

AWS C5.7:2000 (R2006)
An American National Standard

Recommended Practices for Electrogas Welding



American Welding Society



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An American National Standard

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Recommended Practices for Electrogas Welding

Supersedes ANSI/AWS C5.7-89

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

Electrogas Welding (EGW) is a specialized welding process having similarities to the gas metal arc welding (GMAW) or the flux cored arc welding (FCAW) processes for vertical position welding. The electrode deposits filler metal in the cavity formed by backing plates or shoes that bridge the groove between the plates being welded. The electrode may be solid, metal cored, or flux cored, and additional shielding may or may not be obtained from an externally supplied gas or gas mixture. The weld is usually completed in a single pass.

Fundamentals of the process, including the various methods of welding, are presented. A discussion of equipment, consumables, applications, and metallurgical advantages and limitations is provided. The selection of process variables and operating conditions and typical EGW procedures is then presented. Inspection of welds, and training and qualification of welding procedures and operators are described. Finally, a troubleshooting guide, safety considerations, and a supplementary reading list are presented.



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550 N.W. LeJeune Road, Miami, FL 33126



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Foreword

This foreword is not part of [AWS C5.7:2000 \(R2006\)](#), *Recommended Practices for Electrogas Welding*, but is included for informational purposes only.

Electrogas welding (EGW) was introduced as a practical fabricating process in 1961. In recent years, advances have been made so that electrogas welding is now accepted as an efficient and practical method in some metal joining applications. EGW applications should continue to expand as fabricators become more familiar with the fundamentals, techniques, and advantages of this welding process. The increased usage and interest in EGW prompted the American Welding Society to sponsor this *Recommended Practices for Electrogas Welding*.

Sufficient data have been gathered and organized to yield an authoritative source of sound technical practices for electrogas welding. Accordingly, the AWS C5 Committee on Arc Welding and Cutting has prepared these recommended practices as compiled by the Subcommittee on Electrogas Welding. These recommended practices are based on a survey of electrogas welding as used in the metal fabricating and construction industry.

The description of electrogas welding and its features is presented here as clearly and concisely as possible. The Committee has developed these guidelines in the hope that they will lead to further development of the electrogas welding process and thus, to higher quality and performance standards.

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.

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Recommended Practices for Electrogas Welding

1. General

1.1 Scope. This document provides recommended practices for electrogas welding low carbon pressure vessel, and structural steels. Aluminum and stainless steel are excluded because of a lack of general commercial use of electrogas welding for these materials. This standard makes use of the U.S. Customary Units. Approximate mathematical equivalents in the International System of Units (SI) are provided for comparison in parentheses () or in appropriate columns in tables and figures.

Safety and health issues and concerns are beyond the scope of this standard and, therefore, are not fully addressed herein. Some safety and health information can be found in Section 14. Safety and health information is available from other sources, including, but not limited to, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, and applicable federal and state regulations.

1.2 Introduction. Electroslag welding (ESW) was the first single-pass vertical welding process made commercially available. Immediately after its successful implementation, there was a demand for equipment that would enable similar techniques to be applied to workpieces with thinner sections than is generally possible with ESW. Until ESW became available in 1961,¹ almost all vertical joints were welded with the manual shielded metal arc or semiautomatic gas metal arc welding process. Laboratory evaluation using a flux cored electrode with auxiliary gas shielding and an adaptation of an electroslag machine determined that a plate as thin as 1/2 in. (13 mm) could be welded in the vertical position at high speeds by the single-pass electrogas technique. Electro-gas welding (EGW) has enjoyed steady growth in the United States in recent years. This growth has occurred, not only because the process has inherent out-of-position capability, but also due to its high deposition rate, high

efficiency, weld metal soundness, simple joint preparation, and other advantages.

Some of the advantages associated with EGW result in considerable cost savings, particularly in joining thicker materials. Savings have been achieved when joint members can be joined in the vertical position and where thick base metal can be joined with a continuous vertical weld. EGW is often less expensive than the more conventional joining methods such as submerged arc welding (SAW) and flux cored arc welding (FCAW) in thicker base metals or flat position welding by submerged arc welding (SAW) with the prohibitive associated material handling. Even in some applications involving thinner base metals, EGW has resulted in cost savings because of its efficiency, simple joint preparation, etc.

There are two primary variations of the EGW process commonly used in the United States. In the first method, a solid electrode is fed into the joint. When using a solid electrode, external shielding gas is required. In the second method, a flux cored or metal cored electrode is used. When using flux cored electrodes, both the externally gas shielded types, and self-shielded types are available. These methods of EGW for plain carbon, structural, and pressure vessel quality steels will be discussed in more detail later in these recommended practices. Although EGW has been used to join aluminum and some grades of stainless steels, those applications are not discussed in this document.

2. Referenced Standards

The following standards have been cited in this document:

ABS Rules for Building and Classing Steel Vessels

Available through: American Bureau of Shipping
16855 Northcase Drive
Houston, TX 77060

¹ See Supplementary Reading List, Annex B, item number 8.

[API 620](#), *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*

API 650, *Welded Steel Tanks for Oil Storage*

Available through: American Petroleum Institute
1220 L Street NW
Washington, DC 20005-4070

ASME, Section I, *Rules for Construction of Power Boilers*

ASME, Section III, *Rules for Construction of Nuclear Power Plant Components*

ASME, Section VIII, *Rules for Construction of Pressure Vessels*

ASME, Section IX, *Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators*

Available through: American Society of Mechanical Engineers
3 Park Avenue
New York, NY 10017

A 36/A 36M, *Standard Specification for Carbon Structural Steel*

A 131/A 131M, *Standard Specification for Structural Steel for Ships*

A 203/A 203M, *Standard Specification for Pressure Vessel Plates, Alloy Steel, Nickel*

A 242/A 242M, *Standard Specification for High-Strength, Low-Alloy Structural Steel*

A 283/A 283M, *Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates*

A 285/A 285M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*

A 515/A 515M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate and Higher Temperature Service*

A 516/A 516M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

A 537/A 537M, *Standard Specification for Pressure Vessel Plates, Heat Treated, Carbon-Manganese-Silicon Steel*

A 572/A 572M, *Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel*

A 573/A 573M, *Standard Specification for Structural Carbon Steel Plates of Improved Toughness*

A 588/A 588M, *Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4 in. [100 mm] Thick*

Available through: American Society for Testing and Materials
100 Barr Harbor Drive
West Conshohocken, PA 19428

ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*

Available through: American National Standards Institute
11 W. 42nd Street, 13th Floor
New York, NY 10036

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*

AWS A3.0, *Standard Welding Terms and Definitions*

[AWS A4.3](#), *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*

AWS A5.01, *Filler Metal Procurement Guidelines*

[AWS A5.26/A5.26M](#), *Specification for Carbon and Low-Alloy Steel Electrodes for Electrode Gas Welding*

[AWS A5.32/A5.32M](#), *Specification for Welding Shielding Gases*

AWS B1.10, *Guide for Nondestructive Examination of Welds*

AWS B2.1, *Specification for Welding Procedure and Performance Qualification*

[AWS B4.0](#), *Standard Methods for Mechanical Testing of Welds*

AWS D1.1, *Structural Welding Code—Steel*

AWS F6.1, *Method for Sound Level Measurement of Manual Arc Welding and Cutting Processes*

Available through: American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

CSA W59, *Welded Steel Construction (Metal Arc Welding)*

Available through: CSA (Canadian Standards Association) International
178 Rexdale Boulevard
Toronto, ON
M9W 1R3, CANADA

Lloyds Register of Shipping Rules and Regulations for Classification of Ships

Available through: Lloyds Register of Shipping
17 Battery Place
New York, NY 10004

OSHA Safety and Health Standards, 29CFR Part 1910

Available through: U.S. Government Printing Office
Superintendent of Documents
P.O. Box 371954
Pittsburgh, PA 15250-7954

3. Definitions

The definitions listed below are terms used in this guide which may be unfamiliar to the reader. Refer to AWS A3.0, *Standard Welding Terms and Definitions*, for a complete list of terms used in welding. A term preceded by an asterisk is not currently defined in AWS A3.0 or is a variation of the A3.0 definition.

***backing**, *electrogas welding*. A material or device placed against the back side of the joint, or at both sides of a weld in electrogas welding, to support and retain molten weld metal. The material may be partially fused or remain unfused during welding and may be either metal or nonmetal.

backing shoe. A backing device used in electrogas welding that remains unfused during welding.

***consumable guide**. A tubular guide that is consumed along with the wire electrode during welding.

***consumable guide**, *electrogas welding*. An electrogas welding process variation in which filler metal is supplied by an electrode and its guiding member.

***cycle period**. The total time for the electrode to complete one transverse oscillation from one extreme to the other and back, including dwell time at both extremes.

***drag angle**, *electrogas welding*. The electrode drag angle is defined as the angle formed between the electrode and the vertical plane of the weld joint. (See Table 13, item 11d.)

***dwell**. The duration of electrode pause at its extreme transverse positions.

***electrode**, *electrogas welding*. A filler metal component of the welding circuit through which current is conducted from the electrode guiding member to the molten weld pool.

electrode extension, *electrogas welding*. The length of unmelted electrode extending beyond the end of the guide or contact tube.

***electrogas welding (EGW)**. An arc welding process that uses an arc between a continuous filler metal electrode and the weld pool, employing approximately vertical welding progression with backing to confine the molten weld metal. The process is used with or without an externally supplied shielding gas and without the application of pressure. In the case of self shielded electrodes, protection is provided by breakdown of fluxing ingredients contained in the electrode core.

***form factor**. The ratio of the maximum width (root opening plus depth of fusion [sidewall penetration]) to the maximum depth of the molten metal.

***guide**. A conductive supporting member through which the solid or cored electrode passes. It is usually tubular in form, although other shapes may be used.

***inboard shoe**. The backing shoe that is closer to the main portion of the welding machine. See Figures 1 and 2.

molding shoe. A nonstandard term for **backing shoe**.

moving shoe. A backing shoe that slides along the joint during welding.

***nonconsumable guide**. A guide that is not consumed during welding, usually a copper alloy, and may be water-cooled.

***oscillation distance**. The horizontal distance in one direction over which an oscillating electrode traverses.

***oscillation speed**. Oscillation distance divided by oscillation time.

***oscillation time**. Time necessary to complete the oscillation distance.

***outboard shoe**. The backing shoe that is on the side of the plate farthest from the main portion of the welding machine. See Figures 1 and 2.

retaining shoe. A nonstandard term for **backing shoe**.

***riser**. A nonstandard term for **runoff weld tab**.

runoff weld tab. Additional material that extends beyond the end of the joint, on which the weld is terminated.

starting weld tab. Additional material that extends beyond the beginning of the joint, on which the weld is started.

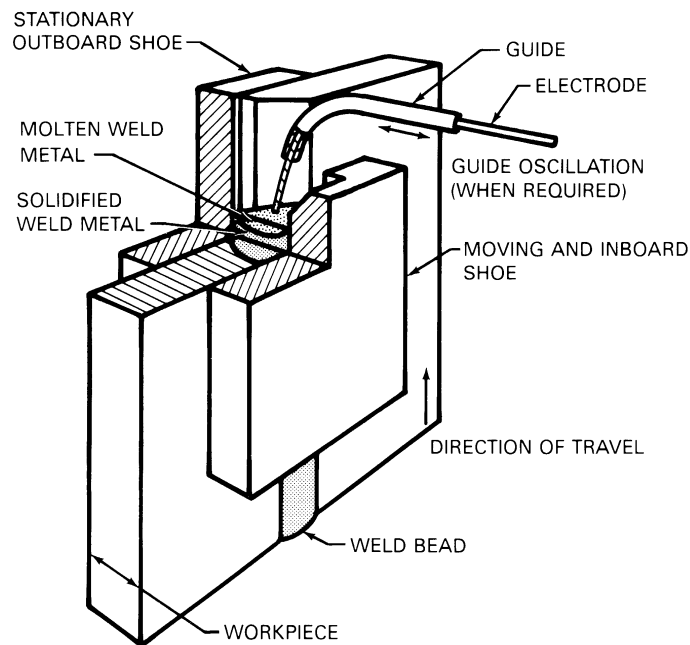


Figure 1—Schematic Diagram of EGW Process Using a Moving Shoe and a Stationary Shoe

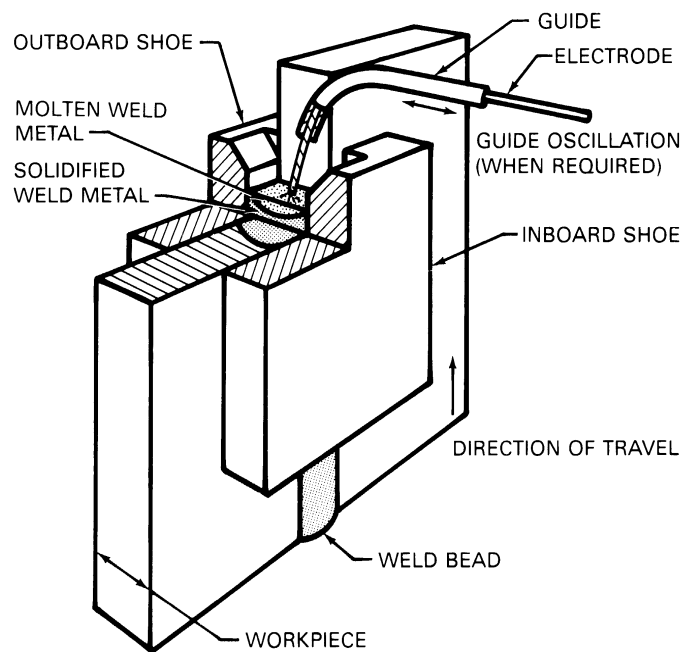


Figure 2—Schematic Diagram of EGW Process Using Two Moving Shoes

stationary shoe. A backing shoe that remains in a fixed position during welding. See Figure 1.

***strongback, electrogas welding.** A U-shaped bracket, used to hold the workpieces in alignment, and allows clearance for the backing shoe.

***sump.** A nonstandard term for **starting weld tab**.

4. Fundamentals

4.1 Process Description. Electro gas welding is similar to both the gas metal arc welding (GMAW) process and the flux cored arc welding (FCAW) process, but uses backing shoes or other backing material to confine the molten weld metal for vertical progression welding. Additional shielding may or may not be obtained from an externally supplied gas or gas mixture.

A joint with a square-groove or single-V-groove joint geometry is typically positioned so that the weld axis, or length of weld, is vertical. Electro gas welding is a machine welding process, and once started, it normally continues to completion and welding is usually done in one pass. The nature of the melting and solidification during welding results in high quality weld metal. There is little or no angular distortion of the workpieces with a single-pass weld.

4.2 Principles of Operation. The consumable electrode, solid, flux cored, or metal cored, is fed downward into a cavity formed by the base metals to be welded and the

backing shoes. A starting weld tab is usually used at the beginning of the weld to allow the process to reach stabilization before the molten weld metal reaches the workpieces. An arc is initiated between the electrode and the starting tab.

Heat from the arc melts the base metal groove faces and the continuously fed electrode. Melted electrode and base metal collect in a pool beneath the arc and solidify to form the weld metal. The electrode may be oscillated horizontally through the joint for uniform distribution of heat and weld metal. As the cavity fills, one or both shoes may move upward. Although the weld axis is vertical, the welding position is actually flat with vertical travel.

4.3 Electrode Variations

4.3.1 Solid Electrode. Figure 3 shows a schematic view of electro gas welding using a solid electrode. One electrode is normally fed into the joint. The electrode is fed through a nonconsumable guide. Horizontal oscillation of the electrode may be performed to weld thicker workpieces. Gas shielding, normally carbon dioxide (CO_2) or an argon-carbon dioxide (Ar-CO_2) mixture ([AWS A5.32/A5.32M, Specification for Welding Shielding Gases](#), class SG-C or class SG-AC-X respectively), is provided in the cavity above the weld pool.

Water-cooled copper shoes are normally used on each side of the joint to retain the molten weld metal. The shoes are usually attached to the welding machine and move vertically as the machine moves. Vertical movement of

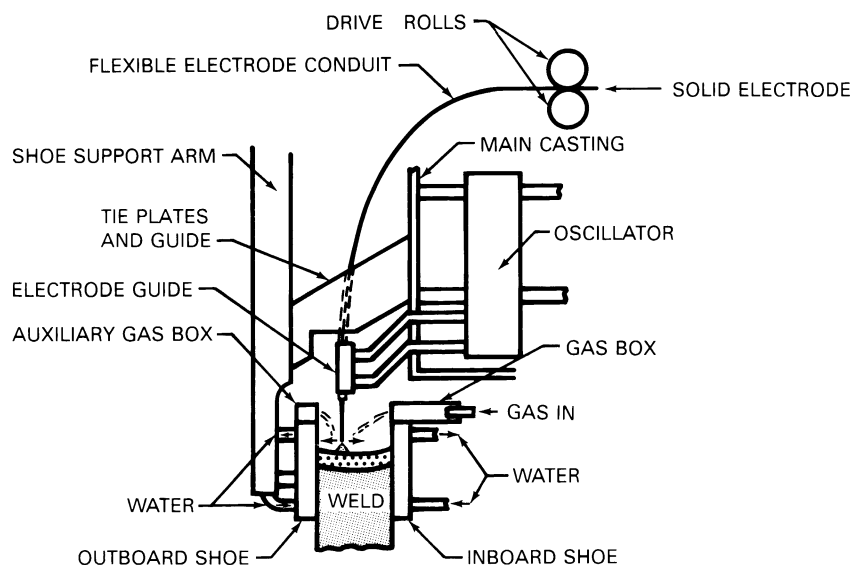


Figure 3—Electro gas Welding with Solid Electrode Using Moving Shoes

the welding machine should be consistent with the deposition rate. Vertical movement may be automatic or controlled by the welding operator.

Electrogas welding with solid electrode can be used to weld base metals ranging in thickness from approximately 3/8 in. (10 mm) to 4 in. (100 mm). Base metal thicknesses from 1/2 in. (13 mm) to 3 in. (76 mm) are most commonly welded. Electrode diameters most commonly used are 1/16, 5/64, 3/32, and 1/8 in. (1.6, 2.0, 2.4, and 3.2 mm).

4.3.2 Flux Cored Electrode. Figure 4 shows a schematic view of electrogas welding using a flux cored electrode. The principles of operation and characteristics are identical with the solid electrode variation, except that with flux cored electrodes, a thin layer of slag forms between the weld metal and copper shoes to provide a smooth weld face.

Electrogas welding with a flux cored electrode may be performed using an external gas shield or a self-shielding electrode. The self-shielded electrode generally operates at a higher deposition rate.

Electrode sizes commonly used range from 1/16 in. to 1/8 in. (1.6 mm to 3.2 mm). The wire (electrode) feeder

must be able to handle the electrode diameter chosen. In the case of smaller diameters, it must feed at high enough speeds to deposit filler metal at desired rates.

4.4 Consumable Guide Variations. The consumable guide method of EGW can be used and is similar to consumable guide electrosag welding. This variation of EGW is primarily used for short weldments in shipbuilding and structural steel fabrication. Consumable guide EGW is very similar to the previously described conventional process, but the equipment is simpler (see Figures 5 and 6). The principal difference is that none of the equipment moves vertically during consumable guide welding. As in conventional EGW, the electrode is fed into the arc, but is fed through a tubular consumable guide which extends the complete length of the joint. As the weld progresses vertically, both the guide tube and the electrode melt and are consumed in the weld.

The consumable guide typically provides five to ten percent of the filler metal, with the balance supplied from the electrode. This percentage may be as high as twenty percent when larger size guide tubes are used on thinner plates. Arc initiation is begun in the same general fashion as in the conventional process.

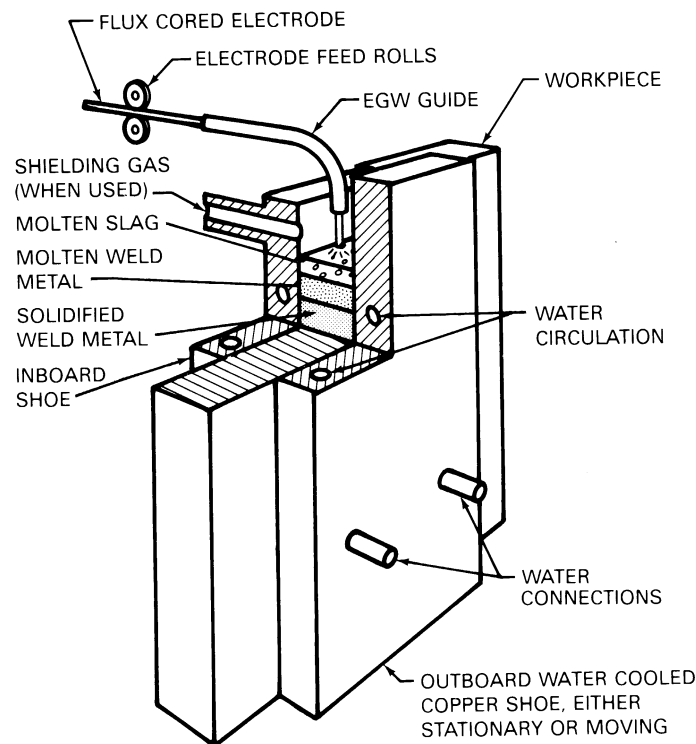


Figure 4—Electrogas Welding with Flux Cored Electrode

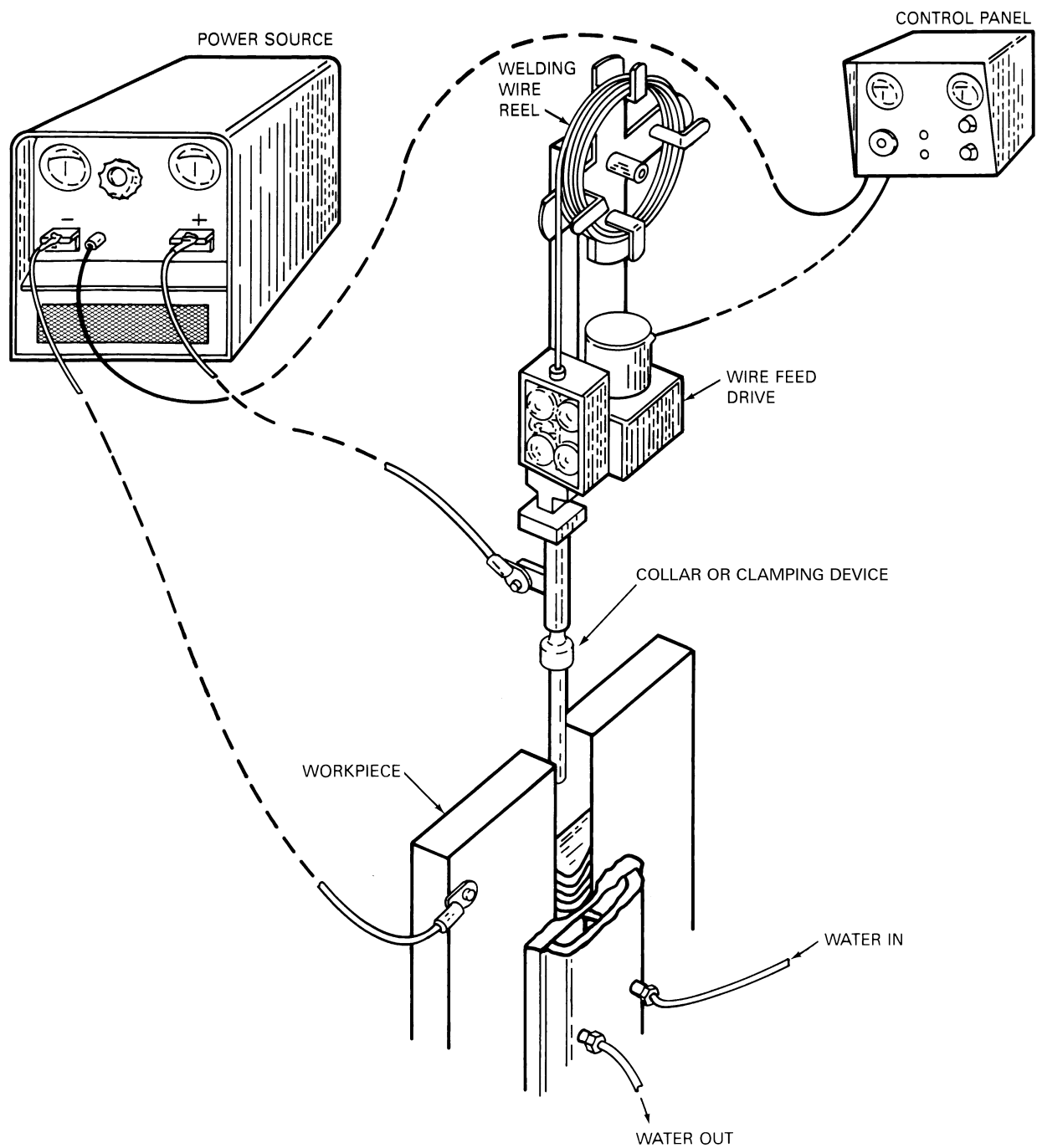


Figure 5—Consumable Guide EGW Equipment

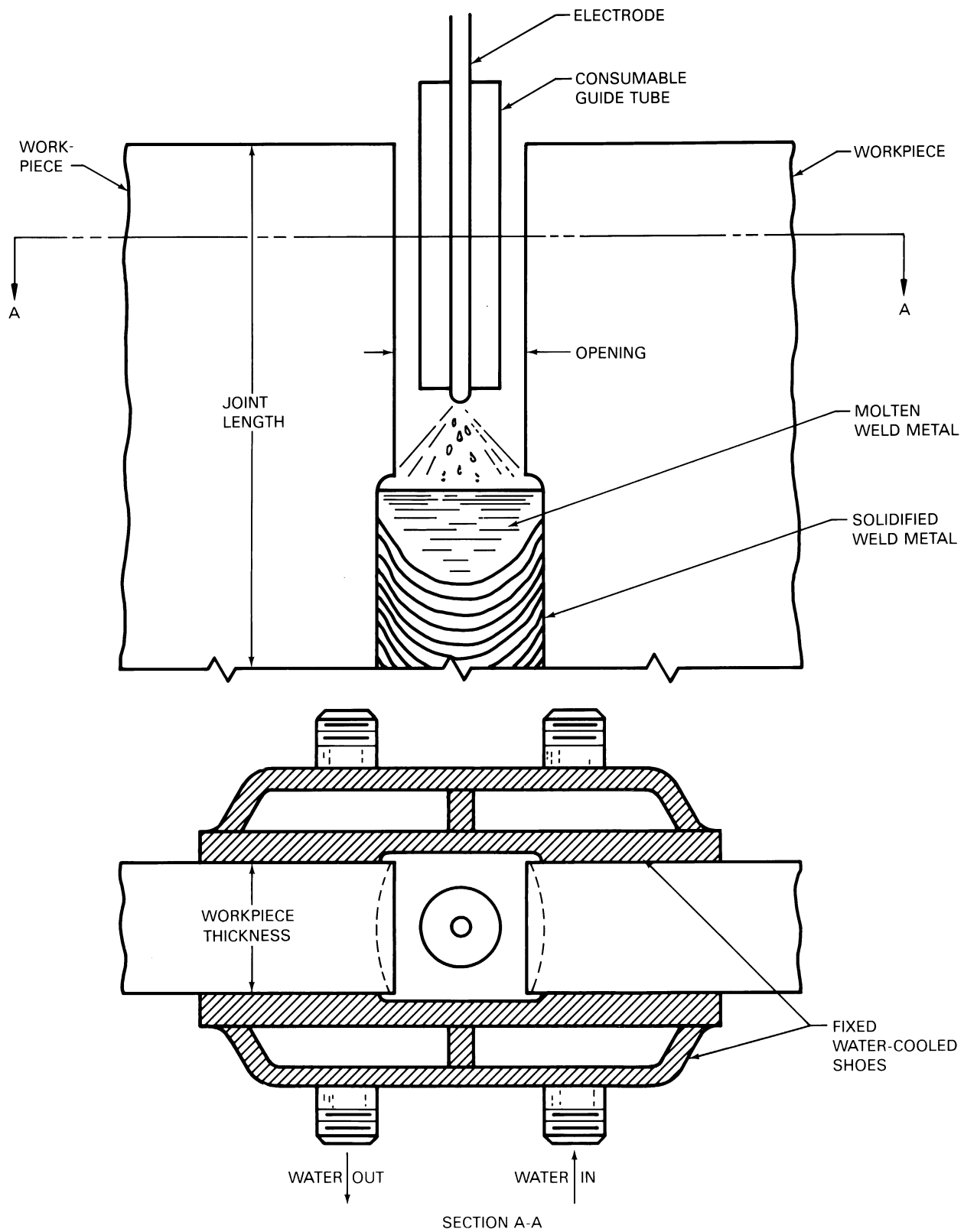


Figure 6—Schematic Diagram of Consumable Guide EGW Process