operation

Note 1 to entry: Examples are *parallel spot welding* (3.1.8) and *series spot welding* (3.1.14).

3.1.8
parallel spot welding
resistance welding secondary circuit variant in which the secondary current is divided in parallel electrical paths to make two or more welds simultaneously

Note 1 to entry: See Figure 11 a).

3.1.9
peel test
destructive test in which a resistance-welded lap joint is tested by applying a peel force which results in stresses mainly in the thickness direction of the weld

3.1.10
pillow test
destructive test in which internal pressure is applied in order to test for leaks and the strength of a seam weld

3.1.11
projection welding
resistance welding in which the resulting welds are localized at predetermined points by projections, embossments or intersections, concentrating force and current by their geometry

Note 1 to entry: The projections are raised on, or formed from, one or more of the *faying surfaces* (3.3.16) and collapse during welding.

3.1.12
resistance spot welding
resistance welding process producing a weld at the *faying surfaces* (3.3.16) between overlapping parts by the heat obtained from resistance to the flow of welding current through the workpieces from the *electrodes* (3.2.1) serving to concentrate the welding current and pressure at the weld area

3.1.13
seam welding
resistance welding in which force is applied continuously and current is applied continuously or intermittently to produce a linear weld, the workpieces being between two *electrode wheels* (3.2.5) or an electrode wheel and an electrode bar

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3.1.14
series spot welding
resistance welding secondary circuit variant in which the secondary current is conducted through the workpieces and *electrodes* (3.2.1) in a series electrical path to simultaneously form multiple resistance spot, seam or projection welds

Note 1 to entry: See Figures 1 and 11 b).

3.1.15
roll spot welding
resistance welding process variant that produces intermittent spot welds using one or more rotating circular electrodes

Note 1 to entry: The rotation of the *electrodes* (3.2.1) may or may not be stopped during the making of a weld.

3.1.16
shunt weld
first weld on a series of spot welds, which acts as a shunt

3.1.17
tensile shear test
test in which a lap-welded specimen is subjected to a tensile force with the aim of determining the mechanical properties of the specimen

3.1.18
stitch welding
spot welding in which successive welds overlap

3.2 Hardware and tools

3.2.1
electrode
resistance welding electrode
component of the electrical circuit that supplies electrical power and applies *electrode force* (3.3.5) to the workpiece

EXAMPLE Rotating wheel, rotating roll, bar, cylinder, plate, clamp, chuck, variations thereof.

3.2.1.1
angled electrode
bent electrode
electrode for spot or *stitch welding* (3.1.18) whose electrode *working face* (3.2.6) is not normal to the mounting axis

3.2.1.2
contact electrode
resistance welding electrode (3.2.1) designed to conduct secondary current through a workpiece without making a weld

3.2.1.3
offset electrode
eccentric electrode
electrode for spot or *stitch welding* (3.1.18) whose *electrode working face* (3.2.6) is not concentric with the axis of the *electrode adaptor* (3.2.2)

3.2.2
electrode adaptor
shank
device used to attach an *electrode* (3.2.1) to an *electrode holder* (3.2.4)

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3.2.3
electrode cap
replaceable *electrode* (3.2.1) tip used in *resistance spot welding* (3.1.12)

3.2.4
electrode holder
device holding a welding *electrode* (3.2.1)

3.2.5
electrode wheel
seam welding wheel
rotating *resistance welding electrode* (3.2.1) of ring or disc shape

3.2.6
electrode working face
<resistance spot welding and projection welding> end of a *resistance welding electrode* (3.2.1) in contact with the workpiece

3.2.7
welding head
device comprising the force generation and guiding system, carrying an *electrode holder* (3.2.4), platen or *electrode wheel* (3.2.5)

3.3 Welding process and parameters

3.3.1
chill time
quench time
period of time between the end of the weld current and the start of post-heat current during which no current flows and the weld is cooled by the *electrodes* (3.2.1)

Note 1 to entry: See Figure 5.

3.3.2
cool time
pause time
time interval between successive heat times in *multiple impulse welding* (3.1.6) or *seam welding* (3.1.13)

Note 1 to entry: See Figures 4 and 7.

3.3.3
current delay time
time interval between reaching set force and initiation of current flow

Note 1 to entry: See Figure 3.

3.3.4
current-off time
period of time between the cessation of current in one *welding cycle* (3.3.43) and the beginning of current in the next one

3.3.5
electrode force
force applied by the electrodes to the workpieces

Note 1 to entry: See *welding force* (3.3.44).

3.3.6
welding electrode force
electrode force applied during *weld time* (3.3.40)

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3.3.7
forging electrode force
forge force
electrode force applied in the forge force time

3.3.8
dynamic electrode force
electrode force applied during the actual *welding cycle* (3.3.43)

3.3.9
static electrode force
electrode force with no current flowing and no movement in the welding machine

3.3.10
theoretical electrode force
force, neglecting friction and inertia, available at the electrodes of a resistance welding machine by virtue of the initial force and the theoretical mechanical properties of the system

3.3.11
electrode force programme
predetermined sequence of changes of force during welding

3.3.12
electrode force and current programme
predetermined sequence of changes of force and current during the *welding cycle* (3.3.43)

3.3.13
electrode movement during welding
physical displacement of *electrodes* (3.2.1) due to thermal expansion, shrinkage and indentation during welding

3.3.14
electrode skidding
lateral movement of the *electrodes* (3.2.1) relative to the surface of the workpieces during the welding process

3.3.15
electrode stroke
physical movement of *electrodes* (3.2.1) in the electrode axis during the *welding cycle* (3.3.43)

3.3.16
faying surface
mating surface of a workpiece in contact with another workpiece to which it is to be joined

3.3.17
force application time
total time of the application of force by the *electrodes* (3.2.1) to the workpiece in a *welding cycle* (3.3.43)

Note 1 to entry: See Figures 3 to 7.

3.3.18
force fall time
time between the start of force decrease to zero force

Note 1 to entry: See Figures 3 to 7.

3.3.19
force maintenance time
time in the *welding cycle* (3.3.43) during which a force is maintained at a predetermined level, excluding the *force rise time* (3.3.20) and *force fall time* (3.3.18)

Note 1 to entry: See Figures 3 to 7.

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3.3.20
force rise time
time between the start of a force increase and the application of the predetermined force

Note 1 to entry: See Figures 3 to 7.

3.3.21
electrode force time
force time
time during which the force is built up and applied

Note 1 to entry: See Figures 3 to 7.

3.3.22
forge time
<welding force programme> time of increased force applied during or after the passage of the welding current

Note 1 to entry: See Figure 6.

3.3.23
head approach time
time of movement of the *electrode* (3.2.1) from the rest position to contact with the workpiece

Note 1 to entry: See Figures 3 to 7.

3.3.24
head return time
time of electrode return from contact with the workpiece to the rest position

3.3.25
heat-affected zone
HAZ
portion of non-melted parent metal whose microstructure has been affected by the heat of welding

Note 1 to entry: See Figure 2.

[SOURCE: ISO/TR 25901-1:2016, 2.1.2.2, modified — "by the heat of welding" has been added to the definition and Note 1 to entry has been added.]

3.3.26
heat time
duration of any one impulse in *multiple impulse welding* (3.1.6) or resistance *seam welding* (3.1.13)

Note 1 to entry: See Figures 4 to 7.

3.3.27
hold time
duration of *electrode force* (3.3.5) after cessation of current flow

Note 1 to entry: See Figures 3 to 7.

3.3.28
off-time
force set off-time
time after hold time until next start of working cycle

Note 1 to entry: See *actual* force *off-time* (3.3.29).

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3.3.29
actual force off-time
actual off-time
measured period of time between two successive *welding cycles* (3.3.43) when no *electrode force* (3.3.5) is being applied to the workpiece

Note 1 to entry: See *off-time* (3.3.28).

Note 2 to entry: See Figures 3 to 7.

3.3.30
opposing forces
forces tending to separate the electrodes, such as from a mismatch of workpieces, spring back, sealants, etc.

Note 1 to entry: See *welding force* (3.3.44).

3.3.31
post-heat time
temper time
time following the *chill time* (3.3.1) during which a current is passed through the weld for heat treatment or improvement of weld microstructure

Note 1 to entry: See Figures 5 and 6.

3.3.32
preheat time
duration of preheating current flow applied before the welding current

Note 1 to entry: See Figures 5 and 6.

3.3.33
expulsion
splash
spatter
flash
metal particles expelled between the *faying surfaces* (3.3.16) of the components or between the components and electrodes during *resistance spot welding* (3.1.12), *projection welding* (3.1.11) or *seam welding* (3.1.13)

3.3.34
squeeze time
set time between the initiation of the *welding cycle* (3.3.43) and first application of current

Note 1 to entry: See *actual squeeze time* (3.3.35).

Note 2 to entry: See Figures 3 to 7.

3.3.35
actual squeeze time
actual time between the initiation of the *welding cycle* (3.3.43) and first application of current

Note 1 to entry: See *squeeze time* (3.3.34).

Note 2 to entry: The time and *electrode force* (3.3.5) diagrams of Figures 3 to 8 show squeeze time.

3.3.36
time base
time expressed in cycles of the power supply frequency or in milliseconds

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3.3.37
upslope
controlled continuous increase of the current from a predetermined value or zero during a set time period

Note 1 to entry: See *down slope* (3.3.38).

3.3.38
down slope
controlled continuous decrease of the current until a predetermined value or zero is reached during a set time period

Note 1 to entry: See *upslope* (3.3.37).

3.3.39
weld contact area
area in the *faying surface* (3.3.16) through which welding current passes from one component to another during resistance welding

3.3.40
weld time
duration of continuous flow of welding current

Note 1 to entry: See Figures 3 to 7.

3.3.41
welding current programme
predetermined sequence of changes of current

3.3.42
welding cycle time
time required to complete a *welding cycle* (3.3.43), excluding the time for positioning the *electrodes* (3.2.1)

Note 1 to entry: See Figures 3 to 7.

3.3.43
welding cycle
<resistance welding> sequence of operations carried out by the machine to make a weld and return the *electrodes* (3.2.1) to their initial position

3.3.44
welding force
force acting on the *faying surfaces* (3.3.16), resulting from the *electrode force* (3.3.5) and any *opposing forces* (3.3.30), e.g. spring back of the workpieces, and the geometry of the parts

3.3.45
welding force programme
predetermined sequence of changes of force

3.3.46
work clearance stroke
physical displacement of *electrodes* (3.2.1), which allows them to move from one welding position to the next

Note 1 to entry: See Figure 8.

3.3.47
working cycle time
duration of a succession of operations carried out by a machine or gun for the making of a weld, including the return to the initial position

Note 1 to entry: See Figures 3 to 7.

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3.3.48
working stroke
minimum movement of the *electrodes* (3.2.1) during the *welding cycle* (3.3.43)

Note 1 to entry: See Figure 8.

3.3.49
maximum stroke
high lift stroke
retract stroke
maximum *electrode* (3.2.1) stroke

3.4 Measurements and values

3.4.1
corona bond area
area surrounding the *nugget* (3.4.11) at the *faying surfaces* (3.3.16) in which only solid phase bonding has occurred

3.4.2
corona bond diameter
d_c
mean diameter of the *corona bond area* (3.4.1)

Note 1 to entry: See Figures 2 and 9.

3.4.3
current pass area
area through which current passes from an *electrode* (3.2.1) to the workpiece, smaller than the *electrode working face* (3.2.6) and which varies during the welding operation

3.4.4
duty cycle
X_c
percentage of time during a specified period when a power source or its accessories can be operated at rated output without overheating

Note 1 to entry: $X_c = \frac{\sum(t_{on})}{t_{sp}} \times 100\,\%$

where t_{on} is the heat time, and t_{sp} is the specific period.

3.4.5
electrode indentation
spot or seam weld depression formed on the surface of workpieces by *electrodes* (3.2.1)

3.4.6
electrode indentation depth
e_u, e_l
maximum depth of the *electrode indentation* (3.4.5) measured in the direction of the *electrode force* (3.3.5)

Note 1 to entry: See Figure 2.

3.4.7
electrode indentation diameter
d_{eu}, d_{el}
diameter of the *electrode indentation* (3.4.5)

Note 1 to entry: See Figure 2.

Note 2 to entry: If possible the mean value should be used.

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3.4.8
electrode life
number of acceptable spot welds or length of weld seam that can be made with an electrode without any redressing or replacement of the electrode

3.4.9
electrode service life
electrode production life
number of acceptable spot welds or length of weld seam that can be made with an *electrode* (3.2.1) before the electrode is no longer useable

3.4.10
electrode misalignment
unintentional offset between the axes of the *electrodes* (3.2.1)

3.4.11
nugget
zone in spot, projection or seam weld where the metal has been melted

Note 1 to entry: See Figure 2.

3.4.12
nugget penetration
p_l, p_u
maximum penetration of the *nugget* (3.4.11) into the upper or lower workpiece, measured perpendicular to the *faying surface(s)* (3.3.16) of the workpieces

Note 1 to entry: See Figure 2.

3.4.13
nugget thickness
p
<spot, projection or seam weld> maximum thickness of the *nugget* (3.4.11) in two or more sheets measured perpendicular to the *faying surface(s)* (3.3.16) of the workpieces

Note 1 to entry: For two sheets, $p = p_l + p_u$; see Figure 2.

3.4.14
nugget overlap
o
<seam weld> length of common area between two adjacent overlapping seam weld *nuggets* (3.4.11)

Note 1 to entry: See Figure 14.

Note 2 to entry: The area contains the portion of the preceding weld nugget remolten by the succeeding weld.

3.4.15
seam weld width
width of the weld metal in the plane of the *faying surfaces* (3.3.16) in a direction normal to the longitudinal axis of the linear seam weld

3.4.16
seam weld nugget length
d_l
length of individual weld *nugget* (3.4.11) in the *seam welding* (3.1.13) direction

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3.4.17
sheet separation
x
gap between the *faying surfaces* (3.3.16) measured at a distance of 0,5 d_n from the edge of the *nugget* (3.4.11)

Note 1 to entry: See Figure 2.

3.4.18
throat area
region bounded by the physical components of the secondary circuit of the welding machine

3.4.19
width of seam weld electrode indentation
width of the *electrode indentation* (3.4.5) measured in a direction normal to the longitudinal axis of the linear seam weld

3.4.20
weld diameter
d_w
mean diameter of fused zone at *faying surface* (3.3.16) after destructive testing without metallurgical examination

Note 1 to entry: See Figure 10.

3.4.21
nugget diameter
d_n
diameter of *nugget* (3.4.11) measured at the *faying surface* (3.3.16) by metallurgical examination

Note 1 to entry: See Figure 2.

3.4.22
plug diameter
d_p
mean diameter of the plug measured after destructive testing

Note 1 to entry: See Figure 10.

3.4.23
plug
button
part of a spot weld, which tears out during destructive testing

Note 1 to entry: It may include all or part of the nugget, the heat-affected zone and base metal.

Note 2 to entry: A hole is left in the mating sheet(s).

3.4.24
interface failure
fracture through the weld nugget along the *faying surface* (3.3.16)

Note 1 to entry: See Figures 9 and 15.

Note 2 to entry: If less than approximately 20 % of the mating sheet thickness is removed, the fracture is still interfacial.

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3.4.25
plug failure
button pull
failure mode of a weld, where separation occurs through base metal or the *heat-affected zone* (3.3.25) of the weld, resulting in a *plug* (3.4.23) on one sheet and a hole in the other sheet

Note 1 to entry: See Figures 10 and 15.

3.4.26
partial thickness failure
failure mode of a weld where parts of the nugget and/or parent metal are pulled out of the mating sheets without leaving a through hole

Note 1 to entry: See Figures 15 and 16.

Note 2 to entry: The portion removed must be more than 20 % of the mating sheet thickness, otherwise the fracture is interfacial. In all cases of partial thickness failures a cavity is left in the mating sheet wherever there is no through thickness hole from a button plug pull.

Note 3 to entry: In case of having a fracture along the boundary between the weld *nugget* (3.4.11) and the heat-affect zone the fracture is called a dome failure.

3.4.27
mixed failure mode
failure mode of a spot weld where two or three different failure modes are combined

Note 1 to entry: See Figure 17.

Note 2 to entry: The three different failure modes are the *interface failure* (3.4.24), the *plug failure* (3.4.25) and the *partial thickness failure* (3.4.26).

3.4.28
fused area
area of the weld at the *faying surface* (3.3.16) after destructive testing in case of interface failure

Note 1 to entry: See Figure 9.

3.4.29
solid phase joint
forged joint formed without melting

3.4.30
asymmetrical weld
elongated or oval welds in spot or *projection welding* (3.1.11)

Note 1 to entry: See Figure 10.

3.4.31
minimum seam weld width
w_{min}
minimum width of the *seam weld width* (3.4.15) along the longitudinal direction

Note 1 to entry: See Figure 18.

3.4.32
brazed area
<welding of metallic coated sheets> area over which the bond is formed between the coatings only

Note 1 to entry: See Figure 19.

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3.4.33
brazed zone diameter
d_{sb}
<welding of metallic coated sheets> diameter of the *brazed area* (3.4.32) measured in the plane of the weld at the *faying surface* (3.3.16)

Note 1 to entry: The mean value should be used (see Figure 19).

3.4.34
distance between nugget centres
a
<seam weld> distance between the centres of two adjacent *nuggets* (3.4.11)

Note 1 to entry: See Figure 16.

Note 2 to entry: The position of the nugget centre normally corresponds with the position of maximum nugget penetration.

3.4.35
heat-affected zone diameter
d_{HAZ}
diameter of the *heat-affected zone* (3.3.25) measured on a macro- or microsection

Note 1 to entry: See Figure 2.

3.4.36
heat-affected zone penetration
$P_{HAZ,u}$, $P_{HAZ,l}$
maximum size of the *heat-affected zone* (3.3.25) in the thickness direction of each sheet

Note 1 to entry: See Figure 2.

3.4.37
maximum thickness of seam weld
p_{max}
<seam weld> maximum thickness of the *nugget* (3.4.11) in the thickness direction

Note 1 to entry: See Figure 14.

3.4.38
minimum thickness of seam weld
p_{min}
<seam weld> minimum thickness of the *nugget* (3.4.11) in the thickness direction

Note 1 to entry: See Figure 14.

Note 2 to entry: It is usually achieved in the overlap area.

Note 3 to entry: The minimum nugget thickness can be measured in discontinuous seam and roll spot welds but the ability to do so in continuous seam and roll spot welds depends on the weld condition and metal.

3.4.39
plug failure in parent metal
button pull in parent metal
special case of *plug failure* (3.4.25) where the failure occurs through the base metal, resulting in a greater plug diameter than the nugget diameter which would be measured in a cross section

Note 1 to entry: See Figure 20.

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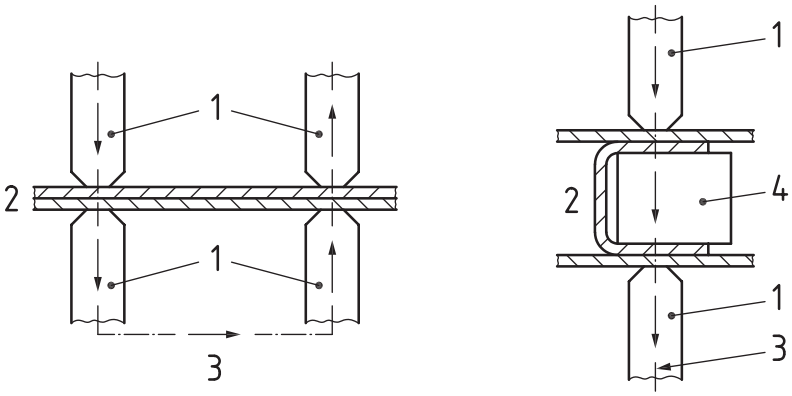

Key

1 electrode
2 workpiece
3 current flow
4 copper packing piece

Figure 1 — Examples of series spot welding

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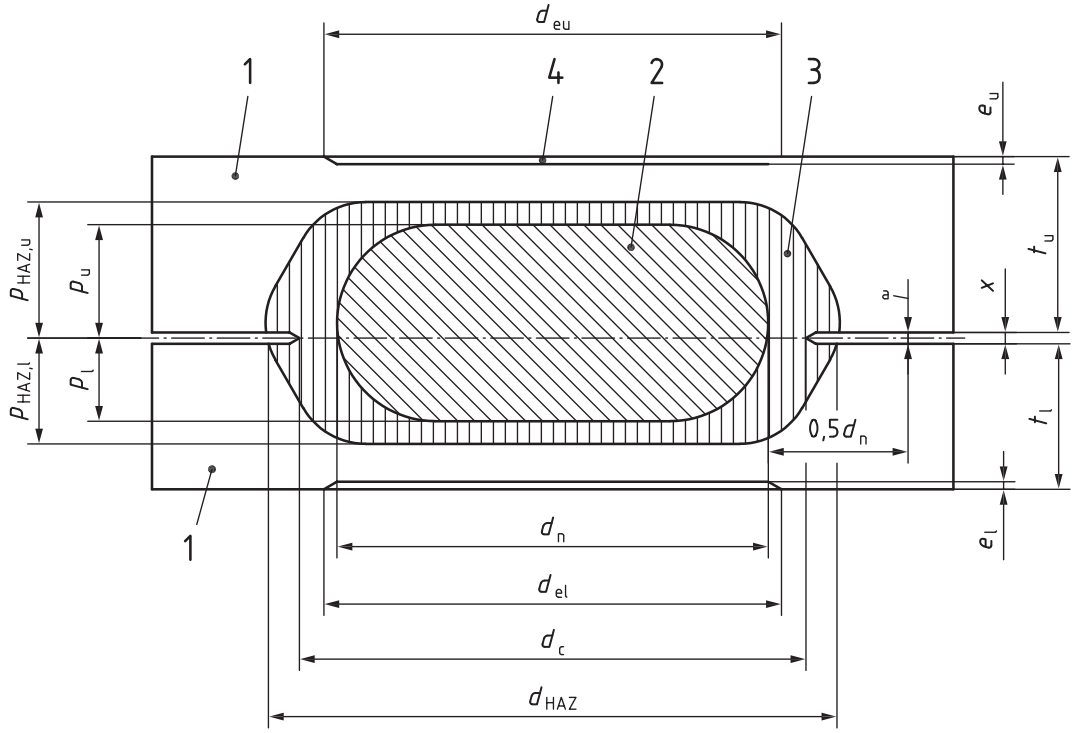

Key

1	workpieces
2	nugget
3	heat-affected zone (HAZ)
4	electrode indentation
d_{HAZ}	diameter of heat-affected zone
$p_{HAZ,l}$	lower penetration of heat-affected zone
$p_{HAZ,u}$	upper penetration of heat-affected zone
t_l	thickness of the lower workpiece
t_u	thickness of the upper workpiece
d_{eu}	electrode indentation diameter
d_{el}	electrode indentation diameter
d_c	corona bond diameter
d_n	nugget diameter
p_u	nugget penetration
p_l	nugget penetration
x	sheet separation
e_u	electrode indentation depth
e_l	electrode indentation depth
a	Location for the measurement of sheet separation (x).

Figure 2 — Measurements taken at weld cross-section

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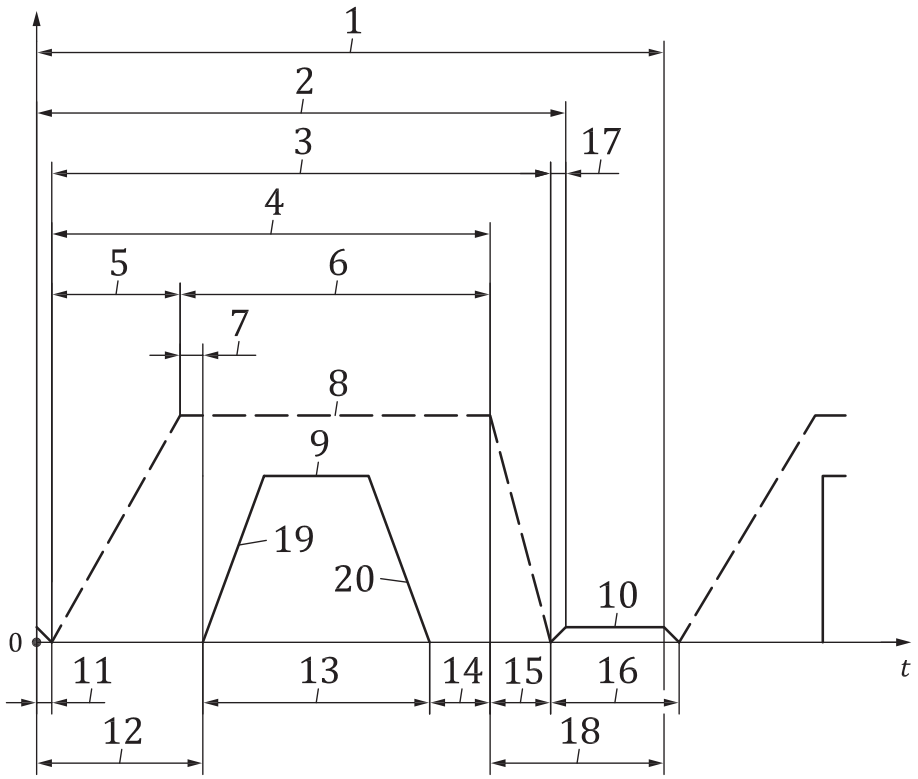

Key

1	working cycle time	11	head approach time
2	welding cycle time	12	squeeze time
3	force application time	13	weld time
4	electrode force time	14	hold time
5	force rise time	15	force fall time
6	force maintenance time	16	actual force off-time
7	current delay time	17	head return time
8	electrode force	18	off-time
9	current	19	upslope
10	head lift off position	20	down slope
		t	time

Figure 3 — Time and electrode force diagram for simple spot, stitch or projection welding

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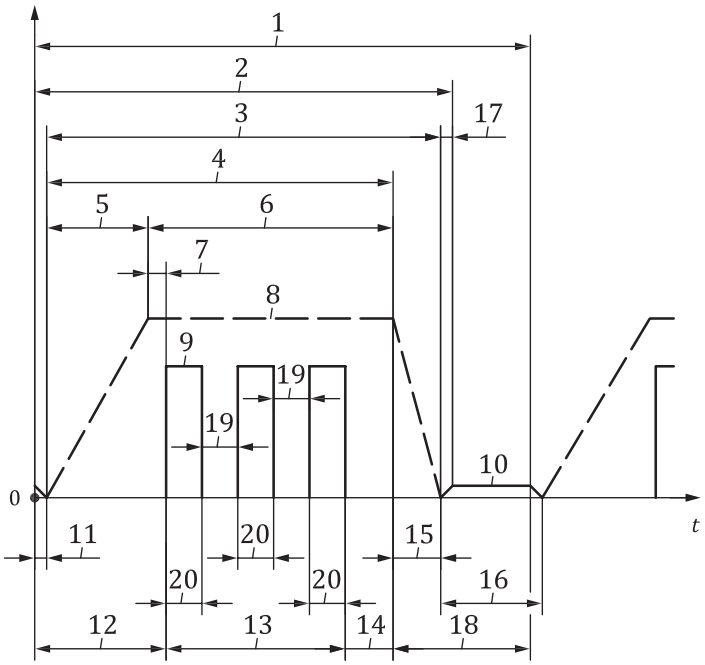

Key

1	working cycle time	12	squeeze time
2	welding cycle time	13	weld time
3	force application time	14	hold time
4	electrode force time	15	force fall time
5	force rise time	16	actual force off-time
6	force maintenance time	17	head return time
7	current delay time	18	off-time
8	electrode force	19	cool time
9	current	20	heat time/individual weld time
10	head lift off position	*t*	time
11	head approach time		

Figure 4 — Time and electrode force diagram for pulsation spot or projection welding

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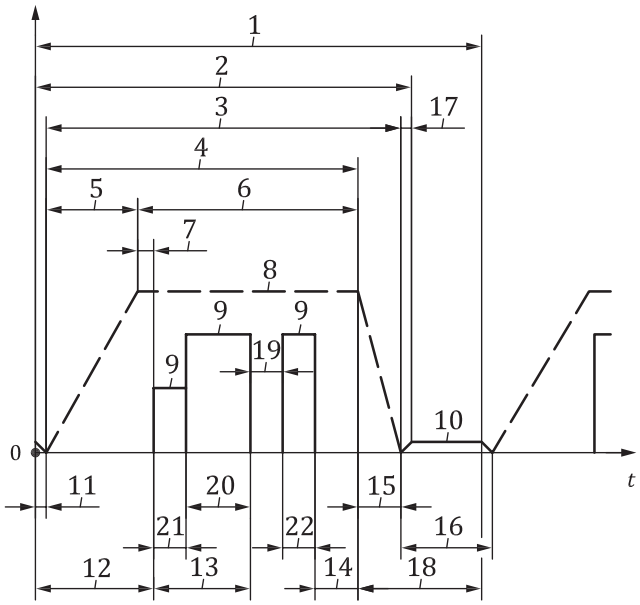

Key

1	working cycle time	12	squeeze time
2	welding cycle time	13	weld time
3	force application time	14	hold time
4	electrode force time	15	force fall time
5	force rise time	16	actual force off-time
6	force maintenance time	17	head return time
7	current delay time	18	off-time
8	electrode force	19	chill time
9	current	20	heat time/individual weld time
10	head lift off position	21	preheat time
11	head approach time	22	post-heat time
		t	time

Figure 5 — Time and electrode force diagram for spot or projection welding — Current programme control

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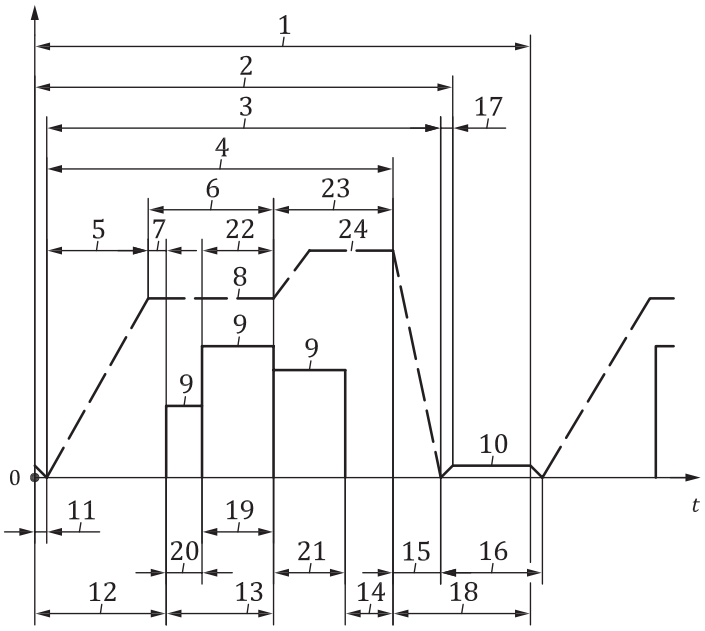

Key

1	working cycle time	13	weld time
2	welding cycle time	14	hold time
3	force application time	15	force fall time
4	electrode force time	16	actual force off-time
5	force rise time	17	head return time
6	force maintenance time	18	off-time
7	current delay time	19	heat time/individual weld time
8	electrode force	20	preheat time
9	current	21	post heat time
10	head lift off position	22	forge delay time
11	head approach time	23	forge time
12	squeeze time	24	forge force
		t	time

Figure 6 — Time and electrode force diagram for spot welding — Current and electrode force programme control

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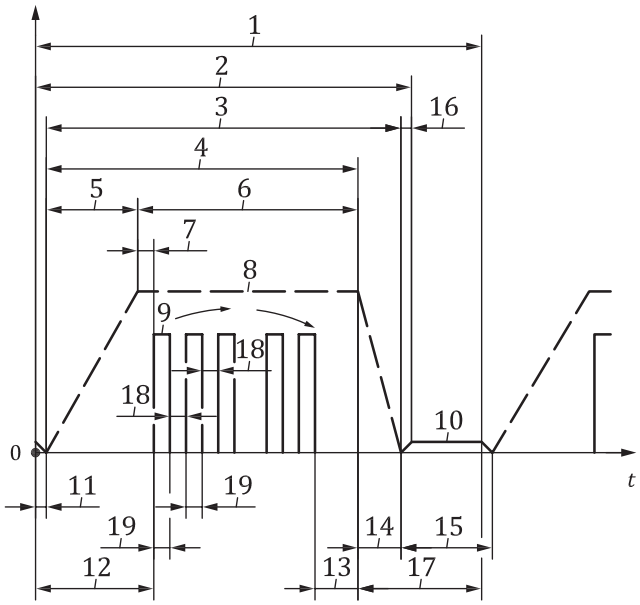
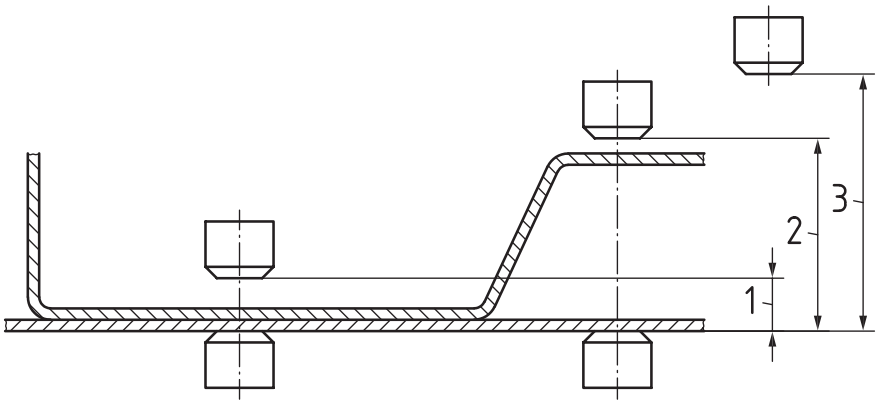


Key

1	working cycle time	11	head approach time
2	welding cycle time	12	squeeze time
3	force application time	13	hold time
4	electrode force time	14	force fall time
5	force rise time	15	actual force off-time
6	force maintenance time	16	head return time
7	current delay time	17	off-time
8	electrode force	18	cool time
9	current	19	heat time/individual weld time
10	head lift off position	*t*	time

Figure 7 — Time and electrode force diagram for seam welding



Key

1 working stroke
2 work clearance stroke
3 high lift stroke

Figure 8 — Position of upper electrode before spot welding

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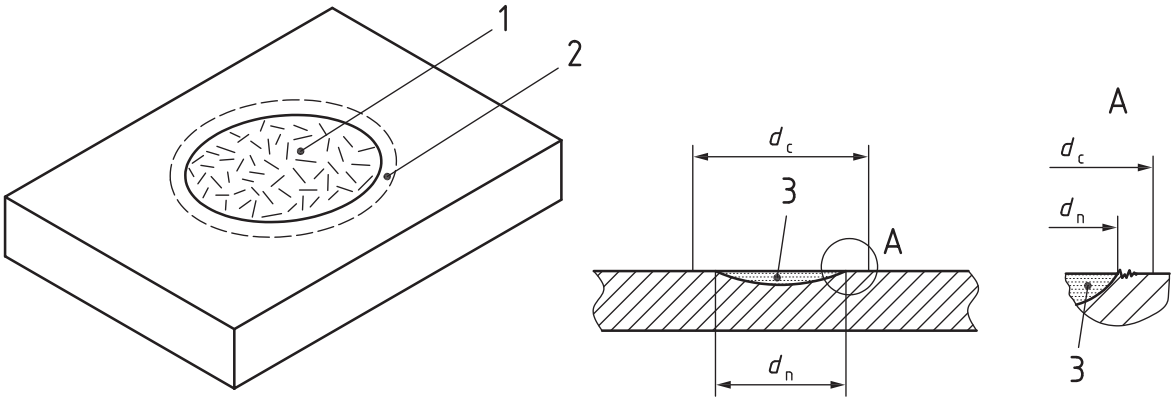

Key

1 fused area
2 corona bond zone
3 nugget
d_c corona bond diameter
d_n nugget diameter

Figure 9 — Measurement of weld diameter for interface failure

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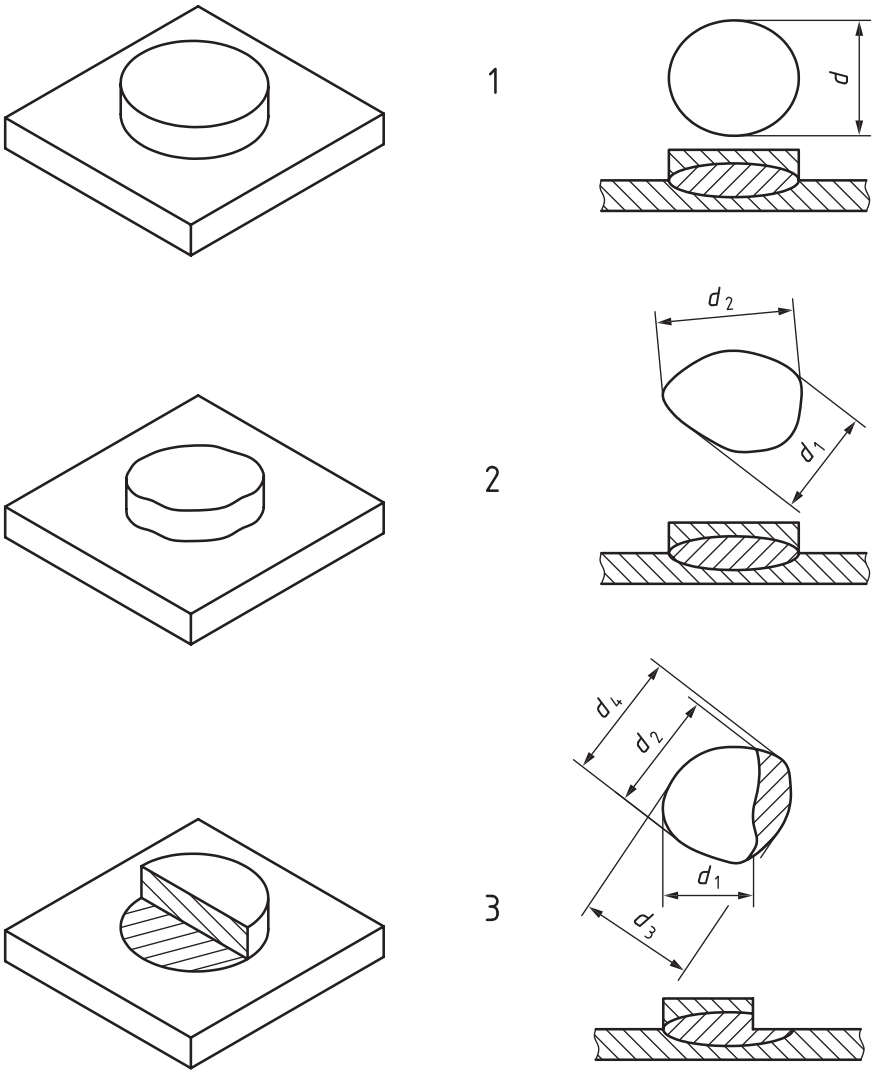

Key

1 symmetrical $d_p = d_w = d$

2 asymmetrical $d_p = d_w = (d_1 + d_2)/2$

3 partial plug with partial interface failure $d_p = (d_1 + d_2)/2$

$d_w = (d_3 + d_4)/2$

d_p plug diameter

d_w weld diameter

NOTE d_1 and d_3 are the minimum diameters. d_2 and d_4 are the maximum diameters.

Figure 10 — Measurement of weld and plug diameter for plug failure and partial plug with interface failure

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