



**SLOVENSKI STANDARD**  
**SIST EN ISO 14555:1999**  
**01-december-1999**

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Welding - Arc stud welding of metallic materials (ISO 14555:1998)

Schweißen - Lichtbogenbolzenschweißen von metallischen Werkstoffen (ISO 14555:1998)

Soudage - Soudage a l'arc des goujons sur les matériaux métalliques (ISO 14555:1998)

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**Ta slovenski standard je istoveten z: EN ISO 14555:1998**

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**ICS:**

25.160.10 Varilni postopki in varjenje Welding processes

**SIST EN ISO 14555:1999**

**en**

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## Welding - Arc stud welding of metallic materials (ISO 14555:1998)

Soudage - Soudage à l'arc des goujons sur les matériaux métalliques (ISO 14555:1998)

Schweißen - Lichtbogenbolzenschweißen von metallischen Werkstoffen (ISO 14555:1998)

This European Standard was approved by CEN on 26 June 1998.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

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## Foreword

The text of EN ISO 14555:1998 has been prepared by Technical Committee CEN/TC 121 "Welding", the secretariat of which is held by DS, in collaboration with Technical Committee ISO/TC 44 "Welding and allied processes".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 1999, and conflicting national standards shall be withdrawn at the latest by April 1999.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZB, which is an integral part of this standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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## Introduction

The purpose of arc stud welding is to weld predominantly pin-shaped metal parts to metal workpieces. In this standard it is only referred as stud welding. Stud welding is used among other things e.g. in bridge building (especially in composite structures), steel structures, shipbuilding, facade-wall fabrication, vehicle manufacture, equipment design, steam-boiler construction, and the manufacture of household appliance.

In stud welding, an arc is briefly struck between the face of the stud and the workpiece; both parts start to melt and are then joined. Depending on the nature of the welding method, a distinction is made between drawn-arc stud welding and stud welding with tip ignition. Each method needs suitable power supplies, actuating devices, studs and accessories (e.g. ceramic ferrules). A feature of stud welding is the very short arc burn time (approximately 0,5 ms to 3,0 s) and the associated high rate of heating and cooling. Normally the diameter of the stud ranges are up to 8 mm for tip ignition welding and up to 25 mm for drawn-arc welding.

The quality of a stud weld depends not only on strict compliance with the welding procedure specification but also on the correct function of the actuating mechanism (e.g. welding guns), on the condition of the components, of the accessories and of the power supply.

## 1 Scope

This standard covers arc stud welding of metallic materials subject to static and dynamic loading. It specifies requirements particular to stud welding related to welding knowledge, quality requirements welding, procedure specification, welding procedure approval, approval testing of welders and testing of production welds.

This standard is appropriate where a contract between the parties concerned, an application standard or regulatory requirements (hereafter designated "contract", see EN 729-1) requires the demonstration of a manufacturers capability to produce welded construction of a specified quality.

It has been prepared in a comprehensive manner to be used as a reference in contracts. The requirements given can be adopted in full or some can be deleted, if not relevant to the construction concerned (see Annex A).

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 287-1

Approval testing of welders – Fusion welding – Part 1: Steels

EN 287-2

Approval testing of welders – Fusion welding – Part 2: Aluminium and aluminium alloys

EN 288-1 : 1992

Specification and approval of welding procedures for metallic materials – Part 1: General rules for fusion welding

EN 288-3

Specification and approval of welding procedures for metallic materials – Part 3: Welding procedure tests for arc welding of steels

EN 288-4

Specification and approval of welding procedures for metallic materials – Part 4: Welding procedure tests for arc welding of aluminium and its alloys

EN 288-6

Specification and approval of welding procedures for metallic materials – Part 6: Approval related to previous experience

EN 288-8

Specification and approval of welding procedures for metallic materials – Part 8: Approval by a pre-production welding test

EN 439

Welding consumables – Shielding gas for arc welding and cutting



- EN 573-3  
Aluminium and aluminium alloys – Chemical composition and form of wrought products – Part 3: Chemical composition
- EN 719  
Welding coordination – Tasks and responsibilities
- EN 729-1  
Quality requirements for welding – Fusion welding of metallic materials – Part 1: Guidelines for selection and use
- EN 729-2  
Quality requirements for welding – Fusion welding of metallic materials – Part 2: Comprehensive quality requirements
- EN 729-3  
Quality requirements for welding – Fusion welding of metallic materials – Part 3: Standard quality requirements
- EN 729-4  
Quality requirements for welding – Fusion welding of metallic materials – Part 4: Elementary quality requirements
- EN 1418 : 1997  
Welding personnel – Approval testing of welding personnel for fully mechanized and automatic welding of metallic materials
- EN 1435  
Non destructive examination of welds – Radiographic examination of welded joints
- EN 10025 + A1  
Hot rolled products of non-alloy structural steels – Technical delivery conditions (includes amendment A1:1993)
- EN 10028-2  
Flat products made of steels for pressure purposes – Part 2: Non-alloy and alloy steels with specified elevated temperature properties
- EN 10088-1  
Stainless steels – Part 1: List of stainless steels
- EN 10204  
Metallic products – Types of inspection documents
- EN 20898-1  
Mechanical properties of fasteners – Part 1: Bolts, screws and studs (ISO 898-1:1988)
- EN 24063  
Welding, brazing, soldering and braze welding of metals – Nomenclature of processes and reference numbers for symbolic representation on drawings (ISO 4063:1990)
- EN 60974-1  
Safety requirements for arc welding equipment – Part 1: Welding power sources (IEC 974-1:1989, modified)
- EN ISO 6947  
Welds – Working positions – Definitions of angles of slope and rotation (ISO 6947:1993)
- EN ISO 13918  
Welding – Studs and ceramic ferrules for arc stud welding
- ISO 426-1  
Wrought copper-zinc alloys – Chemical composition and forms of wrought products – Part 1: Non-lead and special copper-zinc alloys
- ISO/DIS 857  
Welding and allied processes – Welding, brazing and soldering processes – Vocabulary
- ISO 5828  
Resistance welding equipment – Secondary connecting cables with terminals connected to water-cooled lugs – Dimensions and characteristics

### 3 Definitions, symbols and abbreviations

#### 3.1 Definitions

For the purposes of this standard, the definitions given in ISO/DIS 857, in accordance with EN 719, EN 729-1, EN 1418 and EN 288-1 and the following definitions are applicable for stud welding:

**3.1.1 Welding consumables:** In the meaning of this standard studs, pins and other parts to be attached by stud welding are defined as welding consumables.

**3.1.2 Auxiliaries:** Ceramic ferrules and shielding gases.

**3.1.3 Stud welding operator:** Operating personnel for stud-welding equipment, who are familiar with the conditions for stud welding. They have the knowledge to operate the equipment, to adjust the equipment properly, to carry out the welding correctly and while doing so to pay attention to good contact, symmetrical connection of the workpiece cables and uniform distribution of ferromagnetic materials. In special cases (e.g. mass production at the manufacturer's factory) the welding can be carried out by suitable auxiliary personnel, appropriately trained and supervised.

**3.1.4 Stud diameter:** In the drawn arc stud welding with ceramic ferrule or shielding gas, diameter means the diameter at the weld base. In all other stud welding methods, diameter means the diameter above the flange.

**3.1.5 Current intensity:** Mean value of the welding current in the steady state during the burning time of the arc (not applicable to capacitor discharge).

**3.1.6 Welding time:** Time difference between the ignition and the final extinction of the main arc.

**3.1.7 Lift (L in figure 2):** Distance between the stud tip and the workpiece surface with the stud-lifting mechanism in position and activated. For tip ignition this definition applies to the ignition gap.

**3.1.8 Plunge:** Axial movement of the stud towards the surface of the workpiece.

**3.1.9 Protrusion (P in figure 2):** With unregulated, i.e. spring-loaded, lifting mechanisms, the protrusion is the distance between the tip of the stud and the face of the support device in their initial position where it faces the workpiece.

**3.1.10 Arc blow:** Magnetic deflection of the arc from the axial direction of the stud.

**3.1.11 Flux:** Aluminium slug or spray on the weld end of the stud. When melted by the arc, it cleans and de-oxidises the parent metal surface.

### 3.2 Symbols

For the purposes of this standard, the following symbols apply:

- |                                      |                    |
|--------------------------------------|--------------------|
| - $C$ (in millifarad)                | capacitance;       |
| - $d$ (in millimetres)               | stud diameter;     |
| - $I$ (in ampere)                    | current intensity; |
| - $t_w$ (in milliseconds or seconds) | welding time;      |
| - $U$ (in volt)                      | charging voltage;  |
| - $W$ (in wattseconds)               | loading power.     |

### 3.3 Abbreviations

For the purposes of this standard, the following abbreviations apply:

- |        |  |
|--------|--|
| - CF   | ceramic ferrule;                             |
| - DS   | drawn-arc stud welding;                      |
| - HAZ  | heat-affected zone;                          |
| - L    | lift;  |
| - NP   | no protection;                               |
| - P    | protrusion;                                  |
| - PA   | flat position;                               |
| - PC   | horizontal position;                         |
| - PE   | overhead position;                           |
| - SG   | shielding gas;                               |
| - TS   | stud welding with tip ignition;              |
| - WPS  | welding procedure specification;             |
| - WPAR | welding procedure approval record;           |
| - pWPS | preliminary welding procedure specification. |

## 4 Welding knowledge

### 4.1 General

This chapter gives general guidance for the satisfactory production and control of stud welding.

### 4.2 Processes

#### 4.2.1 Drawn arc stud welding (DS)

##### 4.2.1.1 General

This can be done mechanically or automatically, using welding guns or welding heads. The work phases of drawn arc stud welding are illustrated in figure 1. The stud is inserted into the stud holder and - fitted with a ceramic ferrule, if necessary - applied to the workpiece (see figure 1 a)). At the beginning of the welding process the stud is lifted by the mechanism and generally first a pilot arc, then the main arc, are struck between the tip of the stud and the workpiece (see figure 1 b)). This causes the face of the stud and the parent metal to melt. When the welding time has elapsed, the stud is plunged with limited force ( $< 100$  N) into the molten pool, and the current source is switched off (see figure 1 c)). The ceramic ferrule is then removed (see figure 1 d)). Figure 2 shows the sequence of events using a ceramic ferrule.

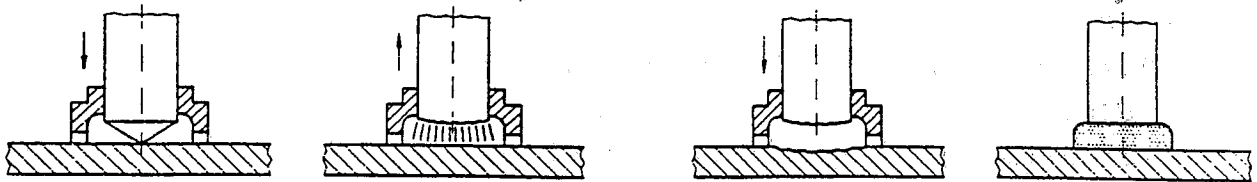


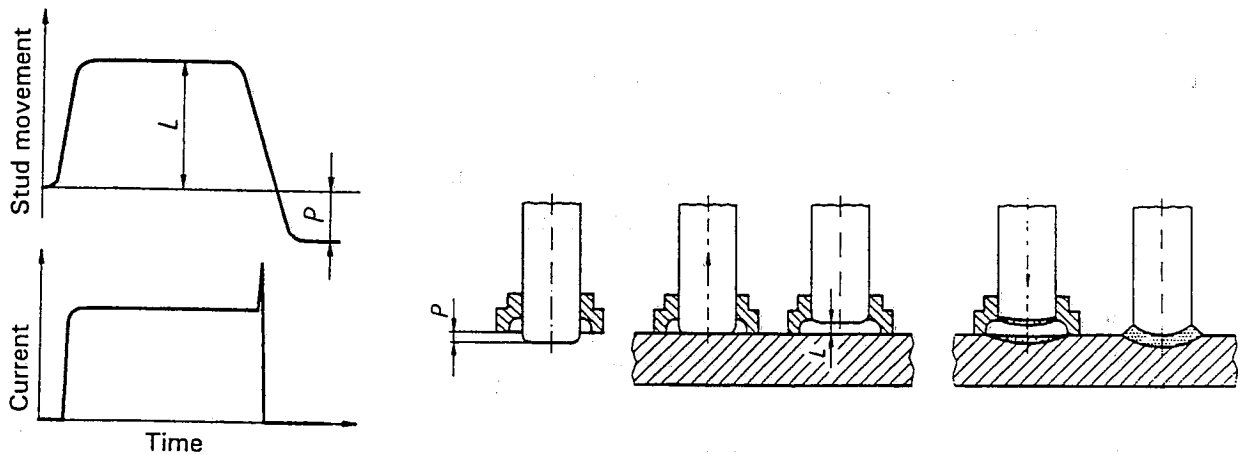
Figure 1a): Application of the stud

Figure 1b): Lift and arc ignition

Figure 1c): Plunge

Figure 1d): Welded stud

Figure 1: Drawn arc stud welding, sequence of operations



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Protrusion

Start

Lift

Plunge  
 $\leq (L + P)$ 

End

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Figure 2: Stud movement in drawn arc stud welding

Stud welding equipment is available for different ranges of work, with different welding times and different forms of shielding of the arc and the weld pool.

#### 4.2.1.2 Methods

A distinction is made between three processes (see table 1):

- drawn arc stud welding with ceramic ferrule or shielding gas (see 4.2.1.2 a));
- short-cycle drawn arc stud welding (see 4.2.1.2 b));
- capacitor discharge drawn arc stud welding (see 4.2.1.2 c)).

Table 1: Working range of the various drawn arc stud welding processes

Processes	Welding time, $t_w$ ms	Stud diameter, $d$ mm	Current intensity, $I$ A	Weld pool protection	Minimum sheet
drawn arc stud welding with ceramic ferrule or shielding gas	> 100	3 to 25	300 to 3000	CF	1/4 $d$ , but not less than 1 mm <sup>1)</sup>
	> 100	3 to 16	300 to 3000	SG	1/8 $d$ , but not less than 1 mm
short-cycle drawn arc stud welding	≤ 100	3 to 12	up to 1500	NP, SG, (CF)	1/8 $d$ , but not less than 0,6 mm
capacitor discharge drawn arc stud welding	< 10	3 to 10	up to 3000 (peak)	NP, (SG)	1/10 $d$ , but not less than 0,5 mm

1) The minimum sheet thickness avoids burn through. Other application requirements can call for bigger thickness.

When the short-cycle process – high-power process (narrow melt zone) – or the capacitor discharge process is used, the stud tips shall be matched to the fusion penetration shape in the workpiece, and be made flatter (e.g. 166° cone angle).

#### a) Drawn arc stud welding with ceramic ferrule or shielding gas

This process is generally used in the 3 mm to 25 mm diameter range, with welding times of 100 ms to 3000 ms. It is usually carried out with a ceramic ferrule and in special cases only with shielding gas or without pool protection. This method is used for the majority of applications. The minimum sheet thickness is 1/4 for CF and for SG 1/8 of stud diameter, but not less than 1 mm.

#### b) Short-cycle drawn arc stud welding

With special equipment a short welding time of ≤ 100 ms, can be achieved. This variant is suitable for studs up to 12 mm diameter, but for about 8 mm up to 12 mm diameter shielding gas should be used to prevent increased pore formation. The fusion zone is narrow and the thermal input modest, so that studs up to 12 mm diameter can be welded to thin sheets. At 10 mm to 12 mm stud diameter a ceramic ferrule enhances the formation of the weld collar. Up to 8 mm diameter the operation is frequently carried out without protection of the weld pool and calls for studs with an upset flange as these afford a larger weld area than the plain stud-shaft diameter and thus reach a higher tensile force than the stud shaft, despite pores in the weld zone. The minimum sheet thickness is 1/8  $d$ , but not less than 0,6 mm.

#### c) Capacitor discharge drawn arc stud welding

Very short welding time (< 10 ms) can be achieved by using a capacitor discharge power source. The range of diameter is 3 mm to 10 mm. The minimum sheet thickness is 1/10  $d$ , but not less than 0,5 mm. The process is similar to the short-cycle drawn arc stud welding process, but the peak current can be up to 3000 A.

### 4.2.1.3 Weld pool protection

A distinction is made between different techniques, on the basis of weld pool protection:

- ceramic ferrule (CF), (see 4.2.1.3 a));
- shielding gas (SG), (see 4.2.1.3 b));
- no protection (NP), (see 4.2.1.3 c)).

## a) Ceramic ferrule (CF)

The ceramic ferrule forms a combustion chamber around the weld location, shielding the welder from both arc and spatter. It concentrates the arc in a small region and reduces heat loss and cooling rate. The atmosphere is only slightly held off by the ceramic ferrule. When the stud is plunged into the weld pool, it forces molten metal out sideways to form an annular weld collar around the stud. Welding can thus be carried out in any position. The ceramic ferrule is used for one weld only and is removed once the molten metal has solidified.

## b) Shielding gas (SG)

In stud welding with shielding gas the atmosphere is displaced from the arc region by a shielding gas supplied from outside, this greatly reduces the formation of pores. Steels and most other metals a mixture of 82 % argon and 18 % carbon dioxide (EN 439-M21) is used. For aluminium and its alloys pure argon Ar 99,99 (EN 439-I1) is required.

The shielding gas influences the arc and affects the fusion of the stud and workpiece and also, via the surface tension, influences the shaping of the weld collar and the penetration shape. It is fundamental principle that the welding position PA according to EN ISO 6947 should be preferred. An additional ceramic ferrule can also be used to improve the shape of the collar and restrict the arc to the immediate area of the workpiece.

## c) No protection (NP)

Stud welding without protection is possible only for small stud diameters (less than 10 mm) and with short welding times (less than 100 ms). Among the drawbacks of this method are severe oxidation of the weld zone, increased pore formation and an irregular weld bead.

## 4.2.2 Capacitor discharge stud welding with tip ignition (TS)

There are two techniques for capacitor discharge stud welding with tip ignition:

- with contact;
- with gap.

In welding with contact, the stud is inserted into the stud holder of the machine (see figure 3a)) and positioned with its ignition tip directly on the surface of the component (see figure 3b)). A spring in the welding gun presses the stud against the metal. Once the capacitor power has been switched on, the ignition tip vaporized and the arc struck (see figure 3c)) the stud is advanced still further towards the sheet metal and finally remains in the solidified melt (see figure 3d)). The welding time is  $\leq 3$  ms.

The difference between welding with gap and the technique described above is that, before welding begins, the stud is held at a defined, adjustable distance from the workpiece (see figure 3a)).

When the capacitor bank is switched on, the stud is speeded up towards the surface of the metal, and the process continues as described above (see figures 3b), 3c), 3d)). A welding time of about 1 ms makes it possible, among other things, to weld aluminium and its alloys without gas shielding.

The recommended sheet thickness should be  $\geq 1/10$  d but not less than 0,5 mm.

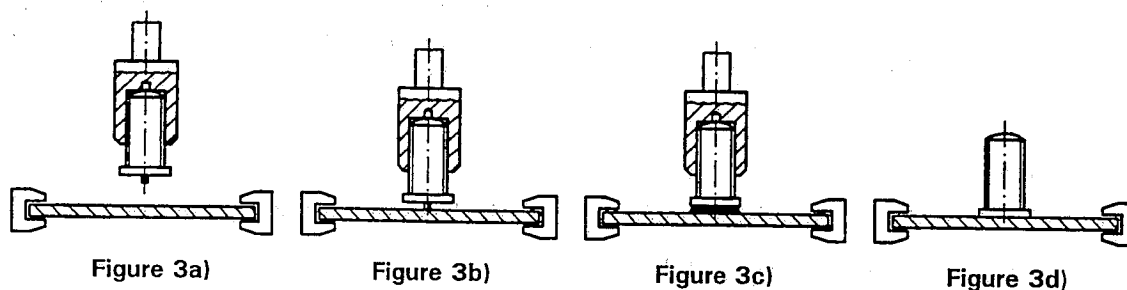


Figure 3: Capacitor discharge stud welding with tip ignition - Main phases of the welding process

### 4.3 Parent metals

#### 4.3.1 General

The brief arc effect initiates melting of both stud and parent metal and the molten pools intermix as the joint is formed, the properties of the heat-affected zone are modified also. This phenomenon differs in the various stud-welding processes. Generally speaking, more stud material melts than parent metal. Usually the weld area on the parent metal is larger than the cross-section of the stud. The strength and deformation properties at the transition from weld to stud shall therefore be investigated with special attention. In the case of steel, particular attention shall be paid to embrittlement due to hardening.

The surface of the parent metal shall be clean. Layers of paint, rust, scale, grease and coatings of non-weldable metals should be removed from the weld location. This can be done mechanically or chemically. Parent metals with scale and rust layers shall be thoroughly ground off. The surface preparation shall be specified in the WPS. Where welding times are short (less than 50 ms), the surface shall be cleaned with particular care.

**Table 2: Weldability of typical combinations of stud and parent metals for drawn arc stud welding with ceramical ferrule or shielding gas and short-cycle drawn arc stud welding**

Stud material	Parent metal			
	EN 288-3/ groups 1 and 2 <sup>3)</sup>	EN 288-3/ groups 4 and 5	EN 288-3/ group 9	EN 288-4/ groups 21 and 22.1
S235 4.8 (weldable) 16Mo3	a	b	b <sup>2)</sup>	–
X10CrAl18 X10CrAl24 X20CrNiSi25-4	c	c	c	–
1.4301 1.4303 1.4401 1.4541 1.4571	b/a <sup>1)</sup>	b	a	–
EN AW-ALMg3 EN AW-ALMg5	–	–	–	b

1) Up to 10 mm in diameter and shielding gas in position PA.  
2) Only for short-cycle drawn arc stud welding.  
3) Maximum yield strength  $R_{eH} \leq 460 \text{ N/mm}^2$ .

Key to weldability numbers:  
–: not weldable  
a: Highly weldable for any application, e.g. for force transfer.  
b: Weldable within limits for force transfer.  
c: Weldable within limits only for heat transfer.