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Resistance welding — Resistance welding equipment — Mechanical and electrical requirements

Soudage par résistance — Matériel de soudage par résistance — Exigences mécaniques et électriques

Reference number
ISO 669:2000(E)

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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.

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.

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

International Standard ISO 669 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 6, *Resistance welding*.

This second edition cancels and replaces the first edition (ISO 669:1981), which has been technically revised.

Annex A forms a normative part of this International Standard. Annex B is for information only.

Resistance welding — Resistance welding equipment — Mechanical and electrical requirements

1 Scope

This International Standard applies to resistance welding equipment, to guns with inbuilt transformers and to complete movable welding equipment.

The following types are included:

— single-phase equipment with alternating welding current;

— single-phase equipment with rectified welding current by rectification of the output of the welding transformer;

— single-phase equipment with inverter welding transformer;

— three-phase equipment with rectified welding current by rectification of the output of the welding transformer;

— three-phase equipment with a current rectification in the input of the welding transformer (sometimes called frequency convertor);

— three-phase equipment with inverter welding transformers.

This International Standard applies neither to welding transformers sold separately nor to safety requirements.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 865:1981, *Slots in platens for projection welding machines.*

ISO 5183-1:1998, *Resistance welding equipment — Electrode adaptors, male taper 1:10 — Part 1: Conical fixing, taper 1:10.*

ISO 5183-2:1988, *Resistance spot welding — Electrode adaptors, male taper 1:10 — Part 2: Parallel shank fixing for end-thrust electrodes*.

ISO 5184:1979, *Straight resistance spot welding electrodes.*

ISO 5821:1979, *Resistance spot welding electrode caps.*

ISO 5826:1999, *Electric resistance welding — Transformers — General specifications applicable to all transformers*.

ISO 5829:1984, *Resistance spot welding — Electrode adaptors, female taper 1:10*.

ISO 5830:1984, *Resistance spot welding — Male electrode caps*.

ISO 8430-1:1988, *Resistance spot welding — Electrode holders — Part 1: Taper fixing 1:10*.

ISO 8430-2:1988, *Resistance spot welding — Electrode holders — Part 2: Morse taper fixing*.

ISO 8430-3:1988, *Resistance spot welding — Electrode holders — Part 3: Parallel shank fixing for end thrust*.

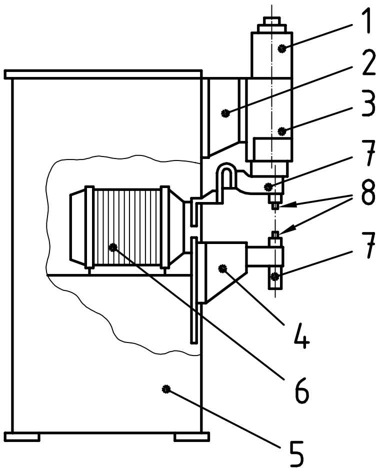
IEC 60051-2:1984, *Direct acting indicating analogue electrical measuring instruments and their accessories — Part 2: Special requirements for amperemeters and voltmeters.*

IEC 60204-1:1992, *Electrical equipment of industrial machines — Part 1: General requirements.*

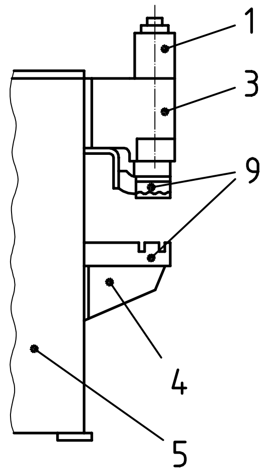
3 Terms and definitions

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

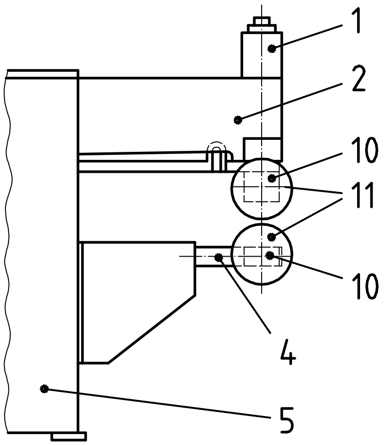
3.1 Mechanical parts of spot, projection and seam welding equipment



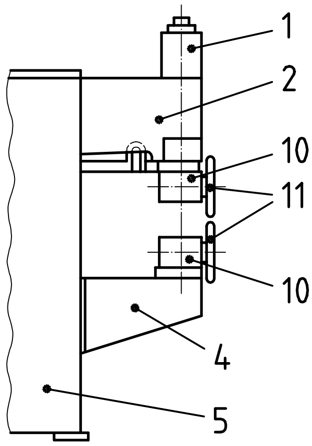
a) spot welding equipment



b) projection welding equipment



longitudinal seam welding equipment



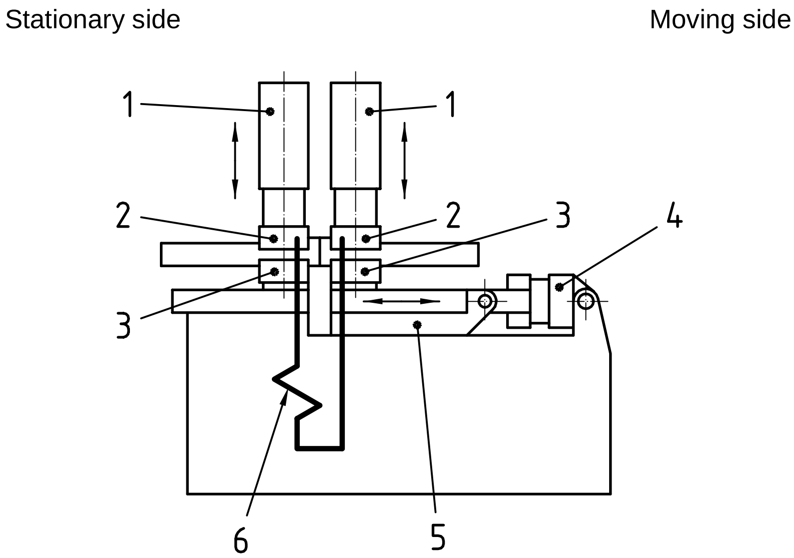
transverse seam welding equipment

c) seam welding equipment

Key

1 Force generation system
2 Upper arm
3 Welding head
4 Lower arm
5 Frame
6 Transformer
7 Electrode holder
8 Electrode
9 Platen
10 Wheel head
11 Electrode wheel

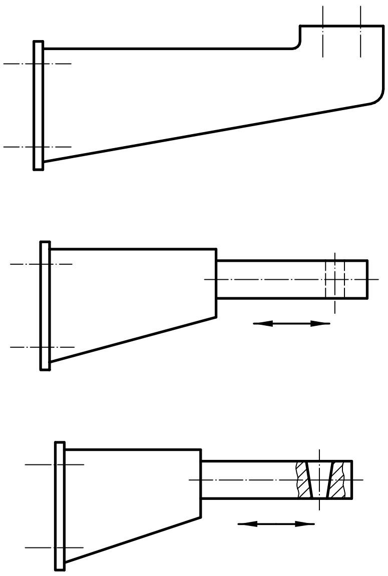
Figure 1 — Elements of spot, projection and seam welding equipment



Key

1 Clamping device
2 Clamping die
3 Current-currying clamping die
4 Slide drive
5 Slide
6 Welding transformer

Figure 2 — Elements of butt welding equipment

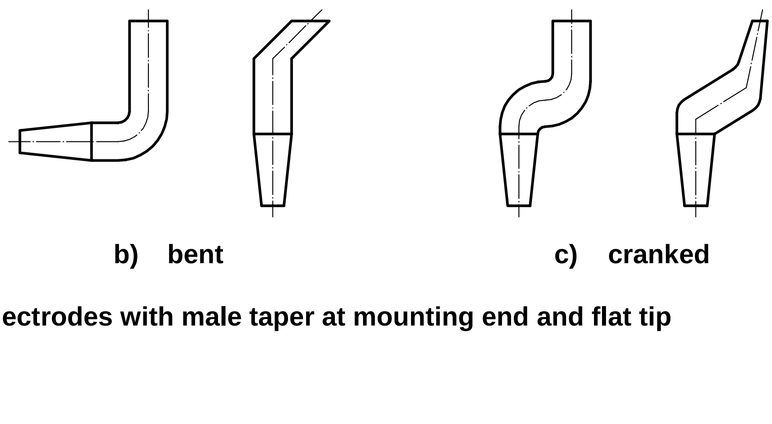


a) not adjustable

b) adjustable with mounting for an electrode holder

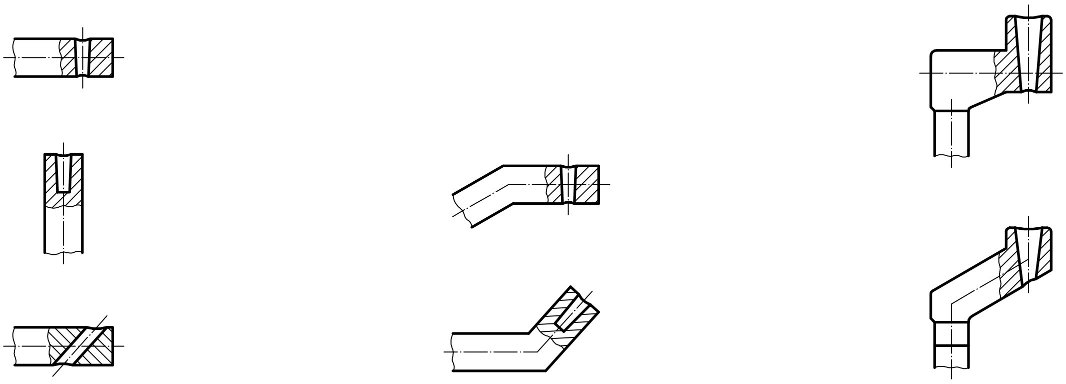
c) adjustable for mounting for a spot welding electrode

Figure 3 — Arms (lower arms)



a) straight **b) bent** **c) cranked**

Figure 4 — Spot welding electrodes with male taper at mounting end and flat tip



a) straight

b) bent

c) cranked

Figure 5 — Electrode holders with female taper for spot welding electrodes (fluid cooling is not illustrated)

3.1.1
arm
device that transmits the electrode force and conducts the welding current or supports a separate conductor

See Figures 1 and 3.

3.1.2
welding head
device comprising the force generation and guiding system carrying an electrode holder, platen or electrode wheel head mounted to the upper arm or directly to the machine body

See Figure 1.

3.1.3
electrode holder
device holding a spot welding electrode or an electrode adaptor 5

[ISO 8430-1, ISO 8340-2 and ISO 8340-3]

See Figures 1 and 5.

3.1.4
spot welding electrode
electrode designed for spot welding

[ISO 5184]

See Figures 1 and 4.

3.1.5
electrode adaptor
device holding an electrode cap by means of male or female taper

[ISO 5183-1, ISO 5183-2 and ISO 5829]

3.1.6
electrode cap
replaceable working end of the spot welding electrode mounted on the electrode adaptor by means of its female or male taper

[ISO 5821 and ISO 5830]

3.1.7
platen
device normally having tee slots and carrying projection welding electrodes or welding tools

[ISO 865]

See Figure 1.

3.1.8
electrode wheel head
device comprising an electrode wheel bearing and mounted on the upper and lower arm for longitudinal and/or transversal seam welding

See Figure 1.

3.1.9
electrode wheel bearing
device guiding the electrode wheel for force transfer and mostly for current transfer

3.1.10
electrode wheel
electrode as a rotating disc

See Figure 1.

NOTE This device may be driven by a motor or moved by the workpiece (idler wheels). The driver may be direct to the electrode shaft or to its circumference (knurl drive), see Figure 6.

3.1.11
electrode wheel profile
form of the electrode wheel being single or double sided bevelled, or radiused depending on the welding conditions and access

See Figure 7.

3.1.12
electrode wheel speed
⟨direct drive⟩ the speed of rotation n

3.1.13
electrode wheel speed
⟨knurl drive⟩ the tangential speed v

3.1.14
throat gap
e
⟨spot and seam welding equipment⟩ usable distance between the arms or the outer current-conducting parts of the welding circuit

See Figure 8.

3.1.15
throat gap
e
⟨projection welding equipment⟩ clamping distance between the platens

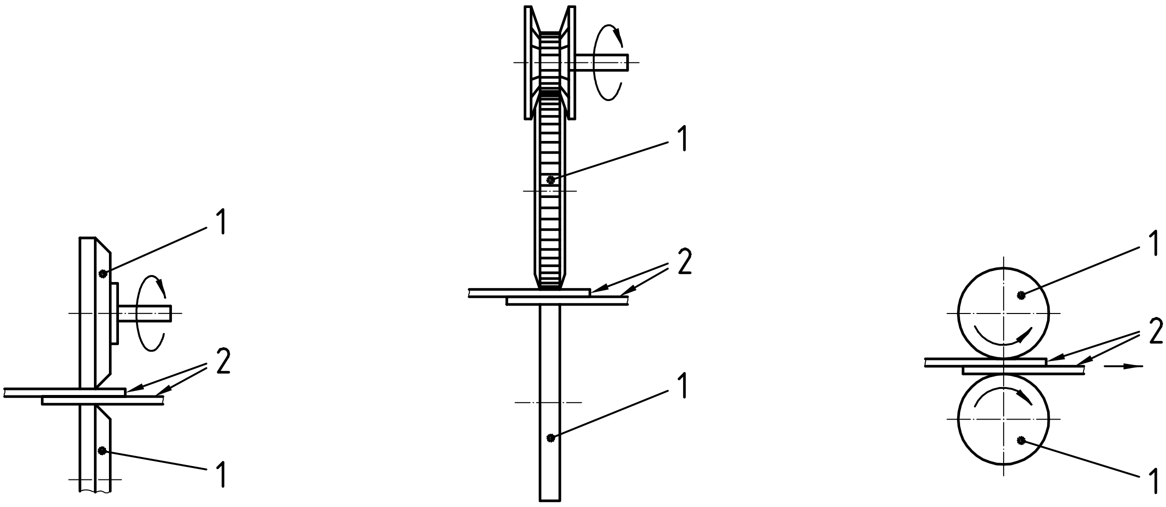
See Figure 8.

NOTE See also die distance, e, 3.2.11.

3.1.16
throat depth
l
usable distance from the centre of the platens or the axes of the electrodes or, in the case of oblique electrodes, the point of intersection of the electrode axes in the working position or the contact line of electrode wheels and that part of the equipment body located closest to it

See Figure 8.

NOTE This definition does not consider any offset of the electrode tips.

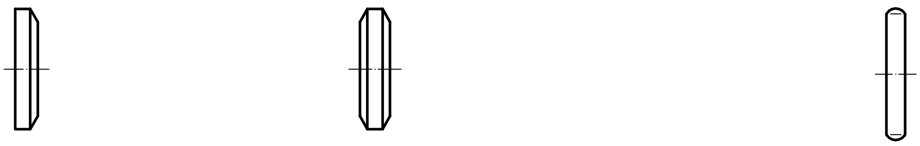


a) direct drive **b) knurl drive** **c) idler wheels**

Key

1 Electrode wheel
2 Components to be welded

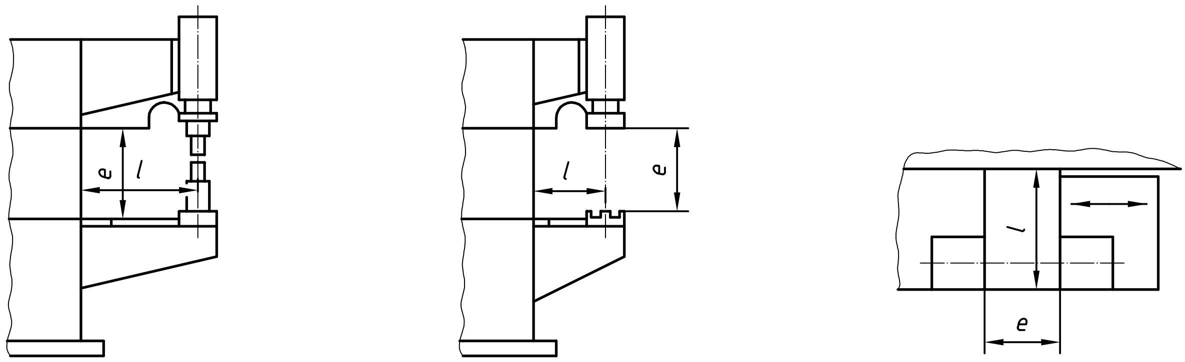
Figure 6 — Drive types of electrode wheels



single sided double sided

a) bevel **b) radiused**

Figure 7 — Profiles of electrode wheel



a) spot welding equipment **b) projection welding equipment** **c) butt welding equipment** (top view)

Figure 8 — Main dimensions

3.1.17
electrode stroke
c
physical displacement of electrodes during process function

NOTE 1 When the electrode is attached to the driving cylinder, the stroke of both the electrode and the driving cylinder, is equal.

NOTE 2 When the moving electrode is attached to a hinged lever moved by a driving cylinder, the maximum stroke of the electrode, by convention, equals the length of the chord of the arc generated by the tip of the moving electrode for the full stroke of the driving cylinder.

NOTE 3 The stroke of the electrode may be composed of a "work clearance stroke" without any contact, facilitating the introduction of the workpiece between the electrodes and a smaller "working stroke".

3.1.18
electrode force
F
force to the workpiece transmitted by the electrodes

3.1.19
maximum electrode force
F_{max}
maximum electrode force, which can be generated by the welding equipment without permament damage to its mechanical parts

3.1.20
minimum electrode force
F_{min}
minimum electrode force which can be used for proper functionning of the welding equipment

3.2 Mechanical parts of butt welding equipment

3.2.1
slide drive
drive generating and transferring the movements and upset forces necessary for welding to a workpiece located in the clamping device

NOTE For flash welding the drive may be required to reciprocate the slide for preheating by following the flashing movement and to provide the upset force.

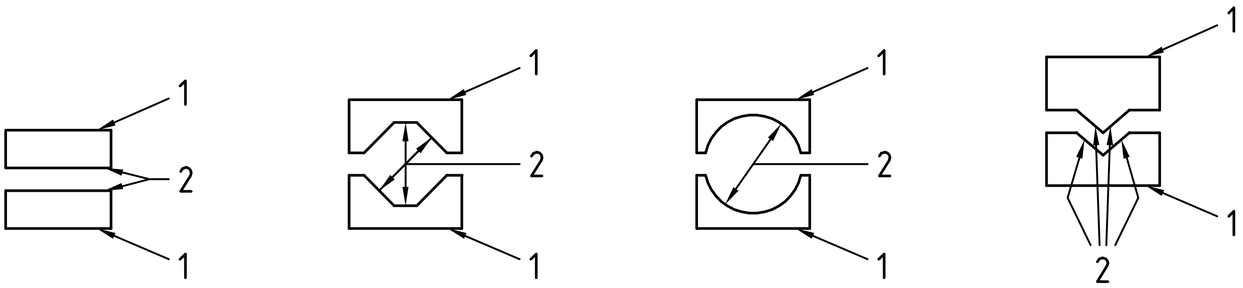
3.2.2
clamping device
device generating the contact force necessary for current flow and providing the clamping force necessary to withstand the upset force if no supplementary clamping devices or backstops exist

3.2.3
supplementary clamping device
non-current-carrying device to provide the clamping force necessary to resist the upset force

3.2.4
backstop
device to support the total or a part of the upsetting force to a workpiece in order to prevent a workpiece from sliding during upsetting

3.2.5
clamping die
device designed to transfer all forces to the workpiece in contacting with its clamping face

See Figure 9.



flat **prism** **cylindrical** **profile**

Key

1 Mounting or support face

2 Contact and/or clamping face

Figure 9 — Types of clamping dies
(illustrated in upsetting direction)

3.2.6
die length
G
usable length of a clamping die in the upsetting direction

See Figure 10.

3.2.7
die width
W
usable width of a clamping die perpendicular to the upsetting and clamping direction

See Figure 10.

3.2.8
die thickness
δ
dimension in the clamping direction

See Figure 10.

3.2.9
die stroke
q
difference between the smallest and largest opening gap

See Figure 10.

3.2.10
opening gap
f
usable distance between flat clamping faces

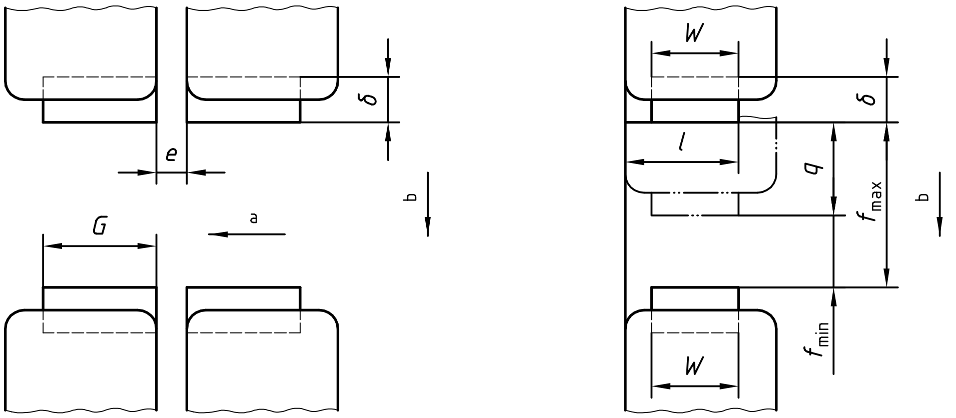
See Figure 10.

NOTE If the workpiece has to be loaded perpendicular to the upsetting direction, the usable gap of profile dies is smaller than flat dies, see Figure 9

3.2.11
distance
e
the clear distance between both die pairs in upsetting direction

See Figure 10.

NOTE See also throat gap, *e*, 3.1.14 and 3.1.15.



view perpendicular to clamping and upsetting direction

view in upsetting direction

[a] Upsetting direction

[b] Clamping direction

Figure 10 — Die measurements

3.2.12
upsetting stroke
difference between the smallest and largest die distance

3.2.13
throat depth
l
distance perpendicular to the direction of the upsetting force between the machine body and the outer edge of the clamping dies

See Figures 8 and 10.

3.2.14
clamping force
F_2
force applied to the workpiece by the clamping dies

3.2.15
maximun clamping force
$F_{2\text{max}}$
maximum force, acting through the dies on each part to be assembled, to prevent any sliding and to maintain good electrical contact with the electrodes when the maximum upsetting force is applied

3.2.16
upsetting force
F_1
force acting in the upsetting direction to press the workpieces together

3.2.17
maximum upsetting force
$F_{1\text{max}}$
maximum upsetting force which can be generated by the welding equipment without damage to its mechanical parts

3.2.18
minimum upsetting force
$F_{1\text{min}}$
minimum upsetting force which can be used for proper functioning of the welding equipment

3.2.19
preheating force
F_{c1}
force acting in the upsetting direction during preheating

3.2.20
upsetting pressure
p_{F1}
pressure created by the upsetting force, concerning the welding cross-section

3.3 Static mechanical, electrical and thermal characteristics

3.3.1
contact faults
faults relating to the eccentricity and deflection

3.3.2
eccentricity
g
distance to which the central points of the electrode working faces or the clamping platens are displaced in relation to each other by the electrode force

See Figures 11 and 12.

NOTE 1 The eccentricity of spot and seam welding equipment (see Figure 11) is calculated by the following formula:

$$g = b - a$$

NOTE 2 The eccentricity of projection welding equipment (see Figure 12) is measured in accordance with 15.2.2.

3.3.3
deflection
α
angle to which the electrode axes, the clamping platen faces or the workpiece axes deviate from their intended position due to the electrode or upsetting force

See Figures 11, 12 and 13.

NOTE 1 The deflection of spot and seam welding equipment (see figure 11) is calculated by the following formula:

$$\alpha = \alpha_2 - \alpha_1$$

NOTE 2 The deflection of projection welding equipment (see figure 12) is calculated by the following formula:

$$\alpha \approx \tan \alpha = \frac{b_1 - b_2}{b_3}$$

NOTE 3 The deflection of butt welding equipment (see figure 13) is calculated by the formula:

$$\alpha \approx \tan \alpha = \frac{b}{k}$$

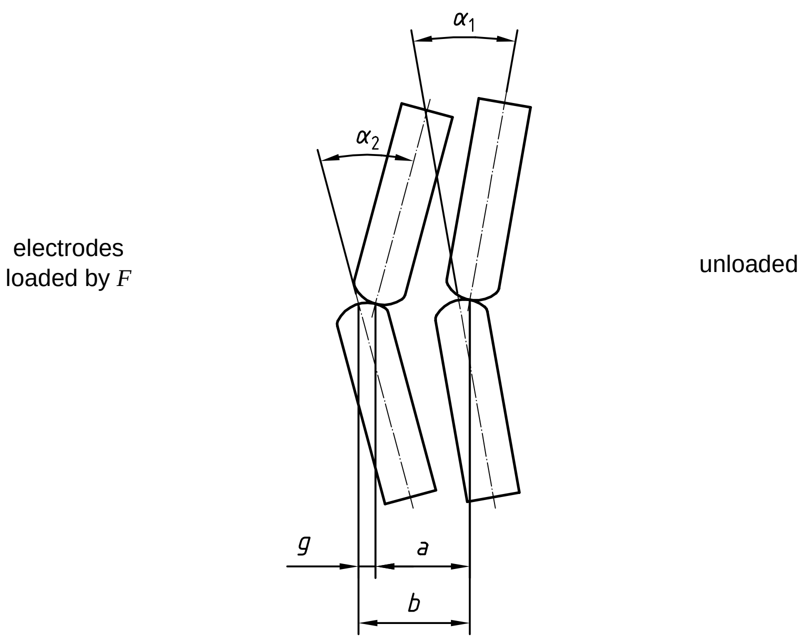


Figure 11 — Contact fault of spot and seam welding equipment

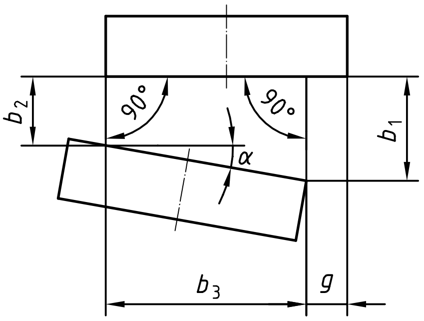


Figure 12 — Contact fault of projection welding equipment

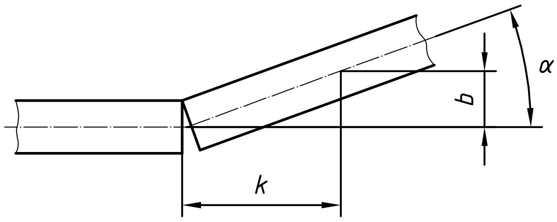


Figure 13 — Contact fault of butt welding equipment

3.3.4
duty
schedule of the operating conditions of equipment (their respective durations and sequences)

3.3.5
continuous duty
duty corresponding to a permanent on-load operation, without any interruption in which case the duty cycle is 100 %

3.3.6
periodic duty
repeated identical cycles of a constant load and a no-load time, the sum of one load time and one no-load time being the weld cycle time

NOTE This International Standard considers the load to be constant, i.e. without any pre-heating and/or post-heating period.

3.3.7
duty factor
X
ratio for a given interval of the on-load duration to the total time

NOTE This ratio, lying between 0 and 1, may be expressed as a percentage.

3.3.8
rated supply voltage
U_{1N}
supply voltage for which the equipment is constructed

3.3.9
rated no-load voltage at the output
U_{20}, U_{2di} or U_{2d}

3.3.9.1
ac no-load voltage
U_{20}
voltage of one output winding of the transformer when the external circuit is open and the rated supply voltage is applied to the input terminals

NOTE Several settings of the input winding result in relevant values of the no-load voltage.

3.3.9.2
dc no-load voltage
U_{2di}
calculated voltage at the output, when the rated supply voltage is applied to the input terminals, ignoring rectifier voltage drop

NOTE U_{2di} depends on the rectifying circuit.

3.3.9.3
dc no-load voltage
U_{2d}
⟨inverter type equipment⟩ voltage of the output when the rated supply voltage is applied to the input terminals

3.3.10
permanent supply current
I_{1p} or I_{Lp}
supply current corresponding to the permanent output current

NOTE The relationship between input and output currents depend on the type of welding equipment.

3.3.11
permanent output current
I_{2p}
highest output current on all settings of the regulator, for continuous operation (100 % duty factor)

3.3.12
permanent power
S_p
maximum electrical input power for 100 % duty factor without the equipment exceeding the specified temperature rise

3.3.13
maximum time per pulse
t_i
time during which the output current may flow without interruption at a given output current or voltage adjustment

NOTE This time is limited

— by the saturation of the magnetic circuit for welding equipment with rectification of the input or

— by the heat rise of the rectifier for welding equipment with rectification of the output.

3.3.14
supply current at a given duty factor
I_{1X} or I_{LX}
the maximum input current when operating at a given duty factor X, without the equipment exceeding the specified temperature rise, the maximum setting of the output voltage being given by:

$$I_{1X} = I_{1p}\sqrt{\frac{100}{X}}$$ for single phase transformers

or

$$I_{LX} = I_{Lp}\sqrt{\frac{100}{X}}$$ for three phase transformers

3.3.15
maximum short-circuit current input
I_{1cc} or I_{Lcc}
root mean-square (rms) value of the current at rated supply voltage at the highest output voltage tapping, the electrodes being short-circuited in accordance with clause 10 and the two values given correspond to the minimum and maximum value of the impedance compatible with this method of short circuit

NOTE I_{Lcc} is used for welding equipment with rectification.

3.3.16
maximum short-circuit current output
I_{2cc}
root mean-square (rms) value of the current at rated supply voltage at the highest output voltage tapping, the electrodes being short-circuited in accordance with clause 10 and the two values given correspond to the minimum and maximum value of the impedance compatible with this method of short circuit

3.3.17
supply pressure of the energizing medium
p_1
pressure at the supply point of the welding equipment

3.3.18
pressure of the energizing medium
p_2
pressure in the driving cylinder or cylinders to obtain maximum force

3.3.19
rated cooling liquid flow
Q
total quantity of cooling liquid to operate the equipment at permanent power without exceeding the temperature rise limits

3.3.20
cooling liquid pressure drop
Δp
pressure drop at the rated cooling liquid flow

3.4 Dynamic mechanical characteristics

See annex A.

4 Symbols

The symbols used in this International Standard are listed in Table 1.

Table 1 — Symbols and their designations

Symbol	Designation	Reference
a	length for determination of the contact fault	3.3.2
$a_{1, 2}$	lengths for determination of the deflection	15.3
b	length for determination of the contact fault	3.3.2, 3.3.3
$b_{1, 2, 3}$	lengths for determination of the contact fault	3.3.3, 15.2, 15.3, 15.4
c	stroke of electrode	3.1.17, 15.1
d	diameter of the tip of electrode or width of the electrode wheels	10.2
d_k	disc diameter	15.2
D_1	ball diameter	15.2
e	1) throat gap 2) platen distance 3) die distance	3.1.14, 3.1.15, 15.1, 16.3 3.1.15,16.3 3.2.11, 10.4, 16.3
e_{min}	minimum platen distance	10.3
e'	distance for calculation of the length of copper bar	10.3
E_a	impact energy	annex A
f	opening gap	3.2.10
f_{max}	maximum opening gap	3.2.11
f_{min}	minimum opening gap	3.2.11
F	electrode force	3.1.18, 10.4
F_{c1}	pre-heating force	3.2.19
F_{max}	maximum electrode force	3.1.19, 10.2, 10.3, 15.1, 16.3
F_{min}	minimum electrode force	3.1.20, 16.3
F_1	upsetting force	3.2.16
F_{1max}	maximum upsetting force	3.2.17, 10.4, 15.1, 16.3
F_{1min}	minimum upsetting force	3.2.18, 16.3
F_2	clamping force	3.2.14
F_{2max}	maximum clamping force	3.2.15, 10.4, 15.4, 16.3
F_{2min}	minimum clamping force	16.3
$F_{1f}...F_{3f}$	force oscillations during follow up	annex A
$F_{1s}...F_{3s}$	force oscillations after electrode contact	annex A
F_1', F_2'	opposite forces	15.2
g	eccentricity	3.3.2, 15ff, 16.2, 16.3
$g_{10, 50, 100}$	eccentricity at 10 %, 50 % or 100 % of the maximum force	16.3
G	die length	3.2.6, 3.2.11
I_{1cc}	maximum input short circuit current	3.3.15
I_{1p}	input permanent current	3.3.10
I_{1X}	input current at a given duty factor	3.3.14
I_{2cc}	maximum output short circuit current	3.3.16, 16.3
I_{2p}	permanent output current to a 100 % duty factor	3.3.11, 16.3
I_{Lcc}	maximum line short circuit current	3.3.15
I_{Lp}	permanent line current	3.3.10
I_{LX}	line current at a given duty factor	3.3.14

Table 1 (*continued*)

Symbol	Designation	Reference
k	distance for determination of deflection	3.3.3, 15.3, 15.4
K_F	coefficient of force	annex A
K_{Fs}, K_{Ff}	electrode contact/follow up force coefficient	annex A
l	throat depth	3.1.14, 3.1.15, 3.1.16, 3.2.13, 15.1, 16.3
L_{sc}	length of copper bar	10.3, 10.4, 15.4
L'	length of copper bar	10.3
m	mass of the welding head	annex A
n	speed of rotation	3.1.12, 16.3
p_1	supply pressure of the energizing medium	3.3.17, 16.3
p_2	pressure of the energizing medium	3.3.18, 16.3
p_{F1}	upsetting pressure	3.2.20
q	die stroke	3.2.9, 3.2.11
Q	rated cooling liquid flow	3.3.19, 16.3
S_p	permanent input power (100 % duty factor)	3.3.12, 16.3
S_{50}	input at 50 % duty factor	16.3
t	impulse time	annex A
t_a	force rise time	annex A
t_{fd}	decay time during follow up	annex A
t_i	maximum time per pulse	3.1.15, 3.3.13
t_{sd}	decay time after electrode contact at A	annex A
T_1	temperature of the cooling medium	12.2
U_{1N}	rated supply voltage	3.3.8, 9, 16.3
U'_{1N}	supply voltage	9
U_{20}	rated ac no-load voltage	3.3.9.1, 9, 16.3
U'_{20}	ac no-load voltage	9
U_{2d}	rated dc no-load voltage from inverter type welding equipment	3.3.9.3, 9, 16.3
U_{2di}	rated dc no-load voltage	3.3.9.2, 9, 16.3
v	tangential speed	3.1.13, 16.3
v_a	impact velocity	annex A
W	die width	3.2.7, 3.2.11, 10.4
X	duty factor	3.3.7, 3.3.14
α	deflection	3.3.3, 15ff, 16.2
$\alpha_{1,\,2}$	angles for determination of the deflection	3.3.3, 15.3
$\alpha_{10,\,50,\,100}$	deflection at 10 %, 50 % or 100 % of the maximum force	16.3
Δp	pressure drop of the cooling liquid circuit	3.3.20, 16.3
δ	die thickness	3.2.8, 3.2.11

5 Classification

Resistance welding equipment is classified as:

a) spot welding equipment [(see Figure 1a)];

b) projection welding equipment [(see Figure 1b)];

c) seam welding equipment [(see Figure 1c)];

d) butt welding equipment [(see Figure 2)].

NOTE Flash welding equipment is a special type of butt welding equipment.

6 Physical environment and operating conditions

6.1 General

Welding equipment shall be suitable for use in the physical environment and operating conditions specified below.

When the physical environment and/or operating conditions are outside those specified below, an agreement may be needed between the supplier and the user (see annex B of IEC 60204-1:1992).

6.2 Ambient air temperature

Welding equipment shall be capable of operating correctly in an ambient air temperature of between + 5 °C and + 40 °C.

For maximum temperatures of the cooling medium see annex C of ISO 5826:1999.

6.3 Humidity

Welding equipment shall be capable of operating correctly with a relative humidity up to 95 %.

Harmfull effects of occasional condensation shall be avoided by proper design of the welding equipment or, where necessary, by proper additional measures (e.g. built-in heaters, air conditioners, drain holes).

6.4 Altitude

Welding equipment shall be capable of operating correctly at altitudes up to 1 000 m above mean sea level.

For other altitudes see annex C of ISO 5826:1999.

6.5 Transportation and storage

Welding equipment shall be designed to withstand, or suitable precautions shall be taken to protect against, transportation and storage temperatures between – 25 °C and + 55 °C and for short periods not exceeding 24 h up to + 70 °C.

Suitable means shall be provided to prevent damage from humidity, vibration and shock.

6.6 Provisions for handling

Heavy and bulky electrical equipment that has to be removed from the welding equipment for transport, or which is independent of the welding equipment, shall be provided with suitable means for handling by cranes or similar equipment.

7 Test conditions

The tests shall be carried out on new, dry and completely assembled welding equipment at an ambient air temperature of between + 10 °C and + 40 °C. The ventilation shall be identical with that prevailing under normal service conditions. The measuring devices used shall not interfere with the normal ventilation of the welding equipment or cause abnormal transfer of heat to or from it.

Liquid cooled welding equipment shall be tested with cooling liquid conditions as specified by the manufacturer.

The accuracy of measuring instruments shall be:

a) electrical measuring instruments: Class 1 (1 % full scale, see IEC 60051-2), appropriate for short time measurements, for a.c. current true rms meter;

   Electrical measurements shall be made under full-wave, non transient conditions.

b) thermometer: ± 2 K.

Unless otherwise specified, the tests required in this International Standard are type tests.

8 Welding transformers

Resistance welding transformers shall comply with ISO 5826.

Compliance shall be checked in accordance with ISO 5826.

9 Rated no-load voltage at the output

The rated no-load voltage shall be given for all settings within a tolerance of ± 2 %.

Compliance shall be checked:

a) in case of a.c. by measurement of U_{20};

NOTE If the supply voltage U'_{1N} differs from the rated supply voltage U_{1N}, the no-load voltage U'_{20} is measured. The rated no-load voltage (U_{20}) is calculated by the formula:

$$U_{20} = U'_{20} \frac{U_{1N}}{U'_{1N}} \text{ in volts}$$

b) in case of dc by calculation of U_{2di} in accordance with Table 2;

Table 2 — "Ideal" dc no-load voltage

Input	Output	U_{2di}
⅄	*	1,17 U_{20}
Δ	*	1,35 U_{20}
single phase	mid point	0,9 U_{20}
frequency converter primary rectifying		1,35 U_{20}

c) in case of d.c. from inverter type welding equipment by measurement of U_{2d}.

10 Maximum short circuit current

10.1 General

The maximum short-circuit current shall be given with the following tolerances:

a) direct measurement: ± 5 %;

b) indirect measurement: $^{+10}_{\ 0}$ % (calculation from input measurement).

The short-circuit shall be affected by copper having a conductance of at least 45 S.

Compliance shall be checked by measurement according to the conditions given in

— 10.2 for spot- and seam-welding equipment;

— 10.3 for projection welding equipment;

— 10.4 for butt welding equipment.

The following measurements are made successively:

a) for the minimum value of impedance (throat gap and throat depth are minimum);

b) for the maximum value of impedance (throat gap and throat depth are maximum).

10.2 Spot- and seam-welding equipment

The electrodes or the rotating electrode wheels are brought into contact by applying the maximum electrode force F_{max} according to the arm length in use. The diameter, d, of the tip of the electrodes or the width of the electrode wheels is related to the electrode force according to the following formula, but it shall be at least 2,5 mm.

$$d = 0{,}16\sqrt{F_{max}} \pm 5\ \%\ \text{in millimetres}$$

where F_{max} is in newtons.

10.3 Projection welding equipment

Between, and directly under, the centre of the platens, a copper bar is placed with a cross section sufficient to prevent overheating. The maximum electrode force F_{max} is applied.

The free length of the copper bar L_{sc} or L' is calculated by the following formulae, but it shall be at least equal to $e' = e_{min} + 5$ in millimetres.

$$L_{sc} = 122\, F_{max}.10^{-5} + 75 \text{ in millimetres}$$

$$L' = L_{sc} + e' \text{ in millimetres}$$

where e' is in millimetres and F_{max} is in newtons.

10.4 Butt welding equipment

Between the dies, a copper bar is placed of section sufficient to prevent overheating. The contact surfaces shall be as large as possible. The maximum clamping force F_{2max} is applied.

L_{sc}, the length of the copper bar between the opposed faces of the dies (see Figure 14), is given by the following formula, but it shall be at least equal to $e + 5$ in millimetres.

$$L_{sc} = 1{,}5\frac{F}{W} + 2 \text{ in millimetres}$$

With preheating is:

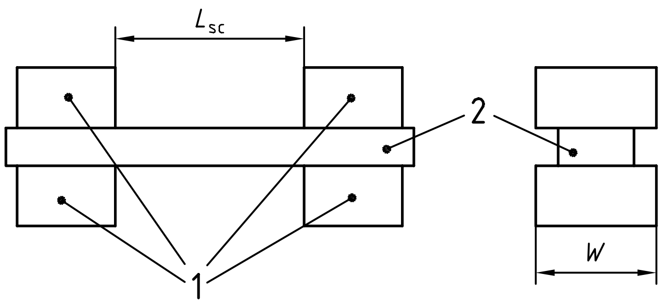
$$F = \frac{F_{1max}}{30} \text{ in newtons}$$

Without preheating is:

$$F = \frac{F_{1max}}{150} \text{ in newtons}$$

where W is in millimetres and F_{1max} is in newtons.

For operations with both with preheating and without preheating the lower value of L_{sc} is used.



Key

1 Die

2 Copper bar

Figure 14 — Short circuit bar for butt welding equipment

11 Thermal rating

The thermal rating shall be:

a) for transformers, in accordance with ISO 5826;

b) for accessible surfaces, in accordance with Table 3;

c) for cooling media, as given by the manufacturer.

If the rated supply voltage is not available, the test can be made with reduced voltage on agreement between manufacturer and purchaser.

Welding equipment with current rectification shall be tested with the rated supply voltage.

Compliance shall be checked:

1) for transformers by measurement in accordance with 6.2 of ISO 5826:1999;

2) for accessible surfaces by measurements immediately before the last loading in accordance with 12 and 13.1;

NOTE The highest temperature taken is recorded.

3) for cooling medium by calculation of the average of the temperature obtained during the last quarter of the test in accordance with 12 and 13.2.

Table 3 —Limits of temperature rise for accessible surfaces

Accessible surface	Temperature rise K
Bare metal enclosures	25
Painted metal enclosures	35
Non-metallic enclosures	45
Metal handles	10
Non-metallic handles	30

12 Heating test

12.1 general

The welding equipment shall be short-circuited according to

— 10.2 for spot- and seam-welding equipment

— 10.3 for projection welding equipment

— 10.4 for butt welding equipment

and operated at the corresponding duty factor at a cycle time according to real operation conditions.

12.2 Beginning of the heating test

The heating test shall be started when:

a) the flow of cooling liquid has started (in case of liquid-cooled welding equipment);

b) the welding equipment has reached a thermal balance with the cooling medium within ± 1 K;

c) the temperature of the cooling medium, T_1, is retained as initial temperature of the winding whose resistance is being measured.

NOTE Except when the temperature of a part is determined by the resistance method the test may be started without the welding equipment having reached a temperature balance with the ambient air.

12.3 Duration of the heating test

The heating test shall be carried out until the rate of the temperature rise of any component does not exceed 2 K/h.

13 Conditions for the measurement of temperature rise

13.1 Accessible surfaces

The temperature rise of other parts than the transformer are measured with appropriate thermosensitive elements that are in the closest possible contact with the part whose temperature rise is to be verified. They are placed at the hottest accessible point.

13.2 Cooling medium

13.2.1 Ambient air

The temperature of the ambient air shall be determined by at least three measuring devices, spaced uniformly around the welding equipment, at a distance of 1 m to 2 m from it and at approximately one-half the height of the welding equipment.

They shall be shielded from heat and draughts.

NOTE The thermometer bulbs may be placed in small holders filled with oil with a view to equalizing the temperature variations.

13.2.2 Cooling liquid

The temperature of the cooling liquid shall be measured where this enters the welding equipment.

14 Cooling liquid circuit (liquid-cooled welding equipment)

Cooling liquid circuits shall enable a sufficient flow in order to ensure efficient cooling.

The cooling liquid circuit shall be tight at a pressure of 10 bar for 10 min and may have a pressure drop up to the value stated on the rating plate.

Compliance shall be checked by leak-tightness and flow checking.

15 Static mechanical characteristics

15.1 General

The following static mechanical characteristics are recommended to be given in agreement between the manufacturer and the purchaser:

a) for spot, projection and seam welding equipment:

   1) eccentricity g in millimetres and

   2) deflection α in milliradians;

b) for butt welding equipment:

   1) deflection α in milliradians.

Compliance shall be checked by measurement with:

a) 10 %,

b) 50 % and

c) 100 %

of the maximum electrode force F_{max} (see 3.1.19) or upsetting force F_{1max} (see 3.2.17) at the maximum adjustment of the:

d) electrode stroke c (see 3.1.17),

e) throat depth l (see 3.1.16) and

f) throat gap e (see 3.1.14 and 3.1.15).

The measurements are carried out according to:

— 15.2 for spot and projection welding equipment;

— 15.3 for seam welding equipment;

— 15.4 for butt welding equipment.

NOTE The results are given as absolute values. If the deflection reverses when the force is increased, this is indicated by plus or minus as appropriate.

15.2 Spot and projection welding equipment

15.2.1 General

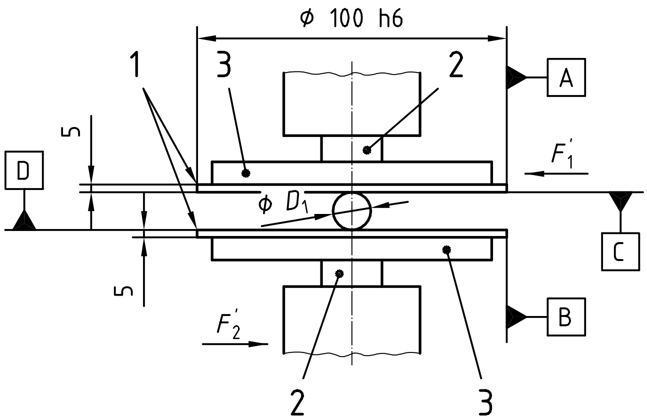
Two hardened discs, as shown Figures 15 and 16, are placed with their plugs (instead of spot welding electrodes) or with their flanges at the centre of the platens in such a way that their opposite faces are parallel and the eccentricity does not exceed 0,05 mm. A steel ball is placed between the two hardened discs and centred using an appropriate flexible device.

NOTE 1 The hardened discs are machined to a tolerance of h6.

NOTE 2 The diameter of the ball D_1, and the material used for the hardened discs are chosen so that no impression appears on the contact faces at maximum force.

NOTE 3 The contact faces, in particular, should be of hardened steel.

Dimensions in millimetres



Key

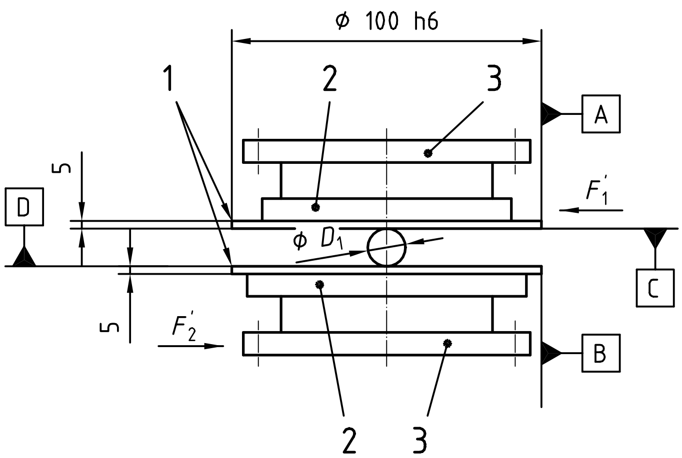
1 Hardened disc

2 Plug

3 Support

Figure 15 — Measurement accessory for spot welding equipment

Dimensions in millimetres



Key

1 Hardened disc

2 Support

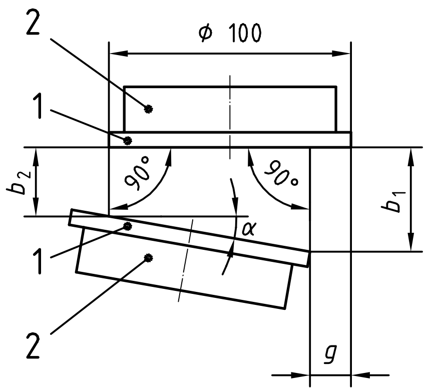
3 Mounting flange

Figure 16 — Measurement accessory for projection welding equipment

15.2.2 Eccentricity

The eccentricity (g) is directly measured with a gauge calibrated to 0,01 mm, see Figure 17.

Dimensions in millimetres



Key

1 Hardened disc

2 Support

Figure 17 — Measurement of eccentricity and deflection

15.2.3 Deflection

The deflection (α) is calculated using the formula:

$$\alpha \approx \tan\alpha = \frac{b_1 - b_2}{100 - g} 1000 \quad \text{in milliradians}$$

The distances b_1 and b_2 between the hardened discs are measured using thickness gauges with an accuracy unit of 0,01 mm.

NOTE 1 For rocker arm welding equipment, the electrodes should be parallel at the beginning of the test.

NOTE 2 The methods of fixing shown in Figures 15 and 16 are for information only. Plugs may be fitted with adaptors to suit the welding equipment.

NOTE 3 If it is not possible to use discs with a diameter of 100 mm because of the dimensions of the welding equipment, smaller diameters d_k may be used, by agreement with the user. In this case the deflection α is given by the formula:

$$\alpha \approx \tan\alpha = \frac{b_1 - b_2}{d_k - g} 1000 \quad \text{in milliradians}$$

NOTE 4 In order to estimate the behaviour of the welding equipment when using offset electrodes, the discs may be subjected to the simultaneous application of:

a) the maximum electrode force;

b) two opposite forces F_1' and F_2' equal to 10 % of the appropriate electrode force, in a plane parallel to reference faces C and D (see Figures 15 and 16) in the less favourable direction for the welding equipment.

This measurement is repeated with the forces F_1' and F_2' reversed.

15.3 Seam welding equipment

15.3.1 General

The welding equipment is fitted with electrode wheels that are normally delivered with it. The measurement device consists of a holder with two knife edges that are applied to the lower electrode wheel, see Figure 18.

Using a gauge calibrated to 0,01 mm, the dimensions a_1 and b_1 with no-load, and a_2 and b_2 with load are measured. The distance between $a_{1,2}$ and $b_{1,2}$ is k, see Figure 18.

15.3.2 Eccentricity

The eccentricity g is calculated using the formula:

$g = a_1 - a_2$ in millimetres

15.3.3 Deflection

The deflection α is calculated using the formula:

$\alpha = \alpha_1 - \alpha_2$ in milliradians

$\alpha_1 \approx \tan\alpha_1 = \frac{b_1 - a_1}{k} 1\,000$ in milliradians and $\alpha_2 \approx \tan\alpha_2 = \frac{b_2 - a_2}{k} 1\,000$ in milliradians

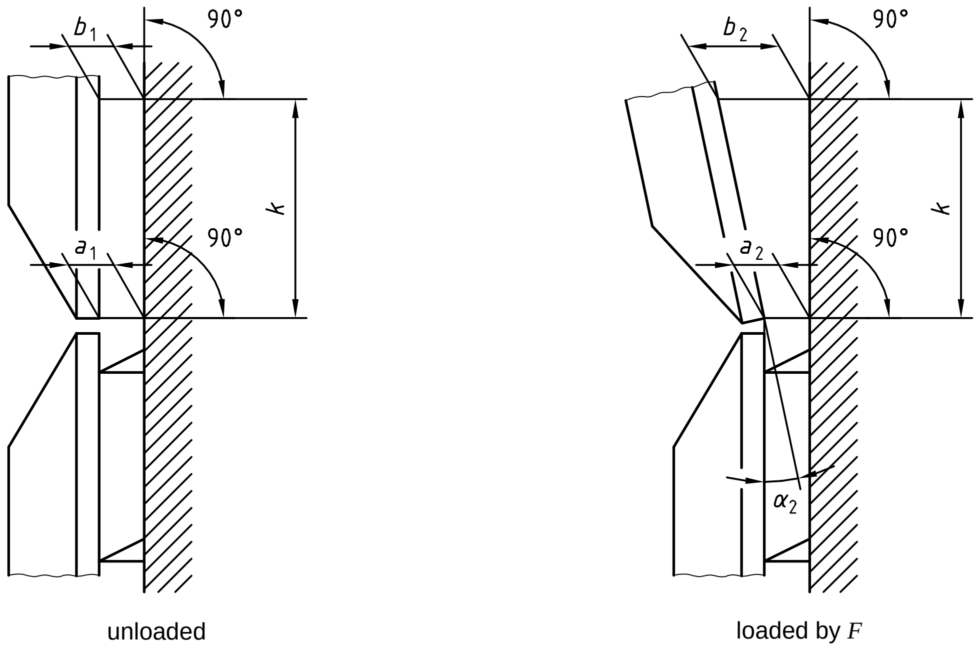


Figure 18 — Measurement arrangement in electrode wheels

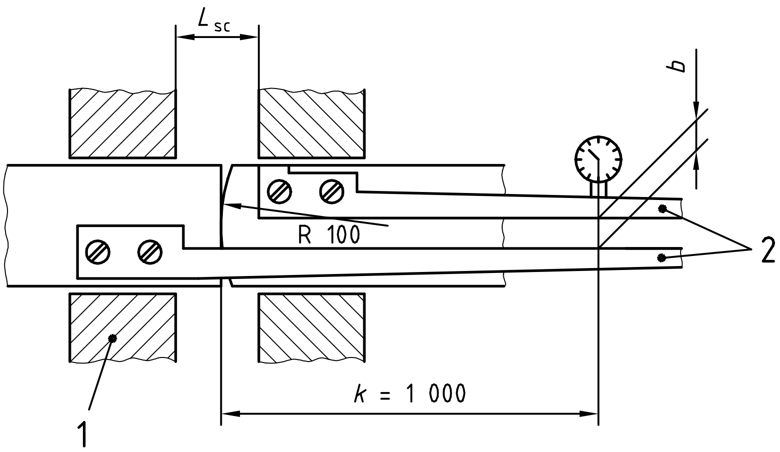
15.4 Butt welding equipment

15.4.1 General

Two bars of steel, having a sectional area equal to the maximum area that can be welded, and each fitted with a graduated scale approximately 1 000 mm in length, are fixed in the dies and placed in contact in such a way that the distance between the dies L_{sc} is as given in 10.4.

These bars are kept in position by application of the maximum clamping force F_{2max}. The contact face of one of the bars shall be curved and of radius R100 mm, see Figure 19.

Dimensions in millimetres



Key

1 Clamping die

2 Graduated straight-edge

Figure 19 — Measurement arrangement for butt welding equipment

Using a gauge calibrated to 0,01 mm, the dimensions b_1 with no-load, and b_2 with load, are measured in the distance k from the plane of the contact, see Figure 19.

15.4.2 Deflection

The deflection α is calculated by the formula:

$$\alpha \approx \tan\alpha = \frac{b_2 - b_1}{k} 1\,000 \quad \text{in milliradians}$$

For a distance k = 1 000 mm:

$$\alpha \approx \tan\alpha = b_2 - b_1 \quad \text{in milliradians}$$

16 Rating plate

16.1 General

A clearly and indelibly marked rating plate shall be fixed securely to or printed on each welding equipment.

NOTE The purpose of the rating plate is to indicate to the user the electrical and mechanical characteristics in order to enable the correct selection of the welding equipment and to allow their comparison.

Compliance is checked by visual inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit.

After the test the marking shall be easily legible and it shall not be easy to remove the rating plate which shall show no curling.

16.2 Description

The rating plate shall be divided into sections containing information and data for the:

a) identification;

b) welding output;

c) mains supply;

d) other characteristics.

The arrangement and sequence of the data shall comply with the principle shown in Figure 20 (for examples see annex B).

The dimensions of the rating plate are not specified and may be chosen freely.

NOTE 1 Additional information (e.g. deflection, eccentricity g, maximum time per impulse t_i) may by given.

NOTE 2 Other useful information may be given in technical litterature supplied by the manufacturer.

16.3 Contents

16.3.1 General

The following data of the welding equipment refer to the numbered boxes shown in Figure 20.

a) Identification

1)	
2)	
4)	5)

b) Welding output

6)	7)	
8)	9)	10)

c) Main supply

11)	12)
13)	

d) Other characteristics

14)	15)
16)	17)
18) if applicable	19) if applicable
20) if applicable	21) if applicable
22)	23)
24)	25)
26)	27) if applicable
28) if agreed	29) if applicable and agreed

Figure 20 — Principle of the rating plate

16.3.2 Identification:

Box 1 Name and address of the manufacturer or distributor or importer and, optionally, a trademark and the country of origin if required.

Box 2 Type (indentification) as given by the manufacturer.

Box 4 Traceability of design and manufacturing data (e.g. serial number) and year of production.

Box 5 Reference to this International Standard confirming that the welding equipment complies with its requirements.

16.3.3 Welding output

Box 6 Welding current symbol e.g.:

⎓ Direct current (dc) or

~ Alternating current (ac), and additionally the rated frequency in Hz (e.g.: ~ 50 Hz)

Box 7	U_{20} = ... V to ... V in ... steps	range of rated ac no-load voltage and number of adjustable steps, or
	U_{2di} = ... V to ... V in ... steps	range of rated dc no-load voltage and number of adjustable steps, or
	U_{2d} = ... V to ... V en ... steps	range of rated dc no-load voltage and number of adjustable steps in case of inverter type welding equipment
Box 8	I_{2cc} = ... A	maximum short circuit current of the output corresponding to the minimum impendance (l and e minimum))
Box 9	I_{2cc} = ... A	maximum short circuit current of the output corresponding to the maximum impendance (l and e maximum)
Box 10	I_{2p} = ... A	permanent output current

16.3.4 Mains supply

Box 11	… ~ ... Hz	number of phases, e.g. 1 or 3, symbol for alternating current (~) and the rated frequency, e.g. 50 Hz or 60 Hz
Box 12	U_{1N} = ... V	rated supply voltage
Box 13	S_p = ... kVA	permanent power (duty factor 100 %)
	S_{50} = ... kVA	power at 50 % duty factor

NOTE $S_{50} = S_p\sqrt{2}$ will only be given for a transition period.

16.3.5 Other characteristics

Box 14	e	= ... mm to ... mm	range of the throat gap
Box 15	l	= ... mm to ... mm	range of the throat depth
Box 16	F_{max}	= ... N	range of maximum electrode force corresponding to the minimum and maximum throat depth
Box 17	F_{min}	= ... N	minimum electrode force
Box 18	F_{1max}	= ... N	maximum upsetting force
Box 19	F_{1min}	= ... N	minimum upsetting force
Box 20	F_{2max}	= ... N	maximum clamping force
Box 21	F_{2min}	= ... N	minimum clamping force

NOTE Boxes 18 to 21 are only applicable for butt welding equipment

Box 22	p_1	= ... bar	supply pressure of the energizing medium
Box 23	p_2	= ... bar	pressure of the energizing medium to obtain maximum forces
Box 24	Q	= ... l/min	rated cooling liquid flow
Box 25	Δp	= ... bar	rated cooling liquid pressure drop
Box 26	Mass	= ... kg	mass of the welding equipment
Box 27	v	=... m/min to ... m/min	range of tangential speed or
	n	=... min^{-1} to ... min^{-1}	range of speed of rotation

NOTE Box 27 is only applicable for seam welding equipment.

Box 28	α_{10} =... mrad	deflection at	10 %	of F_{max} or F_{1max}
	α_{50} =... mrad	deflection at	50 %	of F_{max} or F_{1max}

NOTE These values are given only by agreement between manufacturer and purchaser.

	α_{100} =... mrad	deflection at	100 %	of F_{max} or F_{1max}
Box 29	g_{10} =... mm	eccentricity at	10 %	of F_{max} or F_{1max}
	g_{50} =... mm	eccentricity at	50 %	of F_{max} or F_{1max}
	g_{100} =... mm	eccentricity at	100 %	of F_{max} or F_{1max}

NOTE 1 These values are given only by agreement between manufacturer and purchaser.

NOTE 2 The eccentricity g is not applicable for butt welding equipment.

16.4 Tolerances

The actual values obtained from resistance welding equipment shall meet the rated values within the tolerances given in the corresponding subclauses.

Compliance shall be checked by measurement and comparision.

17 Instruction manual

All welding equipment shall be delivered with an instruction manual which shall include the following information:

a) general description;

b) correct methods of handling e.g. by fork lift or crane and precautions to be taken;

c) the meaning of indications, markings and graphical symbols;

d) supply connections including fuse and/or circuit breaker rating;

e) correct operational use relating to the resistance welding equipment (e.g. cooling requirements, location, control device, indicators);

f) welding capability, mechanical characteristics, limitations of duty and explanation of thermal protection if relevant;

g) limitations of use;

h) basic guidelines regarding protection against personal hazards for operators and persons in the work area (e.g. fumes, noise, hot metal and sparks);

i) maintenance;

j) adequate circuit diagram together with a list of essential parts;

k) information for the circuit of resistance welding equipment designed to supply electrical power at normal supply voltage (for example for lighting or electric tools);

l) installation and mounting.

Other usefull information may be given (e.g. class of insulation, deflection α, eccentricity g, maximum time per impulse t_i, power factor etc.).

Compliance shall be checked by reading the instruction manual.

Annex A
(normative)

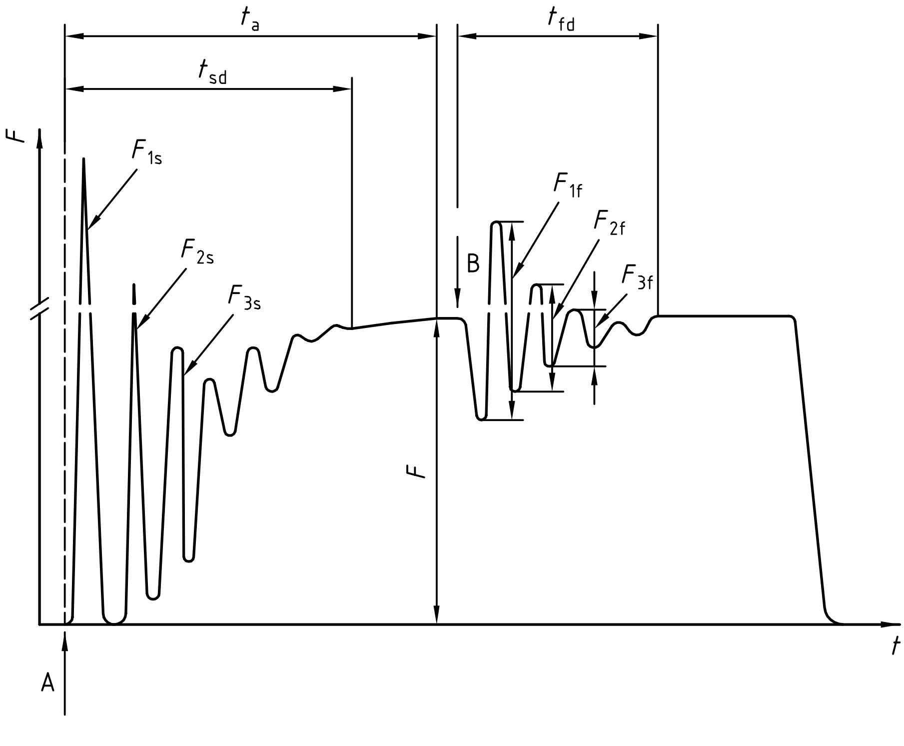
Dynamic mechanical behaviour

A.1 General

In recent years results of investigations on the dynamic mechanical behaviour of resistance welding equipment have become available. In order to create a common basis for discussion in the international engineering community, the new technical terms and the experimental method for measuring these characteristics are given in this annex.

A.2 Dynamic mechanical characteristics

Dynamic mechanical characteristics define the manner in which spot, projection, or seam welding equipment oscillate when electrode contact and follow-up occurs with the component to be welded (see Figure A.1).



A start of electrode contact

B start of electrode follow up

Figure A.1 — Dynamic behaviour of a spot welding equipment (schematic)

The measuring procedure is described in A.3.

The dynamic mechanical characteristics of butt welding equipment cannot yet be described due to lack of sufficient knowledge.

A.2.1 Electrode contact

Electrode contact with the component to be welded is represented by means of point A in Figure A.1. Electrode force ascent starts at this point up to the static electrode force F.

A.2.2 Electrode force oscillations after electrode contact

Force oscillations may occur after contact of the moving electrodes. The intensity and duration of force oscillation are measured and recorded by means of a force transducer located between electrode and welding head (see Figure A.2).

A.2.3 Bounce

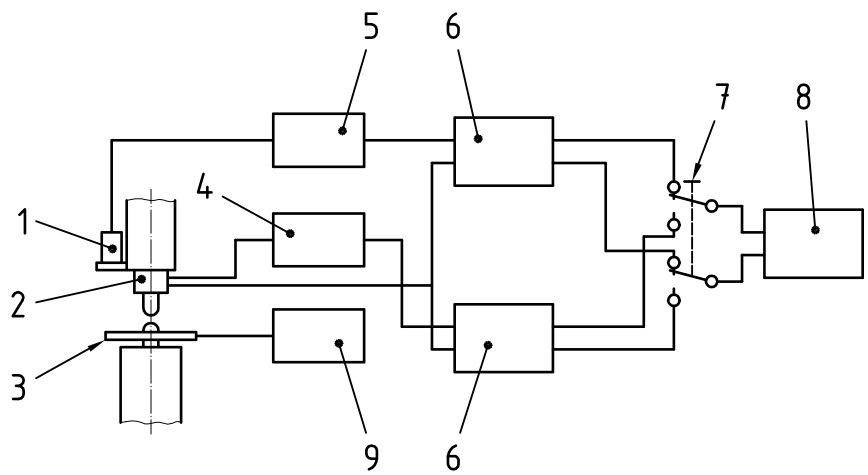
Electrode bounce may occur after electrode impact during which the electrode, due to the extremely high degree of oscillation in the welding equipment, may even lose contact with the component to be welded (see A.2.6.2).

A.2.4 Follow-up

Follow-up of the welding equipment, which starts as of point B in Figure A.1, occurs during expanding and contracting of the material while heating and cooling, due to indentation of the electrodes into the component or when projection collapse occurs.

A.2.5 Force oscillations during follow-up

Force oscillations may occur during follow-up. The intensity and duration of the oscillations are measured and recorded by means of a force transducer located between electrode and welding head (see Figure A.2).



Key

1 Oscillation speed sensor
2 Force and current measuring head
3 Rogowsky belt
4 Charge amplifier
5 Frequency response equalizer
6 Digital store oscilloscope
7 Switch
8 *x–y* writer
9 Impulse circuit measurer

Figure A.2 — Determination of dynamic mechanical characteristics (schematic example)

A.2.6 Characteristic quantities

A.2.6.1 Impact velocity (v_a)

Impact velocity v_a is the velocity of the moving electrode or platen immediately prior to contacting the component to be welded.

A.2.6.2 Impact energy (E_a)

Impact energy E_a is the kinetic energy of the moving mass of the welding head, electrode holder, electrode and a portion of the flexible conductors and/or jumpers just before electrode contact with the component. It is calculated from the moving mass m and the impact velocity v_a according to the following formula:

$$E_a = \frac{m(v_a)^2}{2}$$

A.2.6.3 Coefficients of force (K_F, K_{Fs} and K_{Ff})

Coefficient of force K_F describes the decay of the force amplitude during electrode contact or follow up (See Figure A.1).

$$K_F = \frac{F_1 + F_2 + F_3}{3F}$$

NOTE 1 Coefficient K_F and forces F_1, F_2 and F_3 are written with index s to indicate electrode contact.

NOTE 2 Coefficient K_F and forces F_1, F_2 and F_3 are written with index f to indicate follow-up.

NOTE 3 Forces F_1, F_2 and F_3 are the first three complete oscillations upon electrode contact or follow-up.

A.2.6.4 Force rise time (t_a)

Force rise time t_a is the time span from initial contact of the electrodes up to the point when the nominal static electrode force has been reached (see Figure A.1).

A.2.6.5 Decay time (t_{sd} , t_{fd})

Decay time t_{sd} or t_{fd} of the force oscillations resulting from the electrode contact or follow-up process can be determined by means of Figure A.1.

A.3 Measuring procedures for determination of dynamic mechanical characteristics

A.3.1 General

In order to assess the dynamic mechanical characteristics, impact energy E_a and the time sequence of the electrode force during contact and follow-up need to be determined.

A.3.2 Calculation of impact energy

The impact velocity v_a required for calculation of the impact energy E_a (see A.2.6.2) can be obtained either from the displacement-time curve of the moving electrode or, by means of a sensor measuring the oscillation velocity (frequency range: approximately 10 Hz to 1 kHz). The operational stroke of the electrode shall be 5 mm.

The moving mass of the force generation system including pistons, piston rod, platen, electrode holder, electrode and a portion of the flexible conductors and/or jumpers can either be obtained from information furnished by the manufacturer, by calculation or by weighing.

An example of such a measuring system is shown in Figure A.2 as a block circuit diagram. The impact velocity v_a can be obtained from the oscillation velocity sensor signals.

A.3.3 Calculation of force oscillations during electrode contact and follow up

For measurement of the force-time curve, a force sensor shall be located in the welding head as close as possible to the electrode. The force transducer shall have a frequency of 0 Hz to at least 3 kHz, e.g. a piezo-quartz type, and the output displayed against a time base on an oscilloscope (see Figure A.2). Evaluation of the force amplitudes shall be carried out in accordance with A.2.6.3.

The follow-up behaviour is determined by means of a simulation test. In this test, a circular projection in accordance with ISO 8167, stamped into a steel sheet is rapidly melted away by using a sufficiently high current impulse ($t = 1$ period) above the splash limit. The follow-up of the electrode is determined by measuring the height of the projection weld after application of the electrode force. Evaluation of the force amplitudes is carried out in accordance with A.2.6.3.

Based on the contact fault measurements, the measured values shall be determined in accordance with clause 15 for 10 %, 50 %, and 100 % of the maximum electrode force.

Annex B
(informative)

Examples for rating plates

a) Identification		
1) Manufacturer, country		Trademark
2) Resistance seam welding equipment		
4) Serial number Year of production	5) ISO 669	
b) Welding output		
6) ~	7) U_{20} = 4 V to 8 V in 4 steps	
8) I_{2cc} = 45 kA	9) I_{2cc} = 30 kA	10) I_{2p} = 22 kA
c) Mains supply		
11) 1 ~ 50 Hz	12) U_{1N} = 400 V	
13) S_P = 176 kVA	(S_{50} = 250 kVA)	
d) Other characteristics		
14) e = 215 mm	15) I = 550 mm	
16) F_{max} = 1 200 daN	17) F_{min} = 200 daN	
22) p_1 = 8 bar	23) p_2 = 6 bar	
24) Q = 16 l/min	25) Δp = 2 bar	
26) Mass = 1 350 kg	27) v = 0,8 m/min to 8,0 m/min	
28) α_{10} = mrad α_{50} = 0,05 mrad α_{100} = 0,24 mrad	29) g_{10} = mm g_{50} = 0,015 mm g_{100} = 0,02 mm	

Figure B.1 — Seam welding equipment

a) Identification		
1) Manufacturer, country		Trademark
2) Resistance spot welding equipment		
4) Serial number Year of production	5) ISO 669	
b) Welding output		
6) ~	7) U_{20} = 3,5 V to 7,0 V in 4 steps	
8) I_{2cc} = 21 kA	9) I_{2cc} = 15 kA	10) I_{2p} = 7,8 kA
c) Mains supply		
11) 1 ~ 50 Hz	12) U_{1N} = 400 V	
13) S_P = 56 kVA	(S_{50} = 80 kVA)	
d) Other characteristics		
14) e = 115 mm to 415 mm	15) I = 1 050 mm	
16) F_{max} = 600 daN	17) F_{min} = 100 daN	
22) p_1 = 8 bar	23) p_2 = 6 bar	
24) Q = 12 l/min	25) Δp = 2 bar	
26) Mass = 560 kg		

Figure B.2 — Spot welding equipment
(if indication of deflection α and eccentricity g has not been agreed)

a) Identification

1) Manufacturer, country		Trademark
2) Resistance projection welding equipment		
4) Serial number Year	5) ISO 669	

b) Welding output

6) ⎓	7) U_{2di} = 11 V	
8) I_{2cc} = 165 kA	9) I_{2cc} = 130 kA	10) I_{2p} = 22,5 kA

c) Mains supply

11) 3 ~ 50 Hz	12) U_{1N} = 400 V
13) S_P = 212 kVA	(S_{50} = 300 kVA)

d) Other characteristics

14) e = 200 mm to 500 mm	15) l = 350 mm
16) F_{max} = 3000 daN	17) F_{min} = 230 daN
22) p_1 = 8 bar	23) p_2 = 6 bar
24) Q = 38 l/min	25) Δp = 4 bar
26) Mass = 2 230 kg	

Figure B.3 — Projection welding equipment
(if indication of deflection α and eccentricity g has not been agreed)

a) Identification

1) Manufacturer, country		Trademark
2) Resistance butt welding equipment		
4) Serial number Year of production	5) ISO 669	

b) Welding output

6) ⎓	7) U_{2di} = 11 V	
8) I_{2cc} = 220 kA	9) I_{2cc} = 200 kA	10) I_{2p} = 53,4 kA

c) Mains supply

11) 3 ~ 50 Hz	12) U_{1N} = 400 V
13) S_P = 410 k VA	(S_{50} = 580 kVA)

d) Other characteristics

14) e = 135 mm to 180 mm	15) l = 450 mm
16) F_{max} = 1 000 kN	17) F_{min} = 300 kN
18) F_{1max} = 1 000 kN	19) F_{1min} = 500 kN
20) F_{2max} = 2 000 kN	21) F_{2min} = 1 000 kN
22) p_1 = 140 bar	23) p_2 = 130 bar
24) Q = 150 l/min	25) Δp = 6 bar
26) Mass = 26 000 kg	

Figure B.4 — Butt welding equipment

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