Module Overview

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

Prerequisites

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

Objectives

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

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markers/chalk</td>
<td>Sample site quality standard</td>
</tr>
<tr>
<td>Pencils and scratch paper</td>
<td>Various weld samples as available, including:</td>
</tr>
<tr>
<td>Whiteboard/chalkboard</td>
<td>Fillet welds</td>
</tr>
<tr>
<td>Welding 2 PowerPoint® Presentation Slides</td>
<td>V-groove welds</td>
</tr>
<tr>
<td>Multimedia projector and screen</td>
<td>Plug welds</td>
</tr>
<tr>
<td>Desktop or laptop computer</td>
<td>Slot welds</td>
</tr>
<tr>
<td>AWS A2.4:2007 Standard Symbols for Welding, Brazing, and Nondestructive Examination</td>
<td>Samples of various weld joints</td>
</tr>
<tr>
<td>Drawing #AWS EDU-1 (from page 111 of AWS EG 2.0:2006)</td>
<td>Module Examinations*</td>
</tr>
<tr>
<td></td>
<td>Performance Profile Sheets*</td>
</tr>
</tbody>
</table>

*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.


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

**Session I. Introduction to Welding Symbols**

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

**Session II. Supplemental and Other Weld Symbols; Review and Testing**

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

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

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

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

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

- Markers/chalk
- Pencils and scratch paper
- Whiteboard/chalkboard
- Multimedia projector and screen
- Desktop or laptop computer
- Sample welding drawings
- Predrilled bar stock scaled to the drawings in Figure 18
- Drawing with a missing dimension
- Welding-related bill of materials
- 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.

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.

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

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

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

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

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

Materials and Equipment List

- Markers/chalk
- Pencils and scratch paper
- Whiteboard/chalkboard
- 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

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 website: http://www.lincolnelectric.com offers sources for products and training.
OSHA Standard 1926.351, Arc Welding and Cutting.

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 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.

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

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

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

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.
Module Overview

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

Prerequisites

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

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

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

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Welding 2 PowerPoint® Presentation Slides
Multimedia projector and screen
Desktop or laptop computer
Appropriate personal protective equipment
Sample welds showing proper preheating and postweld heat treatment
Weld defects from improper preheating or postweld heat treatment
Bearing heater
Bearing and shaft
Ice

Metal strain caused by inadequate preheating
Samples of underbead cracking
Temperature-indicating crayons
Heating tips for oxyfuel torches
Gas preheating torch
Open-top or open flat-top preheater
Resistance heating elements
Induction heating device(s)
Pyrometer
Thermocouple device(s)
Temperature-sensitive tape and labels
Heat treatment device
Module Examinations*
Performance Profile Sheets*

*Located in the Test Booklet.
Safety Considerations

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

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.


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 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.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Planned Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session I. Introduction; Preheating and Interpass Temperature Control; Measuring Temperatures; Interpass Temperature</strong></td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Preheating and Interpass Temperature Control</td>
<td></td>
</tr>
<tr>
<td>1. Temperature and Metal Structure</td>
<td></td>
</tr>
<tr>
<td>2. Metals That Require Preheating</td>
<td></td>
</tr>
<tr>
<td>3. Preheating Methods</td>
<td></td>
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<tr>
<td>C. Measuring Temperatures</td>
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</tr>
<tr>
<td>1. Pyrometers</td>
<td></td>
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<tr>
<td>2. Thermocouple Devices</td>
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<tr>
<td>3. Temperature-Sensitive Indicators</td>
<td></td>
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<tr>
<td>D. Interpass Temperature</td>
<td></td>
</tr>
<tr>
<td><strong>Session II. Postheating; Laboratory; Review and Testing</strong></td>
<td></td>
</tr>
<tr>
<td>A. Postheating</td>
<td></td>
</tr>
<tr>
<td>1. Stress Relieving</td>
<td></td>
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<tr>
<td>2. Annealing</td>
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<td>3. Normalizing</td>
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<td>4. Tempering</td>
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<td>5. Hardening</td>
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<td>6. Heat Treatment Devices</td>
<td></td>
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<tr>
<td>7. Time-at-Temperature Considerations</td>
<td></td>
</tr>
<tr>
<td>B. Laboratory</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>
C. Review

D. 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.

E. 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

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

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

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

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

Marketers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Multimedia projector and screen
Desktop or laptop computer
Appropriate personal protective equipment
Engine-driven power source
Inverter power source
Welding cable
Lugs and quick disconnects
Wire feeders
Wire straighteners
GMAW/FCAW-G guns
Shielding gas regulators/flowmeters
Labeled samples of GMAW/FCAW filler wire in various types and sizes
Electrical plugs and outlets

Manufacturer’s instruction manual for an engine-driven generator
Leather welding gloves
Leather welding jacket or sleeves
Welding shield or helmet
Selection of shades 5 to 14 tinted lenses
Cutting goggles
FCAW welding equipment
Electrode wire, 0.45” dual shielded flux-cored carbon steel
GMAW welding equipment
Carbon steel wire electrode
Shielding gas
Welding bench with arm for position work
Portable angle-head grinders
Framing square
Soapstone
Tape measure
Pliers

continued
Half-round bastard file  Workpiece clamps
Wire brush  Module Examinations*
Chipping hammer  Performance Profile Sheets*

*Located in the Test Booklet.

**Safety Considerations**

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**

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 website: http://www.lincolnelectric.com offers sources for products and training.

**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 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.

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

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

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

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

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

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

| Markers/chalk                      | Tape measure         |
| Pencils and scratch paper         | Pliers               |
| Whiteboard/chalkboard             | Half-round bastard file |
| 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

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.
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 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.

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<tr>
<th>Topic</th>
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<td>A. Introduction</td>
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<td>7. Gas Nozzle Cleaning</td>
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<td>D. Laboratory</td>
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<tr>
<td>Have trainees set up the welding area and prepare plate coupons for GMAW and FCAW fillet and groove welds.</td>
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<tr>
<td>Sessions II–III. Bead Types; Laboratory</td>
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<td>A. Bead Types</td>
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<td>1. Stringer Beads</td>
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<td>5. Overlapping Beads</td>
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<td>B. Laboratory</td>
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<tr>
<td>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.</td>
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</tbody>
</table>
Sessions IV–XV. Fillet Welds

A. Flat (1F) Position Welds
   1. Laboratory
      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
   1. Laboratory
      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
   1. Laboratory
      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
   1. Laboratory
      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
   1. Root Pass
   2. Groove Weld Positions
   3. Acceptable and Unacceptable Groove Weld Profiles

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

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.

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.

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.

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.

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.

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.

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.

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.

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.
Module Overview

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

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

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

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

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

- Markers/chalk
- Pencils and scratch paper
- Whiteboard/chalkboard
- 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

*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.

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.

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<td>E. Welding Cable</td>
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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

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

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
B. Positioning the GTAW Equipment
C. Connecting the Shielding Gas
D. Setting the Shielding Gas Flow Rate
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.

F. Selecting the Electrode
G. Preparing the Electrode
H. Laboratory
   Using a supplied WPS, have trainees practice selecting and preparing the electrode. This laboratory corresponds to Performance Task 4.

I. Selecting and Installing the Nozzle
J. Installing the Electrode
K. Laboratory
   Have trainees practice selecting and installing nozzles and electrodes.
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

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

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

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

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

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

Markers/chalk
Pencils and scratch paper
Whiteboard/chalkboard
Welding 2 PowerPoint® Presentation Slides
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.

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 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.

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</table>
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.