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Welding — Studs and ceramic ferrules for arc stud welding

*Soudage — Goujons et bagues céramiques pour le soudage à l'arc
des goujons*

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Quality management in the field of welding*.

This third edition cancels and replaces the second edition (ISO 13918:2008), which has been technically revised.

The main changes compared to the previous edition are as follows:

- a) everything according conformity evaluation has been deleted from this document;
- b) fully-threaded stud (FD), virtually fully-threaded stud (MD) and insulation pin/nail (ND) have been introduced;
- c) threaded stud has been renamed to partially threaded stud (PD);
- d) abbreviation *P* for pitch has been introduced;
- e) that a stud may consist of two different materials combined by friction welding has been introduced in [5.3.3.1](#);
- f) value for CEV ($CEV \leq 0,38$) in [Table 2](#) has been changed;
- g) SD3 materials according ISO 15510 have been introduced in [Table 2](#);
- h) PT, UT and IT materials according ISO/TR 15608 have been introduced in [Table 2](#);
- i) where applicable, the dimensions d_3 and h_4 are now for guidance only.
- j) " y_{\min} " has been changed to " $y + 2P$ " in [Table 5](#), column l_2 ;
- k) " $y_{\min} + 1$ " has been changed to " $y + 2P$ " in [Table 6](#), column d_1 ;
- l) " $\alpha \pm 2,5^\circ$ " has been changed to " $\alpha \pm 7^\circ$ " in [Table 6](#), column d_1 ;

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- m) " $\alpha \pm 2,5^\circ$ " has been changed to " $\alpha \pm 7^\circ$ " in [Table 9](#), column D_6 ;
- n) " b " has been changed to " $b + 2P$ " and values for M 5 and M 8 have been changed to 7,5 mm and 12 mm in [Table 9](#), column D_6 ;
- o) the column header " $d_1 - 0,4$ " has been changed to " $d_1 \pm 0,4$ " in [Table 10](#);
- p) " $\alpha \pm 2,5$ " has been changed to " $\alpha \pm 7$ " in [Table 10](#);
- q) the column header " b_{\min} " has been changed to " $b_{\min} + 2P$ " in [Table 13](#);
- r) the column header " b " has been changed to " $b_{\min} + 2P$ " in [Table 16](#);
- s) a nominal diameter ($d_1 \pm 0,1$) of 8 mm has been introduced with an internal thread diameter (D_6) of M5 and M6 in [Table 16](#);
- t) in all tables for the dimensions of ceramic ferrules, the values for the nominal diameter (D_7), the grip diameter (d_8), the base diameter (d_9) and the height (h_2) have been deleted;
- u) [Table 17](#) has been introduced;
- v) a note that stud and ceramic ferrule are generally a coordinated system from the same manufacturer has been introduced in [Clause 7](#);
- w) [10.1](#) has been introduced;
- x) Annex A has been deleted;
- y) figures, normative references and layout have been editorially revised.

Requests for official interpretations of any aspect of this document should be directed to the Secretariat of ISO/TC 44 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

This corrected version of ISO 13918:2017 incorporates the following correction:

- footnote ^b in [Table 11](#) has been modified.

Introduction

The range of types of studs specified in this document represents customary applications.

This document can be used in all fields of the metal-working industry.

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Welding — Studs and ceramic ferrules for arc stud welding

1 Scope

This document specifies the following:

- requirements for studs and ceramic ferrules for arc stud welding;
- dimensions, materials and mechanical properties.

[Table 1](#) shows types of studs and the symbols for studs and ceramic ferrules that are covered by this document.

Table 1 — Types of studs and symbols for studs and ceramic ferrules

Welding technique	Type of stud ^a	Symbol for studs	Symbol for ceramic ferrules
Drawn arc stud welding with ceramic ferrule or shielding gas	Fully-threaded stud	FD	UF
	Virtually fully-threaded stud ^b	MD	MF
	Partially threaded stud	PD	PF
	Threaded stud with reduced shaft	RD	RF
	Unthreaded stud	UD	UF
	Insulation pin/nail	ND	UF
	Stud with internal thread	ID	UF
	Shear connector	SD	UF/DF
Short-cycle drawn arc stud welding	Threaded stud with flange	PS	—
	Unthreaded stud	US	—
	Stud with internal thread	IS	—
Stud welding with tip ignition	Threaded stud	PT	—
	Unthreaded stud	UT	—
	Stud with internal thread	IT	—
^a Further types of stud and ceramic ferrules can be specified as required for special applications.			
^b Also called MPF, stud with a nearly full thread and a minimum length of the unthreaded part.			

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*

ISO 3506-1, *Mechanical properties of corrosion-resistant stainless steel fasteners — Part 1: Bolts, screws and studs*

ISO 4042, *Fasteners — Electroplated coatings*

ISO 4759-1, *Tolerances for fasteners — Part 1: Bolts, screws, studs and nuts — Product grades A, B and C*

ISO 6947, *Welding and allied processes — Welding positions*

ISO 15510, *Stainless steels — Chemical composition*

ISO/TR 15608, *Welding — Guidelines for a metallic materials grouping system*

ISO 16120-2, *Non-alloy steel wire rod for conversion to wire — Part 2: Specific requirements for general purpose wire rod*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Symbols and abbreviated terms

<i>b</i>	length of the thread
<i>c_d</i>	depth of the crack in the head
<i>d₁</i>	nominal diameter
<i>d₂</i>	diameter at the weld area
<i>d₃</i>	diameter of the weld collar
<i>d₄</i>	diameter of the ignition tip
<i>d₅</i>	head diameter of shear connector
<i>D₆</i>	internal thread diameter
<i>h₁</i>	height of the flange
<i>h₃</i>	height of the head on shear connector
<i>h₄</i>	height of the weld collar
<i>h₅</i>	height of the thread run-out part of stud types PS and PT
<i>l₁</i>	overall length of the stud (excluding aluminium ball or ignition tip)
<i>l₂</i>	nominal length of the stud
<i>l₃</i>	length of the ignition tip
<i>P</i>	pitch
<i>y</i>	length of the unthreaded part
<i>α</i>	face angle

5 Requirements

5.1 Ordering information

At the time of order, the manufacturer shall obtain the following information:

- a) a reference to this document if the purchaser demands compliance;
- b) quantities to be delivered;
- c) complete product designation;
- d) other requirements as agreed with the purchaser (e.g. low-temperature requirements).

5.2 Dangerous substances

Materials used in products shall not release any dangerous substances in excess of the maximum levels permitted in the relevant regulations of the state of destination.

5.3 Product requirements

5.3.1 Dimensions and tolerances on dimensions, form and position

Dimensions and tolerances on dimensions form and position shall be in accordance with the requirements given in [Clause 6](#).

For coated threaded studs, the tolerances shall apply before coating.

Studs shall be free of defects which can affect the application.

5.3.2 Coating

Unless otherwise specified, studs PS, US, IS, PT, UT, IT of property class 4.8 shall be supplied with electroplated copper coating (C1E).

5.3.3 Materials and mechanical characteristics

5.3.3.1 General

The materials listed in [Table 2](#) shall be used, under the provisions of [5.3.4](#).

The mechanical characteristics of the studs shall comply with the specifications in [Table 2](#).

Studs may consist of two different materials combined by friction welding (dual-material stud).

NOTE The welding part corresponds to the parent metal to avoid problems with dissimilar materials in fusion welding, the rest generally consists of high alloy steel for enhanced corrosion resistance.

5.3.3.2 Shear strength

Shear strength shall be checked by testing the minimum tensile strength of the studs.

Table 2 — Materials and mechanical characteristics of finished studs

Symbol	Material/ material group/ property class	Standard	Mechanical properties of the finished stud
FD MD PD RD UD ID	4.8	ISO 898-1 ^c	See ISO 898-1
	A2-50, A2-70, A4-50, A4-70, A5-50, A5-70	ISO 3506-1 ^c	See ISO 3506-1
ND	Mild steel, copper coated C2E	ISO 16120-2	$R_m < 450 \text{ N/mm}^2$
	Austenitic stainless steel	ISO 15510	$R_m < 700 \text{ N/mm}^2$
SD1	Material group 1 with the limits: C $\leq 0,2 \%$ ^a CEV $\leq 0,38^a$ Al $\geq 0,02 \%$ ^{a,b}	ISO/TR 15608	$R_m \geq 450 \text{ N/mm}^2$ $R_{eH} \geq 350 \text{ N/mm}^2$ $A_5 \geq 15 \%$
SD2	Material group 1 with the limits: C $\leq 0,2 \%$ ^a CEV $\leq 0,35^a$ Al $\geq 0,02 \%$ ^{a,b}		$R_m = 400 \text{ N/mm}^2$ to 550 N/mm^2 $R_{eH} \geq 235 \text{ N/mm}^2$ $R_{p0,2} \geq 235 \text{ N/mm}^2$ $A_5 \geq 20 \%$
SD3	X5CrNi18-10 X6CrNi18-12	ISO 15510	$R_m = 500 \text{ N/mm}^2$ to 780 N/mm^2 $R_{p0,2} \geq 350 \text{ N/mm}^2$ $A_5 \geq 25 \%$
PS US IS	4.8	ISO 898-1 ^c	See ISO 898-1
	A2-50, A2-70, A4-50, A4-70, A5-50, A5-70	ISO 3506-1 ^c	See ISO 3506-1
PT	4.8	ISO 898-1 ^c	See ISO 898-1
	A2-50, A2-70, A4-50, A4-70, A5-50, A5-70	ISO 3506-1 ^c	See ISO 3506-1
UT	Group 32	ISO/TR 15608	$R_m \geq 370 \text{ N/mm}^2$
	Group 21	ISO/TR 15608	$R_m \geq 100 \text{ N/mm}^2$
IT	Group 22.3	ISO/TR 15608	$R_m \geq 230 \text{ N/mm}^2$
^a Values from the ladle analysis. ^b If other elements for killing are used, they shall be reported in the inspection document. ^c Only weldable materials shall be used for studs.			

5.3.4 Weldability

Only weldable materials shall be used for studs.

Non-alloyed steel studs are weldable if the hardness increase is low. In general, this is the case when the carbon content is $\leq 0,20 \%$. Free-cutting steel studs are generally not weldable. Killed materials shall be used.

Austenitic stainless steel studs are generally weldable. Free-cutting stainless steel studs are generally not weldable.

5.4 Durability

The durability of studs is dependent on their use and the environmental exposure to which they are subject.

The mechanical durability of studs is ensured for a reasonable economic working life if the studs comply with the requirements of this document.

6 Dimensions of studs

6.1 General

Nominal dimensions are listed in [Tables 3 to 16](#). Other lengths of studs and threads may be used by agreement between contracting parties. Divergence in outline shape, finish or dimensions shall be permitted, provided the welding area complies with the specifications of the said tables.

The length after welding, l_2 , is a design value. By proper control of the welding, it is possible to keep variations in l_2 to within ± 1 mm. Under special conditions, for example, through-deck stud welding, l_2 may be constantly different from the nominal value.

The form of the central part of the stud tip comprised inside the diameter $d_1/3$ for stud types FD, UD, SD ($d_2/3$ for stud types MD, PD, RD, ID) shall be at the manufacturer's discretion. The tip shall be at the manufacturer's discretion in the case of flux in the form of a press-fitted aluminium ball (e.g. flattened in the centre with a diameter not exceeding $0,5 d_1$).

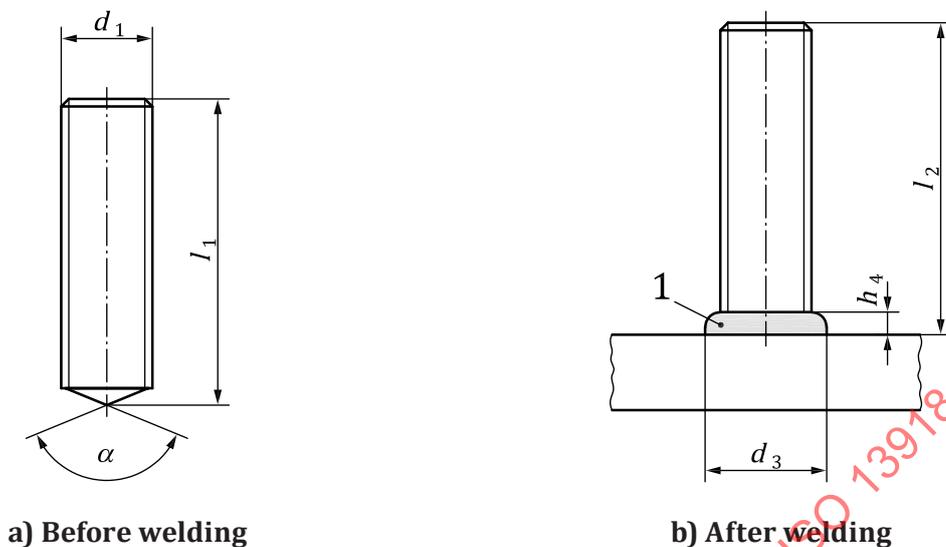
Run-in and run-out for threads is at the manufacturer's discretion.

The dimensions of stud collars shown in [Figures 1 to 8](#) and given in [Tables 3 to 7](#) and [9](#) and [10](#) are guidance values and may generally be achieved in welding position PA in accordance with ISO 6947. The weld collars shown in [Figures 1 to 8](#) are subject to variations regarding evenness and shape.

Details left unspecified shall be at the manufacturer's discretion. This shall apply to any modification of the shape of the stud outside the welding area, e.g. drillings and slots, provided the weldability is not affected.

As long as no tolerances are specified for special dimensions in this document, tolerances on dimensions, form and position shall be such as to comply with product grade A as specified in ISO 4759-1.

6.2 Fully-threaded stud (FD)



Key
1 weld collar

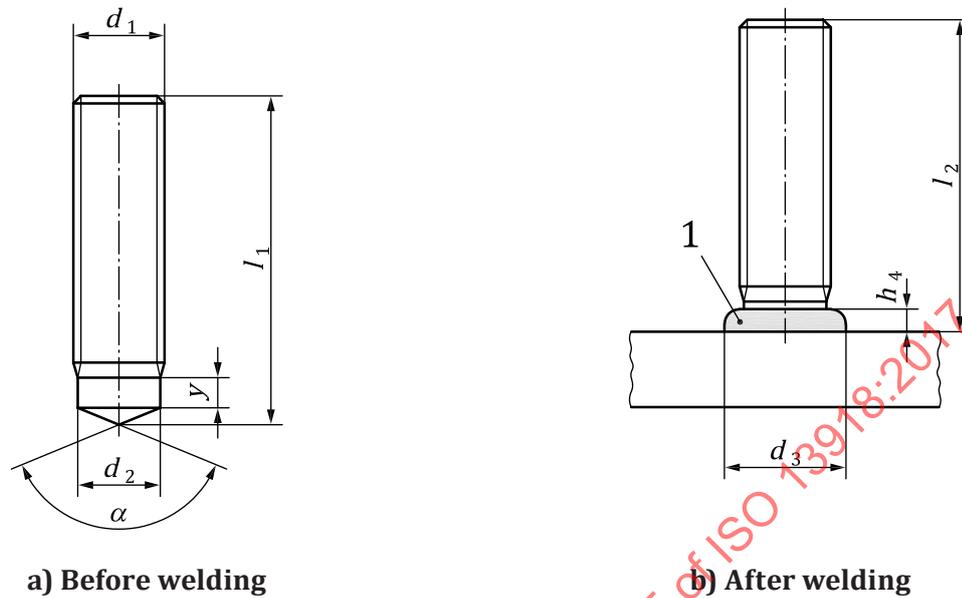
Figure 1 — Fully-threaded stud (FD)

Table 3 — Dimensions of fully-threaded studs (FD)

Dimensions in millimetres

d_1	M6	M8	M10	M12	M16	M20
d_3^b	8,5	11,0	13	16	21	26
h_4^b	4	4	4	5	7	7
$\alpha \pm 7^\circ$	140°					
$l_1 \pm 1^a$	$l_2 + 2,1$	$l_2 + 2,2$	$l_2 + 2,3$	$l_2 + 2,8$	$l_2 + 3,5$	$l_2 + 3,8$
l_2	15 - 100	15 - 100	15 - 100	25 - 100	30 - 100	40 - 100
^a Length l_1 applies to angle 140° only (without tolerance). ^b The given values are for guidance only.						

6.3 Virtually fully-threaded stud (MD)



Key

1 weld collar

Figure 2 — Virtually fully-threaded stud (MD)

Table 4 — Dimensions of virtually fully-threaded stud (MD)

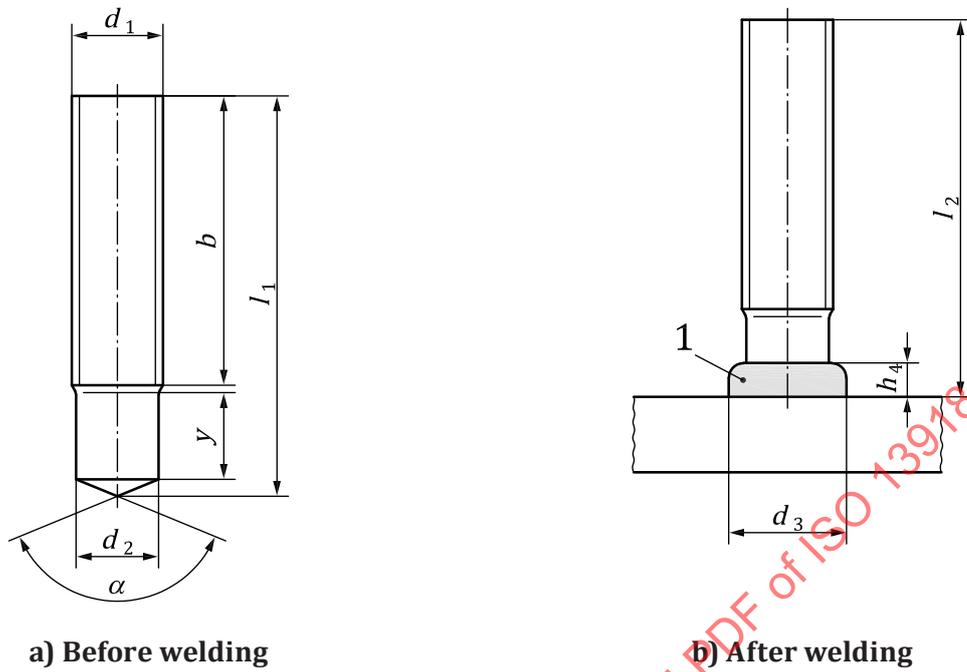
Dimensions in millimetres

d_1	M6	M8	M10	M12	M16
$d_2 \pm 0,1$	5,35	7,19	9,03	10,86	14,6
d_3^b	9,0	9,9	12,5	14,5	17,8
y	5,5	6	6,5	7,5	11
h_4^b	3,5	3,0	3,4	4,2	5,8
$\alpha \pm 7^\circ$	140				
$l_1 \pm 1^a$	$l_2 + 2,1$	$l_2 + 2,2$	$l_2 + 2,3$	$l_2 + 2,8$	$l_2 + 3,5$
l_2	15 - 100	15 - 100	15 - 100	20 - 100	25 - 100

^a Length l_1 applies to angle 140° only (without tolerance).

^b The given values are for guidance only.

6.4 Partially threaded stud (PD)



Key
1 weld collar

Figure 3 — Partially threaded stud (PD)

Table 5 — Dimensions of partially threaded studs (PD)

Dimensions in millimetres

d_1	M6	M8	M10	M12	M16	M20	M24							
$d_2 \pm 0,1$	5,35	7,19	9,03	10,86	14,6	18,38	22,05							
d_3^b	8,5	10	12,5	15,5	19,5	24,5	30							
h_4^b	3,5	3,5	4	4,5	6	7	10							
$\alpha \pm 7^\circ$	140°													
$l_1 \pm 1^a$	$l_2 + 2,1$		$l_2 + 2,2$		$l_2 + 2,3$		$l_2 + 2,8$		$l_2 + 3,5$		$l_2 + 3,8$		$l_2 + 4,5$	
l_2	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b
15	9	—	—	—	—	—	—	—	—	—	—	—	—	—
20	9	—	9	—	9,5	—	—	—	—	—	—	—	—	—
25	9	—	9	—	9,5	—	11,5	—	—	—	—	—	—	—
30	9	—	9	—	9,5	—	11,5	—	13,5	—	—	—	—	—
35	—	20	9	—	9,5	—	11,5	—	13,5	—	15,5	—	—	—
40	—	20	9	—	9,5	—	11,5	—	13,5	—	15,5	—	—	—
45	—	20	9	—	9,5	—	11,5	—	13,5	—	15,5	—	—	—
50	—	20	—	40	—	40	—	40	13,5	—	—	35	20	—
55	—	20	—	40	—	40	—	40	—	40	—	40	—	—
60	—	20	—	40	—	40	—	40	—	40	—	40	—	—
65	—	—	—	40	—	40	—	40	—	40	—	40	—	—

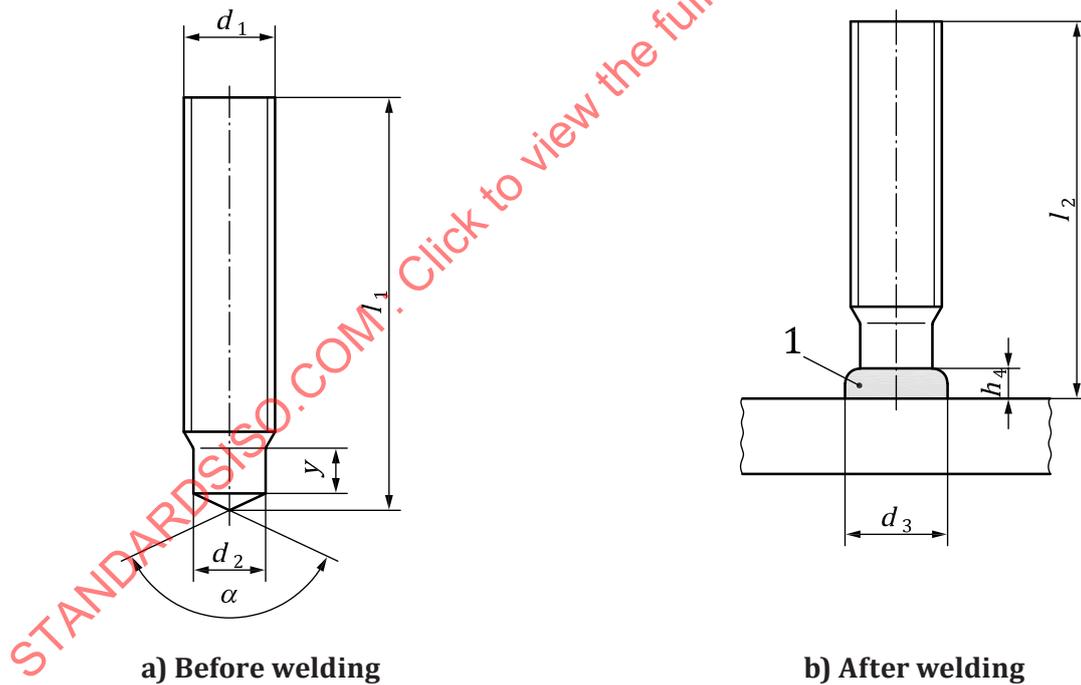
^a Length l_1 applies to angle 140° only (without tolerance).
^b The given values are for guidance only.

Table 5 (continued)

d_1	M6	M8	M10	M12	M16	M20	M24							
$d_2 \pm 0,1$	5,35	7,19	9,03	10,86	14,6	18,38	22,05							
d_3^b	8,5	10	12,5	15,5	19,5	24,5	30							
h_4^b	3,5	3,5	4	4,5	6	7	10							
$\alpha \pm 7^\circ$	140°													
$l_1 \pm 1^a$	$l_2 + 2,1$		$l_2 + 2,2$		$l_2 + 2,3$		$l_2 + 2,8$		$l_2 + 3,5$		$l_2 + 3,8$		$l_2 + 4,5$	
l_2	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b	$y + 2P$	b
70	—	—	—	40	—	40	—	40	—	50	—	50	—	50
80	—	—	—	40	—	40	—	40	—	50	—	50	—	50
100	—	—	—	40	—	40	—	40	—	80	—	70	—	70
140	—	—	—	40	—	80	—	80	—	80	—	70	—	70
150	—	—	—	40	—	80	—	80	—	80	—	70	—	100
160	—	—	—	—	—	80	—	80	—	80	—	70	—	100

^a Length l_1 applies to angle 140° only (without tolerance).
^b The given values are for guidance only.

6.5 Threaded stud with reduced shaft (RD)



Key

1 weld collar

Figure 4 — Threaded stud with reduced shaft (RD)

Table 6 — Dimensions of threaded studs with reduced shaft (RD)

Dimensions in millimetres

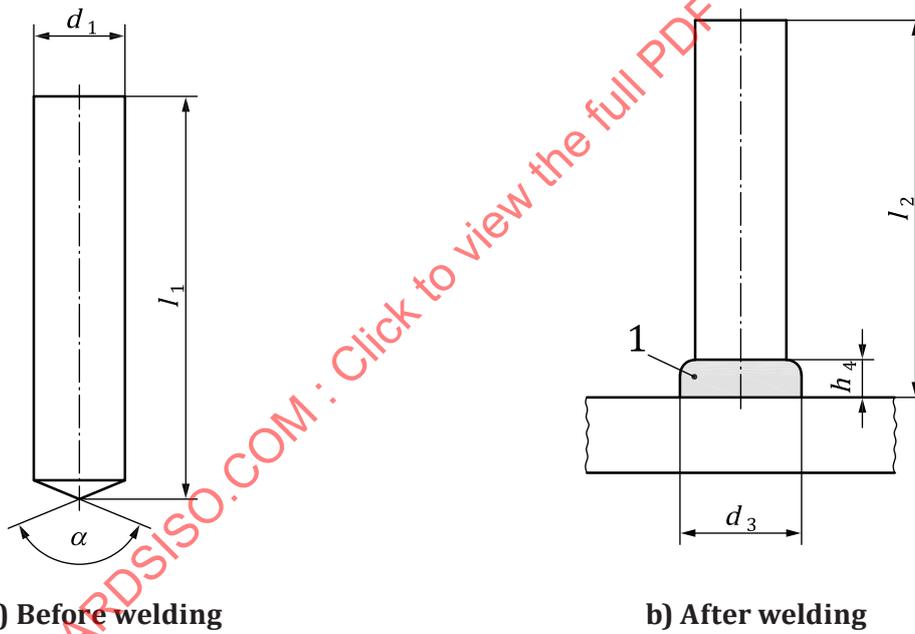
d_1	M6	M8	M10	M12	M16	M20	M24
$d_2 \pm 0,1$	4,7	6,2	7,9	9,5	13,2	16,5	20
d_3^c	7	9	11,5	13,5	18	23	28
h_4^c	2,5	2,5	3	4	5	6	7
$y + 2P$	4	4	5	6	7,5/11 ^a	9/13 ^a	12/15 ^a
$\alpha \pm 7^\circ$	140°						
$l_1 \pm 1^b$	$l_2 + 2,0$	$l_2 + 2,2$	$l_2 + 2,4$	$l_2 + 2,8$	$l_2 + 3,6$	$l_2 + 3,9$	$l_2 + 4,7$
l_2	15 - 100	15 - 100	15 - 100	20 - 100	25 - 100	30 - 100	40 - 100

^a The dimensions after the oblique stroke shall apply if ceramic ferrules, according to the values following the oblique stroke in [Table 17](#), are used.

^b Length l_1 applies to angle 140° only (without tolerance).

^c The given values are for guidance only.

6.6 Unthreaded stud (UD)



Key
 1 weld collar

Figure 5 — Unthreaded stud (UD)

Table 7 — Dimensions of unthreaded studs (UD) for $l_2 \geq 20$ mm

Dimensions in millimetres

$d_1 \pm 0,1$	6	8	10	12	14,6	16
d_3^b	8,5	11	13	16	18,5	21
h_4^b	4	4	4	5	6	7
$\alpha \pm 7^\circ$	140°					
$l_1 \pm 1^a$	$l_2 + 2,4$	$l_2 + 2,6$	$l_2 + 2,8$	$l_2 + 3,4$	$l_2 + 3,9$	$l_2 + 3,9$
^a Length l_1 applies to angle 140° only (without tolerance). ^b The given values are for guidance only.						

6.7 Insulation pin/nail (ND)

The shape of the ends are at the manufacturer's discretion. Chisel point to penetrate shop primer at the manufacturer's discretion. Weld area not defined.

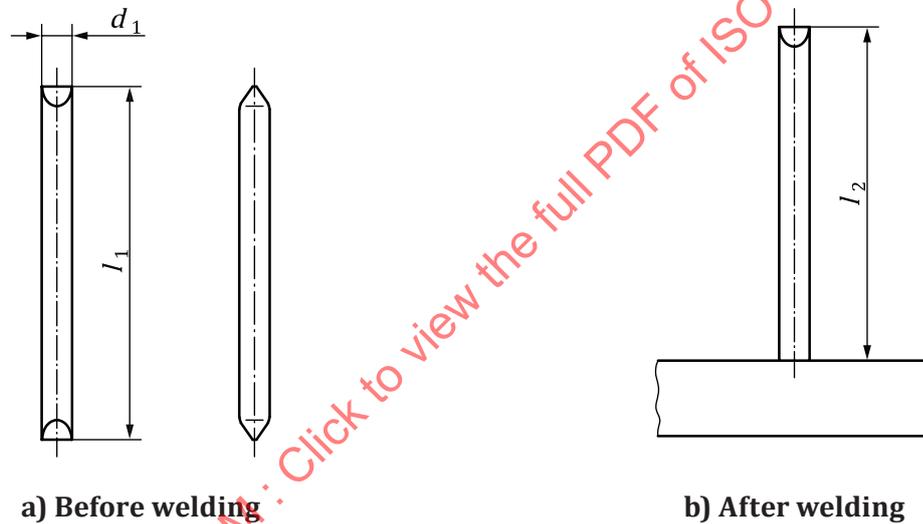


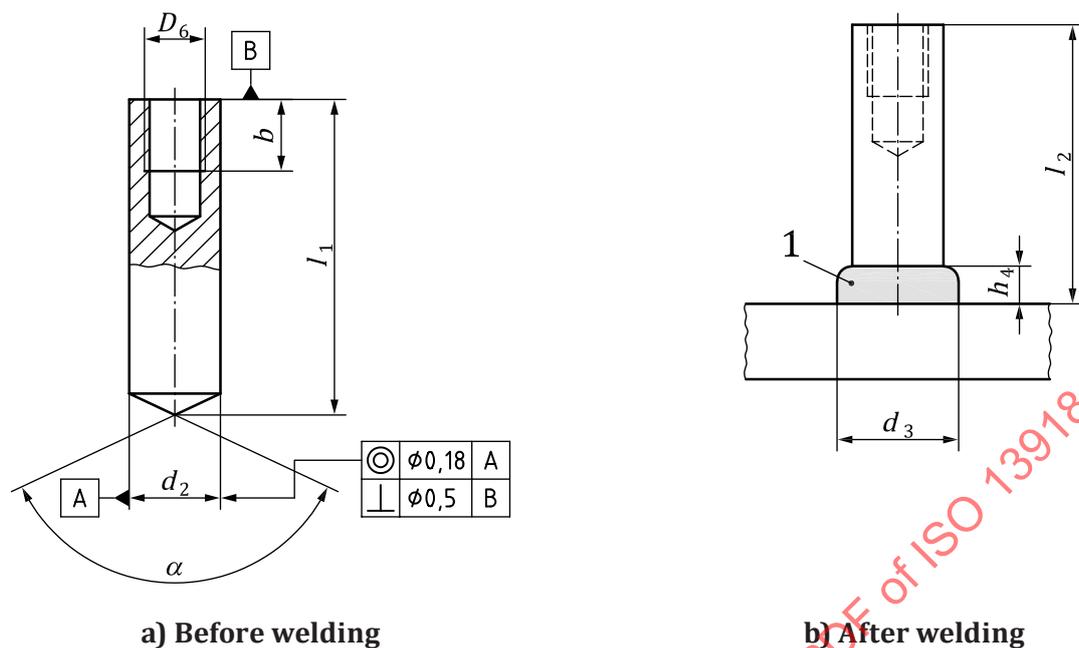
Figure 6 — Insulation pin/nail (ND)

Table 8 — Dimensions of insulation pin/nail (ND)

Dimensions in millimetres

$d_1 \pm 0,1$	3	4	5
$l_2 \pm 1$	25 - 300	25 - 500	25 - 500
l_1	$l_2 + 3$	$l_2 + 3$	$l_2 + 3$

6.8 Stud with internal thread (ID)



Key
1 weld collar

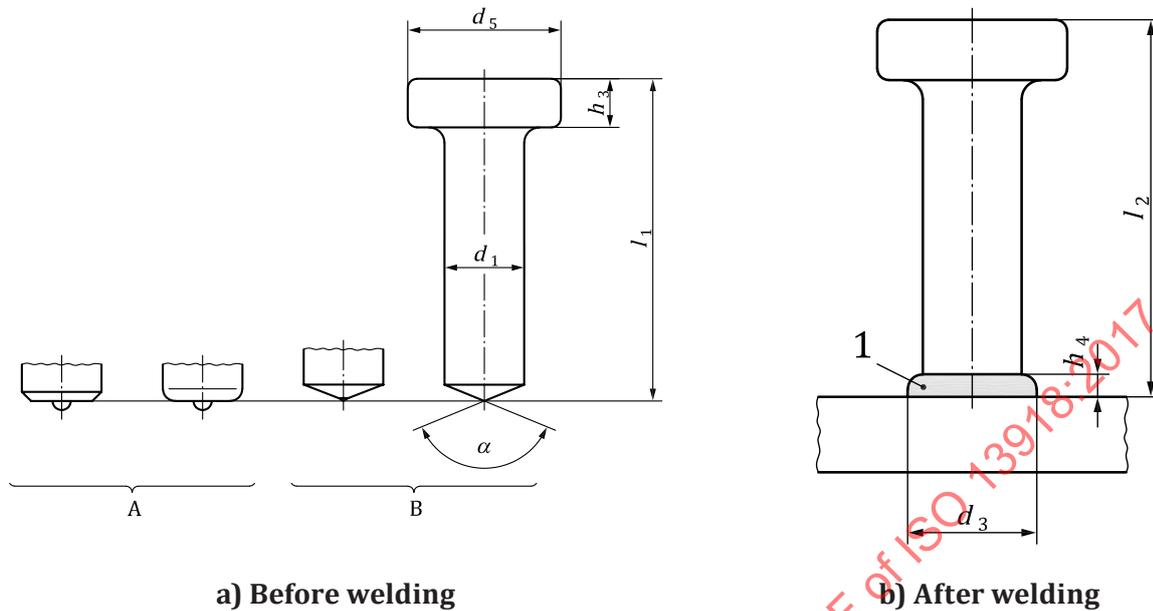
Figure 7 — Stud with internal thread (ID)

Table 9 — Dimensions of studs with internal thread (ID)

Dimensions in millimetres

D_6	M5	M6	M8	M8	M10	M10	M12
$d_2 \pm 0,1$	10	10	12	14,6	14,6	16	18,38
d_3^b	13	13	16	18,5	18,5	21	23
$b+2P$	7,5	9	12	15	15	15	18
h_4^b	4	4	5	6	6	7	7
$l_2 \text{ min}$	15	15	20	25	25	25	30
$\alpha \pm 7^\circ$	140°						
$l_1 \pm 1^a$	$l_2 \text{ min} + 2,3$	$l_2 \text{ min} + 2,3$	$l_2 \text{ min} + 2,8$	$l_2 \text{ min} + 3,5$	$l_2 \text{ min} + 3,5$	$l_2 \text{ min} + 3,5$	$l_2 \text{ min} + 3,7$
^a Length l_1 applies to angle 140° only (without tolerance). ^b The given values are for guidance only.							

6.9 Shear connector (SD)



Key

- 1 weld collar
- A shape A of tip (example)s
- B shape B of tip (example)

Figure 8 — Shear connector (SD)

Table 10 — Dimensions of shear connectors (SD) with l_2g

Dimensions in millimetres

$d_1 \pm 0,4^{a,e}$	9,5	10	12,7	13	16	19	22	25	25,4
$d_5 \pm 0,3^e$	19		25		32 ^d	32	35	40	41
$d_3^{c,f}$	13		17		21	23	29	31	
$h_3^{+1}_{-0,5}$	7		8		8	10	10	12	
$h_4^{c,f}$	2,5		3		4,5	6	6	7	
$\alpha \pm 7^\circ$	140°								
$l_1 \pm 1,5$	$l_2^{b,c} + 3$		$l_2^{b,c} + 3$		$l_2^{b,c} + 4$	$l_2^{b,c} + 4,5$	$l_2^{b,c} + 5$	$l_2^{b,c} + 5,5$	

a Excess diameter or production impressions in the shaft area below the head are permitted up to 0,5 mm, provided they do not affect proper plunge.

b Tolerance on l_2 is $+1,5_{-2}$ mm.

c For special conditions, e.g. through-deck stud welding, the dimensions and the tolerances are not applicable.

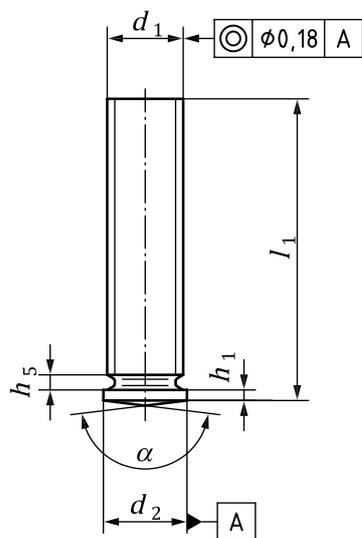
d May be reduced to 29 mm for shear application.

e Use of the optional dimension depends on national regulations.

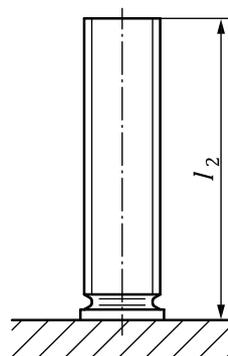
f The given values are for guidance only.

g The minimum of l_2 is approximately three times d_1 .

6.10 Threaded stud with flange (PS)



a) Before welding



b) After welding

NOTE l_2 (length after welding) depends on l_1 and the weld energy.

Figure 9 — Threaded stud with flange (PS)

Table 11 — Dimensions of threaded studs with flange (PS)

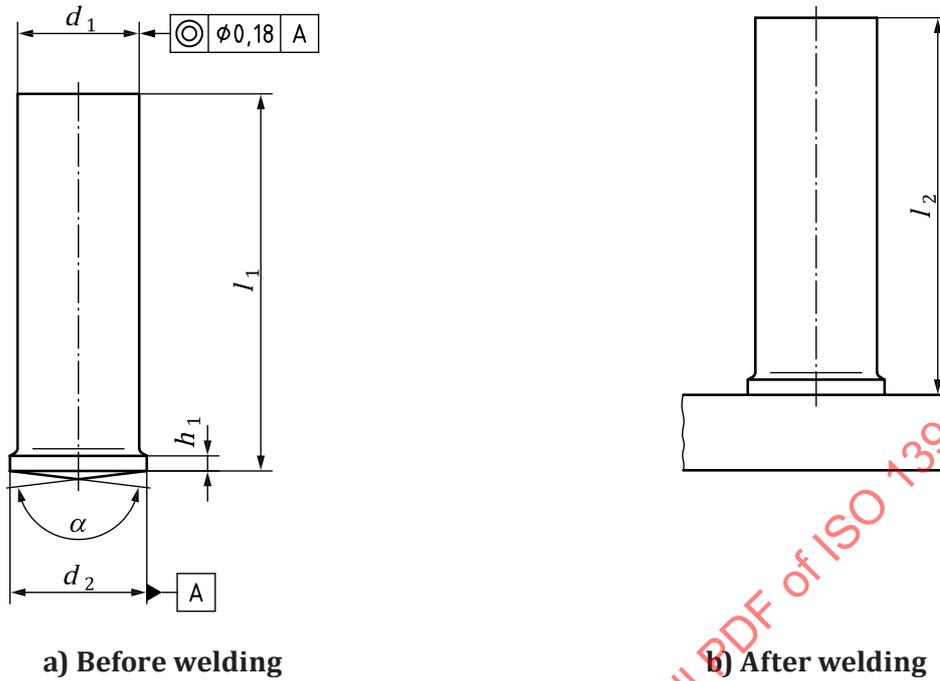
Dimensions in millimetres

d_1^a	$l_1+0,6$	$d_2 \pm 0,2$	max. h_5	h_1	$\alpha \pm 2^{\circ b}$
M3	6	4	0,6		166°
	8				
	10				
	12				
	16				
M4	20	5		0,7 to 1,4	166°
	8				
	10				
	12				
	16				
M5	10	6	1,0		166°
M6	12	7			
	16				
	20				
	25				
M8	30	9	1,5	0,8 to 1,4	166°
	12				
	16				
	20				
	25				
M10	35	11	2,0		166°
	40				
	16				
	20				
	25				
	30				166°
	35				
	40				
	40				

^a Other types of thread are subject to agreement.

^b For applications using sheet thicknesses ≥ 2 mm and welding times >60 ms, the angle, α , may be reduced up to 152°.

6.11 Unthreaded stud (US)



NOTE l_2 (length after welding) depends on l_1 and the weld energy.

Figure 10 — Unthreaded stud (US)

Table 12 — Dimensions of unthreaded studs (US)

Dimensions in millimetres

$d_1 \pm 0,1$	$l_{1min} + 0,6$	$d_2 \pm 0,2$	h_1	$\alpha \pm 2^\circ$ ^a
3	8	4	0,7 to 1,4	166°
4		5		
5		6		
6	12	7		
7,1	15	9	0,8 to 1,4	
8				

^a For applications using sheet thicknesses ≥ 2 mm and welding times > 60 ms, the angle, α , may be reduced up to 152°.

6.12 Stud with internal thread (IS)

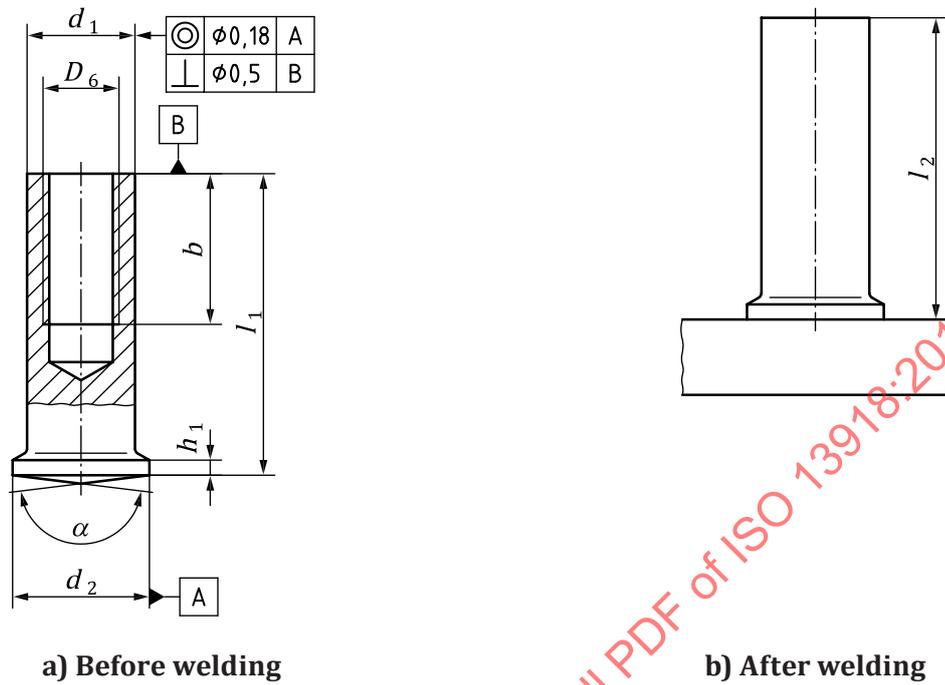


Figure 11 — Stud with internal thread (IS)

l_2 (length after welding) depends on l_1 and the weld energy. The depth of the hole shall be at the discretion of the manufacturer.

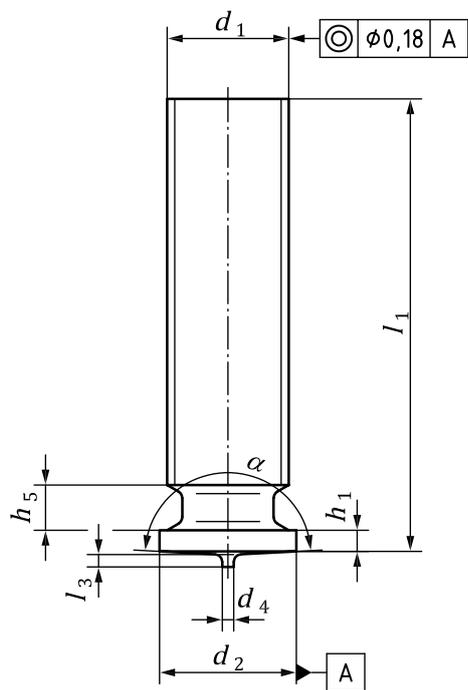
Table 13 — Dimensions of studs with internal thread (IS)

Dimensions in millimetres

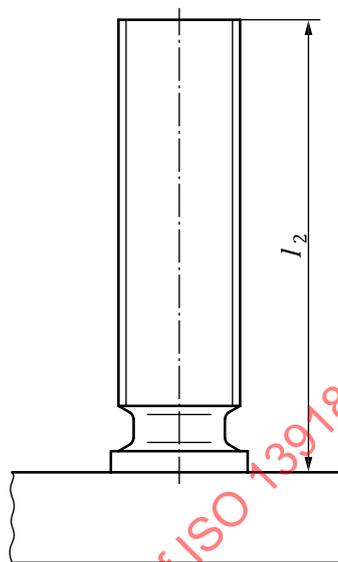
D_6	$l_{1min} + 0,6$	$b_{min} + 2P$	$d_2 \pm 0,2$	$d_1 \pm 0,1$	h_1	$\alpha \pm 2^{\circ a}$
M3	10	5	6,0	5,0	0,7 to 1,4	166°
M4		6	7,0	6,0		
M5			9,0	7,1	0,8 to 1,4	
M5	7,5	8,0				
M6	9					

^a For applications using sheet thicknesses ≥ 2 mm and welding times >60 ms, the angle, α , may be reduced up to 152°.

6.13 Threaded stud (PT)



a) Before welding



$$l_2 \approx l_1 - 0,3 \text{ mm}$$

b) After welding

Figure 12 — Threaded stud (PT)

Table 14 — Dimensions of threaded studs (PT)

Dimensions in millimetres

d_1	$l_1+0,6$	$d_2 \pm 0,2$	$d_4 \pm 0,08$	$l_3 \pm 0,05$	max. h_5	h_1	$\alpha \pm 2^\circ$
M3	6	4,5	0,60	0,55	0,6	0,7 to 1,4	174°
	8						
	10						
	12						
	16						
20							
M4	8	5,5	0,65	0,80	1,0	0,7 to 1,4	
	10						
	12						
	16						
	20						
25							
M5	10	6,5	0,75	0,85	1,5	0,8 to 1,4	
	12						
M6	16	7,5					
	20						
	25						
M8	30	9					
	12						
	16						
	20						
	25						
	30						

6.14 Unthreaded stud (UT)

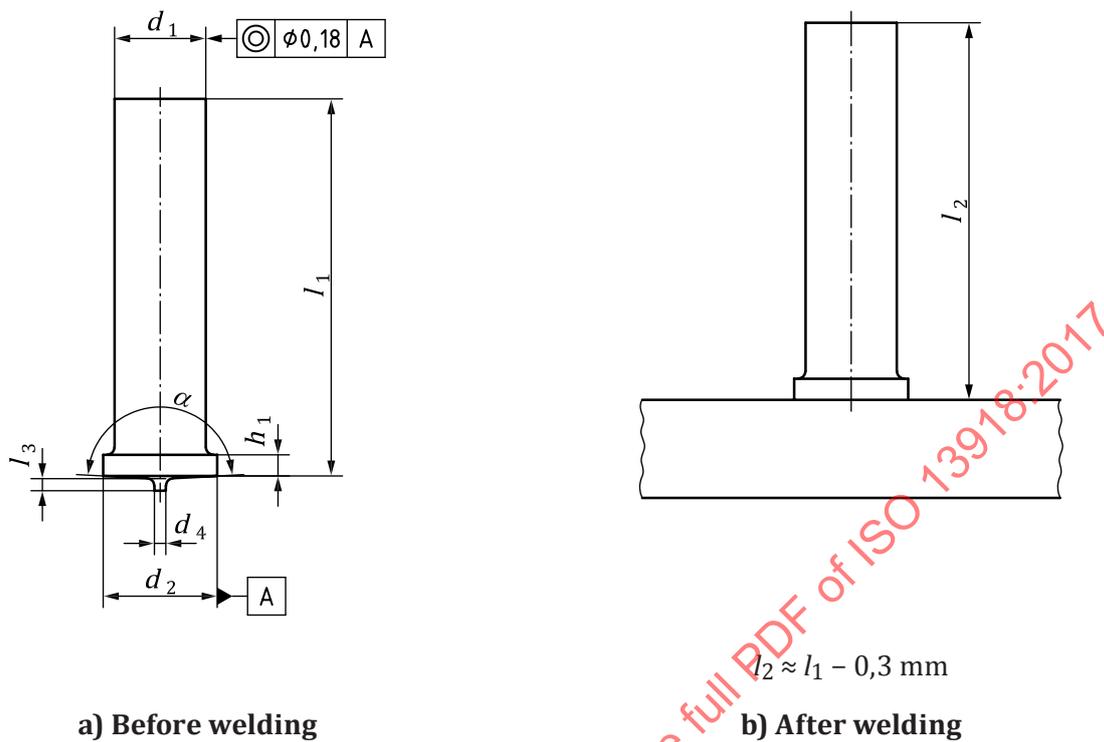


Figure 13 — Unthreaded stud (UT)

Table 15 — Dimensions of unthreaded studs (UT)

Dimensions in millimetres

$d_1 \pm 0,1$	$l_{1\text{min}} + 0,6$	$d_2 \pm 0,2$	$d_4 \pm 0,08$	$l_3 \pm 0,05$	h_1	$\alpha \pm 2^\circ$
3	8	4,5	0,60	0,55	0,7 to 1,4	174°
4		5,5	0,65			
5	12	6,5	0,75	0,80		
6		7,5				
7,1	15	9		0,85	0,8 to 1,4	