

## Module Overview

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This module explains how to identify, interpret, and draw welding symbols on specifications, drawings, and welding procedure specifications (WPS).

## Prerequisites

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Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum* and *Welding Level One*.

## Objectives

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Upon completion of this module, the trainee will be able to do the following:

1. Identify and explain the various parts of a welding symbol.
2. Identify and explain fillet and groove weld symbols.
3. Read welding symbols on drawings, specifications, and welding procedure specifications.
4. Interpret welding symbols from a print.

## Performance Tasks

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

1. Identify and interpret welding symbols on a provided drawing.

## Materials and Equipment List

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Markers/chalk  
Pencils and scratch paper  
Whiteboard/chalkboard  
Welding 2 PowerPoint® Presentation Slides  
(ISBN 0-13-213025-4)  
Multimedia projector and screen  
Desktop or laptop computer  
*AWS A2.4:2007 Standard Symbols for Welding,  
Brazing, and Nondestructive Examination*  
Drawing #AWS EDU-1 (from page 111 of  
*AWS EG 2.0:2006*)

Sample site quality standard  
Various weld samples as available, including:  
Fillet welds  
V-groove welds  
Plug welds  
Slot welds  
Samples of various weld joints  
Module Examinations\*  
Performance Profile Sheets\*

\*Located in the Test Booklet.

## Additional Resources

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This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

- ASTM A325-07a Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength*. West Conshohocken, PA: ASTM International, 2007.
- AWS A2.4:2007 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, 2001.
- AWS D1.1/D1.1M:2008 Structural Welding Code Steel*. Miami, FL: American Welding Society.
- How to Read Shop Drawings*. Cleveland, OH: The James F. Lincoln Arc Welding Foundation, 2008.
- Steel Construction Manual*. 13th ed. Chicago, IL: American Institute of Steel Construction, 2008.

## Teaching Time for this Module

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An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 5 hours are suggested to cover *Welding Symbols*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of trainees may be noted during these exercises for Performance Testing purposes.

Topic	Planned Time
<b>Session I. Introduction to Welding Symbols</b>	
A. Introduction	_____
B. Standard Symbols	_____
C. Welding Symbol Base	_____
1. Weld Symbols	_____
2. Location of Weld Symbols	_____
3. Combining Weld Symbols	_____
4. Sizing and Dimensioning Welds	_____
<b>Session II. Supplemental and Other Weld Symbols; Review and Testing</b>	
A. Supplemental Symbols	_____
1. Weld-All-Around	_____
2. Field Weld	_____
3. Contour Finish	_____
B. Other Weld Symbols	_____
1. Backing and Spacer	_____
2. Back or Backing	_____
3. Melt-Through	_____
4. Surfacing	_____
5. Edge	_____
6. Spot	_____
7. Seam	_____
C. Laboratory	_____
Have trainees practice identifying and interpreting welding symbols on a provided drawing. This laboratory corresponds to Performance Task 1.	
D. Review	_____
E. Module Examination	_____
1. Trainees must score 70% or higher to receive recognition from NCCER.	
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.	
F. Performance Testing	_____
1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.	
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.	

## Module Overview

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This module describes welding detail drawings and their components, including lines, fills, solid round and pipe (or tubing) breaks, and revolved sections. Object views, dimensioning, notes, and bills of materials are also covered.

## Prerequisites

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Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *Welding Level One*; and *Welding Level Two*, Module 29201-09.

## Objectives

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Upon completion of this module, the trainee will be able to do the following:

1. Identify and explain a welding detail drawing.
2. Identify and explain lines, material fills, and sections.
3. Identify and explain object views.
4. Identify and explain dimensioning.
5. Identify and explain notes and bill of materials.
6. Interpret basic elements of a welding detail drawing.
7. Sketch or draw basic welding drawings.

## Performance Tasks

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

1. Draw or sketch a welding drawing based on a given image or object.

## Materials and Equipment List

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Markers/chalk	Sample welding drawings
Pencils and scratch paper	Predrilled bar stock scaled to the drawings in Figure 18
Whiteboard/chalkboard	Drawing with a missing dimension
Welding 2 PowerPoint® Presentation Slides (ISBN 0-13-213025-4)	Welding-related bill of materials
Multimedia projector and screen	Module Examinations*
Desktop or laptop computer	Performance Profile Sheets*

\*Located in the Test Booklet.

## Additional Resources

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This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

- ASTM A325 – 07a Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength*. West Conshohocken, PA: ASTM International, 2007.
- AWS A2.4: 2007 Standard Symbols for Welding, Brazing, and Nondestructive Examination*. Miami, FL: American Welding Society.
- AWS A3.0: 2001 Standard Definitions; Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*. Miami, FL: American Welding Society.
- AWS D1.1/D1.1M: 2008 Structural Welding Code Steel*. Miami, FL: American Welding Society.
- How to Read Shop Drawings*, 2008. Cleveland, OH: The James F. Lincoln Arc Welding Foundation.
- Steel Construction Manual*, 2008. Thirteenth Edition. Chicago, IL: American Institute of Steel Construction.

## Teaching Time for this Module

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An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *Reading Welding Detail Drawings*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of trainees may be noted during these exercises for Performance Testing purposes.

Topic	Planned Time
<b>Session I. Introduction to Welding Detail Drawings; Object Views</b>	
A. Introduction	_____
B. Welding Detail Drawings	_____
C. Drawing Components	_____
1. Lines	_____
2. Material Symbols	_____
3. Solid Round and Pipe (or Tubing) Breaks	_____
4. Revolved Sections	_____
D. Object Views	
1. Isometric View	_____
2. Multiview	_____
3. Section View	_____
<b>Session II. Dimensions</b>	
A. Dimensions	_____
1. Scale	_____
2. Size and Location Dimensions	_____
3. Hole Dimensions	_____
4. Angle and Bevel Dimensions	_____
5. Radius and Arc Dimensions	_____
6. Tolerances	_____
<b>Session III. Notes and Bill of Materials</b>	
A. Notes and Bill of Materials	_____
1. Notes	_____
2. Bill of Materials	_____
B. Laboratory	_____
Have trainees practice drawing or sketching a welding drawing based on a given image or object. This laboratory corresponds to Performance Task 1.	
<b>Session IV. Review and Testing</b>	
A. Review	_____
B. Module Examination	_____
1. Trainees must score 70% or higher to receive recognition from NCCER.	
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.	
C. Performance Testing	_____
1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.	
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.	

# Physical Characteristics and Mechanical Properties of Metal

## Annotated Instructor's Guide

Module 29203-09

### Module Overview

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This module covers the physical characteristics, mechanical properties, composition, and classification of common ferrous and nonferrous metals. Various standard forms and structural shapes of metals are described, as well as methods used to identify metals.

### Prerequisites

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Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *Welding Level One*; and *Welding Level Two*, Modules 29201-09 and 29202-09.

### Objectives

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Upon completion of this module, the trainee will be able to do the following:

1. Identify and explain the composition and classification of base metals.
2. Explain and demonstrate field identification methods for base metals.
3. Identify and explain the physical characteristics and mechanical properties of metals.
4. Identify and explain forms and shapes of structural metals.
5. Explain metallurgical considerations for welding metals.

### Performance Tasks

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This is a knowledge-based module; there are no Performance Tasks.

### Materials and Equipment List

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Markers/chalk  
Pencils and scratch paper  
Whiteboard/chalkboard  
Welding 2 PowerPoint® Presentation Slides  
(ISBN 0-13-213025-4)  
Multimedia projector and screen  
Desktop or laptop computer  
Copies of steel classifications from AISI, ASTM  
International, and/or UNS  
AISI/SAE numbers of common carbon steels  
for identification purposes  
Pictures of wrecked racecars  
Samples of mill markings on metals  
Pictures or examples of labeled metals

Different types of steels, including high-strength  
low-alloy steels  
Various ferrous and nonferrous metals and filler  
metals  
Samples of each type of structural steel  
Standard steel pipe samples  
Rebar with grade markings  
Metal samples to examine and identify by  
appearance and by magnet  
Magnet  
Metal analyzer  
Hardness testers  
Module Examinations\*

\*Located in the Test Booklet.

## Additional Resources

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This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

AWS B1.10:1999 *Guide for the Nondestructive Examination of Welds*. Miami, FL: American Welding Society.  
 AWS B1.11:2000 *Guide for the Visual Examination of Welds*. Miami, FL: American Welding Society.  
 AWS D3.5-93R *Guide for Steel Hull Welding*. Miami, FL: American Welding Society, 1993.  
 AWS D3.6M:1999 *Specification for Underwater Welding*. Miami, FL: American Welding Society.  
 AWS D3.7:2004 *Guide for Aluminum Hull Welding*. Miami, FL: American Welding Society.  
 Lincoln Electric website: <http://www.lincolnelectric.com> offers sources for products and training.  
*Machinery's Handbook*. Erik Oberg, Franklin D. Jones, and Christopher J. McCauley. New York, NY: Industrial Press, Inc., 2008.  
*Metals and How to Weld Them*. T. B. Jefferson. Cleveland, OH: The James F. Lincoln Arc Welding Foundation.  
 OSHA Standard 1926.351, *Arc Welding and Cutting*.  
*Stick Electrode Product Catalog*. Cleveland, OH: The Lincoln Electric Company, 2008.  
*Stick Electrode Welding Guide*. Cleveland, OH: The Lincoln Electric Company, 2004.  
*The Procedure Handbook of Arc Welding*. 14th ed. Cleveland, OH: The James F. Lincoln Welding Foundation, 2000.  
*Welding Handbook*. 4 vols. Miami, FL: American Welding Society.

## Teaching Time for this Module

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An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 7½ hours are suggested to cover *Physical Characteristics and Mechanical Properties of Metals*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources.

Topic	Planned Time
<b>Session I. Introduction; Metal Composition, Classifications, and Identification</b>	
A. Introduction	_____
B. Metal Composition and Classifications	_____
1. Ferrous Metal	_____
2. Low-Alloy Steel	_____
3. Common Grade Stainless Steel	_____
4. Specialty Grade Stainless Steel	_____
5. Nonferrous Metals	_____
C. Field Identification of Base Metals	_____
1. Metal Labeling	_____
2. Identification by Magnet	_____
3. Identification by Appearance	_____
4. Identification by X-Ray Fluorescence Spectrometry	_____
<b>Session II. Characteristics and Properties of Metals; Structural Steel and Common Milled Shapes</b>	
A. Physical Characteristics of Metals	_____
1. Density	_____
2. Electrical Conductivity	_____
3. Thermal Conductivity	_____
4. Thermal Expansion	_____
5. Melting Point	_____
6. Corrosion Resistance	_____

B. Mechanical Properties of Metals

1. Stress-Strain Relationship
2. Elasticity and Elastic Limit
3. Modulus of Elasticity
4. Tensile Strength
5. Ductility
6. Hardness

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C. Structural Steel and Common Milled Shapes

1. Plate, Sheet Metal, Bars, Angles, and Channels
2. Beams and Shapes from Beams
3. Pipe, Reinforcing Bars, and Tubing
4. Seamed and Seamless Tubing and Pipe
5. Forged Shapes, Cast Shapes, and Powdered Metals

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**Session III. Metallurgical Considerations for Welding; Review and Testing**

A. Metallurgical Considerations for Welding

1. Base Metal Preparations
2. Joint Design
3. Filler Metal and Electrode Selection
4. Preheating and Interpass Temperature Control
5. Postweld Heat Treatment

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B. Review

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C. Module Examination

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

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### Module Overview

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This module covers the preheating, interpass temperature control, and postheating procedures that are performed to preserve weldment strength, ductility, and weld quality.

### Prerequisites

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Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *Welding Level One*; and *Welding Level Two*, Modules 29201-09 through 29203-09.

### Objectives

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Upon completion of this module, the trainee will be able to do the following:

1. Explain and demonstrate how to preheat metals.
2. Describe maintaining interpass temperature.
3. Explain postweld heat treatment of metals.
4. Explain the effects of preheat and postheat on metals:
  - Heat-affected zone (HAZ)
  - Cracking
  - Grain or crystal structure

### Performance Tasks

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

1. Preheat base metal to 350°F and verify preheat using a temperature-indicating device.

### Materials and Equipment List

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Markers/chalk	Metal strain caused by inadequate preheating
Pencils and scratch paper	Samples of underbead cracking
Whiteboard/chalkboard	Temperature-indicating crayons
Welding 2 PowerPoint® Presentation Slides (ISBN 0-13-213025-4)	Heating tips for oxyfuel torches
Multimedia projector and screen	Gas preheating torch
Desktop or laptop computer	Open-top or open flat-top preheater
Appropriate personal protective equipment	Resistance heating elements
Sample welds showing proper preheating and postweld heat treatment	Induction heating device(s)
Weld defects from improper preheating or postweld heat treatment	Pyrometer
Bearing heater	Thermocouple device(s)
Bearing and shaft	Temperature-sensitive tape and labels
Ice	Heat treatment device
	Module Examinations*
	Performance Profile Sheets*

\*Located in the Test Booklet.



## Safety Considerations

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Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees will be required to preheat a base metal. Ensure that all lab areas are equipped with properly charged fire extinguishers.

## Additional Resources

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This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

*Welding Handbook*. Vol. 2, Part 1: *Welding Processes*. Miami, FL: American Welding Society, 2004.

*Welding Handbook*. Vol. 3, Part 2: *Welding Processes*. Miami, FL: American Welding Society, 2007.

*The Procedure Handbook of Arc Welding*. 14th ed. Cleveland, OH: The James F. Lincoln Arc Welding Foundation, 2000.

*Welding Essentials: Questions and Answers*. 201 ed. William L. Galvery, Jr. and Frank M. Marlow. New York, NY: Industrial Press, 2007.

## Teaching Time for this Module

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An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 5 hours are suggested to cover *Preheating and Postheating of Metals*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of trainees may be noted during these exercises for Performance Testing purposes.

Topic	Planned Time
<b>Session I. Introduction; Preheating and Interpass Temperature Control; Measuring Temperatures; Interpass Temperature</b>	
A. Introduction	_____
B. Preheating and Interpass Temperature Control	_____
1. Temperature and Metal Structure	_____
2. Metals That Require Preheating	_____
3. Preheating Methods	_____
C. Measuring Temperatures	_____
1. Pyrometers	_____
2. Thermocouple Devices	_____
3. Temperature-Sensitive Indicators	_____
D. Interpass Temperature	_____
<b>Session II. Postheating; Laboratory; Review and Testing</b>	
A. Postheating	_____
1. Stress Relieving	_____
2. Annealing	_____
3. Normalizing	_____
4. Tempering	_____
5. Hardening	_____
6. Heat Treatment Devices	_____
7. Time-at-Temperature Considerations	_____
B. Laboratory	_____
Have trainees practice preheating a base metal to 350°F and verifying the preheat using a temperature-indicating device. This laboratory corresponds to Performance Task 1.	

C. Review

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D. Module Examination

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1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

E. Performance Testing

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1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

## Module Overview

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This module provides an overview of the equipment required for gas metal arc welding and flux-cored arc welding. Topics include safety practices, welding power sources, wire feeders, guns, equipment setup, and filler metals.

## Prerequisites

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Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *Welding Level One*; and *Welding Level Two*, Modules 29201-09 through 29204-09.

## Objectives

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Upon completion of this module, the trainee will be able to do the following:

1. Explain gas metal arc welding (GMAW) and flux-cored arc welding (FCAW) safety.
2. Explain the characteristics of welding current and power sources.
3. Identify and explain the use of GMAW and FCAW equipment:
  - Spray transfer
  - Globular
  - Short circuiting
  - Pulse
4. Identify and explain the use of GMAW and FCAW shielding gases and filler metals.
5. Set up GMAW and FCAW equipment and identify tools for weld cleaning.

## Performance Task

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

1. Set up GMAW and FCAW equipment with appropriate shielding gases and filler metals.

## Materials and Equipment List

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Markers/chalk	Manufacturer's instruction manual for an engine-driven generator
Pencils and scratch paper	Leather welding gloves
Whiteboard/chalkboard	Leather welding jacket or sleeves
Welding 2 PowerPoint® Presentation Slides (ISBN 0-13-213025-4)	Welding shield or helmet
Multimedia projector and screen	Selection of shades 5 to 14 tinted lenses
Desktop or laptop computer	Cutting goggles
Appropriate personal protective equipment	FCAW welding equipment
Engine-driven power source	Electrode wire, 0.45" dual shielded flux-cored carbon steel
Inverter power source	GMAW welding equipment
Welding cable	Carbon steel wire electrode
Lugs and quick disconnects	Shielding gas
Wire feeders	Welding bench with arm for position work
Wire straighteners	Portable angle-head grinders
GMAW/FCAW-G guns	Framing square
Shielding gas regulators/flowmeters	Soapstone
Labeled samples of GMAW/FCAW filler wire in various types and sizes	Tape measure
Electrical plugs and outlets	Pliers

continued

Half-round bastard file  
Wire brush  
Chipping hammer

Workpiece clamps  
Module Examinations\*  
Performance Profile Sheets\*

\*Located in the Test Booklet.

## Safety Considerations

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Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees will be required to set up GMAW and FCAW equipment with appropriate shielding gases and filler metals. Ensure that trainees are properly briefed on the safe use of arc welding equipment and shielding gases and are familiar with all appropriate safety precautions and procedures. Ensure that all labs are equipped with charged fire extinguishers.

## Additional Resources

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This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

- AWS B1.10:1999 Guide for the Nondestructive Examination of Welds.* Miami, FL: American Welding Society.
- AWS B1.11:2000 Guide for the Visual Examination of Welds.* Miami, FL: American Welding Society.
- AWS D3.5-93R Guide for Steel Hull Welding.* Miami, FL: American Welding Society, 1993.
- Lincoln Electric website: <http://www.lincolnelectric.com> offers sources for products and training.
- Modern Welding Technology.* Howard B. Cary. Englewood Cliffs, NJ: Prentice Hall, Inc.
- OSHA 1910.269, Appendix C, Protection from Step and Touch Potentials.* Current edition. Washington, DC: Occupational Safety & Health Administration (OSHA).
- OSHA 1926.351, Arc Welding and Cutting.* Current edition. Washington, DC: Occupational Safety & Health Administration (OSHA).
- Welding Handbook.* Volume 1. *Welding Science & Technology.* Miami, FL: American Welding Society, 2001.
- Welding Handbook.* Volume 2, Part 1: *Welding Processes.* Miami, FL: American Welding Society, 2004.

## Teaching Time for this Module

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An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *GMAW and FCAW: Equipment and Filler Metals*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of trainees may be noted during these exercises for Performance Testing purposes.

Topic	Planned Time
<b>Session I. Introduction; GMAW and FCAW</b>	
A. Introduction	_____
B. Safety Practices	_____
C. Characteristics of Welding Current	_____
D. Welding Power Sources	_____
E. GMAW and FCAW Equipment	_____
1. GMAW Metal Transfer Modes	_____
2. FCAW Metal Transfer Process	_____
3. GMAW Power Sources	_____
4. Welding Cable	_____
5. External Wire Feeders	_____
6. GMAW/FCAW-G Guns	_____
7. FCAW-S Guns	_____
8. Shielding Gas Supply	_____

## Session II. Shielding Gases and Filler Metals

### A. Shielding Gases

1. Shielding Gas Characteristics
2. Shielding Gas Selection
3. Shielding Gas Flow Rate

### B. Filler Metals

1. GMAW Filler Metals
2. FCAW Filler Metals

## Session III. Welding Equipment Setup

### A. Welding Equipment Setup

1. Selecting a Power Source
2. Positioning the Equipment
3. Moving Welding Power Sources
4. Connecting the Shielding Gas
5. Selecting and Installing Filler Wire
6. Placing the Workpiece Clamp
7. Energizing the Power Source
8. Starting Engine-Driven Generators/Alternators

### B. Laboratory

Trainees practice setting up GMAW and FCAW equipment with appropriate shielding gases and filler metals. This laboratory corresponds to Performance Task 1.

## Session IV. Hand Tools; Review and Testing

### A. Hand Tools for Weld Cleaning

### B. Review

### C. Module Examination

1. Trainees must score 70% or higher to receive recognition from the NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

### D. Performance Testing

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

## Module Overview

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This module explains how to make fillet and open V-groove welds on carbon steel plate using gas metal arc welding (GMAW) and flux-cored arc welding (FCAW) processes in all positions.

## Prerequisites

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Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *Welding Level One*; and *Welding Level Two*, Modules 29201-09 through 29205-09.

## Objectives

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Upon completion of this module, the trainee will be able to do the following:

1. Perform GMAW-S (short-circuit) multiple-pass fillet welds on carbon steel plate coupons in multiple positions, using solid or composite wire and shielding gas.
2. Perform GMAW-S (short-circuit) multiple-pass V-groove welds on carbon steel plate coupons in multiple positions (with or without backing), using solid or composite wire and shielding gas.
3. Perform GMAW spray fillet and V-groove welds on carbon steel plate coupons in multiple positions (with or without backing), using solid or composite wire and shielding gas.
4. Perform FCAW multiple-pass fillet welds on carbon steel plate coupons in multiple positions, using flux-cored wire and, if required, shielding gas.
5. Perform FCAW multiple-pass V-groove welds on carbon steel plate coupons in multiple positions (with or without backing), using flux-cored wire and, if required, shielding gas.

## Performance Tasks

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

1. Make multiple-pass GMAW-S (short-circuit) fillet welds on carbon steel plate coupons in the following positions, using solid or composite wire:
  - 1F
  - 2F
  - 3F
  - 4F
2. Make multiple-pass FCAW-G/GM (gas-shielded) or FCAW-S (self-shielded) fillet welds on carbon steel plate coupons in the following positions:
  - 1F
  - 2F
  - 3F
  - 4F
3. Make multiple-pass FCAW-G/GM (gas shielded) or FCAW-S (self-shielded) V-groove welds on carbon steel plate coupons in the following positions (with or without backing):
  - 1G
  - 2G
  - 3G
  - 4G
4. Make multiple-pass GMAW-S (short-circuit) V-groove welds on carbon steel plate coupons in the following positions (with or without backing), using solid or composite wire:
  - 1G
  - 2G
  - 3G
  - 4G

5. Make multiple-pass GMAW spray fillet welds on carbon steel plate coupons in the following positions, using solid or composite wire:
  - 1F
  - 2F
6. Make multiple-pass GMAW spray V-groove welds on carbon steel plate coupons in the 1G position (with or without backing), using solid or composite wire.

## Safety Considerations

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Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees will be required to make fillet and open V-groove welds on carbon steel plate coupons using GMAW and FCAW. Ensure that trainees are properly briefed on the safe use of arc welding equipment and are familiar with all appropriate safety precautions and procedures. Check to be sure that all labs are equipped with charged fire extinguishers.

## Materials and Equipment List

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Markers/chalk	Tape measure
Pencils and scratch paper	Pliers
Whiteboard/chalkboard	Half-round bastard file
Welding 2 PowerPoint® Presentation Slides (ISBN 0-13-213025-4)	Wire brush
Multimedia projector and screen	Chipping hammer
Desktop or laptop computer	Workpiece clamps
Appropriate personal protective equipment	Examples of the following:
FCAW welding equipment	Beads created with different travel speed settings
GMAW welding equipment	Good and bad weld beads
Shielding gas	Stringer beads
Flux-cored wire	Weave beads
Solid or composite wire	Properly and improperly terminated welds
Backing materials	Proper and improper overlapping beads
Plate steel for coupons, ¼" to ¾"	Pads made using stringer and weave beads
Welding bench with arm for position work	Fillet welds from all four welding positions
Portable angle-head grinders with extra grinding discs	Fillet welds that have been sawed to expose their profiles
Anti-splatter material	Ground and unground root passes
MSDS for each cleaning agent used	Broken apart open V-groove root pass weld
Bevel gauge(s)	Module Examinations*
Framing square	Performance Profile Sheets*
Soapstone	

\*Located in the Test Booklet.

## Additional Resources

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This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

- AWS B1.10:1999 Guide for the Nondestructive Examination of Welds.* Miami, FL: American Welding Society.
- AWS B1.11:2000 Guide for the Visual Examination of Welds.* Miami, FL: American Welding Society.
- AWS C5.6-89 Recommended Practices for Gas Metal Arc Welding.* Miami, FL: American Welding Society, 1989.
- AWS D3.5-93R Guide for Steel Hull Welding.* Miami, FL: American Welding Society, 1993.
- E1.10 2009 Product Catalog.* Cleveland, OH: The Lincoln Electric Company.
- GMAW Welding Guide.* Cleveland, OH: The Lincoln Electric Company, 2006.
- Lincoln Electric offers sources for products and training. Website: <http://www.lincolnelectric.com>.
- OSHA 1910.269, Appendix C, Protection from Step and Touch Potentials.* Current edition. Washington, DC: Occupational Safety & Health Administration (OSHA).

OSHA 1926.351, *Arc Welding and Cutting*. Current edition. Washington, DC: Occupational Safety & Health Administration (OSHA).  
*The Procedure Handbook of Arc Welding*. 14th ed. Cleveland, OH: The James F. Lincoln Arc Welding Foundation, 2000.  
*Welding Handbook*. Volume 1. *Welding Science & Technology*. Miami, FL: American Welding Society, 2001.  
*Welding Handbook*. Volume 2, Part 1: *Welding Processes*. Miami, FL: American Welding Society, 2004.

## Teaching Time for this Module

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An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 80 hours are suggested to cover *GMAW and FCAW: Plate*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of trainees may be noted during these exercises for Performance Testing purposes.

Topic	Planned Time
<b>Session I. Introduction; GMAW and FCAW; Welding Safety; Equipment Setup</b>	
A. Introduction	_____
1. The GMAW Process	_____
2. The FCAW Process	_____
3. GMAW and FCAW Equipment	_____
B. Welding Safety	_____
1. Protective Clothing and Equipment	_____
2. Fire/Explosion Prevention	_____
3. Work Area Ventilation	_____
C. Welding Equipment Setup	_____
1. Preparing the Welding Area	_____
2. Preparing the Practice Coupons	_____
3. Welding Machine	_____
4. Welding Voltage, Amperage, and Travel Speed	_____
5. Gun Position	_____
6. Electrode Extension, Stickout, and Standoff Distance	_____
7. Gas Nozzle Cleaning	_____
D. Laboratory	_____
Have trainees set up the welding area and prepare plate coupons for GMAW and FCAW fillet and groove welds.	
<b>Sessions II–III. Bead Types; Laboratory</b>	
A. Bead Types	_____
1. Stringer Beads	_____
2. Weave Beads	_____
3. Weld Restarts	_____
4. Weld Terminations	_____
5. Overlapping Beads	_____
B. Laboratory	_____
Have trainees set up GMAW and FCAW equipment and practice starting, restarting, and terminating welds; altering gun angles to see the effects on stringer and weave beads; and overlapping beads to build a pad.	



## Sessions IV–XV. Fillet Welds

### A. Flat (1F) Position Welds

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#### 1. Laboratory

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Have trainees practice using GMAW (spray and/or short-circuit transfer) and FCAW equipment, filler wire, and shielding gases to make multiple-pass fillet welds on carbon steel plate coupons in the 1F position. This laboratory corresponds to Performance Tasks 1, 2, and 5.

### B. Horizontal (2F) Position Welds

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#### 1. Laboratory

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Have trainees practice using GMAW (spray and/or short-circuit transfer) and FCAW equipment, filler wire, and shielding gases to make multiple-pass fillet welds on carbon steel plate coupons in the 2F position. This laboratory corresponds to Performance Tasks 1, 2, and 5.

### C. Vertical (3F) Position Welds

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#### 1. Laboratory

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Have trainees practice using GMAW (spray and/or short-circuit transfer) and FCAW equipment, filler metals, and shielding gases to make multiple-pass fillet welds on carbon steel plate coupons in the 3F position. This laboratory corresponds to Performance Tasks 1 and 2.

### D. Overhead (4F) Position Welds

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#### 1. Laboratory

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Have trainees practice using GMAW (spray and/or short-circuit transfer) and FCAW equipment, filler wire, and shielding gases to make multiple-pass fillet welds on carbon steel plate coupons in the 4F position. This laboratory corresponds to Performance Tasks 1 and 2.

## Sessions XVI–XXVII. Open V-Groove Welds

### A. Open V-Groove Welds

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#### 1. Root Pass

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#### 2. Groove Weld Positions

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#### 3. Acceptable and Unacceptable Groove Weld Profiles

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### B. Practicing 1G, 2G, 3G, and 4G V-Groove Welds

#### 1. Laboratory

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Have trainees practice using GMAW (spray and/or short-circuit transfer) and FCAW equipment, filler metals, and shielding gases to make multiple-pass V-groove welds on carbon steel plate coupons (with or without backing) in the 1G position. This laboratory corresponds to Performance Tasks 3, 4, and 6.

#### 2. Laboratory

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Have trainees practice using GMAW (spray and/or short-circuit transfer) and FCAW equipment, filler wire, and shielding gases to make multiple-pass V-groove welds on carbon steel plate coupons (with or without backing) in the 2G position. This laboratory corresponds to Performance Tasks 3 and 4.

#### 3. Laboratory

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Have trainees practice using GMAW (spray and/or short-circuit transfer) and FCAW equipment, filler wire, and shielding gases to make multiple-pass V-groove welds on carbon steel plate coupons (with or without backing) in the 3G position. This laboratory corresponds to Performance Tasks 3 and 4.

#### 4. Laboratory

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Have trainees practice using GMAW (spray and/or short-circuit transfer) and FCAW equipment, filler wire, and shielding gases to make multiple-pass V-groove welds on carbon steel plate coupons (with or without backing) in the 4G position. This laboratory corresponds to Performance Tasks 3 and 4.

## Session XXVIII. Review and Testing

### A. Review

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### B. Module Examination

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1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

### C. Performance Testing

---

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

## Sessions XXIX–XXXII. Performance Accreditation Tasks

### A. Performance Accreditation Tasks

Have trainees complete PAT 1 through PAT 8, according to the acceptance criteria.

1. Have trainees perform PAT 1, Make a Fillet Weld in the (1F) Flat Position. This task corresponds to *AWS EG2.0*, Module 5, Gas Metal Arc Welding (GMAW-S, GMAW), Key Indicators 5 and 7, and Module 6, Flux-Cored Arc Welding (FCAW-G, FCAW), Key Indicators 5, 7, 10, and 12. 

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2. Have trainees perform PAT 2, Make a Fillet Weld in the (2F) Horizontal Position. This task corresponds to *AWS EG2.0*, Module 5, Gas Metal Arc Welding (GMAW-S, GMAW), Key Indicators 5 and 7, and Module 6, Flux-Cored Arc Welding (FCAW-G, FCAW), Key Indicators 5, 7, 10, and 12. 

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3. Have trainees perform PAT 3, Make a Fillet Weld in the (3F) Vertical Position. This task corresponds to *AWS EG2.0*, Module 5, Gas Metal Arc Welding (GMAW-S, GMAW), Key Indicators 5 and 7, and Module 6, Flux-Cored Arc Welding (FCAW-G, FCAW), Key Indicators 5, 7, 10, and 12. 

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4. Have trainees perform PAT 4, Make a Fillet Weld in the (4F) Overhead Position. This task corresponds to *AWS EG2.0*, Module 5, Gas Metal Arc Welding (GMAW-S, GMAW), Key Indicators 5 and 7, and Module 6, Flux-Cored Arc Welding (FCAW-G, FCAW), Key Indicators 5, 7, 10, and 12. 

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5. Have trainees perform PAT 5, Make a Groove Weld, with or without Backing, in the (1G) Flat Position. This task corresponds to *AWS EG2.0*, Module 5, Gas Metal Arc Welding (GMAW-S, GMAW), Key Indicators 6 and 11, and Module 6, Flux-Cored Arc Welding (FCAW-G, FCAW), Key Indicators 6 and 11. 

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6. Have trainees perform PAT 6, Make a Groove Weld, with or without Backing, in the (2G) Horizontal Position. This task corresponds to *AWS EG2.0*, Module 5, Gas Metal Arc Welding (GMAW-S, GMAW), Key Indicators 6 and 11, and Module 6, Flux-Cored Arc Welding (FCAW-G, FCAW), Key Indicators 6 and 11. 

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7. Have trainees perform PAT 7, Make a Groove Weld, with or without Backing, in the (3G) Vertical Position. This task corresponds to *AWS EG2.0*, Module 5, Gas Metal Arc Welding (GMAW-S, GMAW), Key Indicators 6 and 11, and Module 6, Flux-Cored Arc Welding (FCAW-G, FCAW), Key Indicators 6 and 11. 

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8. Have trainees perform PAT 8, Make a Groove Weld, with or without Backing, in the (4G) Overhead Position. This task corresponds to *AWS EG2.0*, Module 5, Gas Metal Arc Welding (GMAW-S, GMAW), Key Indicators 6 and 11, and Module 6, Flux-Cored Arc Welding (FCAW-G, FCAW), Key Indicators 6 and 11. 

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## Module Overview

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This module provides an overview of gas tungsten arc welding (GTAW) topics, including welding safety, power sources, electrodes, equipment, GTAW torches, filler metals, and equipment setup.

## Prerequisites

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Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *Welding Level One*; and *Welding Level Two*, Modules 29201-09 through 29206-09.

## Objectives

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Upon completion of this module, the trainee will be able to do the following:

1. Explain gas tungsten arc welding (GTAW) safety.
2. Identify and explain the function of GTAW equipment.
3. Identify and explain the function of GTAW filler metals.
4. Identify and explain the function of GTAW shielding gases.
5. Set up GTAW equipment.

## Performance Tasks

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

Given a WPS:

1. Select shielding gas.
2. Select filler metal.
3. Connect the shielding gas and set the flow rate.
4. Select and prepare the electrode.
5. Break down and reassemble a GTAW torch.

## Safety Considerations

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Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Emphasize the special safety precautions associated with GTAW, including the handling and use of shielding gas and the preparation of electrodes. Ensure that trainees are briefed on shop safety procedures. Verify that labs are equipped with charged fire extinguishers.

## Materials and Equipment List

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Markers/chalk  
Pencils and scratch paper  
Whiteboard/chalkboard  
Welding 2 PowerPoint® Presentation Slides  
(ISBN 0-13-213025-4)  
Multimedia projector and screen  
Desktop or laptop computer  
Appropriate personal protective equipment,  
including:  
    Leather welding gloves  
    Leather welding jacket or sleeves  
    Welding shield or helmet  
    Selection of shades 5 to 14 tinted lenses  
    Cutting goggles  
Soapstone  
Tape measure

Framing square  
Chipping hammer  
Wire brush  
Workpiece clamps  
Files  
Pliers  
GTAW welding equipment  
Tungsten electrodes  
Shielding gas  
Welding bench with arm for position work  
GTAW torches and torch parts  
Various types of tungsten electrodes with their  
    color-coded bands  
Welds done with incorrect shielding gas  
Remote current control units that are foot-, hand-,  
    and finger-operated

AWS specifications  
 Various types and sizes of electrodes (labeled)  
 Shielding gas regulators/flowmeters  
 Electrodes with different end shapes  
 Tungsten grinding wheel

Properly and improperly ground pointed  
 electrode ends  
 WPS(s) for performance testing  
 Module Examinations\*  
 Performance Profile Sheets\*

\*Located in the Test Booklet.

## Additional Resources

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

- AWS B1.10:1999 Guide for the Nondestructive Examination of Welds.* Miami, FL: American Welding Society.  
*AWS B1.11:2000 Guide for the Visual Examination of Welds.* Miami, FL: American Welding Society.  
*AWS D3.5-93R: Guide for Steel Hull Welding.* Miami, FL: American Welding Society, 1993.  
*AWS D3.7:2004 Guide for Aluminum Hull Welding.* Miami, FL: American Welding Society.  
 Lincoln Electric offers sources for products and training. Website: <http://www.lincolnelectric.com>.  
*Modern Welding Technology.* Howard B. Cary. Englewood Cliffs, NJ: Prentice Hall, Inc.  
*OSHA 1910.269, Appendix C, Protection from Step and Touch Potentials.* Current edition. Washington, DC: Occupational Safety & Health Administration (OSHA).  
*OSHA 1926.351, Arc Welding and Cutting.* Current edition. Washington, DC: Occupational Safety & Health Administration (OSHA).  
*Welding Handbook.* Vol. 1. *Welding Science & Technology.* Miami, FL: American Welding Society, 2001.  
*Welding Handbook.* Vol. 2, Part 1: *Welding Processes.* Miami, FL: American Welding Society, 2004.

## Teaching Time for this Module

An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 10 hours are suggested to cover *GTAW: Equipment and Filler Metals*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of trainees may be noted during these exercises for Performance Testing purposes.

Topic	Planned Time
<b>Session I. Introduction; Safety Practices; Welding Current, Power Sources, and Cable</b>	
A. Introduction	_____
B. Safety Practices	_____
1. Protective Clothing and Equipment	_____
2. Fire/Explosion Prevention	_____
3. Work Area Ventilation	_____
4. GTAW-Specific Safety	_____
C. Welding Current	_____
1. Characteristics	_____
2. Types	_____
D. Welding Power Sources	_____
1. Transformer and Transformer-Rectifier Welding Machines	_____
2. Inverter Power Sources	_____
3. Engine-Driven Generators	_____
4. Power Source Ratings	_____
E. Welding Cable	_____

## Session II. GTAW Equipment and Filler Metals

### A. GTAW Equipment

1. GTAW Torches
2. Gas Nozzles
3. Tungsten Electrodes
4. Shielding Gas
5. Remote Current Control

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### B. Laboratory

Using a supplied WPS, have trainees practice selecting the correct shielding gas. This laboratory corresponds to Performance Task 1.

### C. GTAW Filler Metals

1. Carbon Steel and Low-Alloy Steel
2. Stainless Steel and Aluminum/Aluminum Alloy
3. Copper/Copper Alloy and Nickel/Nickel Alloy
4. Magnesium Alloy and Titanium/Titanium Alloy
5. Stainless Steel Flux-Cored Electrodes and Rods

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### D. Laboratory

Using a supplied WPS, have trainees practice selecting filler metals. This laboratory corresponds to Performance Task 2.

## Session III. Welding Equipment Setup

### A. Selecting a GTAW Power Source

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### B. Positioning the GTAW Equipment

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### C. Connecting the Shielding Gas

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### D. Setting the Shielding Gas Flow Rate

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### E. Laboratory

Using a supplied WPS, have trainees practice connecting the shielding gas and setting the flow rate. This laboratory corresponds to Performance Task 3.

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### F. Selecting the Electrode

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### G. Preparing the Electrode

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### H. Laboratory

Using a supplied WPS, have trainees practice selecting and preparing the electrode. This laboratory corresponds to Performance Task 4.

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### I. Selecting and Installing the Nozzle

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### J. Installing the Electrode

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### K. Laboratory

Have trainees practice selecting and installing nozzles and electrodes.

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## Session IV. Laboratory; Review and Testing

### A. Laboratory

Using a supplied WPS, have trainees practice breaking down and reassembling a GTAW torch. This laboratory corresponds to Performance Task 5.

### B. Review

### C. Module Examination

1. Trainees must score 70% or higher to receive recognition from NCCER.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

### D. Performance Testing

1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performance Testing requirements.
2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

## Module Overview

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This module explains how to set up GTAW equipment and how to make fillet and V-groove welds on carbon steel plate coupons in all welding positions.

## Prerequisites

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Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum*; *Welding Level One*; and *Welding Level Two*, Modules 29201-09 through 29207-09.

## Objectives

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Upon completion of this module, the trainee will be able to do the following:

1. Build a pad in the flat position with stringer beads using GTAW and carbon steel filler metal.
2. Perform multiple-pass GTAW fillet welds on carbon steel plate coupons in the following positions, using carbon steel filler metal:
  - 1F
  - 2F
  - 3F
  - 4F
3. Perform multiple-pass GTAW V-groove welds on carbon steel plate coupons in the following positions, using carbon steel filler metal:
  - 1G
  - 2G
  - 3G
  - 4G

## Performance Tasks

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

1. Build a pad with stringer beads on carbon steel plate coupons in the flat (1G) position, using GTAW equipment and carbon steel filler metal.
2. Perform multiple-pass fillet welds on carbon steel plate coupons in the following positions, using GTAW equipment and carbon steel filler metal:
  - 1F
  - 2F
  - 3F
  - 4F
3. Perform multiple-pass V-groove welds on carbon steel plate coupons in the following positions, using GTAW equipment and carbon steel filler metal:
  - 1G
  - 2G
  - 3G
  - 4G

## Safety Considerations

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Ensure that the trainees are equipped with appropriate personal protective equipment and know how to use it properly. Trainees will be required to make multiple-pass fillet and V-groove welds on carbon steel plate coupons using GTAW. Ensure that trainees are properly briefed on the safe use of welding equipment and are familiar with all appropriate safety precautions and procedures. Check to be sure that all labs are equipped with charged fire extinguishers.

## Materials and Equipment List

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Markers/chalk  
 Pencils and scratch paper  
 Whiteboard/chalkboard  
 Welding 2 PowerPoint® Presentation Slides  
 (ISBN 0-13-213025-4)  
 Multimedia projector and screen  
 Desktop or laptop computer  
 Appropriate personal protective equipment,  
 including:  
 Leather welding gloves  
 Welding shield or helmet  
 GTAW welding equipment  
 Tungsten electrodes  
 Carbon steel filler metal  
 Carbon steel plate 3/8" thick  
 Shielding gas  
 Welding bench with arm for position work  
 Soapstone  
 Tape measure  
 Friction lighter

Examples of the following:  
 Beads created with different torch positions  
 Acceptable and unacceptable stringer and  
 weave beads  
 Properly and improperly terminated welds  
 Proper and improper overlapping beads  
 Pads made using stringer and weave beads  
 Fillet welds from all four welding positions  
 Fillet welds that have been sawed to expose  
 their profiles  
 Broken-apart open V-groove root pass weld  
 Portable grinders  
 Framing square  
 Pliers  
 Half-round bastard file  
 Wire brush  
 Chipping hammer  
 Workpiece clamps  
 Module Examinations\*  
 Performance Profile Sheets\*

\*Located in the Test Booklet.

## Additional Resources

---

This module is intended to present thorough resources for task training. The following reference works are suggested for both instructors and motivated trainees interested in further study. These are optional materials for continued education rather than for task training.

- Lincoln Electric offers sources for products and training. Website: <http://www.lincolnelectric.com>.  
*OSHA Standard 1926.351, Arc Welding and Cutting*. Current edition. Washington, DC: Occupational Safety & Health Administration.  
*The Procedure Handbook of Arc Welding*. 14th ed. Cleveland, OH: The James F. Lincoln Arc Welding Foundation, 2000.  
*Welding Handbook*. Vol. 1. *Welding Science & Technology*. Miami, FL: American Welding Society, 2001.  
*Welding Handbook*. Vol. 2, Part 1: *Welding Processes*. Miami, FL: American Welding Society, 2004.

## Teaching Time for this Module

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An outline for use in developing your lesson plan is presented below. Note that each Roman numeral in the outline equates to one session of instruction. Each session has a suggested time period of 2½ hours. This includes 10 minutes at the beginning of each session for administrative tasks and one 10-minute break during the session. Approximately 60 hours are suggested to cover *GTAW: Plate*. You will need to adjust the time required for hands-on activity and testing based on your class size and resources. Because laboratories often correspond to Performance Tasks, the proficiency of trainees may be noted during these exercises for Performance Testing purposes.

Topic	Planned Time
<b>Session I. Introduction; Safety Practices</b>	
A. Introduction	_____
B. Safety Practices	_____
1. Protective Clothing and Equipment	_____
2. Fire/Explosion Prevention	_____
3. Work Area Ventilation	_____



**Sessions II and III. Equipment Setup**

A. GTAW Equipment Setup

- 1. Setting Up the Welding Area
- 2. Preparing Practice Welding Coupons
- 3. Welding Equipment

B. Laboratory

Have trainees practice setting up the GTAW welding area and welding equipment.

C. Laboratory

Have trainees practice preparing welding coupons.

**Session IV. GTAW Techniques**

A. GTAW Techniques

- 1. Torch Travel Speed and Arc Length
- 2. Torch Angles
- 3. Torch and Filler Metal Handling Techniques

**Sessions V and VI. Bead Types**

A. Bead Types

- 1. Stringer Beads
- 2. Weave Beads

B. Practicing Stringer Beads

1. Laboratory

Have trainees practice making stringer beads in the flat position using GTAW equipment.

C. Weld Restarts and Terminations

1. Laboratory

Have trainees practice making weld starts, terminations, and restarts using GTAW equipment.

D. Overlapping Beads

1. Laboratory

Have trainees practice making overlapping beads using GTAW equipment.

**Session VII. Laboratory**

A. Laboratory

Have trainees practice building a pad with stringer beads on carbon steel plate coupons in the flat (IG) position, using GTAW equipment and carbon steel filler metal. This laboratory corresponds to Performance Task 1.

**Sessions VIII–XII. Fillet Welds**

A. Practicing Fillet Welds

- 1. Flat (1F) Position Fillet Welds
- 2. Horizontal (2F) Position Fillet Welds
- 3. Vertical (3F) Position Fillet Welds
- 4. Overhead (4F) Position Fillet Welds

B. Laboratory

Have trainees practice making multiple-pass fillet welds on carbon steel plate coupons in the 1F, 2F, 3F, and 4F positions, using GTAW equipment and carbon steel filler metal. This laboratory corresponds to Performance Task 2.

**Sessions XIII–IXX. Groove Welds**

A. Groove Welds

- 1. Open V-Groove Root Pass Techniques
- 2. Groove Weld Positions
- 3. Acceptable and Unacceptable Groove Weld Profiles

B. Laboratory

Have trainees practice making root passes using the on-the-wire and keyhole root pass techniques.

C. Practicing Open V-Groove Welds

- 1. Flat (1G) Position Open V-Groove Welds
- 2. Horizontal Beads
- 3. Horizontal (2G) Position Open V-Groove Welds
- 4. Vertical Beads
- 5. Vertical (3G) Position Open V-Groove Welds
- 6. Overhead Beads
- 7. Overhead (4G) Position Open V-Groove Welds

D. Laboratory

Trainees practice making multiple-pass V-groove welds on carbon steel plate coupons in the 1G, 2G, 3G, and 4G positions, using GTAW equipment and carbon steel filler metal. This laboratory corresponds to Performance Task 3.

**Session XX. Review and Testing**

A. Review

B. Module Examination

- 1. Trainees must score 70% or higher to receive recognition from the NCCER.
- 2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

C. Performance Testing

- 1. Trainees must perform each task to the satisfaction of the instructor to receive recognition from the NCCER. If applicable, proficiency noted during laboratory exercises can be used to satisfy the Performing Testing requirements.
- 2. Record the testing results on Craft Training Report Form 200, and submit the results to the Training Program Sponsor.

**Sessions XXI–XXIV. Performance Accreditation Tasks**

A. Performance Accreditation Tasks – Have trainees complete PAT 1 through Pat 9 according to the acceptance criteria.

- 1. Have trainees perform PAT 1, Weld a Pad on Carbon Steel Plate in the Flat Position using GTAW Stringer Beads. This PAT corresponds to *AWS EG2.0*, Module 7, Gas Tungsten Arc Welding (GTAW), Key Indicators 1, 3, 4, and 5.
- 2. Have trainees perform PATs 2, 3, 4, and 5, Make Multiple-Pass Fillet Welds on Carbon Steel Plate in the 1F, 2F, 3F, and 4F Positions. This task corresponds to *AWS EG2.0*, Module 7, Gas Tungsten Arc Welding (GTAW), Key Indicators 1, 3, 4, and 5.
- 3. Have trainees perform PATs 6, 7, 8, and 9, Make Multiple-Pass V-Groove Welds on Carbon Steel Plate in the 1G, 2G, 3G, and 4G Positions. This task corresponds to *AWS EG2.0*, Module 7, Gas Tungsten Arc Welding (GTAW), Key Indicators 1, 3, 4, and 6.