

Module Overview

This module covers the basics of aluminum metallurgy. It also explains how to make fillet and V-groove welds on aluminum plate in all positions using GMAW equipment, aluminum wire, and shielding gas.

Prerequisites

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

Objectives

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

1. Identify and explain aluminum metallurgy and the characteristics of aluminum.
2. Explain GMAW and how to set up GMAW equipment to weld aluminum.
3. Build a pad with stringer beads and weave beads, using GMAW equipment, aluminum wire, and shielding gas.
4. Perform multiple-pass fillet welds on aluminum plate in the following positions, using GMAW equipment, aluminum wire, and shielding gas:
 - 1F
 - 2F
 - 3F
 - 4F
5. Perform multiple-pass V-groove welds on aluminum plate with backing in the following positions, using GMAW equipment, aluminum wire, and shielding gas:
 - 1G
 - 2G
 - 3G
 - 4G

Performance Tasks

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

1. Make selected GMAW welds on aluminum plate:
 - Stringer beads
 - Weave beads
 - Weld restarts
 - Weld terminations
 - Overlapping beads
2. Make selected GMAW fillet welds on aluminum plate in the following positions:
 - 1F
 - 2F
 - 3F
 - 4F
3. Make selected GMAW V-groove welds on aluminum plate with backing in the following positions:
 - 1G
 - 2G
 - 3G
 - 4G

Materials and Equipment

Pencils and scratch paper
Whiteboard/chalkboard
Markers/chalk
Advanced Topics in Welding: Aluminum
PowerPoint® Presentation Slides
(ISBN 978-0-13-213766-9)
Multimedia projector and screen
Desktop or laptop computer
Appropriate personal protective equipment
Fully charged fire extinguishers for the labs
Welding curtains or shields
GMAW welding equipment
A supply of the following:

- Shielding gas
- Aluminum filler wire
- Aluminum plate for coupons $\frac{3}{8}$ "-thick
(or substitute $\frac{1}{4}$ "- to $\frac{3}{4}$ "-thick plate)
- Aluminum for backing strips

Cleaning materials for aluminum coupons
MSDS for each cleaning agent used
Welding bench with arm for position work
Portable grinders with extra grinding discs
Bevel gauges
Levels
Framing squares
Precision measurement devices
(micrometers and calipers)
Soapstone
Tape measures
Pliers
Half-round bastard files

Stainless steel wire brushes
Chipping hammers
Workpiece clamps
Examples of the following:

- Heat-treatable and nonheat-treatable aluminum
- Cast and wrought aluminum
- Welds with burn-through and melt-through
- Broken apart or sawed apart aluminum welds showing porosity
- Aluminum welds with solidification and liquation cracking
- Aluminum fillet welds cut apart to show acceptable and unacceptable weld profiles
- Aluminum V-groove welds cut apart to show acceptable and unacceptable weld profiles
- Beads created with different welding voltage and amperage settings
- Beads created with different travel speed settings and gun angles
- Acceptable and unacceptable GMAW stringer and weave beads
- Properly and improperly terminated welds
- Proper and improper overlapping beads
- Fillet and groove welds from all four welding positions
- Root passes before and after grinding

Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

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 V-groove welds on aluminum plate using GMAW. Ensure that trainees are properly briefed on the safe use of GMAW equipment and are familiar with all appropriate safety precautions and procedures. Verify 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.

AWS D1.2/D1.2M:2008 Structural Welding Code – Aluminum. Miami, FL: American Welding Society.

AWS PRGQA The Practical Reference Guide for High Quality Fusion Welding of Aluminum. Miami, FL: American Welding Society, 2001.

AWS PRGWA The Practical Reference Guide for Welding Aluminum in Commercial Applications. Miami, FL: American Welding Society, 2002.

Lincoln Electric website: <http://www.lincolnelectric.com> offers sources for products and training.

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

Welding Aluminum: Theory and Practice. New York, NY: The Aluminum Association, 2002.

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 30 hours are suggested to cover *GMAW – Aluminum 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. The laboratory portion should take approximately 22½ hours or 9 sessions.

Topic	Planned Time
Session I. Introduction; Safety Summary; Aluminum Metallurgy; Characteristics of Aluminum Welding; Welding Preparation	
A. Introduction	_____
B. Safety Summary	_____
1. Protective Clothing and Equipment	_____
2. Fire/Explosion Prevention	_____
3. Work Area Ventilation	_____
C. Aluminum Metallurgy	_____
1. Nonheat-Treatable Alloys	_____
2. Heat-Treatable Alloys	_____
3. Filler Metal Alloys	_____
4. Cast Aluminum	_____
5. Wrought Aluminum	_____
D. Characteristics of Aluminum Welding	_____
1. Surface Preparation	_____
2. Weld Problems	_____
E. Welding Preparation	_____
1. Practice Welding Coupons	_____
2. The Welding Machine	_____
Sessions II-IV. Welding Beads; Laboratory and Performance Testing	
A. Welding Beads	_____
1. Bead Types	_____
2. Weld Restarts	_____
3. Weld Terminations	_____
4. Overlapping Beads	_____
B. Laboratory	
1. Have trainees practice setting up GMAW equipment to weld aluminum.	_____
2. Have trainees prepare aluminum plate coupons for fillet welds.	_____
3. Have trainees practice making selected GMAW welds (stringer beads, weave beads, weld restarts, weld terminations, overlapping beads, and building a pad) on aluminum plate coupons. This laboratory corresponds to Performance Task 1.	_____

Sessions V–VII. Practicing Fillet Welds in the 1F, 2F, 3F, and 4F Positions; Laboratory and Performance Testing

A. Practicing Fillet Welds in the Flat (1F), Horizontal (2F), Vertical (3F), and Overhead (4F) Positions _____

B. Laboratory

1. Have trainees prepare aluminum plate coupons for fillet welds. _____
2. Have trainees practice making selected GMAW fillet welds on aluminum plate in the following positions: (This laboratory corresponds to Performance Task 2.) _____
 - 1F
 - 2F
 - 3F
 - 4F

Sessions VIII–X. Practicing Groove Plate Welds in the 1G, 2G, 3G, and 4G Positions; Laboratory and Performance Testing

A. Practicing Groove Plate Welds in the Flat (1G), Horizontal (2G), Vertical (3G), and Overhead (4G) Positions _____

B. Laboratory

1. Have trainees prepare aluminum plate coupons with backing for groove welds. _____
2. Have trainees make selected GMAW V-groove welds on aluminum plate with backing in the following positions: (This laboratory corresponds to Performance Task 3.) _____
 - 1G
 - 2G
 - 3G
 - 4G

Sessions XI–XII. Review and Testing; Performance Accreditation Tasks

A. Module Review _____

B. Module Examination _____

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

D. 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 Aluminum Plate in the Flat (G) Position using GTAW Stringer Beads. PAT 1 has no AWS correlation. _____
2. Have trainees perform PATs 2, 3, 4, and 5, Make Multiple-Pass Fillet Welds on Aluminum Plate in the 1F, 2F, 3F, and 4F Positions. These tasks correspond to AWS EG3.0-96: 3.3.6.2, Unit #2, GMAW, Learning Objective #6, (1F, 2F, 3F, and 4F). _____
3. Have trainees perform PATs 6, 7, 8, and 9, Make Multiple-Pass V-Groove Welds with Backing on Aluminum Plate in the 1G, 2G, 3G, and 4G Positions. These tasks correspond to AWS EG3.0-96: 3.3.6.2, Unit #2, GMAW, Learning Objective #7, (1G, 2G, 3G, and 4G – with backing). _____

Module Overview

This module covers GTAW equipment setup. It also explains how to make fillet and V-groove welds on aluminum plate in all positions using GTAW equipment and aluminum filler metal.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Welding Level One; Welding Level Two; Welding Level Three; and Advanced Topics in Welding: Aluminum*, Module 29401-10.

Objectives

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

1. Explain GTAW and how to set up GTAW equipment to weld aluminum plate.
2. Explain and demonstrate GTAW techniques used to weld aluminum.
3. Build a pad with stringer beads and weave beads, using GTAW equipment and aluminum filler metal.
4. Make multiple-pass fillet welds on aluminum plate in the following positions, using GTAW equipment and aluminum filler metal:
 - 1F
 - 2F
 - 3F
 - 4F
5. Make multiple-pass V-groove welds on aluminum plate with backing in the following positions, using GTAW equipment and aluminum filler metal:
 - 1G
 - 2G
 - 3G
 - 4G

Performance Tasks

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

1. Set up GTAW equipment to make fillet and V-groove welds on aluminum plate.
2. Weld a pad on aluminum plate in the flat position using GTAW stringer beads.
3. Make multiple-pass fillet welds on aluminum plate in the following positions using GTAW equipment and aluminum filler metal:
 - 1F
 - 2F
 - 3F
 - 4F
4. Make multiple-pass V-groove welds on aluminum plate with backing in the following positions using GTAW equipment and aluminum filler metal:
 - 1G
 - 2G
 - 3G
 - 4G

Materials and Equipment

Pencils and scratch paper
Whiteboard/chalkboard
Markers/chalk
Advanced Topics in Welding: Aluminum
PowerPoint® Presentation Slides
(ISBN 978-0-13-213766-9)
Multimedia projector and screen
Desktop or laptop computer
Appropriate personal protective equipment
Fully charged fire extinguishers for the labs
Welding curtains or shields
GTAW welding equipment
A supply of the following:

- Applicable shielding gases
- Applicable aluminum filler metal rods
- Aluminum plate for coupons 3/8"-thick (or substitute 1/4"- to 3/4"-thick plate)
- Aluminum for backing strips
- Cleaning materials for aluminum coupons

MSDS for each cleaning agent used
Welding bench with arm for position work
Portable grinders with extra grinding discs
Bevel gauges
Levels
Framing squares
Precision measurement devices (micrometers and calipers)
Soapstone
Tape measures

Pliers
Half-round bastard files
Stainless steel wire brushes
Chipping hammers
Workpiece clamps
Examples of the following:

- Different types of filler metal rods, both new and used
- Manufacturers' welding guides for filler metals
- Different types of GTAW torches
- Aluminum fillet welds cut apart to show acceptable and unacceptable weld profiles
- Aluminum V-groove welds cut apart to show acceptable and unacceptable weld profiles
- Beads created with different travel speed settings and different torch angles
- Beads created with freehand and walking-the-cup techniques
- Acceptable and unacceptable GTAW stringer and weave beads
- Welds with acceptable and unacceptable restarts
- Properly and improperly terminated welds
- Proper and improper overlapping beads
- Fillet and groove welds from all four welding positions

Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

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 V-groove welds on aluminum plate using GTAW equipment. Ensure that trainees are properly briefed on the safe use of GTAW welding equipment and are familiar with all appropriate safety precautions and procedures. Verify 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.

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

Welding Aluminum: Theory and Practice. New York, NY: The Aluminum Association, 2002.

Welding Handbook. Volume 1. *Welding Science & Technology*. Miami, FL: The American Welding Society, 2001.

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 30 hours are suggested to cover *GTAW – Aluminum 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. The laboratory portion should take approximately 22½ hours or 9 sessions.

Topic	Planned Time
Session I. Introduction; Safety Practices; Welding Equipment Setup	
A. Introduction	_____
B. Safety Practices	_____
1. Protective Clothing and Equipment	_____
2. Fire/Explosion Prevention	_____
3. Work Area Ventilation	_____
C. Welding Equipment Setup	_____
1. Preparing the Welding Area	_____
2. Selecting Aluminum Filler Metals	_____
3. Preparing Welding Coupons	_____
4. Selecting Shielding Gas	_____
5. Welding Equipment	_____
Session II. GTAW Techniques; Bead Types	
A. GTAW Techniques	_____
1. Torch Travel Speed and Arc Length	_____
2. Torch Angles	_____
3. Torch and Filler Metal Handling Techniques	_____
B. Bead Types	_____
1. Practicing Weave Beads	_____
2. Weld Restarts	_____
3. Weld Terminations	_____
4. Overlapping Beads	_____
5. Building a Pad with Stringer or Weave Beads	_____
Session III–IV. Laboratory and Performance Testing	
A. Laboratory	
1. Have trainees set up the welding area for GTAW on aluminum plate.	_____
2. Have trainees select, inspect, clean, repair, and store filler metal rods.	_____
3. Have trainees prepare aluminum plate coupons and backing strips for practice welds.	_____
4. Have trainees start, terminate, restart, and overlap GTAW welds on aluminum plate.	_____
B. Performance Laboratory	
1. Have trainees set up GTAW equipment to make fillet and V-groove welds on aluminum plate. This laboratory corresponds to Performance Task 1.	_____
2. Have trainees weld a pad on aluminum plate in the flat position, using GTAW stringer beads. This laboratory corresponds to Performance Task 2.	_____

Sessions V–VII. Fillet Welds (1F, 2F, 3F, and 4F);

Laboratory and Performance Testing

A. Practicing Fillet Welds in the Flat (1F), Horizontal (2F), Vertical (3F), and Overhead (4F) Positions _____

B. Laboratory

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

Sessions VIII–XI. V-Groove Plate Welds (1G, 2G, 3G, and 4G);

Laboratory and Performance Testing

A. V-Groove Plate Welds _____

1. Root Pass _____
2. V-Groove Weld Positions _____
3. Acceptable and Unacceptable V-Groove Welds with Backing _____

B. Practicing V-Groove Welds with Backing in the Flat (1G), Horizontal (2G), Vertical (3G), and Overhead (4G) Positions _____

C. Laboratory

1. Have trainees make multiple-pass V-groove welds on aluminum plate with backing in the 1G, 2G, 3G, and 4G positions using GTAW equipment and aluminum filler metal. This laboratory corresponds to Performance Task 4. _____

Session XII. Review and Testing; Performance Accreditation Tasks

A. Module Review _____

B. Module Examination _____

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

D. 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 Aluminum Plate in the Flat (1G) Position using GTAW Stringer Beads. This PAT has no AWS correlation. _____
2. Have trainees perform PATs 2 and 3, Make Multiple-Pass Fillet Welds on Aluminum Plate in the 1F and 2F Positions. PATs 2 and 3 correspond to AWS EG2.0:2006 3.3.1, Module 7, Key Indicator 15, (1F and 2F). _____
3. Have trainees perform PATs 4 and 5, Make Multiple-Pass Fillet Welds on Aluminum Plate in the 3F and 4F Positions. PATs 4 and 5 correspond to AWS EG3.0-96: 3.3.6.4, Unit #4, GTAW, Learning Objective #6, (3F and 4F). _____
4. Have trainees perform PAT 6, Make Multiple-Pass V-Groove Welds on Aluminum Plate with Backing in the 1G Position. PAT 6 corresponds to AWS EG2.0:2006 3.3.1, Module 7, Key Indicator 16, (1G). _____
5. Have trainees perform PATs 7, 8, and 9, Make Multiple-Pass V-Groove Welds on Aluminum Plate with Backing in the 2G, 3G, and 4G Positions. PATs 7, 8, and 9 correspond to AWS EG3.0-96: 3.3.6.4, Unit #4, GTAW, Learning Objective #7 (2G, 3G, and 4G). _____

Module Overview

This module covers welding area setup and gas tungsten arc welding techniques. It also explains how to make GTAW V-groove and modified U-groove welds on aluminum pipe in the 2G, 5G, and 6G positions.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Welding Level One; Welding Level Two; Welding Level Three; and Advanced Topics in Welding: Aluminum*, Modules 29401-10 and 29402-10.

Objectives

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

1. Prepare GTAW equipment for V-groove and modified U-groove welds on aluminum pipe.
2. Identify and explain V-groove and modified U-groove welds on aluminum pipe with GTAW equipment.
3. Perform V-groove and modified U-groove welds on aluminum pipe in the following positions using GTAW equipment:
 - 2G
 - 5G
 - 6G

Performance Tasks

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

1. Set up GTAW equipment to weld aluminum pipe.
2. Make GTAW V-groove and modified U-groove welds on aluminum pipe in the following positions:
 - 2G
 - 5G
 - 6G

Materials and Equipment

Pencils and scratch paper
Whiteboard/chalkboard
Markers/chalk
Advanced Topics in Welding: Aluminum
PowerPoint® Presentation Slides
(ISBN 978-0-13-213766-9)
Multimedia projector and screen
Desktop or laptop computer
Appropriate personal protective equipment
Fully charged fire extinguishers for the labs
Welding curtains or shields
GTAW welding equipment
A supply of the following:

- Shielding gas
- Applicable aluminum filler metal rods
- Aluminum pipe for coupons
(3" to 12" diameter Schedule 40)
- Cleaning materials for coupons

MSDS for each cleaning agent used
Welding bench with arm for position work
Portable grinders with extra grinding discs
Bevel gauges
Levels
Hi-Lo gauges
Framing squares
Precision measurement devices
(micrometers and calipers)
Soapstone
Tape measures
Pliers
Half-round bastard files
Stainless steel wire brushes
Chipping hammers
Workpiece clamps

(continued)

Examples of the following:

- V-groove and modified U-groove pipe coupons
- Backing rings used for 6GR welds
- Acceptable and unacceptable beads created with different travel speeds, arc lengths, and gun angles

- Prepared aluminum pipe coupons with ring for 6GR welds
- V-groove and modified U-groove welds from all four positions

Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

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 V-groove and modified U-groove welds on aluminum pipe with GTAW equipment. Ensure that trainees are properly briefed on the safe use of GTAW equipment and are familiar with all appropriate safety precautions and procedures. Verify 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.

API 1104 – Welding of Pipelines and Related Facilities. Washington, DC: American Petroleum Institute, 2005.

ASME Boiler and Pressure Vessel Code, Section IX: Welding and Brazing Qualifications. New York, NY: ASME International, 2007.

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 D1.2/D1.2M:2008 Structural Welding Code – Aluminum. Miami, FL: American Welding Society.

AWS D10.11M/D10.11:2007 Guide for Root Pass Welding of Pipe Without Backing. Miami, FL: American Welding Society.

Lincoln Electric website: <http://www.lincolnelectric.com> offers sources for products and training.

MIG Welding Handbook. Florence, SC: ESAB, 1994.

Modern Welding Technology. Howard B. Cary and Scott Helzer. Englewood Cliffs, NJ: Prentice Hall, Inc., 2005.

OSHA 1910.269, Appendix C, Protection from Step and Touch Potentials. Current edition. Washington, DC: Occupational Safety & Health Administration.

OSHA 1926.351, Arc Welding and Cutting. Current edition. Washington, DC: Occupational Safety & Health Administration.

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

Welding Aluminum: Theory and Practice. New York, NY: The Aluminum Association, 2002.

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.

Welding Pressure Pipelines and Piping Systems. Cleveland, OH: The Lincoln Electric Company, 2000.

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 50 hours are suggested to cover *GTAW – Aluminum Pipe*. 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. The laboratory portion should take approximately 40 hours or 16 sessions.

Topic	Planned Time
Sessions I–II. Introduction; Safety Summary; Welding Preparation; GTAW Techniques; Groove Welds	
A. Introduction	_____
B. Safety Summary	_____
1. Protective Clothing and Equipment	_____
2. Fire/Explosion Prevention	_____
3. Work Area Ventilation	_____
C. Welding Preparation	_____
1. Practice Pipe Weld Coupons	_____
2. The Welding Machine	_____
3. Filler Metals	_____
D. Gas Tungsten Arc Welding Techniques	_____
1. Torch Travel Speed and Arc Length	_____
2. Torch Angles	_____
3. Torch and Filler Metal Handling Techniques	_____
E. V-Groove and Modified U-Groove Pipe Welds	_____
1. Techniques for Aluminum Pipe GTAW	_____
2. Pipe Groove Weld Test Positions	_____
3. Acceptable and Unacceptable Pipe Weld Profiles	_____
Session III. Laboratory and Performance Testing	
A. Laboratory	_____
Have trainees prepare the area and set up GTAW equipment to weld aluminum pipe. This laboratory corresponds to Performance Task 1.	
B. Laboratory	_____
Have trainees practice preparing pipe coupons, running GTAW beads using the freehand and walking-the-cup techniques, and inspecting GTAW beads.	
Sessions IV–VIII. Practicing V-Groove or Modified U-Groove Pipe Welds (2G); Laboratory and Performance Testing	
A. Practicing Horizontal (2G) Position Groove Welds	_____
B. Laboratory	_____
Have trainees prepare aluminum pipe coupons for GTAW groove welds in the 2G position.	
C. Laboratory	_____
Have trainees practice making GTAW V-groove and modified U-groove welds on aluminum pipe in the 2G position. This laboratory corresponds to Performance Task 2.	

**Sessions IX–XIII. Practicing V-Groove or Modified U-Groove Pipe Welds (5G);
Laboratory and Performance Testing**

A. Practicing Multiple (5G) Position Groove Welds _____

B. Laboratory _____

Have trainees prepare aluminum pipe coupons for GTAW groove welds in the 5G position.

C. Laboratory _____

Have trainees practice making GTAW V-groove and modified U-groove welds on aluminum pipe in the 5G position. This laboratory corresponds to Performance Task 2.

**Sessions XIV–XVIII. Practicing V-Groove or Modified U-Groove Pipe Welds (6G);
Laboratory and Performance Testing**

A. Practicing Multiple Inclined (6G) Position Groove Welds _____

B. Laboratory _____

Have trainees prepare aluminum pipe coupons for GTAW groove welds in the 6G position.

C. Laboratory _____

Have trainees practice making GTAW V-groove and modified U-groove welds on aluminum pipe in the 6G position. This laboratory corresponds to Performance Task 2.

Sessions XIX–XX. Review and Testing; Performance Accreditation Tasks

A. Module Review _____

B. Module Examination _____

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

D. Performance Accreditation Tasks – Have trainees complete PAT 1 through PAT 3, according to the acceptance criteria.

1. Have trainees perform PAT 1, Make V-Groove or Modified U-Groove Welds on Aluminum Pipe in the 2G Position. This task corresponds to AWS EG3.0-96: 3.3.6.4, Unit #4, GTAW, Learning Objective #14, (2G and 5G). _____
2. Have trainees perform PAT 2, Make V-Groove or Modified U-Groove Welds on Aluminum Pipe in the 5G Position. This task corresponds to AWS EG3.0-96: 3.3.6.4, Unit #4, GTAW, Learning Objective #14, (2G and 5G). _____
3. Have trainees perform PAT 3, Make V-Groove or Modified U-Groove Welds on Aluminum Pipe in the 6G (or 6GR) Position. This task corresponds to AWS EG3.0-96: 3.3.6.5, Unit #5, GTAW, Learning Objective #12 (6G with backing ring). _____

Module Overview

This module explains how to make V-groove welds on aluminum pipe with backing in all positions using GMAW equipment, aluminum filler wire, and shielding gas.

Prerequisites

Prior to training with this module, it is recommended that the trainee shall have successfully completed *Core Curriculum; Welding Level One; Welding Level Two; Welding Level Three; and Advanced Topics in Welding: Aluminum*, Modules 29401-10 through 29403-10.

Objectives

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

1. Explain GMAW preparations associated with making V-groove welds on aluminum pipe.
2. Perform V-groove welds on aluminum pipe with backing in the following positions, using GMAW equipment, aluminum wire, and shielding gas:
 - 2G
 - 5G
 - 6G

Performance Tasks

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

1. Make selected V-groove welds on aluminum pipe with backing in the following positions, using GMAW equipment:
 - 2G
 - 5G
 - 6G

Materials and Equipment

Pencils and scratch paper
Whiteboard/chalkboard
Markers/chalk
Advanced Topics in Welding: Aluminum
PowerPoint® Presentation Slides
(ISBN 978-0-13-213766-9)
Multimedia projector and screen
Desktop or laptop computer
Appropriate personal protective equipment
Fully charged fire extinguishers for the labs
Welding curtains or shields
GMAW welding equipment
A supply of the following:

- Shielding gas
- Applicable aluminum filler wire
- Aluminum pipe for coupons
(6" to 12" diameter Schedule 40)
- Cleaning materials for coupons

MSDS for each cleaning agent used
Welding bench with arm for position work
Portable grinders with extra grinding discs
Bevel gauges
Levels
Hi-Lo gauges
Framing squares
Precision measurement devices:
(micrometers and calipers)
Soapstone
Tape measures
Pliers
Half-round bastard files
Stainless steel wire brushes
Chipping hammers
Workpiece clamps

(continued)

Examples of the following:

- Beads/welds created with different voltage and amperage settings
- Beads/welds created with different travel speeds and gun angles
- Welds made with different electrode extensions, stickouts, and standoff distances
- V-groove aluminum pipe coupons with backing
- Aluminum pipe coupons with ground and unground tack welds
- V-groove welds with backing from all four positions
- Backing rings used for 6GR welds
- Prepared aluminum pipe coupons with ring for 6GR welds

Module Examinations*
Performance Profile Sheets*

* Single-module AIG purchases include the printed exam and performance task sheet. If you have purchased the perfect-bound version of this title, download these materials from the IRC using your access code.

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 V-groove welds on aluminum pipe with backing using GMAW equipment. Ensure that trainees are properly briefed on the safe use of GMAW equipment and are familiar with all appropriate safety precautions and procedures. Verify 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.

API 1104 – Welding of Pipelines and Related Facilities. Washington, DC: American Petroleum Institute, 2005.

ASME Boiler and Pressure Vessel Code, Section IX: Welding and Brazing Qualifications. New York, NY: ASME International, 2007.

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 C5.6-1989 Recommended Practices for Gas Metal Arc Welding. Miami, FL: American Welding Society.

AWS D1.2/D1.2M:2008 Structural Welding Code – Aluminum. Miami, FL: American Welding Society.

AWS D10.7M/D10.7:2008 Guide for the Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe. Miami, FL: American Welding Society.

Lincoln Electric website: <http://www.lincolnelectric.com> offers sources for products and training.

MIG Welding Handbook. Florence, SC: ESAB, 1994.

Modern Welding Technology. Howard B. Cary and Scott Helzer. Englewood Cliffs, NJ: Prentice Hall, Inc., 2005.

OSHA 1910.269, Appendix C, Protection from Step and Touch Potentials. Current edition. Washington, DC: Occupational Safety & Health Administration.

OSHA 1926.351, Arc Welding and Cutting. Current edition. Washington, DC: Occupational Safety & Health Administration.

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

Welding Aluminum: Theory and Practice. New York, NY: The Aluminum Association, 2002.

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.

Welding Pressure Pipelines and Piping Systems. Cleveland, OH: The Lincoln Electric Company, 2000.

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 50 hours are suggested to cover *GMAW – Aluminum Pipe*. 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. The laboratory portion should take approximately 40 hours or 16 sessions.

Topic	Planned Time
Session I. Introduction; Safety Summary; Welding Preparation	
A. Introduction	_____
B. Safety Summary	_____
1. Protective Clothing and Equipment	_____
2. Fire/Explosion Prevention	_____
3. Work Area Ventilation	_____
4. Housekeeping and Fall Protection	_____
5. Electrical Hazards	_____
C. Welding Preparation	_____
1. The Welding Machine	_____
2. Practice Welding Coupons	_____
Session II. Laboratory	
A. Laboratory	_____
Have trainees prepare the area and set up GMAW equipment for welding aluminum pipe.	
B. Laboratory	_____
Have trainees prepare aluminum pipe coupons for V-groove welds with backing.	
Sessions III–IV. Practicing V-Groove Pipe Welds (1G-ROTATED); Laboratory	
A. Practicing Flat (1G-ROTATED) Position V-Groove Welds	_____
B. Laboratory	_____
Have trainees prepare aluminum pipe coupons for GMAW V-groove welds in the 1G-ROTATED position.	
C. Laboratory	_____
Have trainees practice making selected V-groove welds on aluminum pipe with backing in the flat (1G-ROTATED) position using GMAW equipment.	
Sessions V–VIII. Practicing V-Groove Pipe Welds (2G); Laboratory and Performance Testing	
A. Practicing Horizontal (2G) Position V-Groove Welds	_____
B. Laboratory	_____
Have trainees prepare aluminum pipe coupons for GMAW V-groove welds in the 2G position.	
C. Laboratory	_____
Have trainees practice making selected V-groove welds on aluminum pipe with backing in the horizontal (2G) position using GMAW equipment. This laboratory corresponds to Performance Task 1.	

**Sessions IX–XIII. Practicing V-Groove Pipe Welds (5G);
Laboratory and Performance Testing**

A. Practicing Multiple (5G) Position V-Groove Welds _____

B. Laboratory _____

Have trainees prepare aluminum pipe coupons for GMAW V-groove welds in the 5G position.

C. Laboratory _____

Have trainees practice making selected V-groove welds on aluminum pipe with backing in the multiple (5G) position using GMAW equipment. This laboratory corresponds to Performance Task 1.

**Sessions XIV–XIX. Practicing V-Groove Pipe Welds (6G);
Laboratory and Performance Testing**

A. Practicing Multiple Inclined (6G) Position V-Groove Welds _____

B. Laboratory _____

Have trainees prepare aluminum pipe coupons for GMAW V-groove welds in the 6G position.

C. Laboratory _____

Have trainees practice making selected V-groove welds on aluminum pipe with backing in the multiple inclined (6G) position using GMAW equipment. This laboratory corresponds to Performance Task 1.

Session XX. Review and Testing; Performance Accreditation Tasks

A. Module Review _____

B. Module Examination _____

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

D. Performance Accreditation Tasks – Have trainees complete PAT 1 through PAT 3, according to the acceptance criteria.

1. Have trainees perform PAT 1, Make V-Groove Welds on Aluminum Pipe with Backing in the 2G Position. This task has no AWS correlation. _____
2. Have trainees perform PAT 2, Make V-Groove Welds on Aluminum Pipe with Backing in the 5G Position. This task has no AWS correlation. _____
3. Have trainees perform PAT 3, Make V-Groove Welds on Aluminum Pipe with Backing in the 6G (or 6GR) Position. This task corresponds to AWS EG4.0-96: 3.3.6.3, Unit #3, GMAW, Learning Objective #8 (6G). _____