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Resistance welding — Procedure for projection welding of uncoated and coated low carbon steels using embossed projection(s)

Soudage par résistance — Procédure pour le soudage par bossage(s) embouti(s) des aciers à bas carbone revêtus et non revêtus

Reference number
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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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16432 was prepared by the International Institute of Welding, recognized as an international standardizing body in the field of welding in accordance with Council Resolution 42/1999.

Introduction

Requests for official interpretations of provisions in this standard should be made in writing and sent to the ISO Central Secretariat who will forward them to the IIW Secretariat for an official response.

Resistance welding — Procedure for projection welding of uncoated and coated low carbon steels using embossed projection(s)

1 Scope

This International Standard specifies requirements for embossed-resistance-projection welding in the fabrication of assemblies of uncoated and metallic coated low carbon steel comprising two thicknesses of metal, where the maximum single sheet thickness of components to be welded is within the range 0,4 mm to 3 mm for the following materials:

— uncoated steels;

— hot-dip zinc or iron-zinc alloy (galvannealed) coated steel;

— electrolytic zinc, zinc-iron, or zinc-nickel coated steel;

— aluminium coated steel;

— zinc-aluminium coated steel.

Organic-coated or primer-coated steels are not covered by this International Standard. Guidelines for appropriate welding equipment and projection welding conditions for various coated steels are given in Annexes A to C. These are for guidance only and may need to be adapted to suit the specified service conditions of the fabrication, prevailing production conditions, type of welding equipment, mechanical and electrical characteristics of the welding machine, electrode configuration, and material. These requirements shall be taken from the relevant welding procedure specification for the application or procedure, where these exist.

2 Normative references

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

ISO 669, *Resistance welding — Resistance welding equipment — Mechanical and electrical requirements*

ISO 5182:1991, *Welding — Materials for resistance welding electrodes and ancillary equipment*

ISO 8167, *Projections for resistance welding*

ISO 10447, *Welding — Peel and chisel testing of resistance spot, projection and seam welds*

ISO 14270, *Specimen dimensions and procedure for mechanized peel testing resistance spot, seam and embossed projection welds*

ISO 14272, *Specimen dimensions and procedure for cross tension testing resistance spot and embossed projection welds*

ISO 14273, *Specimen dimensions and procedure for shear testing resistance spot, seam and embossed projection welds*

ISO 14329, *Resistance welding — Destructive tests of welds — Failure types and geometric measurements for resistance spot, seam and projection welds*

ISO 15609-5, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 5: Resistance welding*

ISO 15614-12, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 12: Spot, seam and projection welding*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 669 and ISO 14329 and the following apply.

3.1
edge distance
minimum distance from the nearest edge of the component to the centre of the weld

3.2
embossed projection
projection in a sheet used for welding and produced by mechanical force using a punch to displace a predetermined amount of material into a cavity

NOTE See ISO 8167 for use on different sheet thicknesses.

3.3
projection base diameter
diameter of an embossed projection measured at the original surface of the stamped sheet

NOTE See ISO 8167.

3.4
weld pitch
distance between centres of adjacent projections

4 Symbols

Symbol	Term	Unit
d	weld diameter	mm
d_b	nominal-projection base diameter	mm
P_s	shear strength of weld	kN
R_m	ultimate tensile strength of steel	MPa
t	sheet thickness	mm

5 Materials

5.1 Form

The steel shall be flat rolled, in coils or cut to length, and shall be free of harmful imperfections.

5.2 Steel grades

A partial list of steel grades to which this International Standard is applicable is given in Annex D.

5.3 Surface conditions

Prior to welding, all surfaces of components to be projection welded shall be free of contaminants such as grease, scale, corrosion products, paint, dirt or excessive pitting. This condition shall be maintained until the welding process is completed. Uncoated hot-rolled steel shall be in the pickled condition.

Certain surface treatments, such as the application of paint primers, rust preventions and oils, may be applied before welding, provided that the coating is uniform in thickness and it has been demonstrated that consistent welds, conforming to this International Standard, can be obtained. Excessive use of surface pre-treatments may adversely affect electrode life and should therefore be avoided.

Coated steels can be supplied with a chromate or phosphate passivation treatment. Phosphated mild steel may be used in certain applications. These materials can be projection welded, although the welding parameters outlined in Annex B may require appropriate adjustment. Generally, more care needs to be taken in selecting welding conditions, particularly with multiple projections. Materials with thicker coatings are more difficult to weld.

6 Component design and manufacture

6.1 Component design

6.1.1 General

The components/joints shall be designed and manufactured to provide adequate matching flange conditions, free from potentially harmful physical deformations to accommodate the projections used in the welding process. The design shall allow unimpeded collapse of the projections during welding, and provide proper access for the electrodes and any necessary tooling. The procedure shall include provision for reviewing the design as a result of tests, to ensure that compliance with this International Standard is achieved. Single or multiple projection arrays may be specified, provided the appropriate welding practices can be maintained.

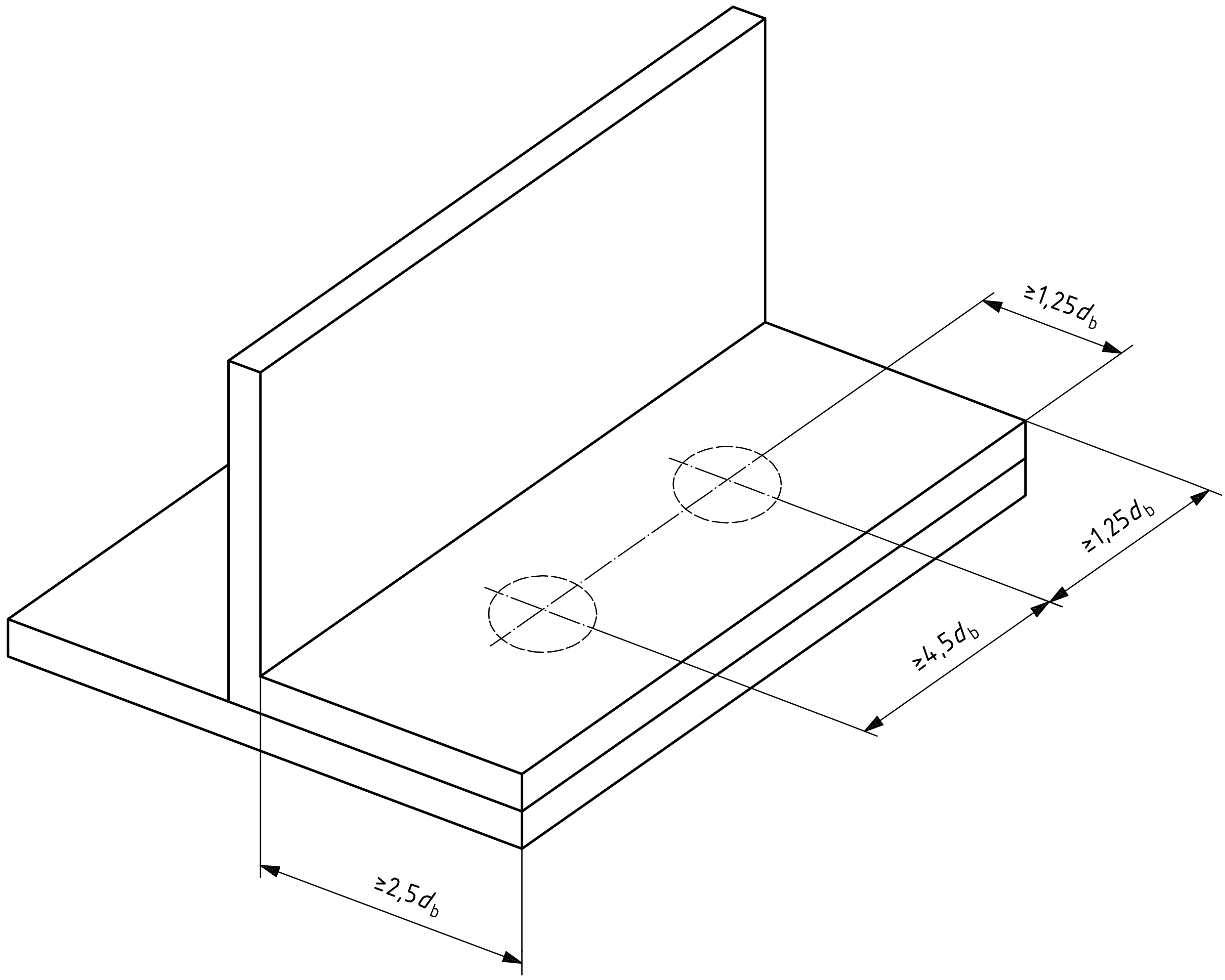
The design of the assembly to be projection welded shall take into account the process requirements specified in Clause 7. The shape of both components shall be such that there is proper contact between the projections and the surface to be welded, to allow unimpeded collapse in response to the welding process.

6.1.2 Placement of projections

The placement of embossed projections from the edge of a component is a function of the projection base diameter (d_b), and hence the sheet thickness (t). The edge distance shall not be less than 1,25 d_b as shown in Figure 1.

It should be noted that short edge distances may adversely affect weld quality. In this case, the nominal weld size may need to be specified below the value given in 8.2.1 and allowance for a lower weld strength shall be made in the design (see 8.2.3).

The weld pitch (see Figure 1), shall not be less than 4,5 d_b, and preferably larger. To avoid imbalance of weld sizes in a multiple array, large pitch variations shall be avoided. The linear pitch should be maintained within ± 10 %, provided the interweld distance does not fall below the specified minimum value.



Key

d_b Nominal-projection base diameter

Figure 1 — Recommended edge conditions and weld pitch

6.2 Projection dimensions

6.2.1 General

Round embossed projections shall be in accordance with ISO 8167. Where a number of projection welds (an array) are welded in one operation, the height of each individual projection of this group on the component shall not vary by more than ± 5 % and the spacing should provide for an even current distribution for the whole group or array.

Elongated projections may replace standard round projections. In this case, the minor axis shall be equal to the diameter of the round projection specified for the sheet thickness specified in ISO 8167. The size and shape of the projection shall be designed to give the required weld area or strength.

The projection strength should be capable of supporting the applied load without excessive cold collapse; i.e. the maximum permissible reduction in projection height shall not exceed 20 %.

6.2.2 Dissimilar sheet thickness

When welding sheets of dissimilar thickness, the dimensions of the projections shall be specified for the thinner of the two sheets. The projection(s) should be made in the thicker sheet.

6.2.3 Multi-weld arrays

In applications where more than one projection weld is used to join two sheet metal components in one plane, all components shall be welded simultaneously to avoid mechanical constraints that can occur if each weld is made sequentially. Sequentially produced projection welds between two components are not covered by this International Standard. Exceptions to this rule may only be made if the geometry of the components dictates this need, or the projections are not in the same plane. In all cases, the resulting arrays shall meet the other requirements of this International Standard .

The design criteria governing size, pitch and edge distances are given in 6.1.2 and 7.3.1.

6.3 Ancillary manufacturing considerations

The components to be welded shall be free from distortions, burrs and other defects which would in any way interfere with proper physical and electrical contact at the electrode or projection interfaces, or impede the proper collapse of the projection during the welding process.

7 Welding equipment

7.1 Welding machine

A machine of suitable electrical and mechanical performance for single- or multiple-projection welding should be specified in the welding procedure specification (WPS) (see ISO 15609-5). This should take into account the application requirements, such as electrode force application, pressure or current programs, current distribution over the effective welding area (platen), thermal duty cycle of machine and any necessary tooling (see 7.3.4 and 7.3.5), etc.

The welding procedure specification should specify the serial or plant numbers of the machine and its control time/programmer, the services required and all fixed settings and feedback control parameters for each application.

7.2 Electrode assembly (tooling)

The electrode holders and conductors shall be made with sufficient strength, section, conductivity, and rigidity to carry the welding current and support the electrode force without overheating or deforming.

The only part in contact with the work piece forming the weld circuit shall be either the electrode(s) or the insert(s) as recommended in ISO 5182:1991, Annex A.

7.3 Design of electrode assembly

7.3.1 Contact face

The shape of the surface of the electrode, or its insert, shall be such that intimate physical and electrical contact is ensured over the entire effective welding area on both sides of the components being assembled.

When using circular electrodes, with or without inserts, to produce welds using standard projections, their face diameter shall not be less than 3 d_b. The distance between the centre of the projection and the edge of the contact face (of the electrode) shall not be less than 1,25 d_b (where possible, it should be considerably greater). In addition, where rectangular electrode faces are used with either round or elongated projections, the distance between the edge of the electrode face and the projection shall not be closer than 1,25 d_b.

7.3.2 Electrode inserts

When inserts are used, there shall be adequate mechanical support to withstand the applied electrode force. Electrical and thermal conduction shall be ensured throughout their working life, minimizing contact resistances between the insert and the backing electrode. Inserts produced from group A and B materials, as specified in ISO 5182, shall not be secured by brazing.

Adequate inspection and maintenance is recommended to ensure continuity of satisfactory production. Inserts thicker than 16 mm may adversely affect the electrical and thermal characteristics of the electrode assembly.

7.3.3 Electrode cooling

Cooling channels shall be provided as close as possible to the welding interface without interfering with the effectiveness of the electrodes.

7.3.4 Location of components (tooling)

When designing/employing devices for locating or clamping components, precautions shall be taken to ensure that no unacceptable alternative shunt paths are created between the components being welded. Such devices shall not impede the free collapse of the projections during welding.

All electrical contact between components, other than through the projections, that are likely to cause unacceptable shunting conditions, should be avoided.

7.3.5 Tooling design considerations

The electrode assembly (tooling) shall be designed and located in the welding machine so as to ensure that both mechanical forces and current are uniformly distributed between all projections that are being produced simultaneously.

In general, magnetic materials should not be used in the construction of the electrode assembly or in any part of the tooling within, or close to, the field of the secondary circuit.

8 Weld assessment — Type tests

8.1 General

The effectiveness of the welding process/machine/tooling and its settings/condition shall be verified using actual components. Where this is impracticable, test pieces from the same batch of material may be substituted in the test, ensuring that the actual production conditions, such as thermal or inductive losses, are reproduced.

A procedure shall be established for each machine, tooling and component, material and welding application. The record of the procedure shall be based on the information provided in ISO 15609-5 and ISO 15614-12.

The following type tests shall be performed:

a) shear test, in accordance with ISO 14272;

b) cross tension test, in accordance with ISO 14273.

In addition, a torsion test may be performed (see ISO 17653).

Finally, visual and metallographic tests in accordance with 8.2.4 and 8.3 shall be performed.

The welded assembly shall conform to the relevant drawings and, unless otherwise specified, a sheet separation gap shall be tolerated provided the test requirements of 8.2 are met.

8.2 Test requirements

8.2.1 Weld diameter

The mean weld diameter shall be measured from the shear test, the cross tension test, and where relevant, the torsion test. It shall not fall below 0,8 d_b (see Annex B), unless the requirements of the relevant welding procedure specification for the application permit this.

The mean diameter is taken to be the average of two diameters measured at right angles, one of which shall be the apparent minimum diameter.

In cases where a small flange width is specified, preventing the prescribed relationship between the appropriate weld size, sheet thickness, and edge distance (1,25 d_b), a smaller weld size shall be specified and reference should be made in the relevant welding procedure specification for the application. In this case, allowance shall be made in the design calculations for the lower strength obtained with smaller welds (see 8.2.3).

8.2.2 Weld fracture mode

All welds made on test pieces or specimens cut from components with sheet thicknesses $t < 2$ mm shall pull a plug on the peel or chisel test.

A plug mode of failure on peel or chisel testing specimens cut from components with sheet thicknesses $t < 2$ mm is desirable. Interfacial failures are allowed if the strength requirements in 8.2.3 are met.

Weld size shall be determined by measuring the weld diameter, as specified in ISO 14329.

8.2.3 Weld strength

The weld strength is defined by weld size, sheet thickness, steel strength, and integrity of the fused zone. Typical minimum values for single projection welds in low carbon steel when tested in shear are given in Table 1. The values given cover weld diameters between $3{,}5\sqrt{t}$ and $6\sqrt{t}$ produced in shear specimens with dimensions specified in the appropriate International Standard and where t is the sheet thickness. Where joints are made between sheets of dissimilar thickness, the minimum weld shear-strength requirement shall be determined by the thickness of the thinner sheet.

The values given in Table 1 are minimum values for use in design calculations for low carbon steel sheets. Higher strengths are generally obtained with high-strength steels and, in this case, the following formula may be applied for calculating the minimum shear strength for a given weld size:

$$P_s = 2{,}6\ t\ d\ R_m \qquad (1)$$

where

P_s is the shear strength of the weld, in kN;

t is the sheet thickness, in mm;

d is the weld diameter, in mm;

R_m is the ultimate tensile strength of steel, in MPa.

8.2.4 Visual and metallographic examination

Test pieces shall be examined visually for appearance and indentation prior to any metallographic examination and any weld defects present shall be reported. Excessive pitting, craters, or weld splashes shall not be acceptable.

Macroscopic examination, if specified, should be used to verify the weld geometry and identify any gross discontinuities. Weld size, weld type, and location of any weld defect or abnormality detected shall be recorded.

So as not to impede visual inspection, no dressing, painting, or other operation interfering with the examination of the weld area shall be carried out on any assembly until after the weld has been examined.

Table 1 — Typical minimum weld shear-strength values for low carbon steel

Sheet thickness	Nominal $3,5\sqrt{t}$		Nominal $4\sqrt{t}$		Nominal $5\sqrt{t}$		Nominal $6\sqrt{t}$	
	Weld diameter	Weld strength	Weld diameter	Weld strength	Weld diameter	Weld strength	Weld diameter	Weld strength
mm	mm	kN	mm	kN	mm	kN	mm	kN
0,6	2,7	1,3	3,1	1,6	3,9	2,0	4,6	2,3
0,8	3,1	2,3	3,6	3,0	4,5	3,6	5,4	4,2
1,0	3,5	3,2	4,0	3,7	5,0	4,3	6,0	5,1
1,2	3,8	4,1	4,4	4,6	5,5	5,4	6,6	6,2
1,6	4,4	5,5	5,1	6,0	6,3	7,4	7,6	8,3
2,0	5,0	7,2	5,7	8,4	7,1	10,8	8,5	13,5
2,5	5,5	10,6	6,3	11,8	7,9	14,5	9,5	17,3
3,0	6,0	12,0	6,9	14,0	8,7	17,8	10,4	22,0

NOTE These values can be used for design calculations. Higher values are generally obtained in practice. Higher strengths are also obtained with higher strength steels.

8.3 Weld appearance — Surface condition

Visual examination of the sheet surface facing the projection and the residual crater at the back of the collapsed projection shall not reveal any surface cracks or porosity. Surface expulsions, sometimes referred to as surface splash (whiskers), shall not be acceptable.

8.4 Distortion

A weld shall be considered unacceptable if the parent metal is excessively deformed by the welding electrodes, or the two sheets have become misaligned during the welding process, or different degrees of separation result where more than one projection weld is produced in one operation.

9 Weld assessment — Routine tests

9.1 General

A system of routine testing shall be established to ensure consistent weld quality in the production of projection welds. Testing shall be carried out using either actual components or test pieces from the same batch of material, ensuring that the actual production conditions/configurations are used. If test pieces are used, the losses due to inductance and shunting should be considered in the preparation of the test sample. The frequency of the testing shall be as stated in 9.2.

The following routine tests shall be performed to ensure consistent projection weld quality under production conditions:

a) visual examination;

b) mechanical peel test in accordance with ISO 14270 or manual peel test and chisel test in accordance with ISO 10447.

No dressing, painting, plating, or other operation interfering with the examination of the weld zone shall be carried out on the assemblies until weld inspection has been completed. Where test pieces are used in the tests, the surface of the test pieces shall be of the same quality as that of the actual assembly being welded.

The test requirements shall be the same as those specified in Clause 8.

9.2 Frequency of testing

Tests shall be performed for each of the following occasions:

a) at the beginning and end of every shift or production period;

b) immediately after new or reconditioned electrodes are fitted to the machine;

c) whenever any of the following occur: major maintenance, repairs, change in key machine components, or machine settings are changed;

d) immediately following a change in component or material supply source.

Production shall not start unless a satisfactory test weld has been obtained at the beginning of each work period.

In the event of a non-conformance, or failure of any test piece, 1 % or 5 assemblies, whichever is the lower, shall be randomly selected from the production items produced on that machine since the previous test. These shall be tested in accordance with the procedure specified in 9.1. In the event of any of the selected assemblies failing, all assemblies produced during the period shall be deemed not to conform to this International Standard .

10 Repair of non-conforming assemblies

This International Standard does not permit repairing of non-conforming assemblies by rewelding the same components using projection welding.

NOTE Repairing using other welding methods is not recommended or covered by this International Standard.

Annex A
(informative)

Recommendations for projection welding equipment

Projection welding equipment should follow the guidelines given in ISO 669. The machine should be equipped with an automatic control that performs at least the following cycle of operations in the sequence given:

a) brings the electrodes into contact with the component, and applies the welding force to the work piece;

b) causes the welding current to flow for a preset time, with the welding force being maintained throughout;

c) interrupts or stops the welding current at the end of the preset time;

d) maintains the welding force for a minimum of 0,02 s [1 cycle (50 Hz)] – the hold time – after the current ceases to flow;

e) releases the force at the end of this time and returns the welding machine to a condition where it is ready to recommence the same cycle of operations.

The welding force, welding current, weld time, and, where needed, the squeeze time and hold time should be variable over a range sufficient to ensure that optimum welding conditions can be obtained.

Pedestal welding machines, gun welders, automatic welding equipment where the equipment is fed by robots or automatic feeding equipment, multi-welders, and robotic welding are covered by this International Standard. Effective tooling should be specified and locating and clamping devices should not interfere with the welding or cause shunting of current through the fixtures.

The moving head of the machine should be free to move in the direction of the applied load, so that it will follow the collapse of the projection and maintain the load on the weld as it is formed.

Annex B
(informative)

Relationship between sheet thickness and projection diameter
(derived from ISO 8167)

For the various applications and the required strength determined by weld strength and material properties, it is recommended that, according to the sheet thickness, the following three different groups of projection diameters (see Table B.1) be adopted.

— Group A Comprises small size projections for applications where space is limited or minimum marking is required.

— Group B Projections for standard applications, which usually need more space and leave larger marks than Group A projections.

— Group C Large-size projections for high-strength steel applications, where space or shape limits the application or use of multi-projections, normally used with high-strength steels.

Table B.1 — Groups of projection diameters

Dimensions in millimetres

Steel thickness	Projection diameters, d_b		
t	Group A	Group B	Group C
$t \leqslant 0,5$	1,6	2,0	2,5
$0,5 < t \leqslant 0,73$	2,0	2,5	3,2
$0,73 < t \leqslant 1,0$	2,5	3,2	4,0
$1,0 < t \leqslant 1,6$	3,2	4,0	5,0
$1,6 < t \leqslant 2,5$	4,0	5,0	6,3
$2,5 < t \leqslant 3,0$	5,0	6,3	8,0

NOTE Larger projections are required for certain coated steels compared to uncoated steel, e. g.,

a) zinc alloy coatings = uncoated steel.

b) zinc coated.

c) aluminium coated = larger projections than uncoated steel.

i.e., if Group B projection is chosen for uncoated steel, then a Group C projection should be chosen for the coated steel, for the same sheet thickness, if a fused weld nugget is required. Use of the smaller projection will generally result in a solid-phase weld in the case of zinc-coated steels. It should be emphasized that the strength of the solid-phase welds can be similar to that achieved with a weld nugget.

Annex C
(informative)

Typical projection welding conditions

Table C.1 to C.4 give guidance on projection welding conditions for the uncoated and coated steels in the more commonly used thicknesses covered by this International Standard when using the projection shape and dimensions indicated in Annex B. These may require modification depending on the mechanical behaviour (stiffness, electrode force actuator, and electrode geometry) and electrical characteristics of the welding equipment (see ISO 669).

When welding sheets of dissimilar thickness, welding conditions may be based on the thinnest sheet or the second thinnest sheet when welding three thicknesses.

In the case of high-strength steels up to 20 %, a higher electrode force may be necessary. The welding current may be reduced by up to 20 %, depending on the grade of high-strength steel being welded.

When welding up to three projections, the force and current should be multiplied by the number of projections. When welding more than three projections, the force and current should be 0,8 × number of projections welded.

NOTE The weld time is independent of the number of projections.

Table C.1 — Typical projection-welding conditions (uncoated mild steel/iron zinc alloy coated steel) (Group B Projections)

Sheet thickness mm		**Welding conditions**				**Projection Designation** (ISO 8167 Group B) mm
		Force kN	Weld Time		Current kA	
Over	Up to and including		Cycles (at 50 Hz)	s		
0,4[a]	0,5	0,4	8	0,16	3,5	2,0
0,5	0,6	0,5	12	0,24	4	2,5
0,6	1,0	0,9	17	0,34	6	3,2
1,0	1,6	1,4	20	0,4	8	4,0
1,6	2,5	2,2	25	0,5	10	5,0
2,5	3,0	2,6	25	0,5	12	6,3

[a] This range includes the thickness 0,4 mm as the lower limit.

Table C.2 — Typical projection-welding conditions (zinc – 53 % aluminium coated) (Group B Projections)

Sheet thickness mm		**Welding conditions**				**Projection Designation** (ISO 8167 Group B) mm
		Force kN	Weld Time		Current kA	
Over	Up to and including		Cycles (at 50 Hz)	s		
0,2	0,4	0,4	4	0,08	5	1,6
0,4	0,5	0,5	8	0,16	8	2,0
0,5	0,6	0,9	12	0,24	10	2,5
0,6	1,0	1,4	17	0,34	12.6	3,2
1,0	and over	2,2	20	0,4	14	4,0

Table C.3 — Typical projection-welding conditions (electric-zinc and hot-dip zinc group) (Group B Projections)

Sheet thickness mm		**Welding conditions**				**Projection Designation** (ISO 8167 Group B) mm
		Force kN	Weld Time		Current kA	
Over	Up to and including		Cycles (at 50 Hz)	s		
0,4	0,5	0,5	12	0,24	4	2,0
0,5	0,6	0,9	17	0,34	6	2,5
0,6	1,0	1,4	20	0,4	8	3,2
1,0	1,6	2,2	25	0,5	10	4,0
1,6	2,0	2,6	25	0,5	12	5,0

Table C.4 — Typical projection-welding conditions (electric-zinc and hot-dip zinc coated) (Group C Projections)

Sheet thickness mm		**Welding conditions**				**Projection Designation** (ISO 8167 Group B) mm
		Force kN	Weld Time		Current kA	
Over	Up to and including		Cycles (at 50 Hz)	s		
0,4	0,5	1,0	17	0,34	7	2,5
0,5	0,6	1,5	20	0,40	9	3,2
0,6	1,0	2,0	25	0,50	11	4,0
1,0	1,6	2,6	30	0,60	13	5,0
1,6	2,5	3,0	35	0,70	15	6,3
2,5	3,0	3,5	40	0,80	18	8

Annex D
(informative)

Partial list of steel types applicable to the standard

D.1 Uncoated steel

Sheet and strip material should comply with the general requirements and chemical composition specified in ISO 3574. Hot rolled steel should be in the pickled condition for best results and should comply with the requirements of ISO 3573, ISO 4950-1 and ISO 4950-2.

D.2 Hot-dip zinc or iron-zinc alloy coated steel

Several types of zinc coatings are available with various steel substrates and surface treatments. They should comply with the requirements for hot-dip zinc coated and iron-zinc coated (galvannealed) steel coil and cut lengths, in forming and structural grades specified in ISO 3575 and ISO 4998. Coating types and coating mass should comply with these standards; the lower-mass zinc coatings and the zinc alloy coatings being the most readily weldable.

D.3 Electrolytic zinc coated steel

Electrolytic zinc coated steel should be produced by electrolytic deposition of pure zinc onto low carbon steel. The maximum coating thickness should be 15 µm nominal (≡ coating mass 107 g/m^2) on each surface and should comply with ISO 5002 for the more readily weldable grades.

D.4 Electrolytic zinc-nickel or zinc-iron coated steel

Such coatings deposited electrolytically should be limited to a maximum coating thickness of 7 µm (≡ coating mass 51 g/m^2) on each surface.

D.5 Aluminium coated steel

Aluminium coated steel produced by the hot-dip process, the coating containing 5 % to 11 % silicon, should comply with ISO 5000. Aluminium coated steels may also be produced by a roll bonding technique. Coating mass up to 150 g/m^2 nominal, including both surfaces, is considered the most readily weldable.

D.6 Zinc – (50-55) % aluminium coated steel

Zinc – (50-55) % aluminium coated steel produced by the hot-dip process, with a maximum coating mass of 185 g/m^2, including both surfaces, for the more readily weldable grades, should comply with ISO 9364. Heavier coating thicknesses can be welded, provided that suitable welding conditions are used.

D.7 Zinc – 5 % aluminium coated steel

Zinc – 5 % aluminium coated steel should be produced by the hot-dip process. The maximum coating mass should be 180 g/m^2, including both surfaces, for the more readily weldable grades.

Bibliography

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[2] ISO 3574, *Cold-reduced carbon steel sheet of commercial and drawing qualities*

[3] ISO 3575, *Continuous hot-dip zinc-coated carbon steel sheet of commercial and drawing qualities*

[4] ISO 4950-1, *High yield strength flat steel products — Part 1: General requirements*

[5] ISO 4950-2, *High yield strength flat steel products — Part 2: Products supplied in the normalized or controlled rolled condition*

[6] ISO 4998, *Continuous hot-dip zinc-coated carbon steel sheet of structural quality*

[7] ISO 5000, *Continuous hot-dip aluminium-silicon-coated cold-reduced carbon steel sheet of commercial and drawing qualities*

[8] ISO 5002, *Hot-rolled and cold-reduced electrolytic zinc-coated carbon steel sheet of commercial and drawing qualities*

[9] ISO 9364, *Continuous hot-dip aluminium/zinc-coated steel sheet of commercial, drawing and structural qualities*

[10] ISO 17653, *Destructive tests on welds in metallic materials — Torsion test of resistance spot welds*

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