

ANSI/AWS C5.4-93
An American National Standard

Recommended Practices for Stud Welding



American Welding Society

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Recommended Practices for Stud Welding

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Prepared by the
American Welding Society (AWS) C5 Committee on Arc Welding and Cutting

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

These recommended practices for stud welding, prepared by the Subcommittee on Stud Welding of the AWS Committee on Arc Welding and Cutting, are intended to serve as a basic guide for those interested in attaching fasteners by arc and capacitor discharge stud welding.

The variations of the process, stud design, equipment, welding procedures, quality control, and safety precautions are discussed. The information presented will guide the designer and the shop in the utilization of studs in many fields including automotive manufacture, boiler and building construction, farm and industrial equipment, railroads and shipbuilding, aircraft and aerospace, metal furniture, and other metal working industries.



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Foreword

This foreword is not part of ANSI/AWS C5.4-93, *Recommended Practices for Stud Welding*, but is included for informational purposes only.

These recommended practices for stud welding are intended to serve as a basic guide for those interested in attaching fasteners by arc stud welding, including capacitor discharge methods.

Arc stud welding is an alternative method to other welding processes, as well as drilling and tapping through bolting, etc., and provides a one-sided method of attachment. The present document further expands the document published in 1984.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS C5 Committee on Arc Welding and Cutting, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Errata

ANSI/AWS C5.4-93, *Recommended Practices for Stud Welding*

The following Errata have been identified and incorporated into the current reprint of this document.

Page 3, Paragraph 1.2.1, change from “currency” to “current” in third sentence.

Page 19, Table 8, last entry under Stud Base Diameter in inches, change “01.000” to “1.000”.

Page 23, Table 10, under Shielding Gas Flow heading, “litre/min.” should read “liter/min.”.

Page 23, Table 10, under Shielding Gas Flow, CFH heading, change “1” to “15”.

Page 23, Table 10, under Shielding Gas Flow, liter/min. heading, change “57.1” to “7.1”.

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Table of Contents

	Page No.
<i>Personnel</i>	v
<i>Foreword</i>	vii
<i>List of Tables</i>	xi
<i>List of Figures</i>	xi
1. Process Description	1
1.1 Arc Stud Welding	1
1.2 Capacitor Discharge Stud Welding	3
2. Selection of Method	4
2.1 Fastener Size	5
2.2 Base Metal Thickness	5
2.3 Base Metal Composition	5
2.4 Capacitor Discharge (CD) Method	5
3. Designing for Stud Welding	6
3.1 Base Metal	6
3.2 Stud Design Ratio	7
4. Considerations for Stud Selection	7
4.1 Arc Stud Welding	7
4.2 Capacitor Discharge Studs	11
4.3 Stud Tensile and Torque Strengths	12
5. Equipment for Stud Welding	12
5.1 Arc Stud Welding Equipment	12
5.2 Capacitor Discharge Stud Welding Equipment	17
5.3 Automatic Feed Systems	17
6. Stud Welding Low Carbon and Austenitic Stainless Steels	17
6.1 Base Metal Preparation	17
6.2 Welding Requirements	18
6.3 Welding Technique for Steels	18
7. Stud Welding Aluminum Alloys	20
7.1 Base Metal Preparation	20
7.2 Shielding Gas	20
7.3 Welding Requirements	20
7.4 Welding Technique for Aluminum	20
8. Stud Locating Techniques	23
8.1 Locating with Templates	23
8.2 Locating with Spacers	23
8.3 Fixed Guns	24
8.4 Methods of Ensuring Perpendicularity	24
8.5 Special Accessories	28
9. Quality Control and Inspection	28
9.1 Steel Studs	28
9.2 Aluminum Studs	30

	Page No.
10. Method of Manufacture	31
10.1 Cold Welds	31
10.2 Hot Welds	31
10.3 Stud Hang-Up	31
11. Safety Precautions	32
11.1 General	32
11.2 Electrical	32
11.3 Fire Protection	32
11.4 Vision Protection	32
11.5 Hearing Protection	32
11.6 Protective Clothing	32
11.7 Ventilation	33
11.8 Other	33
11.9 Maintenance	33
11.10 References	33
Annex A (Informative)—Commonly Used Metric Conversions	35
List of AWS Documents on Arc Welding and Cutting	37

List of Tables

Table		Page No.
1	Stud Welding Method Selection Chart	5
2	Typical Combinations of Base and Stud Metals for Stud Welding.....	6
3	Recommended Minimum Base Metal Thickness of Steel and Aluminum for Arc Stud Welding	8
4	Typical Length Reductions of Studs in Arc Stud Welding	9
5	Weld Flash Clearance for Arc Welded Full Base Studs.....	12
6	Standard Arc Welding Studs — Tensile/Torque Strengths.....	14
7	Approximate Tensile and Torque Strengths of Capacitor Discharge Welded Studs.....	15
8	Typical Stud Welding Conditions for Joining Low Carbon and Stainless Steel Studs to Similar Base Metals	19
9	Comparable Rectangular and Round Studs	21
10	Typical Welding Conditions for Arc Stud Welding of Aluminum Alloys.....	23
11	Minimum Required Torque Values and Tension Loads for Arc Stud Welding	31

List of Figures

Figure		Page No.
1A	Equipment Setup for Arc Stud Welding of Steel.....	2
1B	Power-Control Type Power Source Setup for Arc Stud Welding of Steel.....	2
2	Steps in Arc Stud Welding.....	3
3	Steps in Contact Capacitor Discharge Stud Welding.....	4
4	Steps in Gap Capacitor Discharge Stud Welding.....	4
5	Steps in Drawn-Arc Capacitor Discharge Stud Welding.....	4
6	Commonly Used Studs and Fastening Devices for Arc Stud Welding.....	8
7	Typical Stud Welds with Shrink Fissures in the Upper Portion of the Weld Flash	10
8	Stud Flash May be Accommodated by Use of Oversized Clearance Holes, Use of Gasket Material, and Use of a Dog or Hold-Down Clip.....	12
9	Commonly Used Studs for Capacitor Discharge Stud Welding	13
10	Oscillograph Traces of Current and Voltages in Arc Stud Welding	15
11	Arc Stud Welding Capacity for DC Power Sources	16
12	Effect of Cable Size and Length on Available Welding Current from a 2000A Power Source.....	17
13	Portable Arc Stud Welding Equipment.....	18
14	Recommended Orientation for Welding Rectangular Studs to a Vertical Surface	19
15	Satisfactory and Unsatisfactory Arc Stud Welds	20
16	Arc Stud Weld with Proper Flash Indicative of a Good Weld	21
17	Examples of Satisfactory and Unsatisfactory Capacitor Discharge Stud Welds	22
18	Equipment Setup for Arc Stud Welding of Aluminum.....	22
19	Simple Template Used to Locate Studs Within $\pm 1/32$ in. (0.8 mm).....	24
20	Simple Template for Capacitor Discharge Welds	24
21	Template with Hardened and Ground Bushing and Welding Gun Adaptor	24
22	Locating with Spacer	25
23	Locating from Adjacent Studs	25
24	Locating from Nearby Surface and Previous Stud.....	25

Figure	Page No.
25 Mounting Gun in a Fixed Position.....	25
26 Bipod Foot Plate Assembly for 1/2 in. (12.7 mm) Diameter and Smaller Studs.....	25
27 Bipod Foot for 1/2 in. (12.7 mm) Diameter and Larger Shear Connector Studs.....	25
28 Bipods for Unusual Surface Contours	26
29 Typical Ferrule Tube Extension Application	27
30 Typical Offset Assembly	27
31 Ferrule Foot Plate.....	27
32 Typical Extension Assembly.....	28
33 Stud Hang-Up	28
34 Cold Weld	29
35 Hot Weld	29
36 Bend Test of Welded Studs to Determine Acceptable Welding Procedures.....	30
37 Method of Applying a Tensile Load to a Welded Stud Using Torque — a Bolt Can Be Used for an Internal Thread	30

Recommended Practices for Stud Welding

1. Process Description

Stud welding is a general term for joining a metal stud or similar part to a workpiece.¹ Welding can be done by a number of welding processes including arc, resistance, friction, and percussion. The arc stud welding process (SW), including capacitor discharge methods, will be covered in this document.

In arc stud welding, the base (end) of the stud is joined to the other work part by heating them with an arc drawn between the two. When the surfaces to be joined are properly heated, they are brought together under pressure. Stud welding guns are used to hold the studs and move them in proper sequence during welding. There are two basic power supplies used to create the arc for welding studs. One type uses dc power sources similar to those used for shielded metal arc welding. The other type uses a capacitor storage bank to supply the arc power.

The arc stud welding processes using these power sources are commonly known as *arc stud welding* and *capacitor discharge stud welding* respectively.

1.1 Arc Stud Welding. The arc stud welding process involves the same basic principles as any other arc welding process. Application of the process consists of two steps:

- (1) Welding heat is developed with an arc between the stud and the plate (work).
- (2) The two pieces are brought into intimate contact when the proper temperature is reached.

The equipment consists of the stud gun, a control unit (timing device), studs and ferrules, and an available

source of dc welding current. Typical arc stud welding equipment connections are shown in Figures 1A and 1B. The mechanics of the process are illustrated in Figure 2. The stud is loaded into the chuck, the ferrule (also known as an *arc shield*) is placed in position over the end of the stud, and the gun is properly positioned for welding, Figure 2(A). The trigger is then depressed, starting the automatic welding cycle.

A solenoid coil within the body of the gun is energized. This lifts the stud off the work and, at the same time, creates an arc, Figure 2(B). The end of the stud and part of the workpiece are melted by the arc. When the preset arc period is completed, the welding current is automatically shut off and the solenoid de-energized by the control unit. The mainspring of the gun plunges the stud into the molten pool on the work to complete the weld, Figure 2(C). The gun is then lifted from the stud and the ferrule is broken off, Figure 2(D).

The time required to complete a weld varies with the cross-sectional area of the stud. For example, weld time typically would be about 0.13 seconds for a 10 gage (0.134 in. [2.6 mm]) stud, and 0.92 seconds for a 7/8 in. (22 mm) diameter stud. Application rates vary with the size of the stud and other factors such as working conditions. An average rate is approximately six studs per minute, although a rate of fifteen studs per minute is common in many applications.

The equipment involved in stud welding compares with that of manual shielded metal arc welding with regard to portability and ease of operation. The initial cost of such equipment varies with the size of the studs to be welded.

The gun and the control unit are connected to a dc power source. The control unit connections shown in Figure 1 are for power sources designed for secondary interruption, as is the case with motor-generator sets, battery units, and

¹ Stud welding is also discussed in the *Welding Handbook*, Vol. 2, 8th Ed., American Welding Society, 1991.

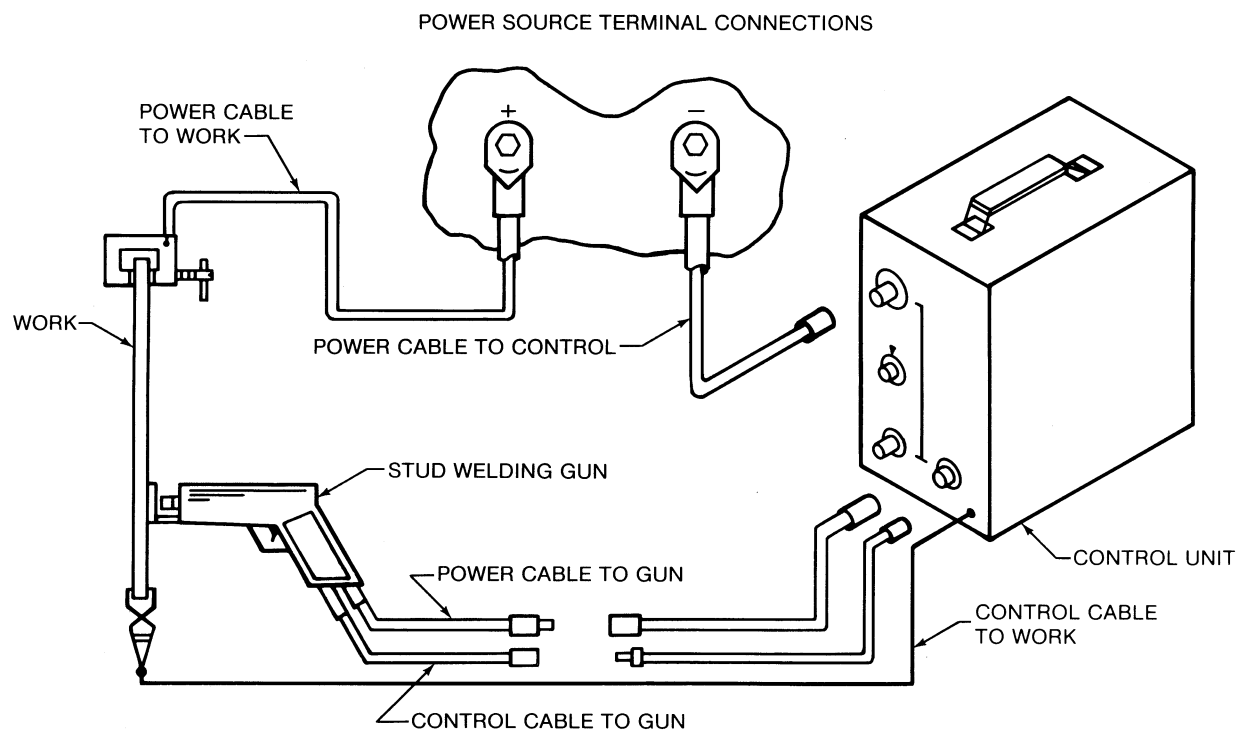


Figure 1A — Equipment Setup for Arc Stud Welding of Steel

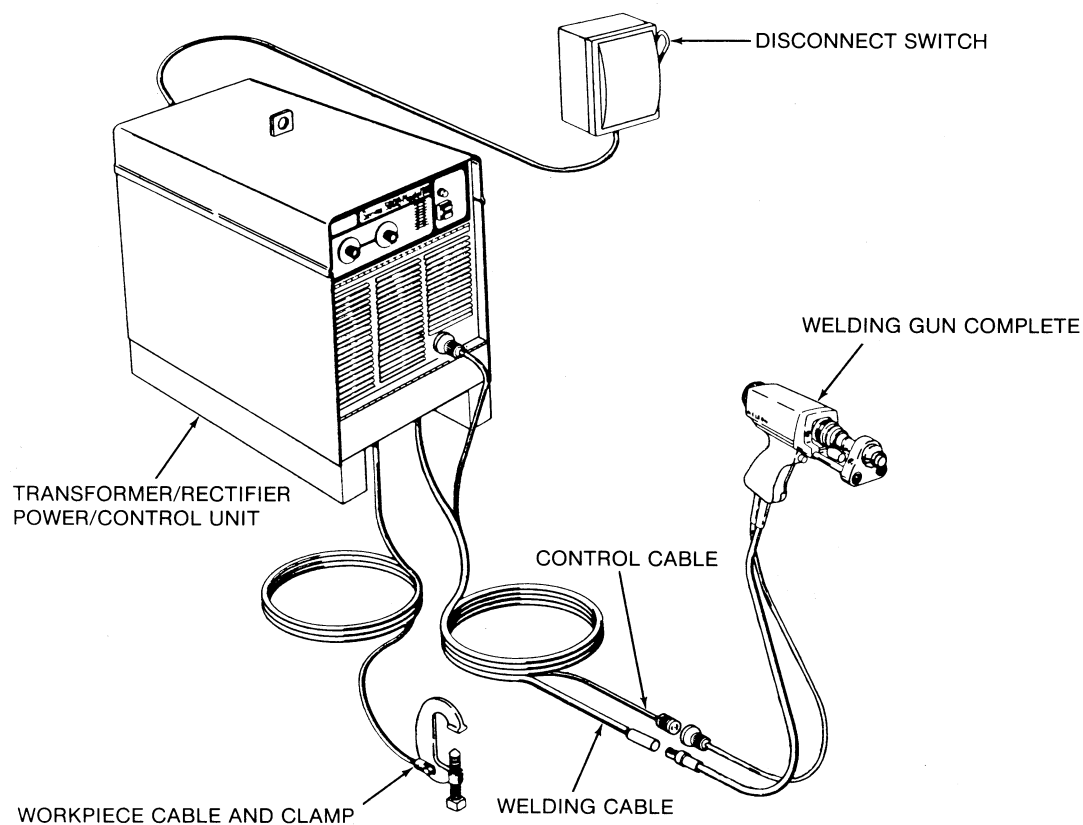
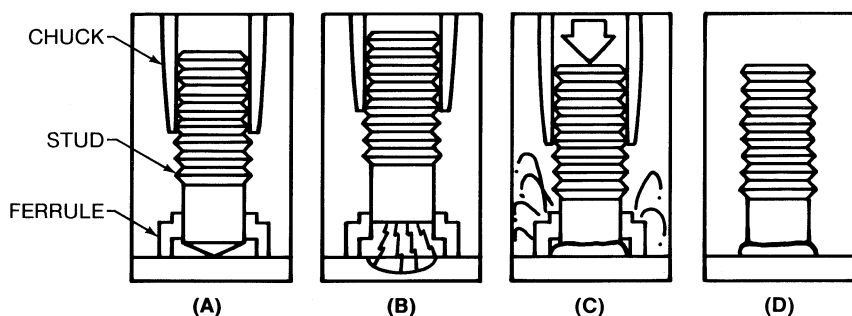


Figure 1B — Power-Control Type Power Source Setup for Arc Stud Welding of Steel



- (A) Gun is properly positioned.
 (B) Trigger is depressed and stud is lifted, creating an arc.
 (C) Arcing period is completed, and stud is plunged into the molten pool of metal on the base metal.
 (D) Gun is withdrawn from the welded stud, and ferrule is removed.

Figure 2 — Steps in Arc Welding

most rectifier-type welding machines. Figure 1A shows connection for an integrated power-control-type power source.

Arc stud welding is used to best advantage when the base metal is heavy enough to support the full strength of the welded stud, but it is often used with lighter gage metals.

1.2 Capacitor Discharge Stud Welding. Capacitor discharge methods of the arc stud welding process use dc power produced by a rapid discharge of stored electrical energy with pressure applied during or immediately following the electrical discharge. The method uses an electrostatic storage system as a power source in which the weld energy is stored in capacitors of high capacitance. No ferrule or fluxing is required. There are two basic pieces of equipment with associated cables: (1) the control-power unit, and (2) the stud gun.

There are three types of capacitor discharge stud welding: contact, gap, and drawn-arc. They differ primarily in the manner of arc initiation. Initial contact and initial gap capacitor discharge stud welding utilize studs having a small, specially designed projection (tip) on the weld end of the stud. Drawn-arc capacitor discharge stud welding creates a pilot arc as the stud is lifted off the workpiece by the stud gun. It is similar to arc stud welding.

1.2.1 Contact Method. With the contact method, the stud is first placed against the work as shown in Figure 3(A). The stored energy is then discharged through a projection on the base of the stud. The small projection presents a high resistance to the stored energy, and it rapidly disintegrates from the high current density. This creates an arc that melts the two surfaces to be joined, Figure 3(B). During arcing, Figure 3(C), the pieces to be joined are being brought together by action of a spring, weight, or an air cylinder. When the two surfaces come in contact, fusion takes place, and a weld is produced between the stud and the workpiece, Figure 3(D).

1.2.2 Gap Method. The sequence of events in the gap method is shown in Figure 4. Initially, the stud is positioned off the work, leaving a gap between it and the work, as shown in Figure 4(A). The stud is released and continuously moves toward the work under gravity, air pressure, or spring loading. At the same time, open-circuit voltage is applied between the stud and the work. When the stud contacts the work, Figure 4(B), high current flashes off the tip and initiates an arc. The arc melts the surface of the stud and work as the stud continues to move forward, Figure 4(C). Finally, the stud plunges into the work, and the weld is completed, Figure 4(D).

With proper design of the electrical characteristics of the circuit and size of the projection, it is possible to produce a high current arc of such short duration, about 6 milliseconds (ms), that its effect upon the stud and workpiece is purely superficial. A surface layer only a few thousandths of an inch in thickness on each surface reaches the molten state yet produces a strong welding joint.

1.2.3 Drawn-Arc Method. In the drawn-arc capacitor discharge method, arc initiation is accomplished in a manner similar to that of arc stud welding. The stud does not require a small tip on the weld face. An electronic control is used to sequence the operation. Weld time is controlled by an electronic circuit in the unit. The welding gun is similar to that used for arc stud welding. The operation is shown in Figure 5. In sequence, the stud is positioned against the work as shown in Figure 5(A). The trigger switch on the stud welding gun is actuated, energizing the welding circuit and a solenoid coil in the gun body. The coil motion lifts the stud from the work, Figure 5(B), drawing a low-amperage pilot arc between them. When the lifting coil is de-energized, the stud starts to return to the work. The welding capacitors are then discharged across the arc. The high amperage from the capacitors melts the end of the stud and the adjacent work