Welding

Fifth Edition

LEVEL 2

Trainee Guide

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Welding

Level 2

Trainee Guide
Fifth Edition

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Printer/Binder: Courier/Kendallville
Cover Printer: Courier/Kendallville
Text Fonts: Palatino and Univers

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10 9 8 7 6 5 4 3 2 1

PEARSON

Perfect bound	ISBN10:	0-13-416310-9
	ISBN13:	978-0-13-416310-9
Case bound	ISBN10:	0-13-413110-8
	ISBN13:	978-0-13-413110-4

Preface

Welding is a cutting-edge profession that provides skilled welders the opportunity to work in settings that span across the globe. Welders, when equipped with the proper training and passion for the trade, can find steady jobs ranging from ship building to manufacturing automobiles to working in steel mills and industrial plants.

If you have the desire and motivation to further your education in the welding industry, you will find that you have many options for employment and great potential for career growth. According to the Department of Labor, "skilled welders with up-to-date training should have good job opportunities." Welders will continue to be in high demand since there is a continuous need to rebuild aging infrastructure such as highways and buildings. In addition, the creation of new power generation facilities will yield new job prospects for trained and skilled welders.

Welding techniques are continually evolving. For example, new methods are being developed to bond dissimilar materials and nonmetallic materials, such as plastics, composites, and new alloys. Also, advances in laser beam and electron beam welding, new fluxes, and other new technologies all point to an increasing need for educated, skilled welders.

Each level of the Welding curriculum presents an apprentice approach and will help you be knowledgeable, safe, and effective on the job. This curriculum has been revised by industry subject matter experts from across the nation who incorporated the latest methods and technology of the trade.

New with *Welding Level Two*

This fifth edition of *Welding Level Two* features a new instructional design that organizes the material into a layout that mirrors the learning objectives. The new format engages trainees and enhances the learning experience by presenting concepts in a clear, concise manner. For example, trade terms are defined at the beginning of each section in which they appear and each section concludes with a brief section review. The images and diagrams have been updated to exemplify the most current welding practices with special emphasis on safety.

In addition to a new training order and updates to technology and methodology, some changes to the modules are as follows: *Welding Symbols* (29201-15) now only covers the five basic joints recognized by AWS (butt, corner, tee, lap, edge). *Physical Characteristics and Mechanical Properties of Metals* (29203-15) now includes more detailed information about electrodes. *GMAW and FCAW – Equipment and Filler Metals* (29205-15) introduces a modified form of short-circuit transfer used only with inverter machines. *GMAW and FCAW – Plate* (29206-09) was made into two separate modules titled *GMAW – Plate* (29209-15) and *FCAW – Plate* (29210-15), both of which have 60 suggested teaching hours.

This edition also aligns with the new American Welding Society's Schools Excelling through National Skills Education (SENSE) EG2.0 guidelines for Entry Welder and to the most current AWS standards. This means that, in addition to conforming to NCCER guidelines for credentialing through its Registry, this program can also be used to meet guidelines provided by AWS for Entry Welder training. For more information on the AWS SENSE program, contact AWS at 1-800-443-9353 or visit **www.aws.org**. For information on NCCER's Accreditation and Registry, contact NCCER Customer Service at 1-888-622-3720 or visit **www.nccer.org**.

We invite you to visit the NCCER website at **www.nccer.org** for the latest releases, training information, newsletter, and much more. You can also reference the Pearson product catalog online at **www.nccer.org**. Your feedback is welcome. You may email your comments to **curriculum@nccer.org** or send general comments and inquiries to **info@nccer.org**

NCCER Standardized Curricula

NCCER is a not-for-profit 501(c)(3) education foundation established in 1995 by the world's largest and most progressive construction companies and national construction associations. It was founded to address the severe workforce shortage facing the industry and to develop a standardized training process and curricula. Today, NCCER is supported by hundreds of leading construction and maintenance companies, manufacturers, and national associations. The NCCER Standardized Curricula was developed by NCCER in partnership with Pearson Education, Inc., the world's largest educational publisher.

Some features of the NCCER Standardized Curricula are as follows:

- An industry-proven record of success
- Curricula developed by the industry for the industry
- National standardization providing portability of learned job skills and educational credits
- Compliance with Office of Apprenticeship requirements for related classroom training (*CFR 29:29*)
- Well-illustrated, up-to-date, and practical information

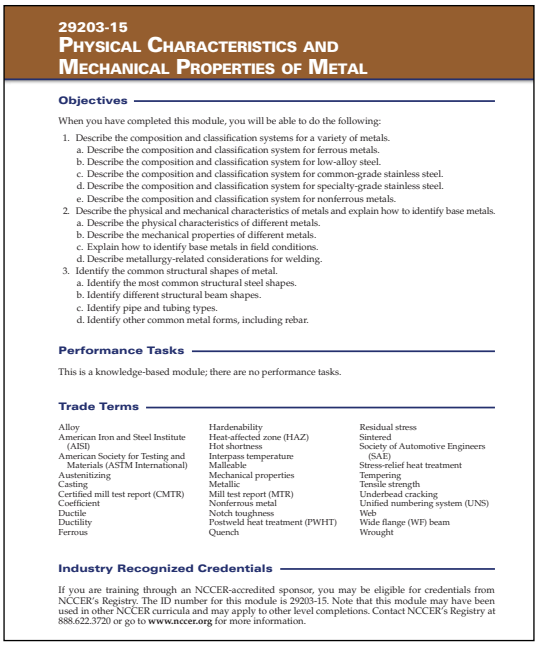
NCCER also maintains a Registry that provides transcripts, certificates, and wallet cards to individuals who have successfully completed a level of training within a craft in the NCCER Standardized Curricula. *Training programs must be delivered by an NCCER Accredited Training Sponsor in order to receive these credentials.*

Special Features

In an effort to provide a comprehensive user-friendly training resource, we have incorporated many different features for your use. Whether you are a visual or hands-on learner, this book will provide you with the proper tools to get started in the welding industry.

Introduction Page

This page is found at the beginning of each module and lists the Objectives, Performance Tasks, and Trade Terms, for that module. The Objectives list the skills and knowledge you will need in order to complete the module successfully. The Performance Tasks give you an opportunity to apply your knowledge to real-world tasks. The list of Trade Terms identifies important terms you will need to know by the end of the module.



29203-15
PHYSICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF METAL

Objectives

When you have completed this module, you will be able to do the following:

1. Describe the composition and classification systems for a variety of metals.
   a. Describe the composition and classification system for ferrous metals.
   b. Describe the composition and classification system for low-alloy steel.
   c. Describe the composition and classification system for common-grade stainless steel.
   d. Describe the composition and classification system for specialty-grade stainless steel.
   e. Describe the composition and classification system for nonferrous metals.
2. Describe the physical and mechanical characteristics of metals and explain how to identify base metals.
   a. Describe the physical characteristics of different metals.
   b. Describe the mechanical properties of different metals.
   c. Explain how to identify base metals in field conditions.
   d. Describe metallurgy-related considerations for welding.
3. Identify the common structural shapes of metal.
   a. Identify the most common structural steel shapes.
   b. Identify different structural beam shapes.
   c. Identify pipe and tubing types.
   d. Identify other common metal forms, including rebar.

Performance Tasks

This is a knowledge-based module; there are no performance tasks.

Trade Terms

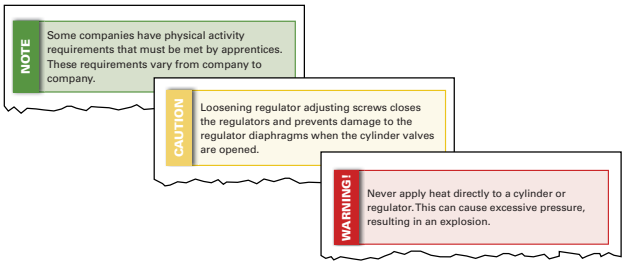
Alloy
American Iron and Steel Institute (AISI)
American Society for Testing and Materials (ASTM International)
Austenitizing
Casting
Certified mill test report (CMTR)
Coefficient
Ductile
Ductility
Ferrous
Hardenability
Heat-affected zone (HAZ)
Hot shortness
Interpass temperature
Malleable
Mechanical properties
Metallic
Mill test report (MTR)
Nonferrous metal
Notch toughness
Postweld heat treatment (PWHT)
Quench
Residual stress
Sintered
Society of Automotive Engineers (SAE)
Stress-relief heat treatment
Tempering
Tensile strength
Underbead cracking
Unified numbering system (UNS)
Web
Wide flange (WF) beam
Wrought

Industry Recognized Credentials

If you are training through an NCCER-accredited sponsor, you may be eligible for credentials from NCCER's Registry. The ID number for this module is 29203-15. Note that this module may have been used in other NCCER curricula and may apply to other level completions. Contact NCCER's Registry at 888.622.3720 or go to **www.nccer.org** for more information.

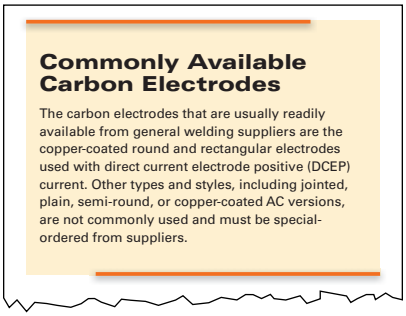
Notes, Cautions, and Warnings

Safety features are set off from the main text in highlighted boxes and organized into three categories based on the potential danger of the issue being addressed. Notes simply provide additional information on the topic area. Cautions alert you of a danger that does not present potential injury but may cause damage to equipment. Warnings stress a potentially dangerous situation that may cause injury to you or a co-worker.



Special Features

Features present technical tips and professional practices from the construction industry. These features often include real-life scenarios similar to those you might encounter on the job site.

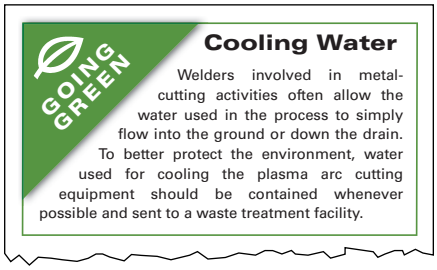


Commonly Available Carbon Electrodes

The carbon electrodes that are usually readily available from general welding suppliers are the copper-coated round and rectangular electrodes used with direct current electrode positive (DCEP) current. Other types and styles, including jointed, plain, semi-round, or copper-coated AC versions, are not commonly used and must be special-ordered from suppliers.

Going Green

Going Green looks at ways to preserve the environment, save energy, and make good choices regarding the health of the planet. Through the introduction of new construction practices and products, you will see how the "greening of the world" has already taken root.



GOING GREEN

Cooling Water

Welders involved in metal-cutting activities often allow the water used in the process to simply flow into the ground or down the drain. To better protect the environment, water used for cooling the plasma arc cutting equipment should be contained whenever possible and sent to a waste treatment facility.

Around The World

The Around the World features introduce trainees to a global construction perspective, emphasizing similarities and differences in standards, codes, and practices from country to country.

Around the World

Recycled Steel

Steel is the world's most recycled material. According to the World Steel Association, more than 650 million tons of steel were recycled annually between 2009 and 2013.

Think About It

The *Think About It* features introduce historical tidbits or modern information about the welding trade. Interesting and sometimes surprising facts about welding are also presented.

Think About It

Location of Unequal Fillet Weld Legs

How does a welder determine which side of a fillet weld has the longer leg?

Color Illustrations and Photographs

Full-color illustrations and photographs are used throughout each module to provide vivid detail. These figures highlight important concepts from the text and provide clarity for complex instructions. Each figure is denoted in the text in *italic type* for easy reference.

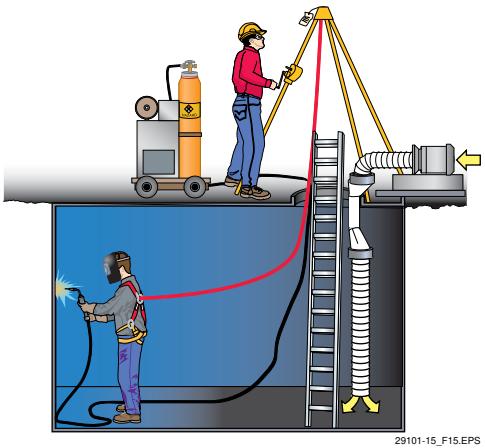


Figure 15 Worker in a confined space.

Step-by-Step Instructions

Step-by-step instructions are used throughout to guide you through technical procedures and tasks from start to finish. These steps show you not only how to perform a task but also how to do it safely and efficiently.

Follow these steps to make an overhead fillet weld:

Step 1 Tack two plates together to form a T-joint for the fillet weld coupon.

Step 2 Tack-weld the coupon so it is in the overhead position.

Step 3 Run the first bead along the root of the joint using an electrode angle of approximately 45 degrees with a 10- to 15-degree drag angle. Use a slight oscillation (circular or side-to-side motion) to tie-in the weld at the toes.

Step 4 Properly dispose of the electrode stub immediately and chip/clean the weld bead.

Step 5 Using a slight oscillation, run the second

Trade Terms

Each module presents a list of Trade Terms that are discussed within the text, defined in the Glossary at the end of the module, and reinforced with a Trade Terms Quiz. These terms are denoted in the text with **blue bold type** upon their first occurrence. To make searches for key information easier, a comprehensive Glossary of Trade Terms from all modules is found at the back of this book.

Metals are classified into two basic groups: **ferrous** metals, which are composed mainly of iron, and **nonferrous metals**, which contain very little or no iron. Ferrous metals include all steel, cast iron, **wrought** iron, **malleable** iron, and **ductile** (nodular) iron. Nonferrous metals and their alloys include the light metals (aluminum, magnesium, titanium); the heavy metals (copper, nickel,

Section Review

The Section Review features helpful additional resources and review questions related to the objectives in each section of the module.

Additional Resources

2014 Technical Training Guide. Current Edition. Cleveland, OH. USA: The Lincoln Electric Company. **www.lincolnelectric.com**

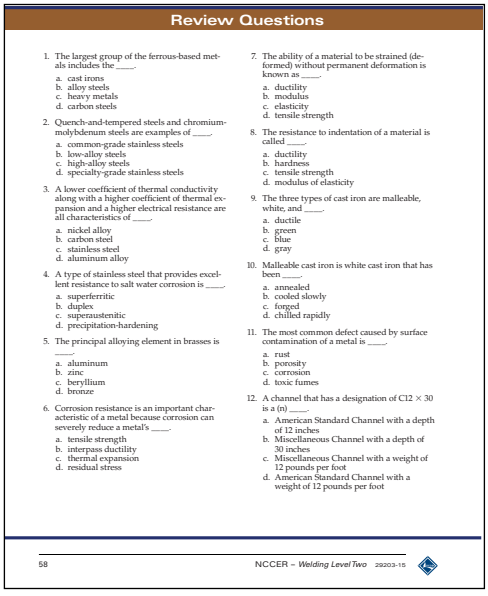
Welding Handbook. Current Edition. Miami, FL: The American Welding Society.

2.0.0 Section Review

1. Which of the following can be quenched without concern?
   a. Weld test coupons
   b. Functional welds
   c. Practice coupons
   d. Welds done in the 3G position
2. On an open-root V-groove weld in the 4G position, the electrode work angle should be _____.
   a. 30 degrees
   b. 45 degrees
   c. 90 degrees
   d. varied as needed to tie in

Review Questions

Review Questions are provided to reinforce the knowledge you have gained. This makes them a useful tool for measuring what you have learned.



Review Questions

1. The largest group of the ferrous-based metals includes the _____.
   a. cast irons
   b. alloy steels
   c. heavy metals
   d. carbon steels
2. Quench-and-tempered steels and chromium-molybdenum steels are examples of _____.
   a. common-grade stainless steels
   b. low-alloy steels
   c. high-alloy steels
   d. specialty-grade stainless steels
3. A lower coefficient of thermal conductivity along with a higher coefficient of thermal expansion and a higher electrical resistance are all characteristics of _____.
   a. nickel alloy
   b. carbon steel
   c. stainless steel
   d. aluminum alloy
4. A type of stainless steel that provides excellent resistance to salt water corrosion is _____.
   a. superferritic
   b. duplex
   c. superaustenitic
   d. precipitation-hardening
5. The principal alloying element in brasses is _____.
   a. aluminum
   b. zinc
   c. beryllium
   d. bronze
6. Corrosion resistance is an important characteristic of a metal because corrosion can severely reduce a metal's _____.
   a. tensile strength
   b. interpass ductility
   c. thermal expansion
   d. residual stress
7. The ability of a material to be strained (deformed) without permanent deformation is known as _____.
   a. ductility
   b. modulus
   c. elasticity
   d. tensile strength
8. The resistance to indentation of a material is called _____.
   a. ductility
   b. hardness
   c. tensile strength
   d. modulus of elasticity
9. The three types of cast iron are malleable, white, and _____.
   a. ductile
   b. green
   c. blue
   d. gray
10. Malleable cast iron is white cast iron that has been _____.
    a. annealed
    b. cooled slowly
    c. forged
    d. chilled rapidly
11. The most common defect caused by surface contamination of a metal is _____.
    a. rust
    b. porosity
    c. corrosion
    d. toxic fumes
12. A channel that has a designation of C12 × 30 is a (n) _____.
    a. American Standard Channel with a depth of 12 inches
    b. Miscellaneous Channel with a depth of 30 inches
    c. Miscellaneous Channel with a weight of 12 pounds per foot
    d. American Standard Channel with a weight of 12 pounds per foot

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NCCER Standardized Curricula

NCCER's training programs comprise more than 80 construction, maintenance, pipeline, and utility areas and include skills assessments, safety training, and management education.

Boilermaking
Cabinetmaking
Carpentry
Concrete Finishing
Construction Craft Laborer
Construction Technology
Core Curriculum: Introductory Craft Skills
Drywall
Electrical
Electronic Systems Technician
Heating, Ventilating, and Air Conditioning
Heavy Equipment Operations
Highway/Heavy Construction
Hydroblasting
Industrial Coating and Lining Application Specialist
Industrial Maintenance Electrical and Instrumentation Technician
Industrial Maintenance Mechanic
Instrumentation
Insulating
Ironworking
Masonry
Millwright
Mobile Crane Operations
Painting
Painting, Industrial
Pipefitting
Pipelayer
Plumbing
Reinforcing Ironwork
Rigging
Scaffolding
Sheet Metal
Signal Person
Site Layout
Sprinkler Fitting
Tower Crane Operator
Welding

Maritime

Maritime Industry Fundamentals
Maritime Pipefitting
Maritime Structural Fitter

Green/Sustainable Construction

Building Auditor
Fundamentals of Weatherization
Introduction to Weatherization
Sustainable Construction Supervisor
Weatherization Crew Chief
Weatherization Technician
Your Role in the Green Environment

Energy

Alternative Energy
Introduction to the Power Industry
Introduction to Solar Photovoltaics
Introduction to Wind Energy
Power Industry Fundamentals
Power Generation Maintenance Electrician
Power Generation I&C
Maintenance Technician
Power Generation Maintenance Mechanic
Power Line Worker
Power Line Worker: Distribution
Power Line Worker: Substation
Power Line Worker: Transmission
Solar Photovoltaic Systems Installer
Wind Turbine Maintenance Technician

Pipeline

Control Center Operations, Liquid
Corrosion Control
Electrical and Instrumentation
Field Operations, Liquid
Field Operations, Gas
Maintenance
Mechanical

Safety

Field Safety
Safety Orientation
Safety Technology

Supplemental Titles

Applied Construction Math
Tools for Success

Management

Fundamentals of Crew Leadership
Project Management
Project Supervision

Spanish Titles

Acabado de concreto: nivel uno
Aislamiento: nivel uno
Albañilería: nivel uno
Andamios
Carpintería:
Formas para carpintería, nivel tres
Currículo básico: habilidades introductorias del oficio
Electricidad: nivel uno
Herrería: nivel uno
Herrería de refuerzo: nivel uno
Instalación de rociadores: nivel uno
Instalación de tuberías: nivel uno
Instrumentación: nivel uno, nivel dos, nivel tres, nivel cuatro
Orientación de seguridad
Paneles de yeso: nivel uno
Seguridad de campo

Acknowledgments

This curriculum was revised as a result of the farsightedness and leadership of the following sponsors:

Central Louisiana Technical College
Claddagh Enterprises
KBR Industrial Services
Lee College
Lincoln Electric Company
Northeast Community College
Northland Pioneer College
Spec-Weld Technologies
TIC-The Industrial Company
Toledo Refining Co. LLC
Zachry Industrial, Inc.

This curriculum would not exist were it not for the dedication and unselfish energy of those volunteers who served on the Authoring Team. A sincere thanks is extended to the following:

Gerald Bickerstaff
Curtis Casey
Bill Cherry
Rod Hellyer
Frank Johnson
John Knapp
Terry Lowe
Jason Scales
Dan Sterry
Holley Thomas
Jerry Trainor

NCCER Partners

American Fire Sprinkler Association
Associated Builders and Contractors, Inc.
Associated General Contractors of America
Association for Career and Technical Education
Association for Skilled and Technical Sciences
Construction Industry Institute
Construction Users Roundtable
Construction Workforce Development Center
Design Build Institute of America
GSSC – Gulf States Shipbuilders Consortium
ISN
Manufacturing Institute
Mason Contractors Association of America
Merit Contractors Association of Canada
NACE International
National Association of Minority Contractors
National Association of Women in Construction
National Insulation Association
National Technical Honor Society
NAWIC Education Foundation
North American Crane Bureau
North American Technician Excellence
Pearson
Pearson Qualifications International
Prov
SkillsUSA®
Steel Erectors Association of America
U.S. Army Corps of Engineers
University of Florida, M. E. Rinker School of Building Construction
Women Construction Owners & Executives, USA

NCCER Business Partners

Contents

Module Seven

FCAW – Plate

Explains how to set up and use FCAW equipment and how to select and use different filler metals and shielding gases. Describes how to make multiple-pass fillet and V-groove welds on carbon steel plate in various positions. (Module ID 29210-15; 60 hours)

Module Eight

GTAW – Equipment and Filler Metals

Explains GTAW safety. Identifies and explains the use of GTAW equipment, filler metals, and shielding gases. Covers the setup of GTAW equipment. (Module ID 29207-15; 10 hours)

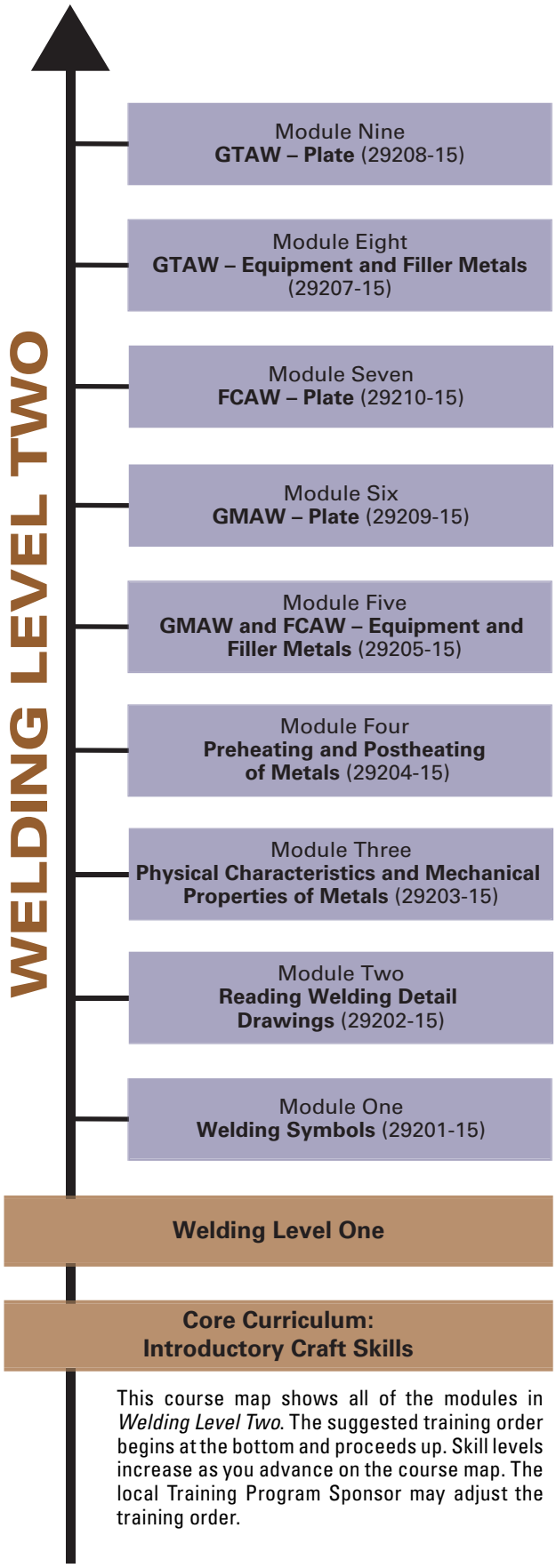
Module Nine

GTAW – Plate

Describes how to build pads on carbon steel plate using GTAW and carbon steel filler metal. Also explains how to make multiple-pass GTAW fillet welds on carbon steel plate coupons in the 1F, 2F, 3F, and 4F positions, and how to make GTAW V-groove welds in the 1G, 2G, 3G, and 4G positions. (Module ID 29208-15; 60 hours)

Glossary

Index



This course map shows all of the modules in *Welding Level Two*. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map. The local Training Program Sponsor may adjust the training order.

Correlations Chart: AWS S.E.N.S.E. EG2.0 Guidelines and NCCER Welding Levels One and Two

SENSE Guidelines				NCCER
Modules	Passing Score	Visual	Destructive	NCCER Standardized Curricula
1 – Occupational Orientation *	No Test	No Test	No Test	Core Curriculum: Module 00107-15, Basic Communication Skills; Module 00108-15, Basic Employability Skills
2 – Safety and Health of Welders *	100%	No Test	No Test	Welding Level 1: Module 29101-15, Welding Safety
3 – Drawing and Welding Symbol Interpretation *	75%	No Test	No Test	Welding Level 2: Module 29201-15, Welding Symbols; Module 29202-15, Reading Welding Detail Drawings
4 – Shielded Metal Arc Welding	75%	Pass /Fail	Pass /Fail	Welding Level 1: Module 29107-15, SMAW—Equipment and Setup; Module 29109-15, SMAW—Beads and Fillet Welds; Module 29111-15, SMAW—Groove Welds with Backing
5 – Gas Metal Arc Welding	75%	Pass /Fail	No Test	Welding Level 2: Module 29205-15, GMAW and FCAW—Equipment and Filler Metals; Module 29209-15, GMAW – Plate
6 – Flux Cored Arc Welding	75%	Pass /Fail	No Test	Welding Level 2: Module 29205-15, GMAW and FCAW—Equipment and Filler Metals; Module 29210-15, FCAW – Plate
7 – Gas Tungsten Arc Welding	75%	Pass /Fail	No Test	Welding Level 2: Module 29207-15, GTAW—Equipment and Filler Metals; Module 29208-15, GTAW—Plate
8 – Thermal Cutting Process * †	75%	No Test	No Test	
Unit 1 Manual Oxyfuel Gas Cutting (OFC) †		Pass /Fail	No Test	Welding Level 1: Module 29102-15, Oxyfuel Cutting
Unit 2 Mechanized Oxyfuel Gas Cutting (OFC) †		Optional	No Test	Welding Level 1: Module 29105-15, Base Metal Preparation
Unit 3 Manual Plasma Arc Cutting—PAC †		Pass /Fail	No Test	Welding Level 1: Module 29103-15, Plasma Arc Cutting
Unit 4 Manual Air Carbon Arc Cutting †		Optional	No Test	Welding Level 1: Module 29104-15, Air-Carbon Arc Cutting and Gouging
9 – Welding Inspection and Testing *	75%	Pass /Fail	No Test	Welding Level 1: Module 29106-15, Weld Quality

* Required module for Level 1 Entry Welder Completion (plus one welding process module)

† Completion of Units 1 and 3 minimum

29201-15

Welding Symbols

Overview

Project drawings and specifications contain numerous symbols that communicate critical information about the welds to be used at various locations throughout the project. Welders must learn this symbolic language so they can properly interpret the symbols and make welds that meet design specifications. This module introduces a wide range of welding symbols, describes how they are structured, and explains the basic rules for applying the information that the symbols convey.

Module One

Trainees with successful module completions may be eligible for credentialing through the NCCER Registry. To learn more, go to **www.nccer.org** or contact us at **1.888.622.3720**. Our website has information on the latest product releases and training, as well as online versions of our *Cornerstone* magazine and Pearson's product catalog.

Your feedback is welcome. You may email your comments to **curriculum@nccer.org,** send general comments and inquiries to **info@nccer.org**, or fill in the User Update form at the back of this module.

This information is general in nature and intended for training purposes only. Actual performance of activities described in this manual requires compliance with all applicable operating, service, maintenance, and safety procedures under the direction of qualified personnel. References in this manual to patented or proprietary devices do not constitute a recommendation of their use.

29201-15
Welding Symbols

Objectives

When you have completed this module, you will be able to do the following:

1. Identify and interpret welding symbols and their structure.
   a. Describe the structure and placement of welding symbols and identify basic symbols.
   b. Identify and interpret size and dimension markings for common types of welds.
   c. Identify and interpret various supplemental symbols.
   d. Identify and interpret less common welding symbols.

Performance Task

Under the supervision of your instructor, you should be able to do the following:

1. Identify and interpret welding symbols on an instructor-provided drawing.

Trade Terms

Arrow line
Countersink
Pitch
Reference line
Weld symbol
Welding symbol

Industry Recognized Credentials

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Contents

Topics to be presented in this module include:

Figures and Tables

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Section One

1.0.0 Welding Symbols

Objective

Identify and interpret welding symbols and their structure.

a. Describe the structure and placement of welding symbols and identify basic symbols.
b. Identify and interpret size and dimension markings for common types of welds.
c. Identify and interpret various supplemental symbols.
d. Identify and interpret less common welding symbols.

Performance Task

1. Identify and interpret welding symbols on an instructor-provided drawing.

Trade Terms

Arrow line: The line drawn at an angle from the reference line (either end or both ends) to an arrowhead at the location of the weld.

Countersink: A hole with tapered sides and a wider opening that allows a flat-head fastener to seat flush to the surface of the material in which the hole is made.

Pitch: The center-to-center distance between welds.

Reference line: The horizontal line in the center of the welding symbol from which all elements of the welding symbol are referenced. The reference line is one of the most important elements of the welding symbol.

Weld symbol: A graphic character connected to the reference line of a welding symbol specifying the weld type.

Welding symbol: A graphical representation of the specifications for producing a welded joint; includes a reference line and arrow line and many also include a weld symbol.

Welding symbols are used on drawings, project specifications, and welding procedure specifications (WPS) to convey the design specifications for welds. A series of symbols is used to indicate the joint configuration and weld type, location, size, and length of weld required. Welders must be able to properly interpret welding symbols to ensure that the welds they make will meet the design specifications.

Most companies use the symbols that have been standardized by the American Welding Society (AWS) in *AWS A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination*. Most companies also have a site quality standard that provides guidelines and examples of how welding symbols are to be used. Always refer to the site-specific quality standard when interpreting welding symbols.

1.1.0 Welding Symbol Construction

The base for all welding symbols is the horizontal **reference line** which has an arrow at one end. The **arrow line**, which can be on either side of the reference line, points to the location to which the welding symbol applies (*Figure 1*). The welding symbol describes the type of weld, its size, and its surface finish.

The opposite end of the reference line, called the tail, is used for information that aids in making the weld but does not have its own special place on the symbol (*Figure 2*). For instance, the tail may be used to indicate the welding and cutting processes, the reference to a note, or the welding procedure or electrode type to be used. When a reference is not required, the tail is omitted, as shown in *Figure 1*.

In the case of a T-joint, the arrow points to the two sides of the joint, and welding may be accomplished on either side. The welding symbol distinguishes between the two sides of a joint by using the arrow line and the spaces above and below the reference line. The side of the joint to which the arrow points is called the arrow side, and its weld is made in accordance with the instructions below the reference line. The opposite side of the joint is referred to as the other side,

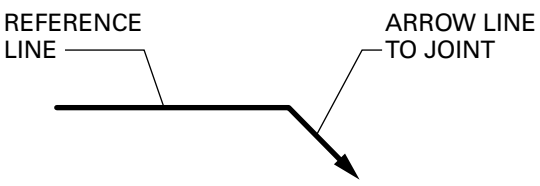


Figure 1 Horizontal reference line.

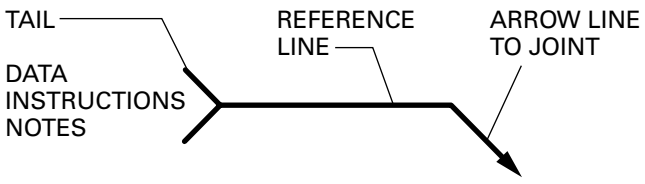


Figure 2 Tail-side information

Welding and Cutting Processes

The *Appendixes* in this module contain tables listing AWS abbreviations for various welding and cutting processes. Abbreviations from all three tables can be used in tail references, or in single-line or multiple-line welding symbols.

and its weld is made in accordance with the instructions found above the reference line. *Figure 3* shows examples of these symbols.

Regardless of which end of the reference line the arrow line is on, information on the reference line is always read from left to right. *Figure 4* shows a welding symbol base and the numerous elements of a welding symbol.

The **weld symbols** used to identify the type of weld to be made signify a basic type of weld or joint preparation (*Figure 5*). It is important to note the difference between welding symbols and weld symbols. A weld symbol is a graphic character connected to the reference line of a welding symbol, specifying the weld type. A welding symbol graphically represents the specifications for producing a welded joint; it includes any weld symbols as well as the additional components. All welding symbols include a reference line and arrow line, at a minimum. Many also include a weld symbol.

1.1.1 Symbols for Welds

The type of weld used is determined by the way the members to be welded are positioned to form the joint. The five basic types of weld joints are the butt, corner, tee, lap, and edge joints (*Figure 6*).

1.1.2 Location of Weld Symbols

When the weld symbol is on both the top and bottom of the reference line, the information applies to both sides of the joint or surface to which the arrow is pointing. Symbols appear on both sides of the reference line when a double-fillet or double-groove weld is specified. *Figure 7* shows symbols for arrow-side, other-side, and both sides for fillet and V-groove welds.

The shape of the groove weld symbol indicates how the groove is to be prepared. In the case of the bevel-groove and J-groove weld symbols, only one of the two members to be welded is prepared. The arrow indicates which member is to be prepared by breaking toward that member (*Figure 8*).

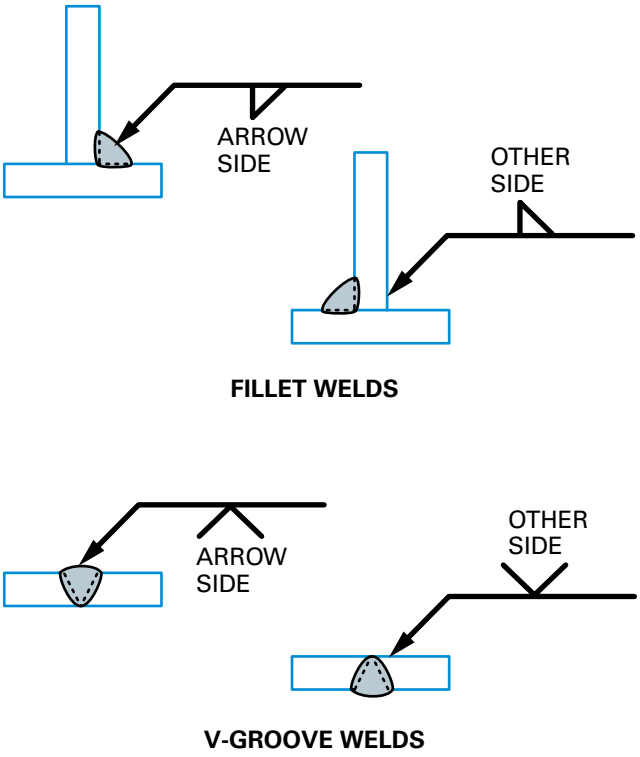


Figure 3 Arrow-side and other-side significance.

Notice also that the vertical leg of the weld symbol is shown drawn to the left of the slanted/curved leg(s). Regardless of whether the symbol is for a fillet, bevel-groove, J-groove, or flare bevel-groove weld, the vertical leg is always drawn to the left.

1.1.3 Combining Weld Symbols

When more than one type of weld is to be made on the same joint, it is necessary to combine weld symbols (*Figure 9*). A typical combination weld is made by adding a fillet weld to a single or double bevel groove weld in a T-joint. The fillet weld symbol is always placed on top of the groove weld symbol, just as it would be on the actual weld.

1.1.4 Multiple Reference Lines

When more than one welding operation must be performed in a certain sequence, two or more reference lines may be used to indicate the sequence.

Think About It

Breaking the Arrow

Are the symbol representations shown in *Figure 8* the only ways a breaking arrow can be shown?

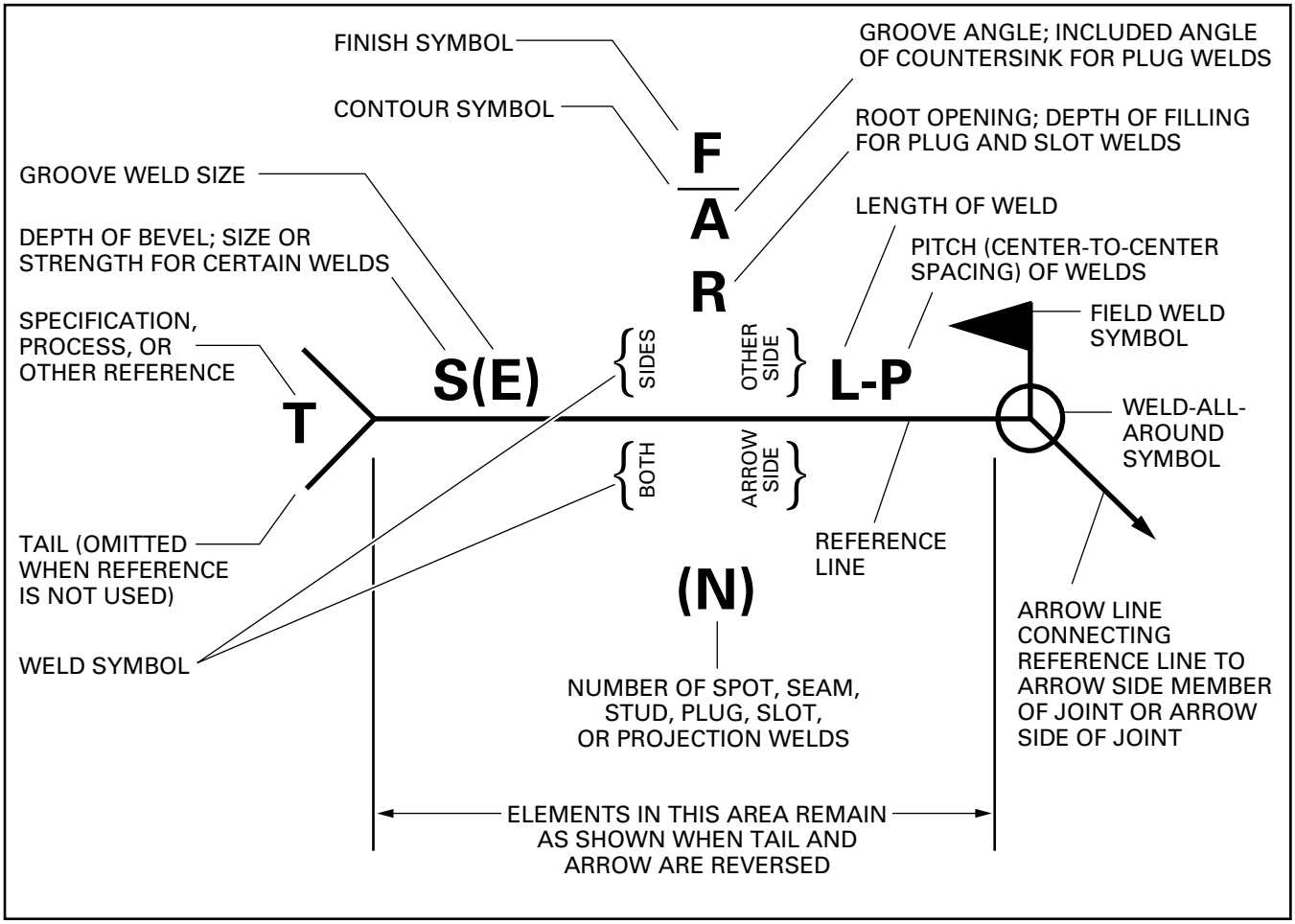


Figure 4 Standard location of elements of a welding symbol.

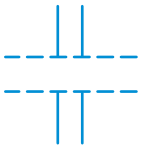
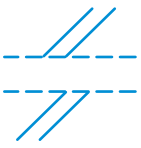
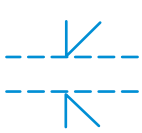
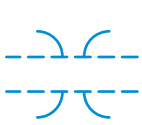
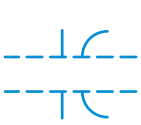
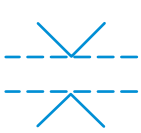
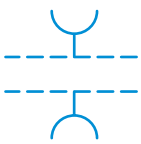
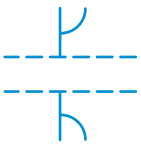
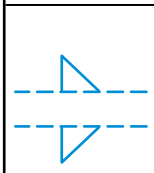
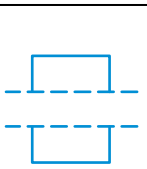
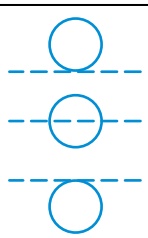
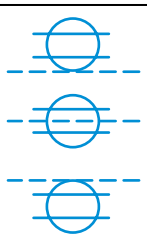
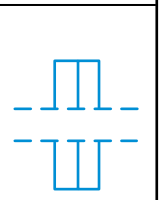
GROOVE WELDS							
SQUARE	SCARF	BEVEL	FLARE-V	FLARE-BEVEL	V	U	J
							
OTHER WELDS							
FILLET	PLUG OR SLOT	STUD	SPOT OR PROJECTION	SEAM	BACK OR BACKING	SURFACING	EDGE
							

Figure 5 Basic weld symbols.

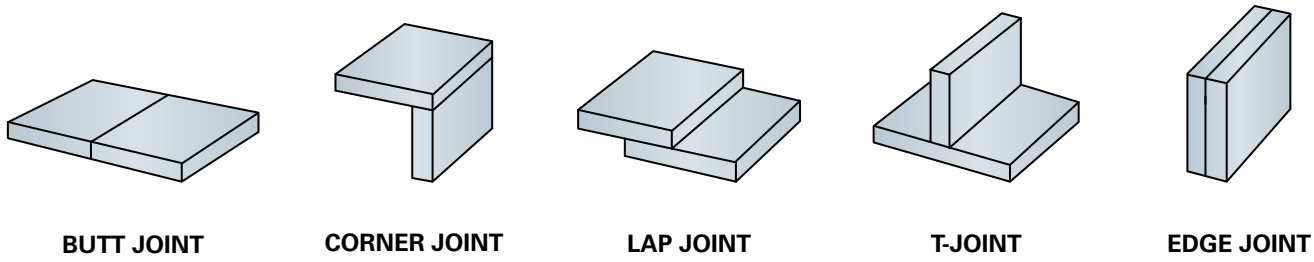


Figure 6 Basic types of weld joints.

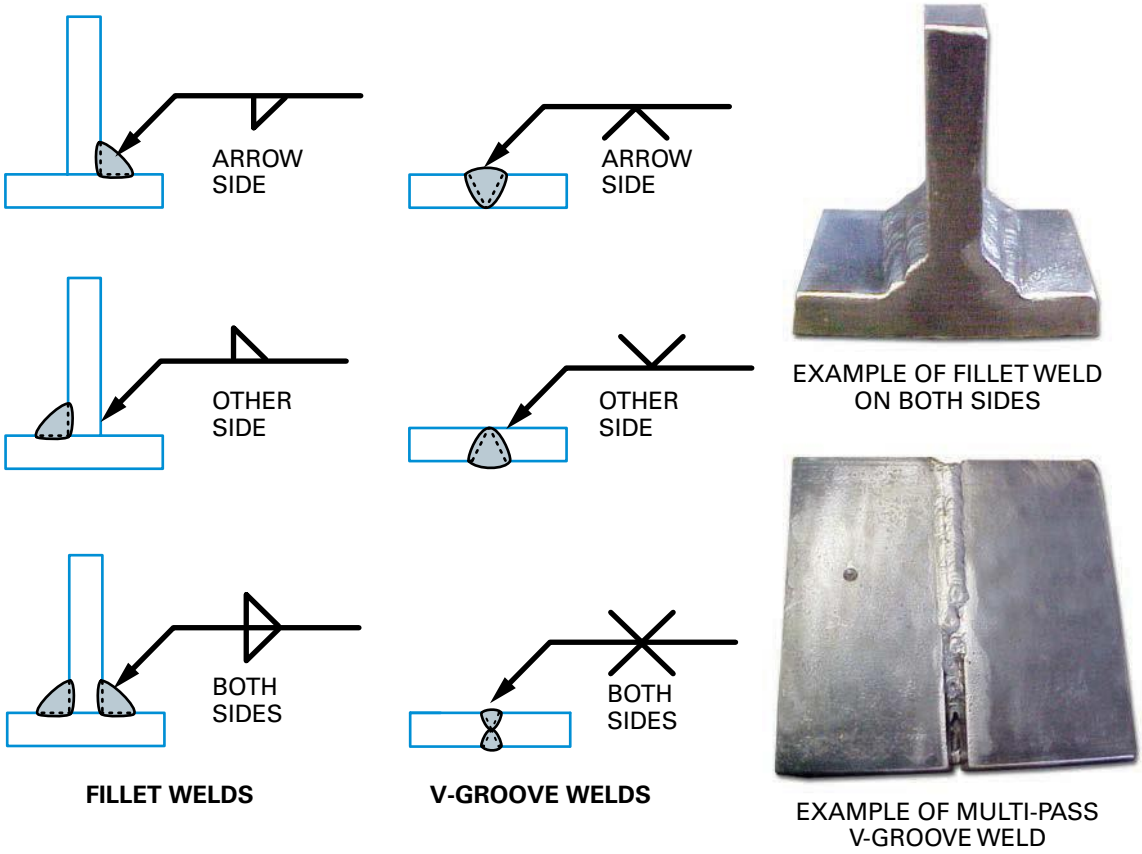


Figure 7 Fillet and V-groove welds.

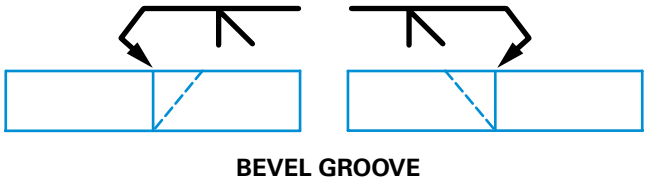
Figure 10 illustrates the typical sequences of operation when multiple reference lines are used. In each sequence, the first operation to be performed will be closest to the arrow. The first operation must be shown on the reference line that is nearest to the arrow. Subsequent operations may be shown sequentially on other reference lines. The last operation to be performed will be the one farthest from the arrow.

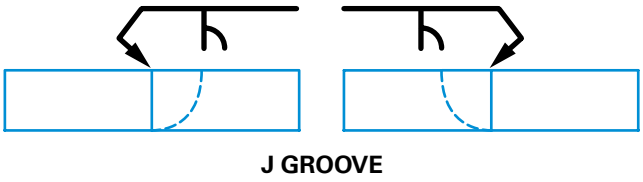
Multiple reference lines may also be used to show data supplementary to welding symbol information that is on the reference line nearest the arrow. As shown in *Figure 11*, test information may be shown on a second or third line, away from the arrow.

When required, the weld-all-around symbol, shown in *Figure 12(A)*, must be placed at the junction of the arrow line and reference line for each operation to which it applies. The field weld symbol shown in *Figure 12(B)* may also be used in this manner. Supplemental symbols are discussed in more detail later in this module.

1.2.0 Sizing and Dimensioning Welds

Unless defined in a drawing note, the size data for a weld is always shown to the left of the symbol to which it applies. For example, the size of the fillet weld shown in *Figure 13* is ¼ inch. The length of the weld is always shown to the right of the symbol to which the length applies. An example of this is seen in *Figure 14*, where the length is 6 inches.





NOTE: DASHED LINES INDICATE PREPARATION SPECIFIED BY WELD SYMBOL

Figure 8 Bevel and J-groove weld symbols.

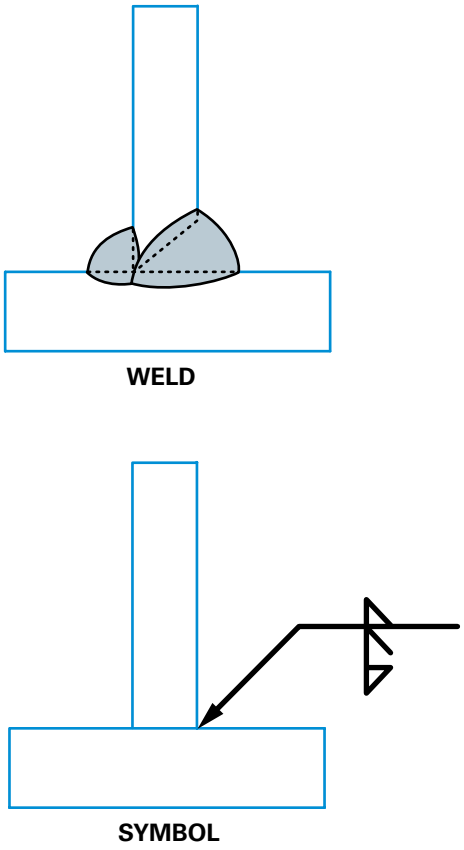


Figure 9 Combination weld symbol.

Dimensions can be given as fractions, decimals, or metric measurements. The following sections explain how to size and dimension the following weld types:

- Fillet
- Groove
- Plug
- Slot

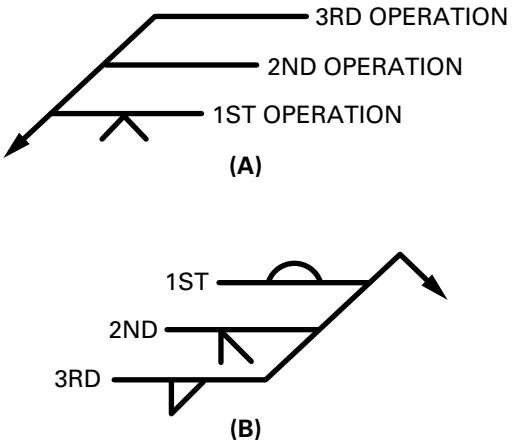


Figure 10 Multiple reference lines.

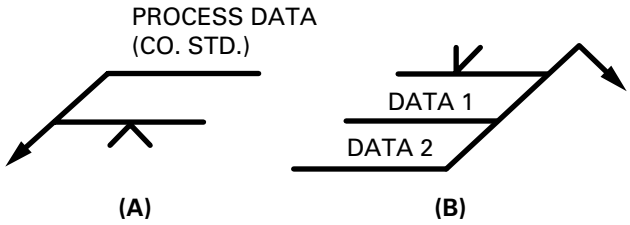


Figure 11 Supplementary data.

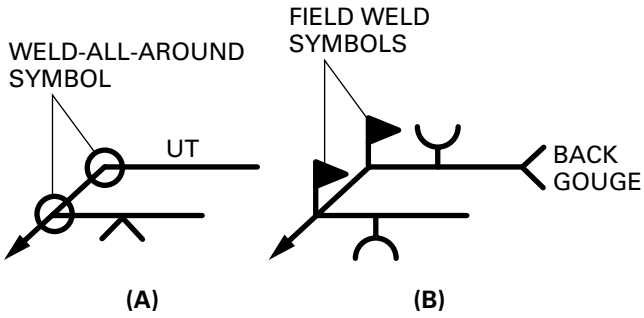


Figure 12 Typical placement of supplemental symbols.

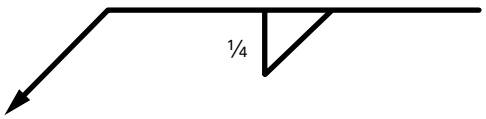


Figure 13 Sizing welds

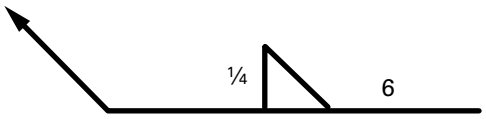


Figure 14 Dimensioning welds.

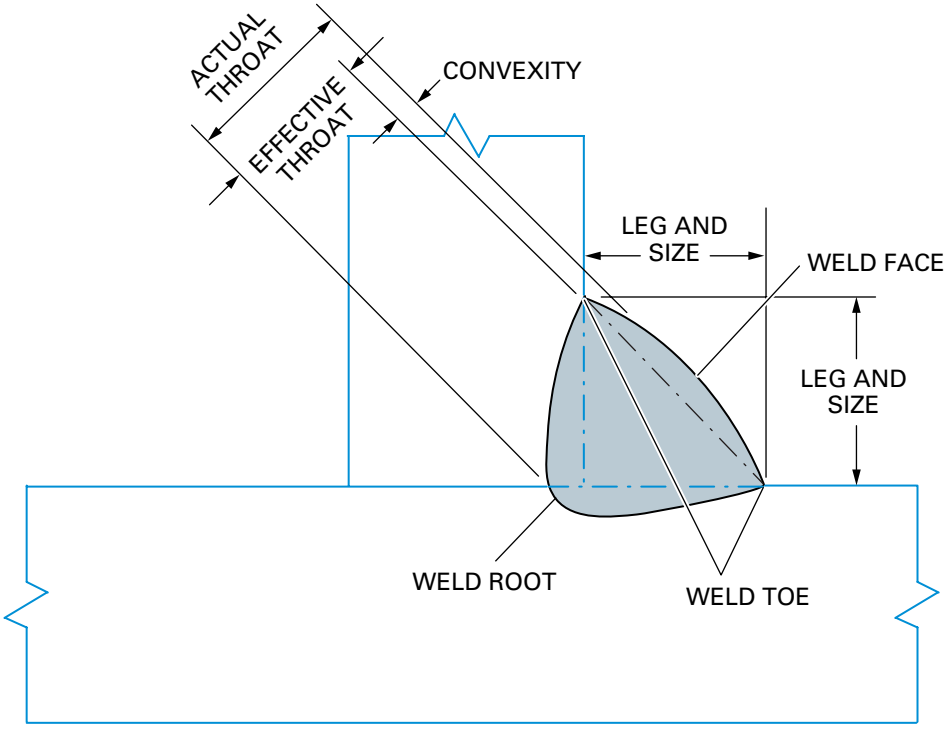
1.2.1 Sizing Fillet Welds

A fillet weld is a weld made in a corner. It is roughly triangular in shape and joins two welding surfaces that are perpendicular to each other, such as in a lap, T-, or corner joint. The size of a fillet weld is the length of the legs (sides) of the

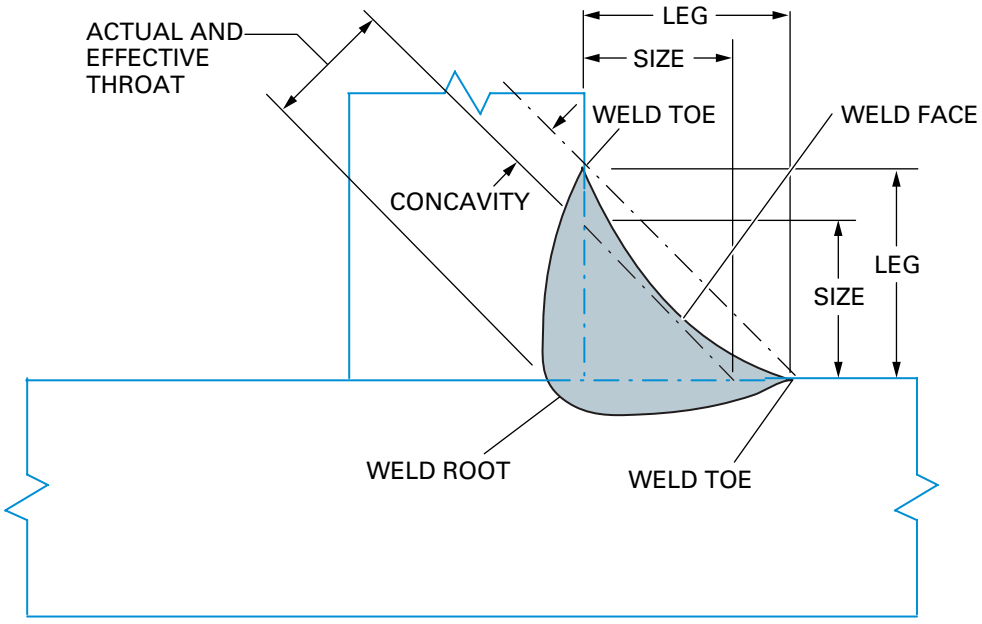
largest triangle that can be inscribed within the fillet weld cross-section. *Figure 15* shows the profiles of convex and concave welds.

The lengths of the legs on a typical fillet weld are equal, so only one dimension is given. Equal-leg fillet welds are sized by placing the size to the left of the fillet weld symbol or as defined in a drawing note.

If the fillet weld has unequal legs, the size of each leg is given in parentheses or brackets to the



CONVEX FILLET WELD



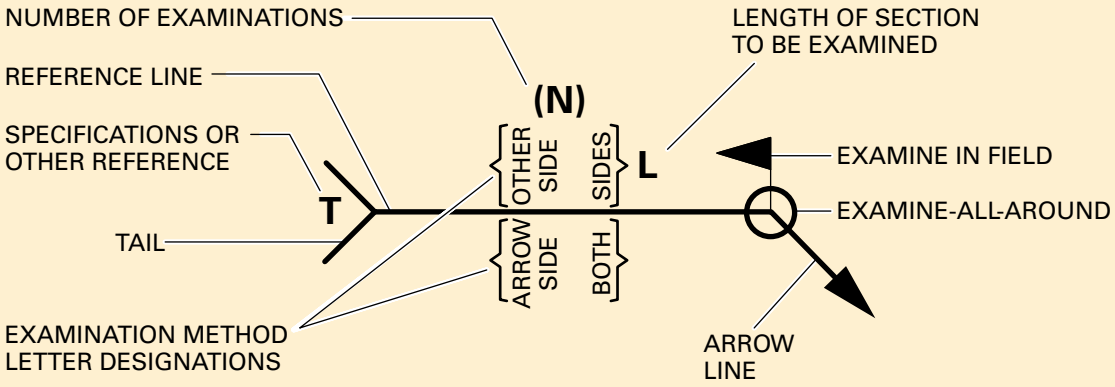
CONCAVE FILLET WELD

Figure 15 Profiles of fillet welds.

Nondestructive Examination Symbols

Nondestructive examination symbols may appear on the same drawings as (and look very similar to) welding symbols. Inspectors use nondestructive examination symbols to examine joints once welding is complete. The nondestructive methods of inspection are defined by letter codes on the reference line. For instance, VT indicates visual testing, UT indicates ultrasonic testing, RT indicates radiographic testing, and PT indicates penetrant testing.

NDT symbols and weld symbols may be combined by using two reference lines. In contrast to the arrow for welding symbols, the arrow for NDT always points to the weld that is to be tested, and never to a weld on the other side of the joint. If a double fillet weld were to be tested, for example, this would be shown with a separate arrow on each side of the joint.



left of the fillet weld symbol with a drawing or explanation of leg orientation. An example of this is shown in *Figure 16* where the unequal legs are ¼ inch (6.4 mm) and ½ inch (12.7 mm).

1.2.2 Dimensioning Fillet Welds

The length of a fillet weld is shown to the right of the fillet weld symbol. If the fillet weld is to be an intermittent fillet weld, the length (length of each segment) and the **pitch** (center-to-center distance between welds) are shown with a dash. The dash appears between the length, which is always shown first, and the pitch, which is always shown second. *Figure 17* shows a length of 2 inches (5.1 cm) and a pitch of 6 inches (15.2 cm). If fillet welds are required on both sides of the joint, they can be back-to-back or staggered. If the welds are back-to-back, as shown in *Figure 17(A)*, the fillet weld symbols are aligned evenly on both sides of the reference line, as shown in *Figure 17(B)*. If the welds are to be staggered, as shown in *Figure 17(C)*, the fillet weld symbols above and below the reference line are offset, as shown in *Figure 17(D)*.

Unequal Fillet Weld Legs

The only practical use of unequal fillet weld legs is on metal of unequal thickness. Unequal legs do not make the weld stronger; the thinner material prevails. An unequal fillet leg weld helps distribute loads and eliminates incomplete fusion discontinuities that would be caused by making a small weld on heavy material without preheat.

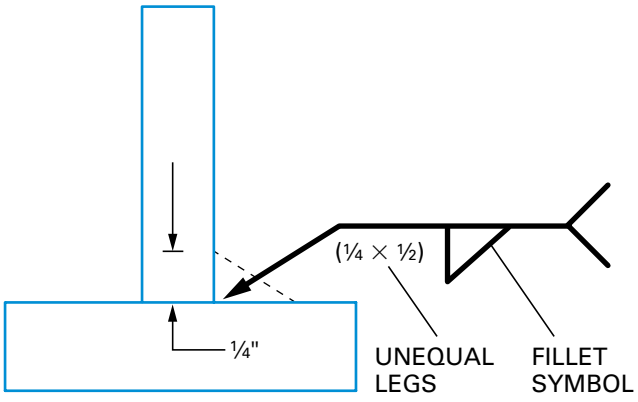
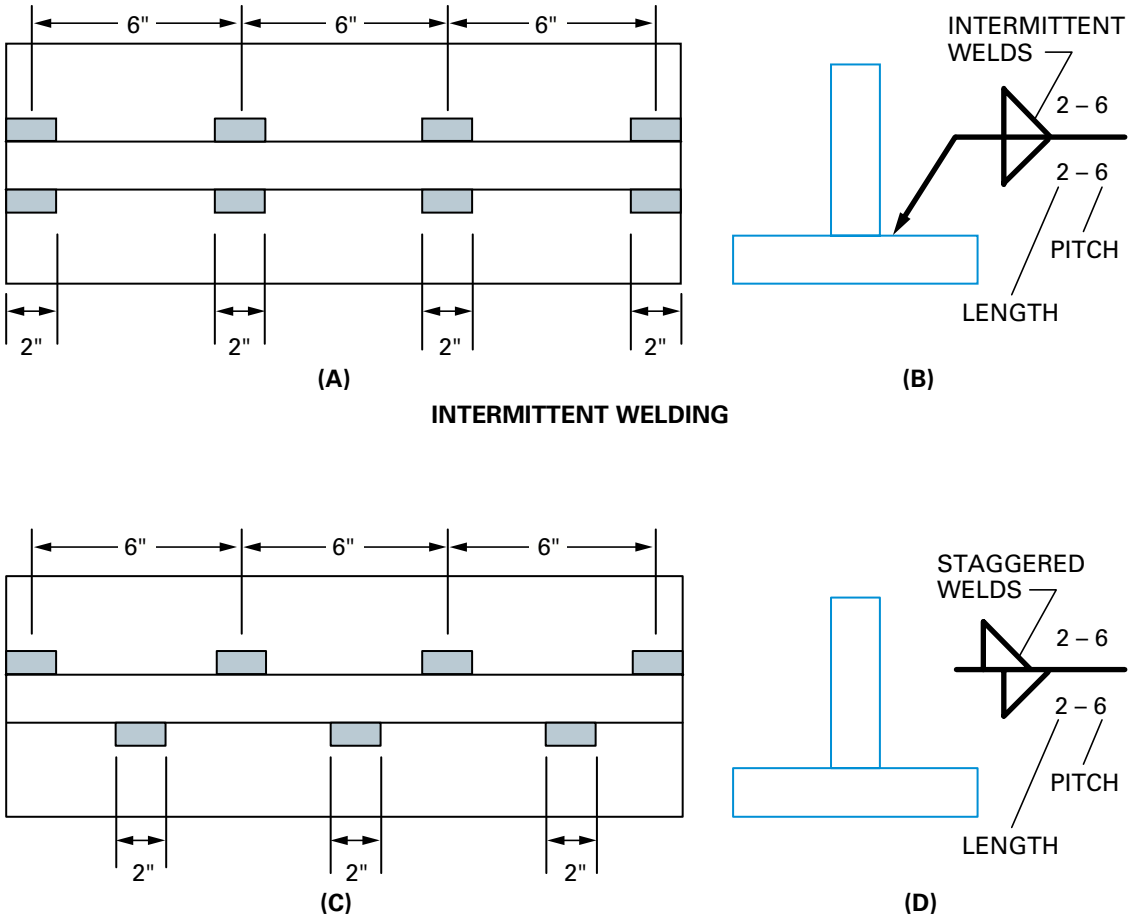


Figure 16 Sizing fillet welds.



INCHES	CENTIMETERS
2	5.1
6	15.2

Figure 17 Dimensioning fillet welds.

When there is no dimension to the right of the fillet weld symbol, the weld extends the full length of the joint.

1.2.3 Sizing Groove Welds

A groove weld is a weld that is made in the groove formed by two beveled pieces of metal (*Figure 18*).

Think About It

Location of Unequal Fillet Weld Legs

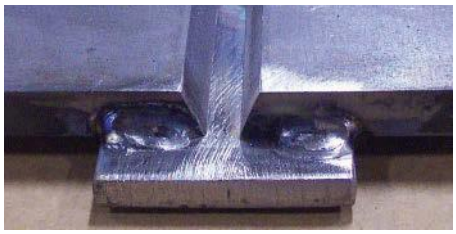
How does a welder determine which side of a fillet weld has the longer leg?

Several factors must be considered when sizing groove welds. These factors apply to all groove weld types.

Groove preparation is the depth to which the groove extends into the base metal. When the groove weld extends all the way through the joint, as shown in *Figure 19(A)*, no preparation size needs to be shown. When the groove weld extends only part of the way through the joint, as shown in *Figure 19(B)*, the depth of the groove is shown to the left of the symbol. *Figure 19(B)* shows sizing a groove with a depth of ¼ inch (6.4 mm).

For partial joint penetration (PJP) groove welds, both the depth of the groove and weld size (joint penetration) are shown, as in *Figure 20*. The depth of the groove is shown first and the weld size is shown next, in parentheses. In

U-GROOVE



V-GROOVE

BEVEL-GROOVE

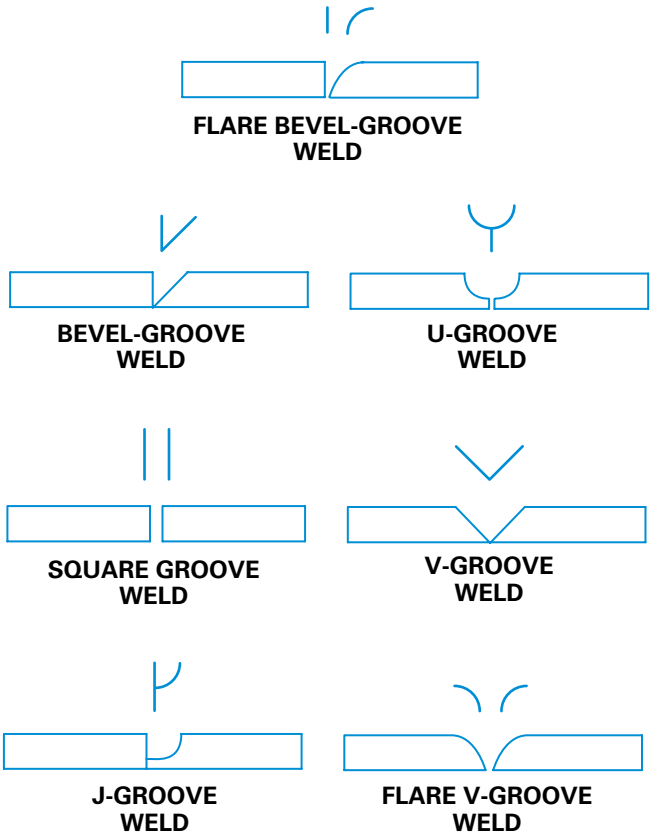


Figure 18 Types of groove welds.

this example, the groove depth is 0.25 inch (6.4 mm) and the weld size is 0.385 inch (9.8 mm). For complete joint penetration (CJP) groove welds, the weld metal extends through the joint thickness.

If a root opening is required, the root opening dimension of a groove weld will be shown inside the symbol. In *Figure 21*, the root opening is ⅛ inch (3.6 mm) and is shown on only the arrow-side symbol because the opening is common to both grooves.

The angle for the type of groove is shown above or below the welding symbol, depending on whether the symbol is above or below the reference line. In *Figure 22*, the groove angle is shown as 45 degrees and is shown only by the arrow-side symbol because the groove is the same on both sides. The bevel angle for groove preparation on each workpiece is 22½ degrees.

1.2.4 Dimensioning Groove Welds

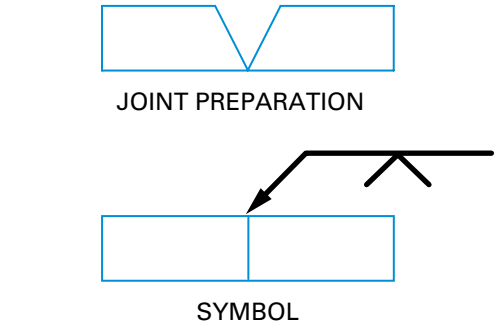
The length of a groove weld is shown to the right of the groove-weld symbol. If there is no dimension on the right of the groove-weld symbol, the weld extends the full length of the joint.

1.2.5 Sizing and Dimensioning Plug Welds

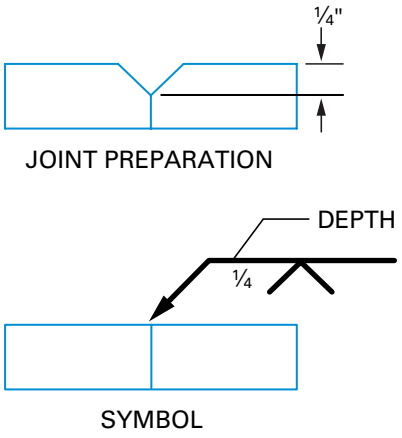
A plug weld is a weld made in a circular hole in one member of a joint, fusing that member to another member. The size of a plug weld, which is the diameter of the plug, is shown to the left of the welding symbol. The number of plug (and slot) welds can be shown below the symbol. If the plug is not completely filled, the depth of the fill is given inside the plug weld symbol, as shown in *Figure 23(A)*. If the plug weld is to be countersunk, the angle of the **countersink** is shown below or above the weld symbol, depending on which side of the reference line the symbol is on, as shown in *Figure 23(B)*. The pitch, shown in *Figure 23(C)*, represents the center-to-center spacing of the plugs shown in *Figure 23(B)* to the right of the plug weld symbol. *Figure 23* shows a composite view of sizing and dimensioning plug welds.

1.2.6 Sizing and Dimensioning Slot Welds

The only time depth of fill is used with a slot weld symbol is when the slots are partially filled. The partial depth of fill is shown in the symbol (*Figure 24*). All other information, such as length, width, spacing, angle of countersink, and location of slots, is shown in a special detail on the print.

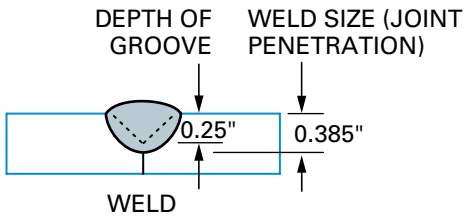


(A) COMPLETE JOINT PENETRATION (CJP) V-GROOVE WELD

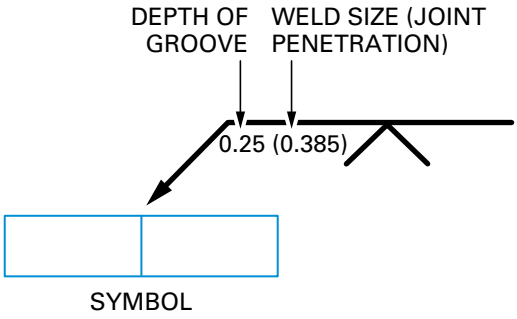


(B) PARTIAL JOINT PENETRATION (PJP) V-GROOVE WELD

Figure 19 Sizing groove welds.

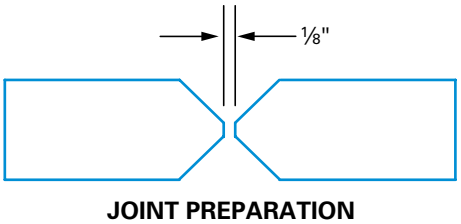


(A)



(B)

Figure 20 Sizing partial joint preparation (PJP) welds.



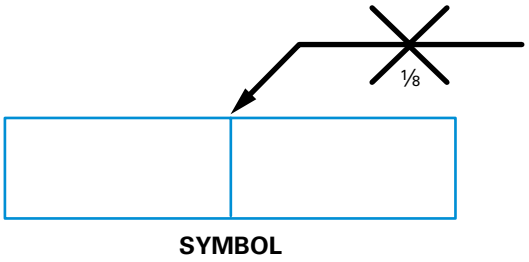


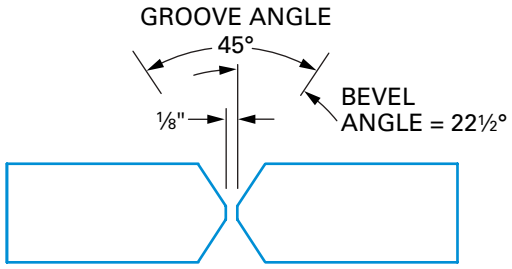
Figure 21 Sizing the root opening.

1.3.0 Supplemental Symbols

The following supplemental symbols are used to convey special instructions that apply to the welding symbol:

- Weld-all-around
- Field weld
- Contour finish (flush, convex, concave)

Figure 25 shows these and other supplemental symbols.



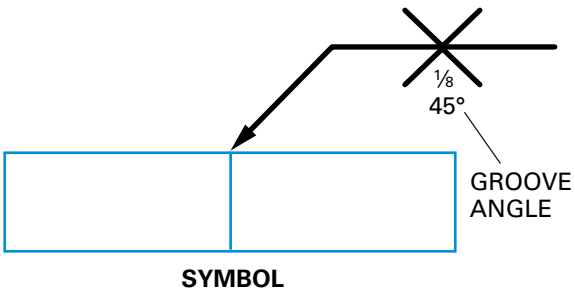
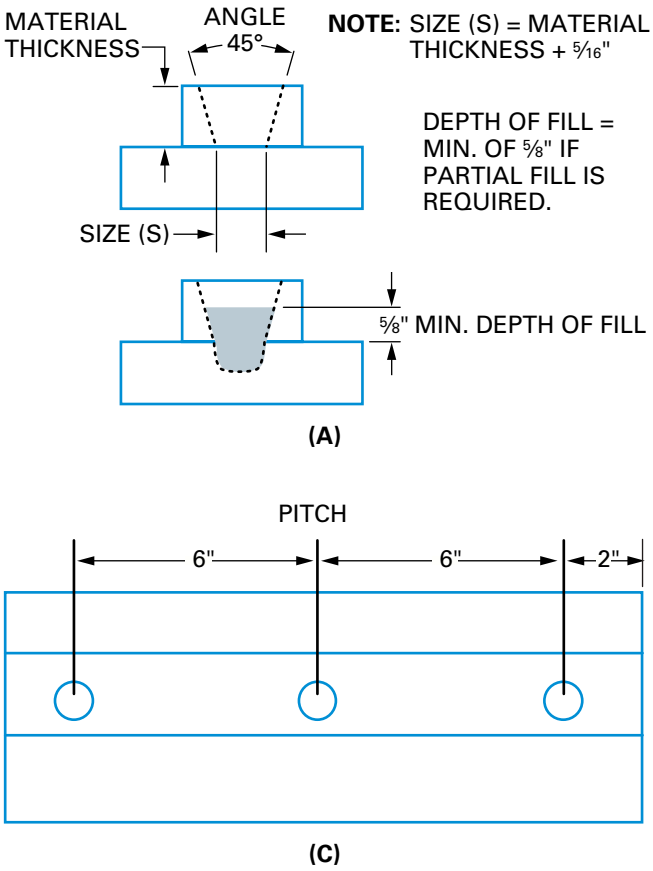
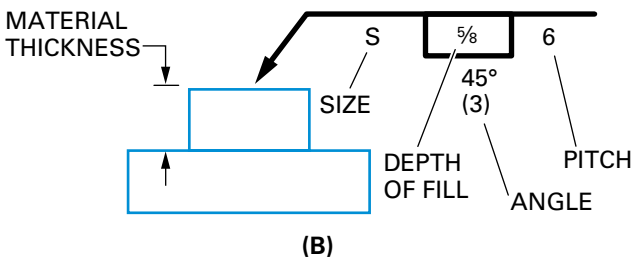


Figure 22 Specifying the groove angle.





TYPICAL PLUG WELD

INCHES	MILLIMETERS
5/16	7.9
5/8	15.9
2	50.8
6	152.4

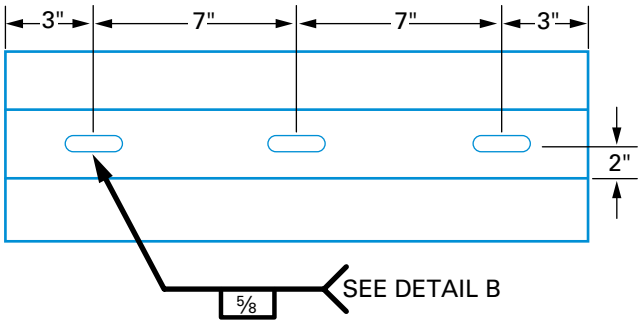
Figure 23 Sizing and dimensioning plug welds.

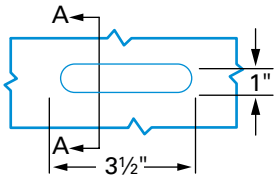
1.3.1 Weld-All-Around

When a weld is to extend completely around the joint, such as when welding a channel to a base plate, a small circle is shown where the arrow line meets the reference line. *Figures 25* and *26* both show examples of the symbol placement. *Figure 26* also shows the intended result of a typical weld-all-around symbol.

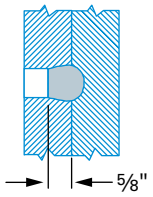
1.3.2 Field Weld

When the weld indicated by the welding symbol is to be made at a location other than that of the initial construction, a small flag is placed where the arrow line meets the reference line. The flag can be pointing either left or right. It can also point either up and down. *Figure 27* shows two examples of field welding symbols.





DETAIL B SLOT WELDS



SECTION A - A

TYPICAL SLOT WELD

INCHES	MILLIMETERS
⅝	15.9
1	25.4
2	50.8
3	76.2

Figure 24 Sizing slot welds.

1.3.3 Contour Finish

When the face of the weld must have a finished shape that is not its normal as-welded condition, a finish symbol that indicates a flush, convex, or concave surface is placed adjacent to the welding symbol. The method used to finish the weld face is specified by a letter, such as M for machining (*Figure 28*). *Table 1* shows the related finishing methods with their letter symbols.

The Letters TYP

The letters TYP (meaning typical) are placed in the tail of the welding symbol to indicate multiple joints of the same configuration. This eliminates duplication of the same welding symbol on the drawing.

1.4.0 Other Symbols

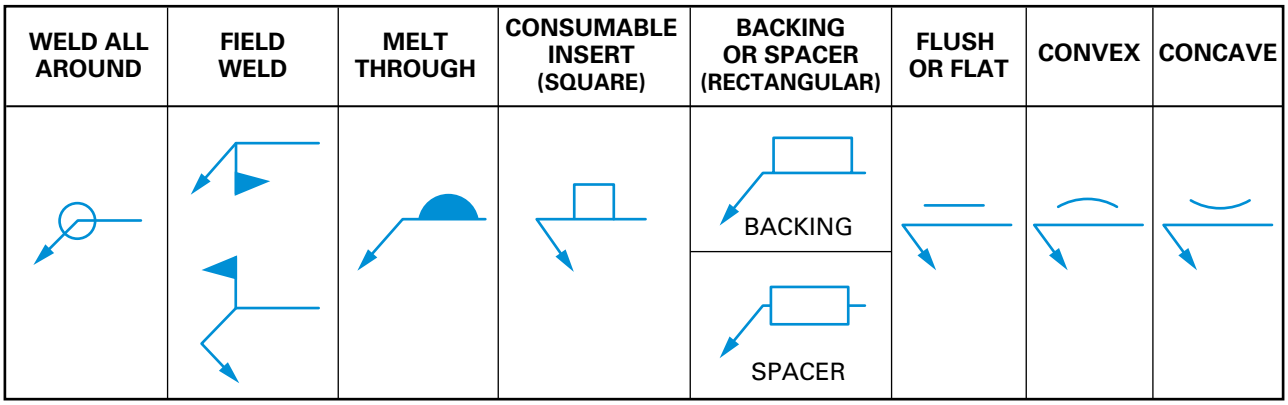
Other, less common weld symbols are shown in *Figure 29.* They include the following:

- Backing and spacer
- Back or backing
- Melt-through
- Surfacing
- Edge
- Spot
- Seam

If a consumable insert is required, details are provided with the symbol.

1.4.1 Backing and Spacer Symbols

Backing is used at the root of the weld to control melt-through. The backing can be metal strips or shapes, flux-coated tape, fiberglass-coated tape, or ceramic tape. The backing symbol is placed opposite a groove weld symbol on the reference line. The material, size, and shape of the backing are specified in the tail of the welding symbol. Spacers are metal strips or shapes that are placed at the root of the joint to control burn-through. They are used most often on double-groove joint preparations. The spacer symbol is centered on the reference line. The joint weld symbol is modified to project from the corners of the spacer symbol. The material and size of the spacer are noted in the tail of the welding symbol. *Figure 30* includes illustrations of typical backing and spacer symbols.



INCHES	MILLIMETERS
3 ½	88.9
7	177.8

Figure 25 Supplemental symbols.

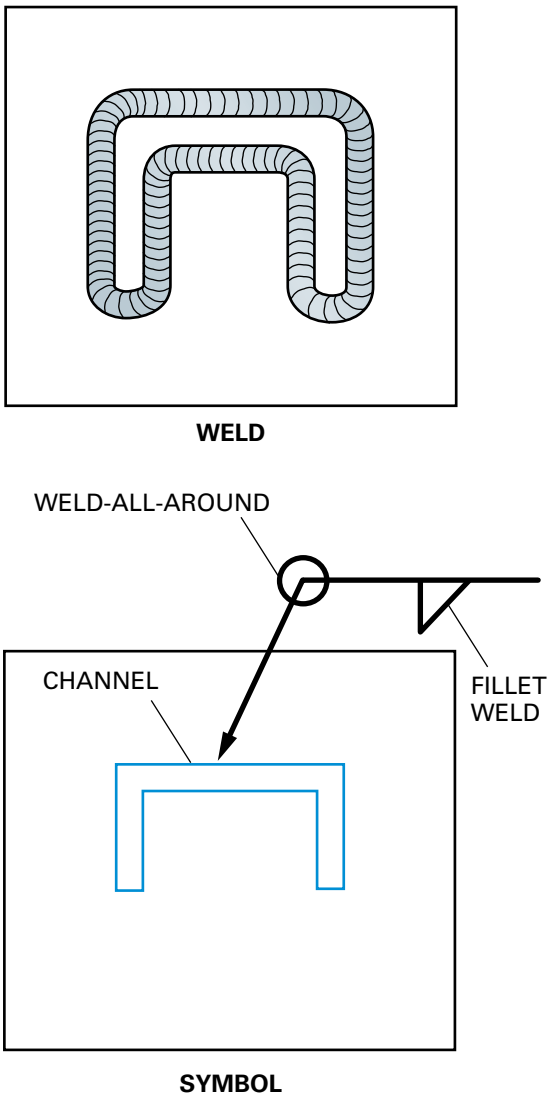


Figure 26 Weld-all-around symbol.

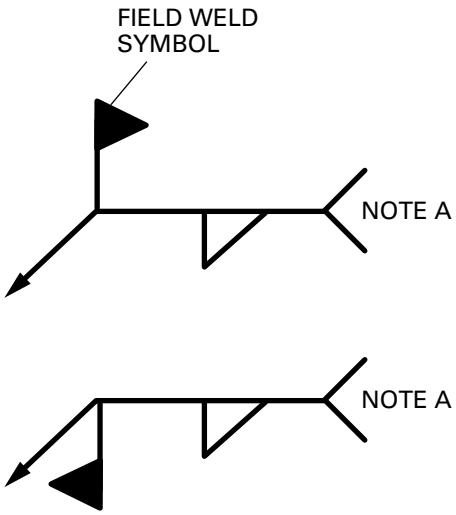


Figure 27 Field welding symbols.

1.4.2 Back or Backing Weld Symbols

A back weld is made after the groove weld. A backing weld is made before the groove weld. The same symbol is used to indicate either a back or a backing weld (*Figure 31*). The back or the backing weld symbol is placed opposite a groove weld symbol on the reference line. A note in the tail of the welding symbol indicates which weld is to be made.

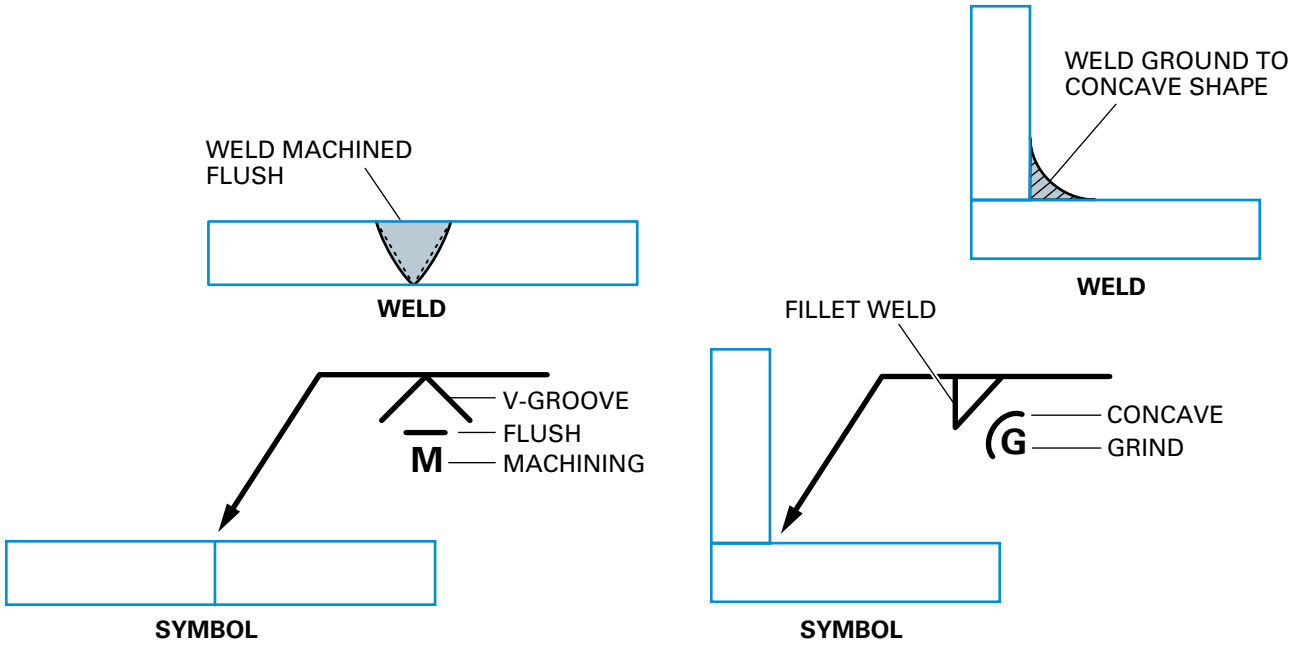


Figure 28 Examples of contour finishes and symbols.

Table 1 Finishing Methods

Method	Letter
Chipping	C
Grinding	G
Hammering	H
Machining	M
Rolling	R
Unspecified	U

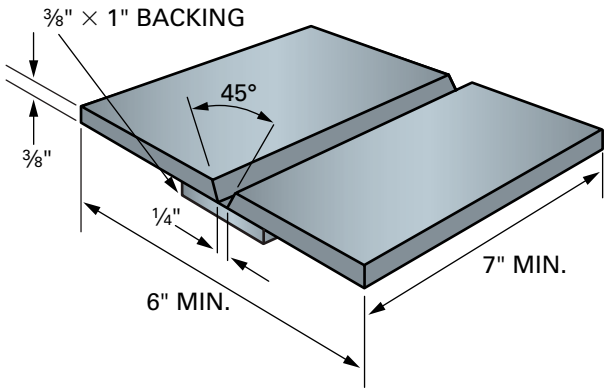
Think About It

Unspecified Contour Finishes

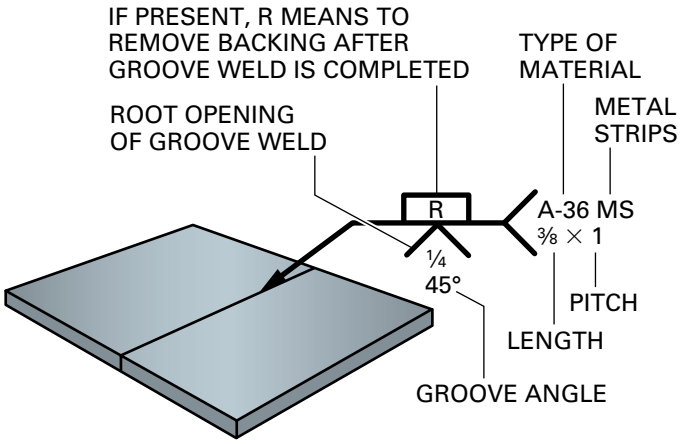
Refer to *Table 1*. What might an unspecified (U) contour finish mean?

BACKING, SPACER	BACK OR BACKING WELD	MELT THROUGH	SURFACING	EDGE	SPOT OR PROJECTION	SEAM
						

Figure 29 Other symbols.

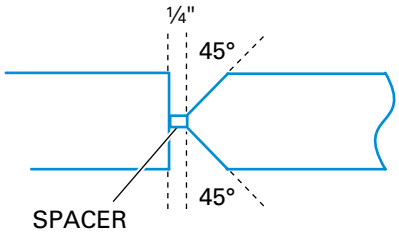


WELD PREPARATION

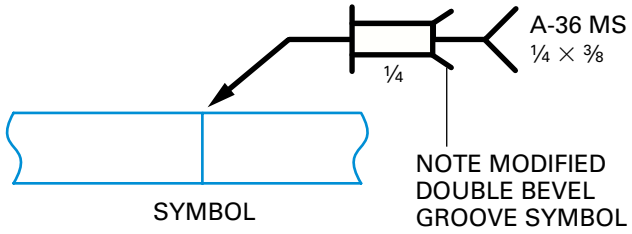


SYMBOL

BACKING



WELD PREPARATION



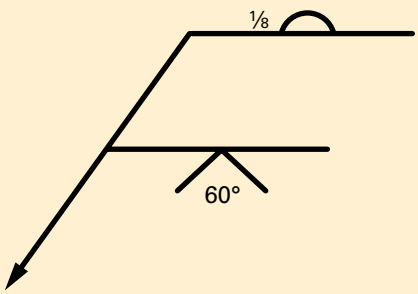
SPACER

INCHES	MILLIMETERS
¼	6.4
⅜	9.5
1	25.4
6	152.4
7	177.8

Figure 30 Backing and spacer symbols.

An Alternate Welding Symbol

The welding symbol shown in *Figure 31* could also be presented as a multiple line symbol. Using a multiple line symbol eliminates the need for the tail information showing the back weld. The multiple line symbol indicates that the first operation is the groove weld and the second operation, by definition, can only be a back weld rather than a backing weld.



1.4.3 Melt-Through Symbols

When complete penetration is required from one side of a joint and root reinforcement is desired, a melt-through symbol (*Figure 32*) can be used to specify the amount of melt-through. The symbol is placed opposite a groove weld symbol on the reference line. A melt-through symbol is similar in shape to the semi-circle of a back or a backing symbol. However, the semi-circle for a melt-through symbol is solidly filled in, instead of remaining blank. The amount of melt-through required is placed to the left of the melt-through symbol.

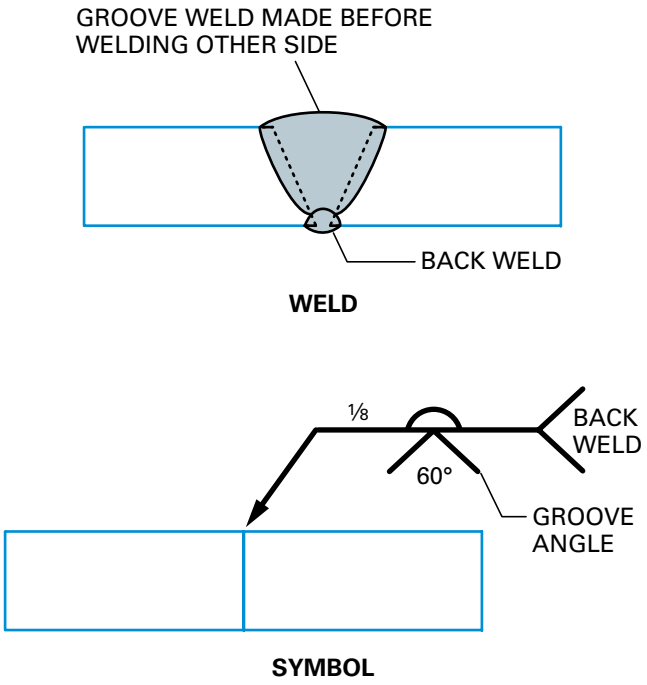


Figure 31 Back or backing weld symbol.

1.4.4 Surfacing Weld Symbols

The AWS defines surfacing as "the application by welding, brazing, or thermal spraying of a layer of material to a surface to obtain desired properties or dimensions, as opposed to making a joint." Examples of surfacing welds are shown in *Figure 33*. A surfacing weld symbol is used when a surface is to be built up with weld. The depth of buildup is indicated to the left of the symbol.

When less than the entire surface is to be built up, the surface to be built up is dimensioned on the blueprint in a detail drawing.

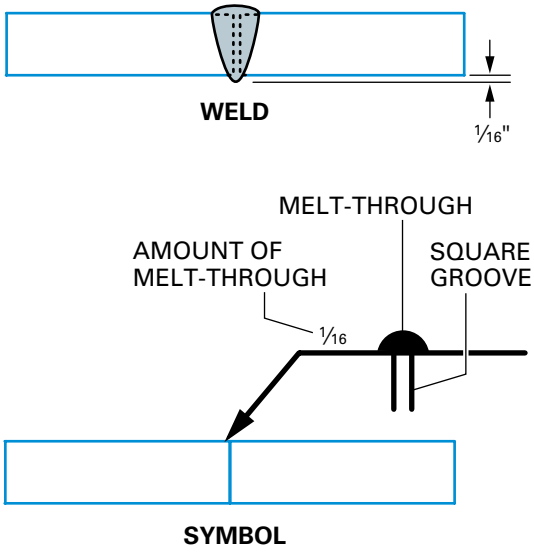
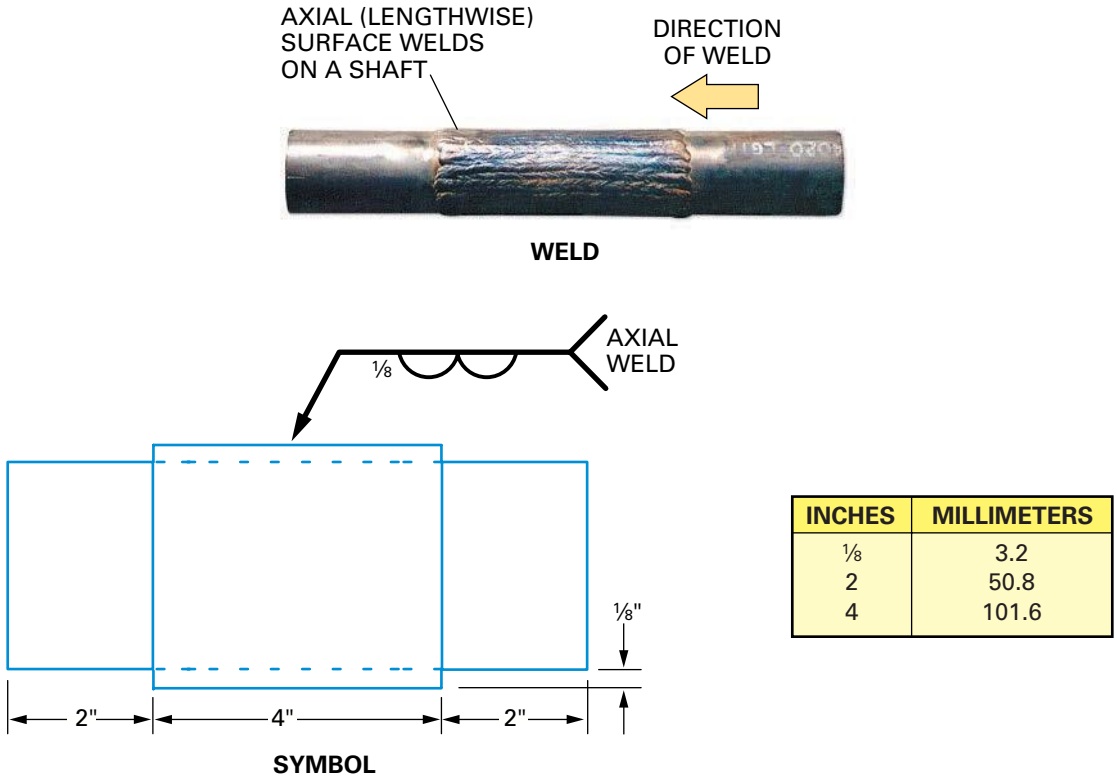


Figure 32 Melt-through symbol.



INCHES	MILLIMETERS
⅛	3.2
2	50.8
4	101.6

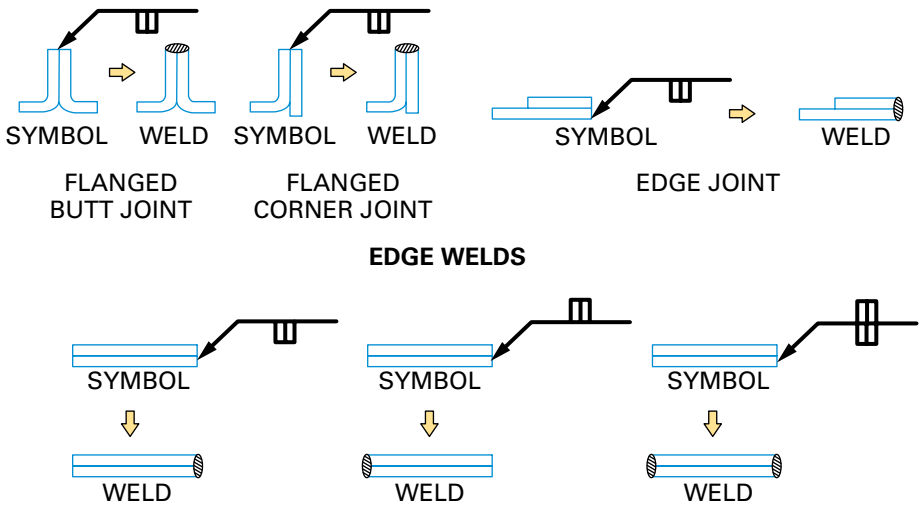
Figure 33 Surfacing welds and symbols.

1.4.5 Edge Weld Symbols

The AWS defines an edge weld as "a joint between the edges of two or more parallel or nearly parallel members." Edge welds are commonly used on sheet metal and can be flanged butt joints or flanged T-joints. *Figure 34* shows a variety of edge welds, symbols, and dimensioning.

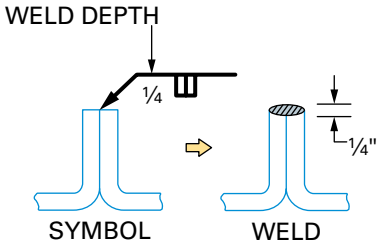
1.4.6 Spot Weld Symbols

Spot welding (*Figure 35*) is a process used to join sheet metal using a series of small spots. There are two types: resistance spot welding (RSW) and arc spot welding. RSW uses electrical resistance heating and clamping pressure to fuse sheet metal panels. Arc spot welding involves either gas metal arc welding (GMAW) or gas tungsten arc welding (GTAW). The process used to make the spot weld is specified in the tail. The size of a spot weld is indicated to the left of the symbol. The pitch is indicated to the right of the symbol. The number of spot welds is defined in parentheses beneath the symbol. For arrow-side spot welds, the circle is placed on the bottom of the reference line. When the spot weld is placed on the other side, the circle is placed on top of the reference line. When there is no side significance (such as with a resistance spot), the circle is centered on the reference line. The drawings will define the starting or ending locations for the spot welds.

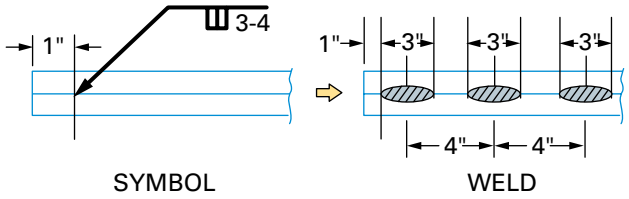


EDGE WELDS

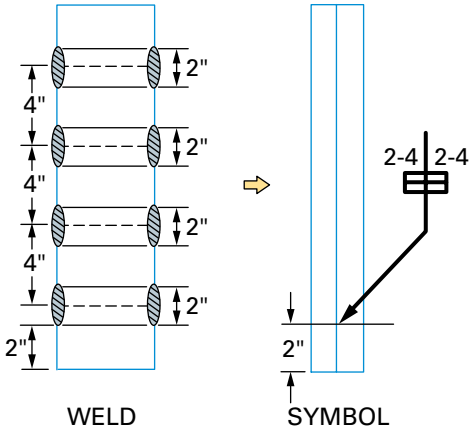
PARALLEL PLATE EDGE JOINTS



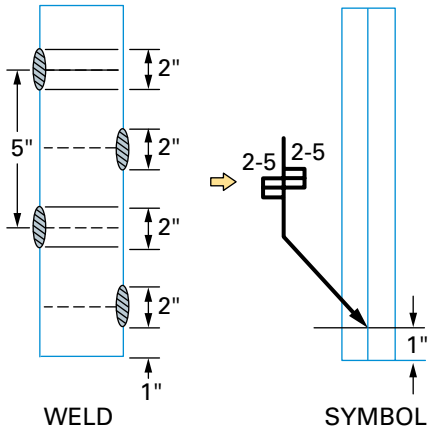
DEFINING WELD DEPTH



INTERMITTENT WELDS



INTERMITTENT, BOTH SIDES WELDS



INTERMITTENT, BOTH SIDES STAGGERED WELDS

INCHES	MILLIMETERS
¼	6.4
1	25.4
2	50.8
3	76.2
4	101.6
10	254

Figure 34A Edge welds and symbols (1 of 2).

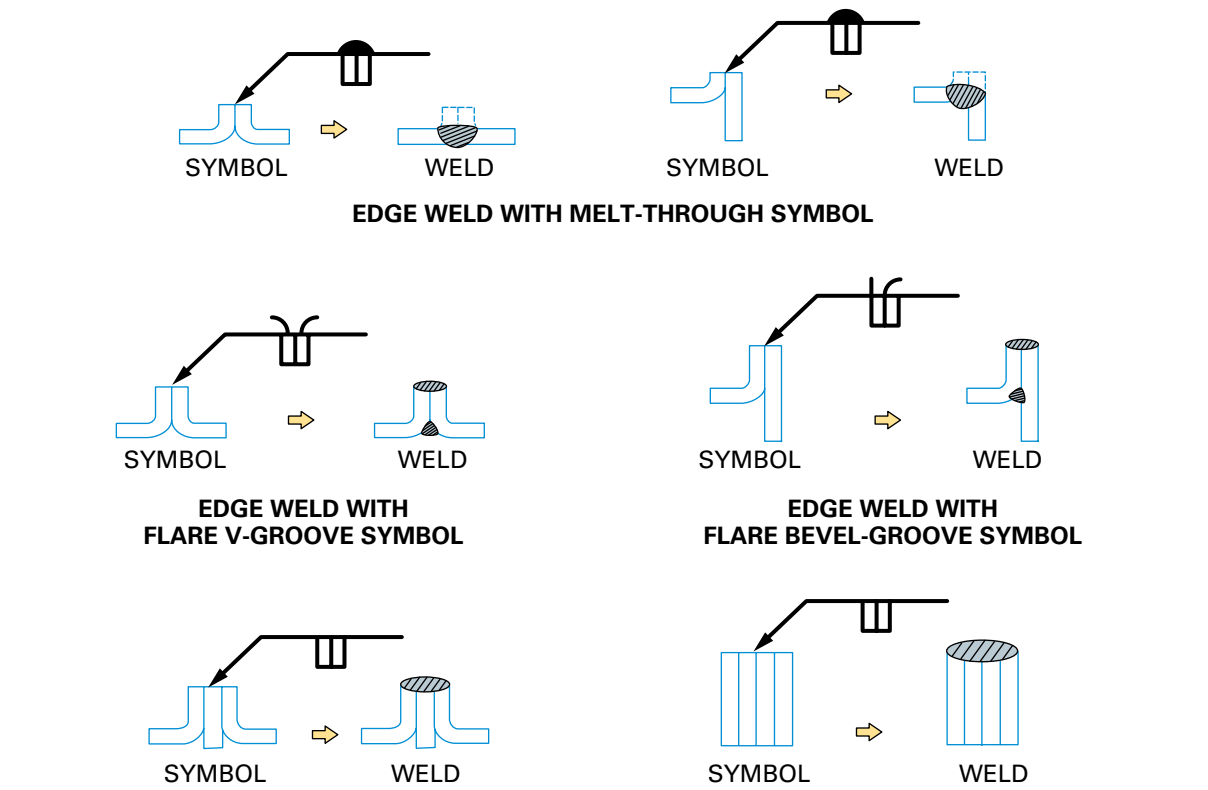


Figure 34B Edge welds and symbols (2 of 2).

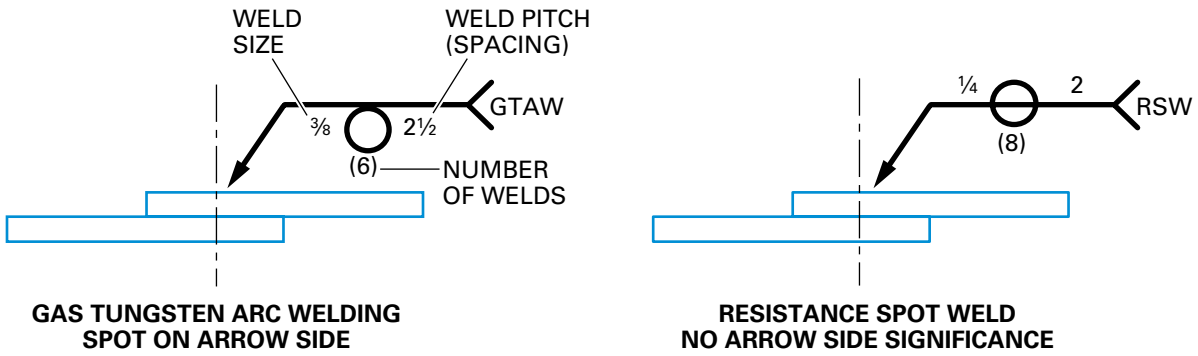
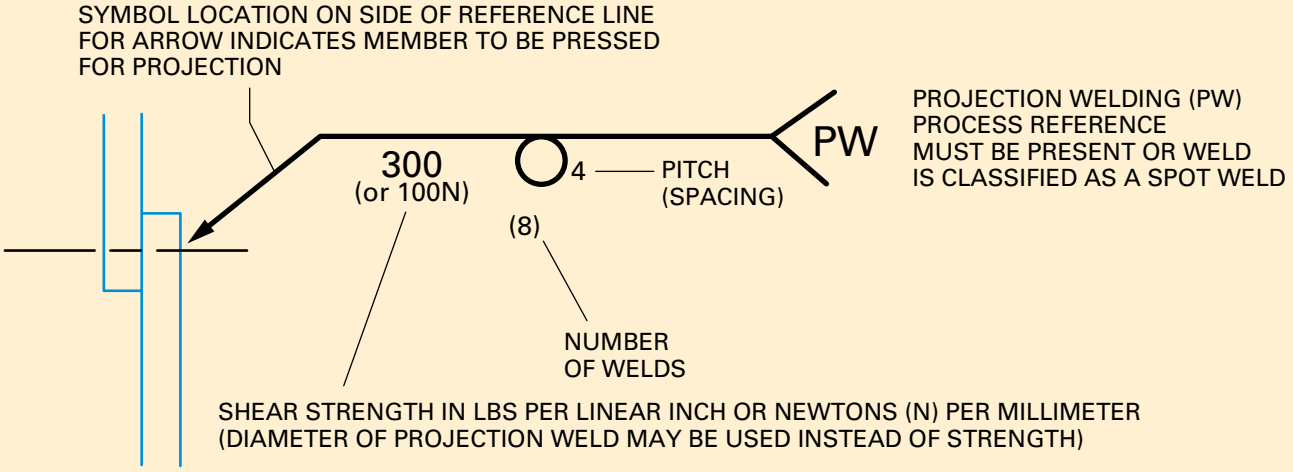


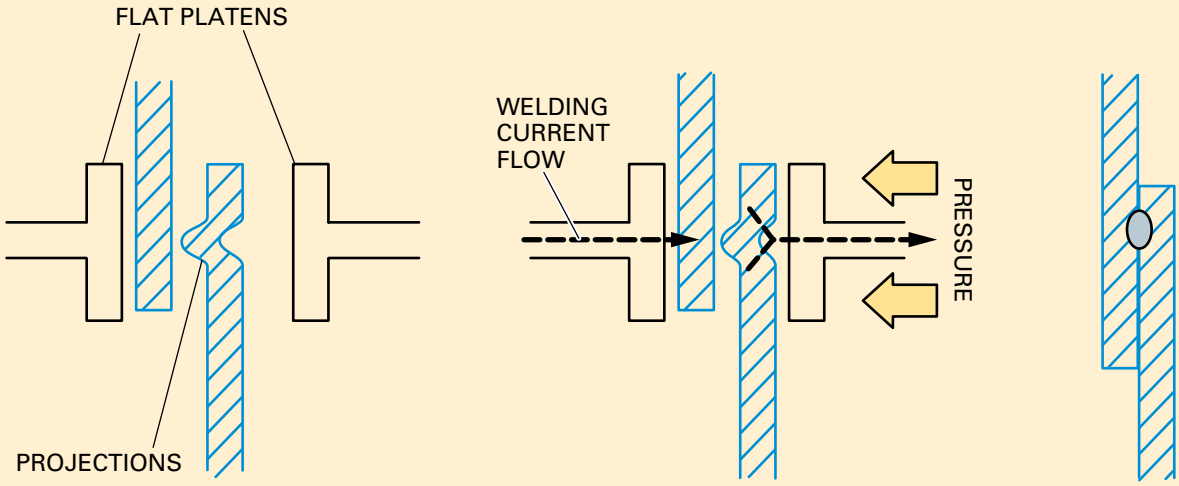
Figure 35 Spot weld symbols.

Projection Welding

Projection welding (PW) is a type of spot welding in which a number of welds are performed simultaneously with one welding machine. Because of tooling costs, projection welding is primarily used in high-production applications.

Prior to welding, one of the members to be joined is passed through a machine that presses projections at specified locations on the member. This member is joined to another member in a welding machine by pressing the two members together and applying current through the projections. The resistance at the points of contact of the projections causes the members to heat, melt, and fuse together while under pressure. This results in welded members that are fused closely together. The side without the projections has minimal surface marking as a result of the weld.





STEP 1 ONE MEMBER IS PRESSED TO CREATE PROJECTIONS AND BOTH MEMBERS ARE PLACED BETWEEN FLAT PLATENS IN WELDING MACHINE

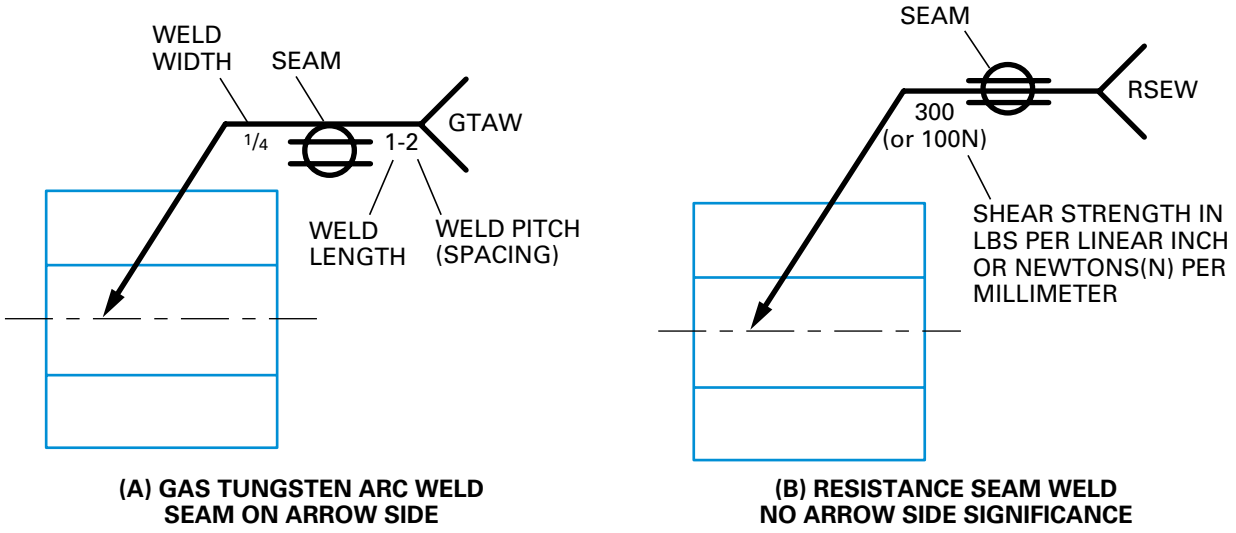
STEP 2 MEMBERS HEAT AND MELT AT PROJECTIONS UNDER PRESSURE

STEP 3 COMPLETED WELD

1.4.7 Seam Weld Symbols

Seam welding is used to join two pieces of sheet metal in a continuous seam or in a series of overlapping spot welds. Several processes can be used to make a seam weld. The most common are GMAW, GTAW, and resistance seam welding (RSEW). The process used to make the seam weld is specified in the tail. The size of a seam weld (width) or strength of the weld is given to the left of the symbol. The length and pitch are given on the right of the symbol for intermittent welds. For welds that are less than the full length of the joined members, the drawing details the starting point and the length of the weld.

For arrow-side seam welds, the circle is placed on the bottom of the reference line, as shown in *Figure 36(A)*. When the seam weld is placed on the other side, the circle is placed on top of the reference line. When there is no side significance, such as with a resistance weld seam, the circle is centered on the reference line, as shown in *Figure 36(B)*. Flush contour symbols can be applied to seam weld symbols for other than resistance weld seams. For parallel seams, a drawing note detailing the spacing and number of seams is included in the tail.



(A) GAS TUNGSTEN ARC WELD SEAM ON ARROW SIDE

(B) RESISTANCE SEAM WELD NO ARROW SIDE SIGNIFICANCE

Figure 36 Seam weld symbols.

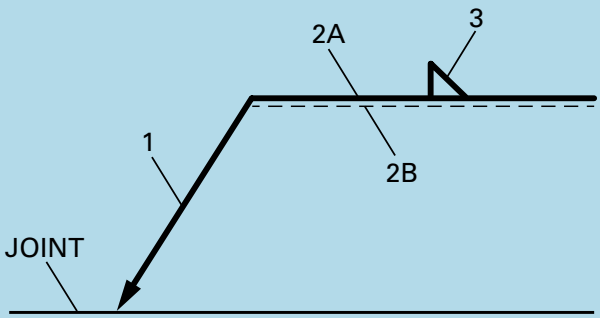
Around the World

AWS and ISO Welding Symbol Standards

AWS A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination is the welding symbols standard used in the United States. AWS welding symbols comply with the requirements of the American National Standards Institute (ANSI) and are designated ANSI/AWS. The AWS system of welding symbols has long been used in the oil industry, which is a global enterprise. Today, the AWS system is used by approximately half of the world's welding industry.

The other widely used welding symbols standard is *ISO 2553, Welded, Brazed, and Soldered Joints — Symbolic Representation on Drawings*. The ISO system was designed by the International Organization for Standardization (ISO).

The AWS and the ISO systems are very similar. For example, the reference line and arrow system in the ISO system are the same as in the AWS system. There are, however, differences that welders need to be aware of in order to interpret the symbols correctly. The most significant difference, as shown in *Figure A*, is that the ISO system uses a dashed identification line that is not used in the AWS system. The dashed identification line, which may be drawn above or below the solid reference line, is used to indicate the other side of the joint. Information that applies to the arrow side of the joint is placed on the solid reference line. Information that applies to the other side of the joint is placed on the dashed line.

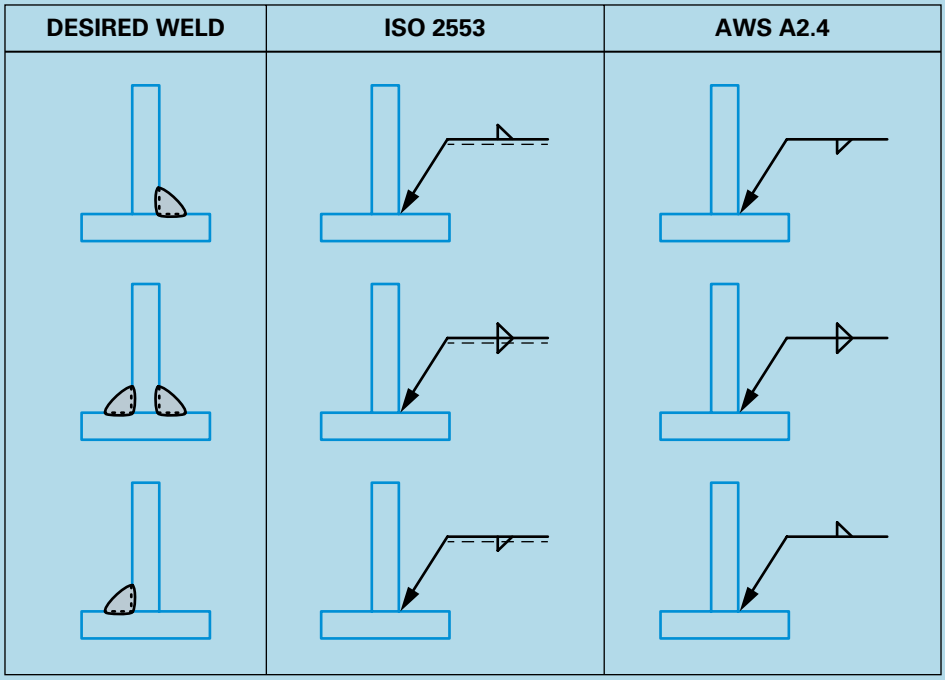


1. ARROW LINE
2A. REFERENCE LINE (CONTINUOUS LINE)
2B. IDENTIFICATION LINE (DASHED LINE)
3. WELDING SYMBOL

(A) ISO WELDING SYMBOL SYSTEM

Figure B uses fillet welding symbols as an example to further illustrate typical differences between AWS and ISO welding symbols.

Some countries that have extensive international trade relationships have actually used one system of welding symbols in their own country and symbols from the other system as needed to satisfy the requirements of their overseas customers. With the publication of *ISO 2553-2013*, the ISO has sought to provide a set of standardized welding symbols that recognizes both the AWS and the ISO welding symbol systems and can be applied on a worldwide basis.



(B) COMPARISON OF ISO AND AWS SYMBOLS

Additional Resources

ASTM A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength. West Conshohocken, PA: ASTM International.

AWS A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination. Miami, FL: American Welding Society.

AWS A3.0, Standard Definitions; Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying. Miami, FL: American Welding Society.

AWS D1.1/D1.1M, Structural Welding Code Steel. Miami, FL: American Welding Society.

How to Read Shop Drawings. Cleveland, OH: The James F. Lincoln Arc Welding Foundation, 2012.

ISO 2553, Welded, Brazed, and Soldered Joints—Symbolic Representation on Drawings. Geneva, Switzerland: International Organization for Standardization (ISO).

Steel Construction Manual. 14th Edition. Chicago, IL: American Institute of Steel Construction, 2011.

1.0.0 Section Review

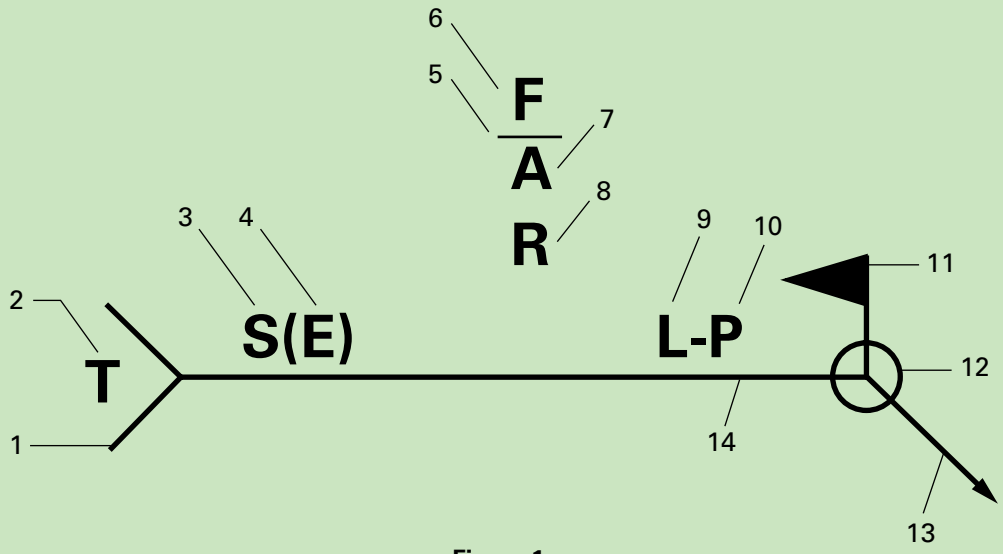


Figure 1

1. Match each of the terms listed below to the number that identifies the corresponding welding symbol shown on *Section Review Question Figure 1*.
   a. Arrow line = ____
   b. Groove weld size = ____
   c. Field weld symbol = ____
   d. Specification or process = ____
   e. Reference line = ____

2. A weld made in a corner is a ____.
   a. slot weld
   b. fillet weld
   c. plug weld
   d. groove weld

3. Which one of the symbols in *Section Review Question Figure 2* is a supplemental symbol?
   a. Symbol A
   b. Symbol B
   c. Symbol C
   d. Symbol D

4. The symbol in *Section Review Question Figure 3* that indicates that complete penetration from one side of a joint and root reinforcement are required is ____.
   a. Symbol A
   b. Symbol B
   c. Symbol C
   d. Symbol D

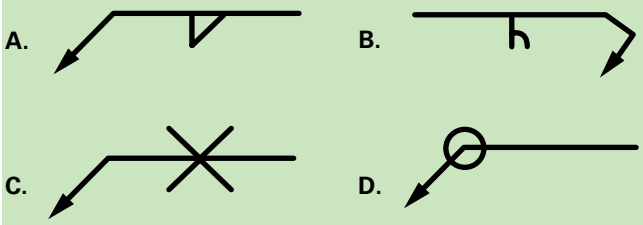


Figure 2

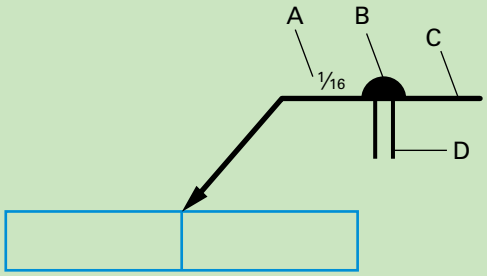


Figure 3

SUMMARY

Welding symbols are a graphic language that is used to convey precise instructions about how a weld is to be made. By learning the symbols and the basic rules for applying them, welders build a foundation of knowledge that they must have in order to accurately prepare and make the required welds. This module covered the welding and weld symbols used to convey the design specifications for various types of welds. Understanding these symbols is an essential preparation for using and interpreting WPS and design drawings.

Review Questions

1. The welding symbol describes the type of weld, its size, and its ____.
   a. surface finish
   b. tail references
   c. cutting process
   d. depth of field

2. The side of the joint or surface that is opposite the side to which the arrow of a reference line is pointing is called the ____.
   a. arrow side
   b. other side
   c. tail joint
   d. countersink

3. Regardless of which end of the reference line the arrow line is on, information on the reference line is always read from ____.
   a. top to bottom
   b. bottom to top
   c. left to right
   d. right to left

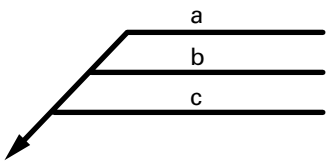


Figure 1

4. In the welding symbol shown in *Review Question Figure 1*, the operation to be conducted first is ____.
   a. Operation A
   b. Operation B
   c. Operation C
   d. not critical

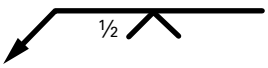


Figure 2

5. In the welding symbol shown in *Review Question Figure 2*, ½ represents the ____.
   a. size of the weld
   b. width of the weld
   c. length of the weld
   d. depth of preparation

6. In relation to the fillet weld symbol, the fillet weld size is placed ____.
   a. above the symbol
   b. below the symbol
   c. to the left of the symbol
   d. to the right the symbol

Figure 3

7. In the welding symbol shown in *Review Question Figure 3*, the number 9 represents the weld ____.
   a. pitch
   b. depth
   c. width
   d. length

8. In relation to the plug weld symbol, the pitch of a plug weld is shown ____.
   a. above the symbol
   b. below the symbol
   c. to the left of the symbol
   d. to the right of the symbol

9. The field weld symbol is a(n) ____.
   a. number
   b. letter
   c. arrow
   d. flag

10. When the face of the weld must have a finished shape, a finish symbol is placed adjacent to the welding symbol, along with a letter indicating ____.
    a. size of the weld
    b. method of finish
    c. smoothness of the finish
    d. width of the finished area

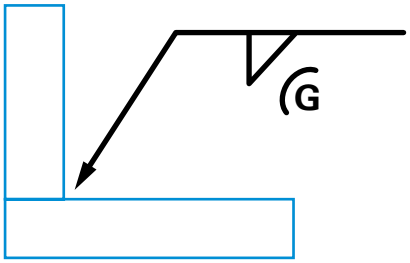


Figure 4

11. The finish of the weld face in *Review Question Figure 4* is to be achieved by ____.
    a. filleting
    b. grinding
    c. chipping
    d. reaming

12. When backing is to be used at the root of the weld to control melt-through, the backing symbol is placed opposite which weld symbol on the reference line?
    a. tail
    b. field
    c. spacer
    d. groove

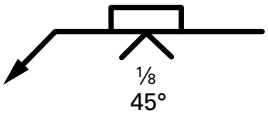


Figure 5

13. In the weld symbol shown in *Review Question Figure 5*, the numbers inside the symbol represent the ____.
    a. root opening and groove angle
    b. groove angle and depth
    c. root opening and pitch
    d. pitch and angle

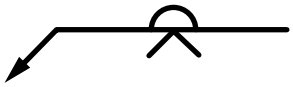


Figure 6

14. The type of weld symbol shown above the reference line in *Review Question Figure 6* is a ____.
    a. spot weld
    b. back weld
    c. surfacing weld
    d. melt-through

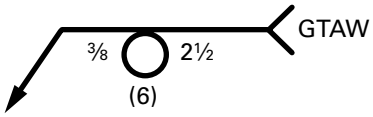


Figure 7

15. The type of weld represented by the weld symbol in *Review Question Figure 7* is a ____.
    a. spot weld
    b. backing weld
    c. surfacing weld
    d. melt-through

Appendix A

Letter Designations for Welding Processes			
AAW	Air Acetylene Welding	GTAW	Gas Tungsten Arc Welding
AB	Adhesive Bonding	GTAW-P	Gas Tungsten Arc Welding–Pulsed Arc
AHW	Atomic Hydrogen Welding	HPW	Hot Pressure Welding
AW	Arc Welding	IB	Induction Brazing
B	Brazing	IRB	Infrared Brazing
BB	Block Brazing	IW	Induction Welding
BMAW	Bare Metal Arc Welding	LBW	Laser Beam Welding
CAW	Carbon Arc Welding	OAW	Oxyacetylene Welding
CAW-G	Gas Carbon Arc Welding	OHW	Oxyhydrogen Welding
CAW-T	Twin Carbon Arc Welding	PAW	Plasma Arc Welding
CEW	Coextrusion Welding	PEW	Percussion Welding
CW	Cold Welding	PGW	Pressure Gas Welding
DP	Dip Brazing	PW	Projection Welding
DFB	Diffusion Brazing	RB	Resistance Brazing
DFW	Diffusion Welding	ROW	Roll Welding
EBW	Electronic Beam Welding	RSEW	Resistance Seam Welding
EBW-HV	Electronic Beam Welding–High Vacuum	RSEW-HF	Resistance Seam Welding–High Frequency
EBW-MV	Electronic Beam Welding–Medium Vacuum	RSEW-I	Resistance Seam Welding–Induction
EBW-NV	Electronic Beam Welding–Nonvacuum	RSW	Resistance Spot Welding
EGW	Electrogas Welding	RW	Resistance Welding
ESW	Electroslag Welding	SAW	Submerged Arc Welding
EXW	Explosion Welding	SAW-S	Series Submerged Arc Welding
FB	Furnace Brazing	SMAW	Shielded Metal Arc Welding
FCAW	Flux Cored Arc Welding	SSW	Solid-State Welding
FLB	Flow Brazing	SW	Stud Arc Welding
FLOW	Flow Welding	TB	Torch Brazing
FOW	Forge Welding	TCAB	Twin Carbon Arc Brazing
FRW	Friction Welding	TW	Thermite Welding

Appendix B

Letter Designations for Cutting Processes			
AC	Arc Cutting	LOC	Oxygen Lance Cutting
AOC	Oxygen Arc Cutting	MAC	Metal Arc Cutting
CAC	Carbon Arc Cutting	OC	Oxygen Cutting
CAC-A	Air Carbon Arc Cutting	OC-F	Flux Cutting
EBC	Electron Beam Cutting	OFC	Oxyfuel Gas Cutting
GMAC	Gas Metal Arc Cutting	OFC-A	Oxyacetylene Cutting
GTAC	Gas Tungsten Arc Cutting	OFC-H	Oxyhydrogen Cutting
LBC	Laser Beam Cutting	OFC-N	Oxynatural Gas Cutting
LBC-A	Laser Beam Cutting–Air	OFC-P	Oxypropane Cutting
LBC-EV	Laser Beam Cutting–Evaporative	OC-P	Metal Powder Cutting
LBC-IG	Laser Beam Cutting–Inert Gas	PAC	Plasma Arc Cutting
LBC-O	Laser Beam Cutting–Oxygen	SMAC	Shielded Metal Arc Cutting

Appendix C

Letter Designations for Applying Welding Processes	
AU	Automatic
ME	Mechanized
MA	Manual
SA	Semi-Automatic

Trade Terms Introduced in This Module

Arrow line: The line drawn at an angle from the reference line (either end or both ends) to an arrowhead at the location of the weld.

Countersink: A hole with tapered sides and a wider opening that allows a flat-head fastener to seat flush to the surface of the material in which the hole is made.

Pitch: The center-to-center distance between welds.

Reference line: The horizontal line in the center of the welding symbol from which all elements of the welding symbol are referenced. The reference line is one of the most important elements of the welding symbol.

Weld symbol: A graphic character connected to the reference line of a welding symbol specifying the weld type.

Welding symbol: A graphical representation of the specifications for producing a welded joint; includes a reference line and arrow line and many also include a weld symbol.

Additional Resources

This module is intended as a thorough resource for task training. The following reference works are suggested for further study.

ASTM A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength. West Conshohocken, PA: ASTM International.

AWS A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination. Miami, FL: American Welding Society.

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Steel Construction Manual. 14th Edition. Chicago, IL: American Institute of Steel Construction, 2011.

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Topaz Publications, Inc., Figures 7 (photos), 24 (photo), 33 (photo)

Specialty Welding & Fabricating of New York, Inc., Figures 18 (photos), 23 (photos)

Section Review Answer Key

Answer	Section Reference	Objective
Section One		
1. a. 13 b. 4 c. 11 d. 2 e. 14	1.1.0	1a
2. b	1.2.1	1b
3. d	1.3.0	1c
4. b	1.4.3	1d

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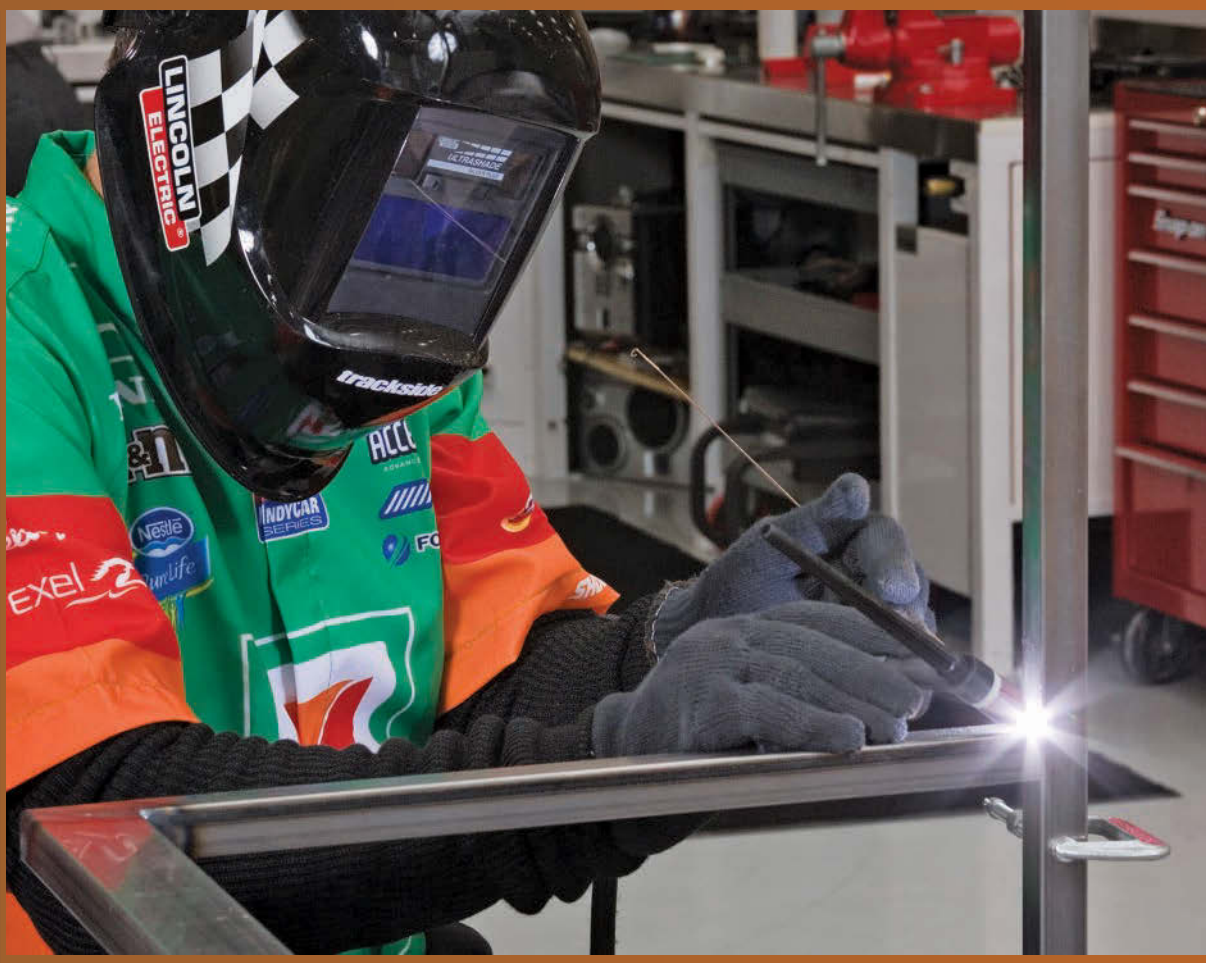
Reading Welding Detail Drawings



Overview

Reading and interpreting the information contained on construction drawings is an essential skill for welders. Incorrectly interpreting this information can result in producing work that fails to meet design specifications, building codes, and safety standards. This module focuses on how to read and interpret assembly and detail drawings. It introduces the various object views and basic drawing elements that are used in welding detail drawings. It also explains how to interpret dimensional information, notes, and bills of materials.

Module Two