

# GMAW – ALUMINUM PLATE

**Module One (29401-16)** presents gas metal arc welding (GMAW)—one of the more common welding processes now used. As with most welding systems, GMAW equipment is available in many different sizes and varieties. However, the basic operating principles of GMAW apply to all makes and models of equipment. This module describes how GMAW equipment is used to weld aluminum plate and examines different techniques used to produce fillet and V-groove plate welds in aluminum base metals.

### Objectives

#### Learning Objective 1

- Identify aluminum-welding metallurgical considerations and the types of weld problems commonly encountered.
  - a. Describe various aluminum alloys and their characteristics.
  - b. Identify key characteristics of aluminum welding using GMAW.
  - c. Describe the types of problems commonly encountered in aluminum welding.

#### Learning Objective 2

- Explain how to prepare for GMAW of aluminum plate and describe specific welding techniques.
  - a. Identify common welding safety practices.
  - b. Explain how to prepare the area and materials for GMAW practice.
  - c. Describe how to prepare GMAW equipment for aluminum welding.
  - d. Describe how to accomplish terminations and restarts and create basic GMAW weld beads.
  - e. Describe how to make aluminum fillet welds in various positions.
  - f. Describe how to make aluminum plate V-groove welds in various positions.

### Performance Tasks

#### Performance Task 1 (Learning Objective 2)

- Complete the following GMAW aluminum-plate welding tasks:
  - Stringer beads
  - Weave beads
  - Weld terminations
  - Weld restarts
  - Overlapping beads

#### Performance Task 2 (Learning Objective 2)

- Complete GMAW fillet welds on aluminum plate in the following positions:
  - 1F
  - 2F
  - 3F
  - 4F

#### Performance Task 3 (Learning Objective 2)

- Complete GMAW V-groove welds on aluminum plate with backing in the following positions:
  - 1G
  - 2G
  - 3G
  - 4G

### Teaching Time: 30 Hours

(Twelve 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the accompanying PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and Performance Profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER's Registry is 70% or above for the written examination; all Performance Tasks are graded pass or fail.



## Safety Considerations

This module requires that trainees work with and around equipment that generates high voltages, extremely high temperatures, and intense ultraviolet radiation. Trainees must also handle shielding gases under high pressure. Safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to unseen hazards related to welding and the welding environment. Any deficiencies must be corrected to ensure the future safety of all trainees. All practice sessions and Performance Tasks must be completed under your direct supervision.

## Classroom Equipment and Materials

Whiteboard  
Dry-erase markers  
A variety of standard marker sizes  
Pencils and paper  
Poster board  
Flip chart  
*Welding Level Four* PowerPoint® presentation slides  
LCD projector and screen  
Computer (Internet access optional)  
Module Review answer key  
Copies of the Module Examination and answer key (for paper-based exams)  
Performance Profile sheets

## Equipment and Materials for Laboratories and Performance Testing

Minimum Safety Equipment:  
Appropriate flame-retardant clothing  
Safety glasses  
Face shields  
Work gloves  
Welding gloves  
Welding hood with a lens of the appropriate shade  
Proper footwear as directed by the instructor or training facility provider  
Hearing protection as directed by the instructor or training facility provider  
Hard hat as directed by the instructor or training facility provider  
Fire extinguisher  
Welding machines capable of GMAW, complete with welding guns, cables, and shielding gas hoses  
Wire feeders or spool guns  
Sufficient supply of appropriate electrode wire

Sufficient supply of shielding gas  
Sufficient supply of aluminum plate for practice, ¼" (6 mm metric plate) preferred; up to ½" (12 mm metric plate) thickness with the joint design described herein  
Welding bench with arm suited for position work; alternatively, a welding positioner may be used  
Metal cutting equipment  
Angle grinders  
Grinding wheels appropriate for aluminum  
Squares  
Tape measures or steel rules  
Soapstone  
Files dedicated to aluminum  
Wire brushes dedicated to aluminum  
Common hand tools

## Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study:

*Aluminum GMAW Welding Guide* (PDF). The Lincoln Electric Company, Cleveland, OH, USA. [www.lincolnelectric.com](http://www.lincolnelectric.com). Last accessed May 26, 2016.

*Guide for Aluminum Welding*. 2013. Troy, OH: Hobart Brothers Corporation.

*AWS C5.6-89R, Recommended Practices for Gas Metal Arc Welding*. Miami, FL: American Welding Society.

*GMAW Welding Guide* (PDF). The Lincoln Electric Company, Cleveland, OH, USA. [www.lincolnelectric.com](http://www.lincolnelectric.com). Last accessed May 26, 2016.

*OSHA 1926.351, Arc Welding and Cutting*. Current Edition. Washington, DC: Occupational Safety and Health Administration (OSHA).

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

*Welding Handbook*, Volume 1 and Volume 2. Welding Science & Technology. Miami, FL: American Welding Society.

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

There are a number of online resources available for trainees who would like more information on welding aluminum plate using the GMAW process. A search for additional information may be assigned as homework to interested trainees. Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Numerous videos related to the topic are available on the Internet. These can be located by searching "GMAW plate welding" or similar terms, and using the Video tab on the results page of your preferred search engine.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the presentations throughout the program.

## Session Outline for Module 29401-16

# GMAW – ALUMINUM PLATE

The Lesson Plan for this module is divided into twelve 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### SESSION ONE

Session One introduces trainees to the characteristics of aluminum and aluminum alloys, as well as welding safety practices and the required preparations for GMAW plate welding. This session covers Sections 1.0.0 through 2.3.6.

1. Open the Session One presentation.
2. Use the Kickoff Activity to emphasize the importance of cleaning aluminum thoroughly.
3. Review the issues related to welding aluminum and aluminum alloys.
4. Review common welding safety practices, emphasizing any practices directly related to GMAW.
5. Describe how to prepare the welding area, welding coupons, and the welding equipment.
6. Use the Section Review questions to review the topics of this session.

### SESSION TWO

Session Two reviews the techniques needed to produce GMAW fillet and V-groove welds on aluminum plate. This session covers Sections 2.4.0 through 2.6.4.

1. Open the Session Two presentation.
2. Use the Kickoff Activity to review the use of spool guns for GMAW.
3. Discuss terminations, restarts, and basic GMAW beads.
4. Discuss acceptable and unacceptable weld profiles.
5. Review the techniques and required positions for aluminum fillet welds.
6. Review the techniques and required positions for aluminum V-groove welds.
7. Use the Section Review questions to review the topics of this session.
8. Go over the Module Review to prepare trainees for the Module Exam.
9. Administer the Module Exam. Record the testing results on the Registration of Training Modules form and submit the form to your Training Program Sponsor.

### SESSIONS THREE THROUGH TWELVE

Sessions Three through Twelve are laboratory sessions that provide an opportunity to practice and complete the Performance Tasks associated with this module.

1. Note that no slide presentation is associated with these laboratory sessions.
2. Demonstrate how to complete GMAW fillet and V-groove welds on aluminum plate.
3. Trainees practice and complete the requirements of Performance Tasks 1 through 3.
4. Document successful Performance Task completions for each trainee on the Performance Profile sheet and submit the results to the Training Program Sponsor.



**Materials Checklist for Module 29401-16, GMAW – Aluminum Plate**

Equipment and Materials					
<b>Personal protective equipment:</b>		Whiteboard/chalkboard		Wire feeders or spool guns	
Appropriate flame-retardant clothing		Dry erase markers / chalk		Sufficient supply of appropriate electrode wire	
Safety glasses		Pencils and paper		Sufficient supply of shielding gas	
Face shields		Poster board		Metal cutting equipment	
Work gloves		Flip chart		Angle grinders	
Welding gloves		LCD projector and screen		Welding bench with arm suited for position work; alternatively, a welding positioner may be used	
Welding hood with a lens of the appropriate shade		Computer with Internet access (optional)		Grinding wheels appropriate for aluminum	
Proper footwear as designated by instructor or training facility provider		Copies of Module Examination and Module Examination answer key (for paper-based exams)		Wire brushes dedicated to aluminum	
Hearing protection as directed by instructor or training facility provider		<i>Welding Level Four</i> PowerPoint® Presentation Slides		Squares	
Hard hat as directed by instructor or training facility provider		Performance Profile Sheets		Tape measures or steel rules	
Fire extinguisher		Welding machines capable of GMAW, complete with welding guns, cables, and shielding gas hoses		Sufficient supply of aluminum plate for practice, ¼" (6 mm metric plate) preferred; up to ½" (12 mm metric plate) thickness with the joint design described herein	
				Soapstone	
				Files dedicated to aluminum	
				Common hand tools	
				Common hand tools	

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.



## GMAW – ALUMINUM PIPE

**Module Two (29404-16)** presents gas metal arc welding (GMAW) as one of the more common welding processes now used. As with most welding systems, GMAW equipment is available in many different sizes and types. However, the basic operating principles of GMAW apply to all makes and models of equipment. This module describes how GMAW equipment is used to weld aluminum pipe and presents the techniques used to produce V-groove pipe welds with backing.

### Objectives

#### Learning Objective 1

- Explain how to prepare for GMAW of aluminum pipe and describe specific welding techniques.
  - a. Identify common welding safety practices.
  - b. Describe how to prepare GMAW equipment for aluminum pipe welding.
  - c. Explain how to prepare the area and materials for aluminum pipe GMAW.
  - d. Describe how to make aluminum V-groove pipe welds using GMAW.

### Performance Tasks

#### Performance Task 1 (Learning Objective 1)

- Make GMAW V-groove welds on aluminum pipe with backing in the following positions:
  - 2G
  - 5G
  - 6G

### Teaching Time: 50 Hours

(Twenty 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the accompanying PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and Performance Profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER's Registry is 70% or above for the written examination; all Performance Tasks are graded pass or fail.



## Safety Considerations

This module requires that trainees work with and around equipment that generates high voltages, extremely high temperatures, and intense ultraviolet radiation. Trainees must also handle shielding gases under high pressure. Safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to unseen hazards related to welding and the welding environment. Any deficiencies must be corrected to ensure the future safety of all trainees. All practice sessions and Performance Tasks must be completed under your direct supervision.

### Classroom Equipment and Materials

Whiteboard  
Dry-erase markers  
A variety of standard marker sizes  
Pencils and paper  
Poster board  
Flip chart  
*Welding Level Four* PowerPoint® presentation slides  
LCD projector and screen  
Computer (Internet access optional)  
Module Review answer key  
Copies of the Module Examination and answer key (for paper-based exams)  
Performance Profile sheets

### Equipment and Materials for Laboratory and Performance Testing

Minimum Safety Equipment:

- Appropriate flame-retardant clothing
- Safety glasses
- Face shields
- Work gloves
- Welding gloves
- Welding hood with a lens of the appropriate shade
- Proper footwear as directed by the instructor or training facility provider
- Hearing protection as directed by the instructor or training facility provider
- Hard hat as directed by the instructor or training facility provider
- Fire extinguisher

Welding machines capable of GMAW, complete with welding guns, cables, and shielding gas hoses  
Wire feeders or spool guns

Sufficient supply of appropriate electrode wire  
Sufficient supply of shielding gases  
Sufficient supply of aluminum pipe for practice, preferably SCH 40 6" to 12" (DN150 to DN300)  
Welding bench with arm suited for position work; alternatively, a welding positioner may be used  
Metal cutting equipment  
Angle grinders  
Grinding wheels appropriate for aluminum  
Squares  
Tape measures or steel rules  
Soapstone  
Files dedicated to aluminum  
Wire brushes dedicated to aluminum  
Common hand tools

### Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study:

*Aluminum GMAW Welding Guide* (PDF). The Lincoln Electric Company, Cleveland, OH, USA. [www.lincolnelectric.com](http://www.lincolnelectric.com). Last accessed May 26, 2016.

*Guide for Aluminum Welding*. 2013. Troy, OH: Hobart Brothers Corporation.

*AWS C5.6-89R, Recommended Practices for Gas Metal Arc Welding*. Miami, FL: American Welding Society.

*GMAW Welding Guide* (PDF). The Lincoln Electric Company, Cleveland, OH, USA. [www.lincolnelectric.com](http://www.lincolnelectric.com). Last accessed May 26, 2016.

*OSHA 1926.351, Arc Welding and Cutting*. Current Edition. Washington, DC: Occupational Safety and Health Administration (OSHA).

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

*Welding Handbook*, Volume 1 and Volume 2. Current Editions. Welding Science & Technology. Miami, FL: American Welding Society.

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

There are a number of online resources available for trainees who would like more information on welding aluminum pipe using the GMAW process. A search for additional information may be assigned as homework to interested trainees. Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Numerous videos related to the topic are available on the Internet. These can be located by searching "GMAW pipe welding" or similar terms, and using the Video tab on the results page of your preferred search engine.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the presentations throughout the program.

## Session Outline for Module 29404-16

# GMAW – ALUMINUM PIPE

The Lesson Plan for this module is divided into twenty 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### SESSION ONE

Session One introduces trainees to welding aluminum pipe using the GMAW process. This session covers the complete module, Sections 1.0.0 through 1.4.6.

1. Open the Session One presentation.
2. Use the Kickoff Activity to help the trainees recall what they already know about welding aluminum and considering how the information may or may not apply to welding aluminum pipe.
3. Review common welding safety practices, emphasizing any practices directly related to GMAW.
4. Describe how to prepare the welding area, welding coupons, and the welding equipment.
5. Review the techniques and required positions for aluminum pipe V-groove welds.
6. Use the Section Review questions to review the topics of this session.

### SESSION TWO

Session Two is a review and testing session. Have trainees complete the Module Review. Alternatively, these may have been assigned as homework at the end of the previous session. Go over the Module Review in class prior to the exam and answer any questions that the trainees may have.

1. Go over the Module Review to prepare trainees for the Module Exam.
2. Administer the Module Exam. Record the testing results on the Registration of Training Modules form and submit the form to your Training Program Sponsor.

### SESSIONS THREE THROUGH TWENTY

Sessions Three through Twenty are laboratory sessions that provide an opportunity to practice and complete the Performance Tasks associated with this module.

1. Note that no slide presentation is associated with these laboratory sessions.
2. Demonstrate how to complete GMAW V-groove welds with backing on aluminum pipe.
3. Trainees practice and complete the requirements of Performance Task 1.
4. Document successful Performance Task completions for each trainee on the Performance Profile sheet and submit the results to the Training Program Sponsor.



**Materials Checklist for Module 29404-16, GMAW – Aluminum Pipe**

Equipment and Materials					
<b>Personal protective equipment:</b>		Poster board		Metal cutting equipment	
Appropriate flame-retardant clothing		Flip chart		Squares	
Safety glasses		<i>Welding Level Four</i> PowerPoint® Presentation Slides		Wire brushes dedicated to aluminum	
Face shields		LCD projector and screen		Common hand tools	
Work gloves		Computer (Internet access optional)		Sufficient supply of shielding gases	
Welding gloves		Module Review answer key		Grinding wheels appropriate for aluminum	
Welding hood with lens of the appropriate shade		Copies of the Module Examination and answer key (for paper-based exams)		Sufficient supply of aluminum pipe for practice, preferably SCH 40 6" to 12" (DN150 to DN300)	
Proper footwear as designated by instructor or training facility provider		Performance Profile Sheets		Sufficient supply of appropriate electrode wire	
Hearing protection as designated by instructor or training facility provider		Welding machines capable of GMAW, complete with welding guns, cables, and shielding gas hoses		Welding bench with arm suited for position work; alternatively, a welding positioner may be used	
Hard hat as designated by instructor or training facility provider		Tape measures or steel rules		Files dedicated to aluminum	
Fire extinguisher		Angle grinders		Soapstone	
Whiteboard/chalkboard		Wire feeders or spool guns			
Markers/chalk					
A variety of standard marker sizes					
Pencils and paper					

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.



## GTAW – ALUMINUM PLATE

**Module Three (29402-16)** provides insight into welding aluminum using the GTAW process and an opportunity to hone the necessary skills. The GTAW process is unique since the welder must add the filler metal using the opposite hand. The process is well suited for welding aluminum, using the freehand or walking-the-cup technique and both stringer and weave beads.

### Objectives

#### Learning Objective 1

- Explain how to prepare for GTAW aluminum welding and describe specific fillet and groove welding techniques.
  - a. Describe common GTAW welding techniques.
  - b. Identify common welding safety practices.
  - c. Explain how to prepare the area and materials for aluminum GTAW practice.
  - d. Explain how to prepare GTAW equipment for welding.
  - e. Describe how to accomplish terminations and restarts and create basic GTAW weld beads.
  - f. Describe how to make aluminum fillet welds in various positions.
  - g. Describe how to make aluminum plate V-groove welds in various positions.

### Performance Tasks

#### Performance Task 1 (Learning Objective 1)

- Weld a pad on aluminum plate in the flat position using GTAW stringer and weave beads.

#### Performance Task 2 (Learning Objective 1)

- Make multiple-pass GTAW fillet welds on aluminum plate in the following positions:
  - 1F
  - 2F
  - 3F
  - 4F

#### Performance Task 3 (Learning Objective 1)

- Make multiple-pass GTAW V-groove welds with backing on aluminum plate in the following positions:
  - 1G
  - 2G
  - 3G
  - 4G

### Teaching Time: 30 Hours

(Twelve 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the accompanying PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and Performance Profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER's Registry is 70% or above for the written examination; all Performance Tasks are graded pass or fail.



## Safety Considerations

This module requires that trainees work with and around equipment that generates high voltages, extremely high temperatures, and intense ultraviolet radiation. Trainees must also handle shielding gases under high pressure. Safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to unseen hazards related to welding and the welding environment. Any deficiencies must be corrected to ensure the future safety of all trainees. All practice sessions and Performance Tasks must be completed under your direct supervision.

### Classroom Equipment and Materials

Whiteboard  
Dry-erase markers  
A variety of standard marker sizes  
Pencils and paper  
Poster board  
Flip chart  
*Welding Level Four* PowerPoint® presentation slides  
LCD projector and screen  
Computer (Internet access optional)  
Module Review answer key  
Copies of the Module Examination and answer key (for paper-based exams)  
Performance Profile sheets

### Equipment and Materials for Laboratory and Performance Testing

Minimum Safety Equipment:  
Appropriate flame-retardant clothing  
Safety glasses  
Face shields  
Work gloves  
Welding gloves  
Welding hood with a lens of the appropriate shade  
Proper footwear as designated by the instructor or training facility provider  
Hearing protection as designated by the instructor or training facility provider  
Hard hat as designated by the instructor or training facility provider  
Fire extinguisher  
Welding machines capable of GTAW, complete with torches, cables, and shielding gas hoses

Sufficient supply of appropriate filler metal  
Sufficient supply of appropriate tungsten electrodes  
Sufficient supply of shielding gases  
Sufficient supply of aluminum plate for practice, preferably ¼" (6 mm metric plate) but no more than ½" thickness (12 mm metric plate)  
Welding bench with arm suited for position work; alternatively, a welding positioner may be used  
Metal cutting equipment  
Angle grinders  
Grinding wheels suitable for aluminum  
Squares  
Tape measures or steel rules  
Soapstone  
Files dedicated to aluminum  
Wire brushes dedicated to aluminum  
Common hand tools

### Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study:

*OSHA Standard 1926.351, Arc Welding and Cutting.* Current Edition. Washington, DC: Occupational Safety and Health Administration.

*The Procedure Handbook of Arc Welding.* Current Edition. Cleveland, OH: The Lincoln Electric Company.

*Welding Handbook, Volume 1 and Volume 2.* Miami, FL: The American Welding Society.

*Gas Tungsten Arc Welding.* Current Edition. Cleveland, OH: The James F. Lincoln Arc Welding Foundation.

*Gas Tungsten Arc Welding.* Current Edition. Appleton, WI: Miller Electric Manufacturing Company.

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

The following websites offer resources for products and training:

The Lincoln Electric Company, [www.lincolnelectric.com](http://www.lincolnelectric.com).

Miller Electric Manufacturing, [www.millerwelds.com](http://www.millerwelds.com).

There are a number of online resources available for trainees who would like more information on welding aluminum plate using the GTAW process. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Numerous videos related to the topic are available on the Internet. These can be located by searching "GTAW plate welding" or similar terms, and using the Video tab on the results page of your preferred search engine.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the presentations throughout the program.

## Session Outline for 29402-16

# GTAW – ALUMINUM PLATE

The Lesson Plan for this module is divided into twelve 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### SESSION ONE

Session One introduces trainees to welding safety practices and the required preparations for GTAW aluminum plate welding. This session covers Sections 1.0.0 through 1.5.4.

1. Open the Session One presentation.
2. Use the Kickoff Activity to determine trainees' experience with GTAW and aluminum, and to review some basic GTAW concepts.
3. Review the basic concepts of GTAW aluminum plate welding.
4. Review common welding safety practices, emphasizing any practices directly related to GTAW.
5. Describe how to prepare the welding area, welding coupons, and the welding equipment.
6. Discuss how trainees will practice basic stringer and weave beads by building pads.
7. Use the Section Review questions to review the topics of this session.

### SESSION TWO

Session Two reviews the techniques needed to produce GTAW fillet and V-groove with backing welds in aluminum plate. This session covers Sections 1.6.0 through 1.7.4.

1. Open the Session Two presentation.
2. Use the Kickoff Activity to review the use of helium to reduce the required welding current.
3. Review the primary fillet-weld positions.
4. Discuss acceptable and unacceptable fillet-weld profiles.

5. Review the techniques required for fillet welds on aluminum.
6. Review the primary V-groove weld positions.
7. Discuss acceptable and unacceptable V-groove weld profiles.
8. Review the techniques required for V-groove welds with backing on aluminum.
9. Use the Section Review questions to review the topics of this session.
10. Go over the Module Review to prepare trainees for the Module Exam.
11. Administer the Module Exam. Record the testing results on the Registration of Training Modules form and submit the form to your Training Program Sponsor.

### SESSIONS THREE THROUGH TWELVE

Sessions Three through Twelve are laboratory sessions that provide an opportunity to practice and complete the Performance Tasks associated with this module.

1. Note that no slide presentation is associated with these laboratory sessions.
2. Demonstrate how to complete GTAW fillet and V-groove welds on aluminum plate coupons.
3. Trainees practice and complete the requirements of Performance Tasks 1 through 3.
4. Document successful Performance Task completions for each trainee on the Performance Profile sheet and submit the results to the Training Program Sponsor.



**Materials Checklist for Module 29402-16, GTAW – Aluminum Plate**

Equipment and Materials					
<b>Personal protective equipment:</b>		<i>Welding Level Four</i> PowerPoint® presentation slides		Sufficient supply of appropriate filler metal	
Appropriate flame-retardant clothing		LCD projector and screen		Sufficient supply of appropriate tungsten electrodes	
Safety glasses		Computer (Internet access optional)		Grinding wheels suitable for aluminum	
Face shields		Module Review answer key		Metal cutting equipment	
Work gloves		Copies of the Module Examination and answer key (for paper-based exams)		Wire brushes dedicated to aluminum	
Welding gloves		Performance Profile sheets		Tape measures or steel rules	
Welding hood with lens of the appropriate shade		Welding machines capable of GTAW, complete with torches, cables, and shielding gas hoses		Welding bench with arm suited for position work; alternatively, a welding positioner may be used	
Proper footwear as designated by instructor or training facility provider		Sufficient supply of appropriate tungsten electrodes		Sufficient supply of aluminum plate for practice, preferably ¼" (6 mm metric plate) but no more than ½" thickness (12 mm metric plate)	
Hearing protection as designated by instructor or training facility provider		Angle grinders		Files dedicated to aluminum	
Hard hat as designated by instructor or training facility provider		Soapstone		Squares	
Fire extinguisher		Common hand tools			
Whiteboard/chalkboard					
Markers/chalk					
Pencils and paper					
Poster board					
Flip chart					

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.



## GTAW – ALUMINUM PIPE

**Module Four (29403-16)** provides insight into welding aluminum pipe using the GTAW process and the modified U-groove joint, which does not require a metal backing or a backing gas. The GTAW process is unique since the welder must add the filler metal using the opposite hand. The process is well suited for welding aluminum, using the freehand or walking-the-cup technique. One thing welders must understand about welding aluminum is that a significant amount of welding current is required, especially when working with thick materials.

### Objectives

#### Learning Objective 1

- Explain how to prepare for GTAW aluminum pipe welding and describe specific pipe-welding techniques.
  - a. Describe common GTAW pipe-welding techniques.
  - b. Identify common welding safety practices.
  - c. Explain how to prepare the area and materials for aluminum GTAW practice.
  - d. Explain how to prepare GTAW equipment for welding.
  - e. Describe techniques and positions related to aluminum pipe GTAW.
  - f. Describe how to make modified U-groove GTAW welds on aluminum pipe.

### Performance Tasks

#### Performance Task 1 (Learning Objective 1)

- Make GTAW modified U-groove welds on aluminum pipe in the following positions:
  - 2G
  - 5G
  - 6G

### Teaching Time: 50 Hours

(Twenty 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the accompanying PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and Performance Profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER's Registry is 70% or above for the written examination; all Performance Tasks are graded pass or fail.



## Safety Considerations

This module requires that trainees work with and around equipment that generates high voltages, extremely high temperatures, and intense ultraviolet radiation. Trainees must also handle shielding gases under high pressure. Safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to unseen hazards related to welding and the welding environment. Any deficiencies must be corrected to ensure the future safety of all trainees. All practice sessions and Performance Tasks must be completed under your direct supervision.

### Classroom Equipment and Materials

Whiteboard  
Dry-erase markers  
A variety of standard marker sizes  
Pencils and paper  
Poster board  
Flip chart  
LCD projector and screen  
Computer (Internet access optional)  
Module Review answer key  
Copies of the Module Examination and answer key (for paper-based exams)  
Performance Profile sheets

### Equipment and Materials for Laboratory and Performance Tasks

Minimum Safety Equipment:  
Appropriate flame-retardant clothing  
Safety glasses  
Face shields  
Work gloves  
Welding gloves  
Welding hood with a lens of the appropriate shade  
Proper footwear as directed by the instructor or training facility provider  
Hearing protection as directed by the instructor or training facility provider  
Hard hat as directed by the instructor or training facility provider  
Fire extinguisher  
Welding machines capable of GTAW, complete with torches, cables, and shielding gas hoses

Sufficient supply of appropriate filler metal  
Sufficient supply of appropriate tungsten electrodes  
Sufficient supply of shielding gases  
Sufficient supply of aluminum pipe for practice, preferably SCH 40 3" to 12" (DN80 to DN300) pipe  
Welding bench with arm suited for position work; alternatively, a welding positioner may be used  
Metal cutting equipment  
Angle grinders  
Grinding wheels suitable for aluminum  
Squares  
Tape measures or steel rules  
Soapstone  
Files dedicated to aluminum  
Wire brushes dedicated to aluminum  
Common hand tools

### Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study:

*OSHA Standard 1926.351, Arc Welding and Cutting.* Current Edition. Washington, DC: Occupational Safety and Health Administration.

*The Procedure Handbook of Arc Welding.* Current Edition. The Lincoln Electric Company, Cleveland, OH, USA.

*Welding Handbook, Volume 1 and Volume 2.* Miami, FL: The American Welding Society.

*Gas Tungsten Arc Welding.* Current Edition. Cleveland, OH: The James F. Lincoln Arc Welding Foundation.

*Gas Tungsten Arc Welding.* Current Edition. Appleton, WI: Miller Electric Manufacturing Company.

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

The following websites offer resources for products and training:

The Lincoln Electric Company, [www.lincolnelectric.com](http://www.lincolnelectric.com)

Miller Electric Manufacturing, [www.millerwelds.com](http://www.millerwelds.com)

There are a number of online resources available for trainees who would like more information on welding aluminum pipe using the GTAW process. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Numerous videos related to the topic are available on the Internet. These can be located by searching "GTAW pipe welding" or similar terms, and using the Video tab on the results page of your preferred search engine.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the presentations throughout the program.

## Session Outline for 29403-16

# GTAW – ALUMINUM PIPE

The Lesson Plan for this module is divided into twenty 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### SESSION ONE

Session One introduces trainees to welding safety practices and the required preparations for GTAW pipe welding. This session covers Sections 1.0.0 through 1.5.2.

1. Open the Session One presentation.
2. Use the Kickoff Activity to expose trainees to some of the unique applications and positions related to welding aluminum pipe and tube.
3. Review the basic concepts of GTAW aluminum pipe welding.
4. Review common welding safety practices, emphasizing any practices directly related to GTAW.
5. Describe how to prepare the welding area, welding coupons, and the welding equipment.
6. Review the positions related to pipe welding.
7. Use the Section Review questions to review the topics of this session.

### SESSION TWO

Session Two reviews the techniques used to produce GTAW pipe welds on aluminum using the U-groove joint configuration. This session covers Sections 1.6.0 through 1.6.3.

1. Open the Session Two presentation.
2. Use the Kickoff Activity to expose trainees to the welding of cast aluminum materials.
3. Review the primary pipe-welding positions.
4. Review the techniques and steps required to complete welds in the 2G, 5G, and 6G position.
5. Use the Section Review questions to review the topics of this session.
6. Go over the Module Review to prepare trainees for the Module Exam.
7. Administer the Module Exam. Record the testing results on the Registration of Training Modules form and submit the form to your Training Program Sponsor.

### SESSIONS THREE THROUGH TWENTY

Sessions Three through Twenty are laboratory sessions that provide an opportunity to practice and complete the Performance Tasks associated with this module.

1. Note that no slide presentation is associated with these laboratory sessions.
2. Demonstrate how to complete GTAW U-groove welds on aluminum pipe coupons.
3. Trainees practice and complete the requirements of Performance Task 1.
4. Document successful Performance Task completions for each trainee on the Performance Profile sheet and submit the results to the Training Program Sponsor.



**Materials Checklist for Module 29403-16, GTAW – Aluminum Pipe**

Equipment and Materials					
<b>Personal protective equipment:</b>		LCD projector and screen		Sufficient supply of shielding gases	
Appropriate flame-retardant clothing		Computer (Internet access optional)		Sufficient supply of appropriate filler metal	
Safety glasses		<i>Welding Level Four</i> PowerPoint® presentation slides		Sufficient supply of appropriate tungsten electrodes	
Face shields		Module Review answer key		Metal cutting equipment	
Work gloves		Performance Profile sheets		Grinding wheels suitable for aluminum	
Welding gloves		Copies of Module Examination and answer key (for paper-based exams)		Wire brushes dedicated to aluminum	
Welding hood with lens of the appropriate shade		Welding machines capable of GTAW, complete with torches, cables, and shielding gas hoses		Welding bench with arm suited for position work; alternatively, a welding positioner may be used	
Proper footwear as designated by instructor or training facility provider		Sufficient supply of aluminum pipe for practice, preferably SCH 40 3" to 12" (DN80 to DN300) pipe		Files dedicated to aluminum	
Hearing protection as designated by instructor or training facility provider		Tape measures or steel rules		Common hand tools	
Hard hat as designated by instructor or training facility provider		Angle grinders		Squares	
Fire extinguisher		Soapstone			
Whiteboard/chalkboard					
Markers/chalk					
Pencils and paper					
Poster board					
Flip chart					
Computer					
Copies of the Module Examination					

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.



## SOLDERING AND BRAZING

**Module Five (29405-16)** presents soldering and brazing as the two thermal methods used for joining copper tubing and fittings. It describes the safety equipment, tools, and materials needed for soldering and brazing copper tubing for various applications. It also presents the preparations required and the processes involved in soldering and brazing copper tubing.

### Objectives

#### Learning Objective 1

- Describe how to properly prepare and solder copper tubing.
  - a. Describe the proper use of the PPE, tools, and materials needed to solder copper tubing.
  - b. Describe how to prepare materials for soldering.
  - c. Describe how to solder copper tubing.

#### Learning Objective 2

- Describe how to properly prepare and braze copper tubing.
  - a. Describe the proper use of the PPE, tools, and materials needed to braze copper tubing.
  - b. Describe how to prepare the equipment and materials for brazing.
  - c. Describe how to braze copper to copper as well as to dissimilar metals.

### Performance Tasks

#### Performance Task 1 (Learning Objective 1)

- Properly set up and shut down air-acetylene equipment.

#### Performance Task 2 (Learning Objective 1)

- Properly prepare and solder copper tubing in various planes, using various fittings.

#### Performance Task 3 (Learning Objective 2)

- Properly set up and shut down oxyfuel equipment.

#### Performance Task 4 (Learning Objective 2)

- Properly prepare and braze copper tubing in various planes, using various fittings.

### Teaching Time: 12.5 hours

(Five 2.5-Hour Sessions)

Session time may be adjusted to accommodate your class size, schedule, and teaching style.

### Before You Begin

As you prepare for each session, allow sufficient time to review the course objectives, content, visual aids (including the accompanying PowerPoint® presentation), and these lesson plans, and to gather the required equipment and materials. Consider time required for demonstrations, laboratories, field trips, and testing.

Using your access code, download the written examinations and Performance Profile sheets from [www.nccerirc.com](http://www.nccerirc.com). The passing score for submission into NCCER's Registry is 70% or above for the written examination; all Performance Tasks are graded pass or fail.



## Safety Considerations

This module requires that trainees work with and in the vicinity of open flames, sparks, combustible and explosive gases, and hot objects and surfaces. Safety must be emphasized at all times. Trainees should be carefully observed to ensure that they wear the proper PPE, follow safe practices, and give due respect to unseen hazards related to soldering and brazing. Any deficiencies must be corrected to ensure future trainee safety. All practice sessions and Performance Tasks must be completed under the direct supervision of the instructor.

## Classroom Equipment and Materials

Whiteboard  
Dry-erase markers  
A variety of standard marker sizes  
Pencils and paper  
Poster board  
Flip chart  
Welding Level Four PowerPoint® presentation slides  
LCD projector and screen  
Computer (Internet access optional)  
Module Review answer key  
Copies of the Module Examination and answer key (for paper-based exams)  
Performance Profile sheets

## Equipment and Materials for Laboratories and Performance Testing

### Minimum Safety Equipment:

Appropriate flame-retardant clothing  
Safety glasses or welding goggles with the appropriate tint  
Face shields (appropriately tinted if glasses or goggles are not)  
Work gloves  
Flame-retardant gloves, such as those used for GMAW or GTAW welding  
Proper footwear as directed by the instructor or training facility provider  
Hearing protection as directed by the instructor or training facility provider  
Hard hat as directed by the instructor or training facility provider  
Fire extinguisher  
Self-igniting soldering torch head for small propane cylinders

Air-acetylene torch set with appropriate tips  
Oxyacetylene torch set, or comparable equipment, with appropriate brazing tips  
Soldering and brazing filler metals  
Soldering and brazing fluxes  
Copper tubing and fittings; ½" (12 mm) copper tubing is suggested for soldering. ¾" or 1" (22 or 28 mm) tubing is suggested for oxyacetylene brazing practice  
Sand cloth and/or abrasive pads  
Flux brushes  
Tape measures  
Tube-cutting tools  
Reamers suitable for copper tubing  
Tube brushes  
Nitrogen cylinder with regulator (optional)  
Accessories for nitrogen purging (optional)

## Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study:

*A Guide to Brazing and Soldering* (PDF). The Harris Products Group, Mason, Ohio. [www.harrisproductsgroup.com](http://www.harrisproductsgroup.com).

*Gas Welding, Cutting, Brazing, & Heating Torch Instruction Manual* (PDF). The Harris Products Group, Mason, Ohio. [www.harrisproductsgroup.com](http://www.harrisproductsgroup.com).

*Filler Metal Selection Chart* (PDF). The Harris Products Group, Mason, Ohio. [www.harrisproductsgroup.com](http://www.harrisproductsgroup.com).

There are a number of online resources available for trainees who would like more information on soldering and brazing. A search for additional information may be assigned as homework to interested trainees.

Instructors should view any videos that may be identified in the lesson plan before using them to ensure their suitability. The videos can provide teachable moments in both proper and improper work processes and behaviors. Be prepared to stop the videos at appropriate times to point out and discuss both proper and improper conduct and techniques.

Numerous videos related to the topic are available on the Internet. These can be located by searching "soldering" and "brazing", and using the Video tab on the results page of your preferred search engine.

Instructors are encouraged to locate additional audiovisual aids available on the Internet, make personal videos, and take still pictures related to the subject matter and add them to the presentations throughout the program.

## Session Outline for 75119-13

The Lesson Plan for this module is divided into five 2.5-hour sessions. This time includes 10 minutes for administrative tasks and a 10-minute break per session.

### SESSION ONE

Session One introduces trainees to the PPE, tools, and materials needed to safely solder copper tubing and fittings. The session concludes with an introduction to brazing. This session covers Sections 1.0.0 through 2.1.3.

1. Show the Session One PowerPoint® presentation.
2. Use the Kickoff Activity to introduce trainees to the soldering process.
3. Review the appropriate PPE and safety guidelines related to soldering.
4. Explain how to prepare the equipment and materials for soldering.
5. Review soldering techniques.
6. Introduce brazing and the related PPE.

### SESSION TWO

Session Two focuses on the preparations and techniques required to braze copper tubing and fittings. This session covers Sections 2.2.0 through 2.3.2.

1. Show the Session Two PowerPoint® presentation.
2. Identify and explain how to prepare the materials and equipment for brazing.
3. Describe how to purge refrigerant lines using nitrogen to reduce the formation of copper oxides.
4. Describe the brazing process and techniques.
5. Explain how brazing dissimilar metals differs from brazing copper only.

### SESSION THREE

Session Three is a review and testing session. Have trainees complete the Module Review. Alternatively, if the Module Review was assigned as homework at the end of the previous session, have them retrieve their answers. Go over the Module Review in class prior to the Module Exam and answer any questions that the trainees may have.

1. Go over the Module Review to prepare trainees for the Module Exam.
2. Administer the Module Exam. Record the testing results on the Registration of Training Modules form and submit the form to your Training Program Sponsor.

### SESSIONS FOUR AND FIVE

Sessions Four and Five are laboratory sessions that provide an opportunity to practice and complete the Performance Tasks associated with this module.

1. Note that no PowerPoint® presentation is associated with these laboratory sessions.
2. Demonstrate how to set up an air-acetylene torch, prepare and solder copper tubing and fittings, and shut down the equipment when finished.
3. Demonstrate how to set up oxyfuel equipment, prepare and braze copper tubing and fittings, and shut down the equipment when finished.
4. Trainees practice and complete the requirements of Performance Tasks 1 through 4.
5. Document successful Performance Task completions for each trainee on the Performance Profile sheet and submit the results to the Training Program Sponsor.



## Materials Checklist for Module 29405-16, Soldering and Brazing

Equipment and Materials					
<b>Personal protective equipment:</b>		Poster board		Air-acetylene torch set with appropriate tips	
Appropriate flame-retardant clothing		Flip chart		Reamers suitable for copper tubing	
Safety glasses or welding goggles with appropriate tint		<i>Welding Level Four</i> PowerPoint® presentation slides		Self-igniting soldering torch head for small propane cylinders	
Face shields (appropriately tinted if glasses or goggles are not)		LCD projector and screen		Soldering and brazing fluxes	
Work gloves		Computer (Internet access optional)		Oxyacetylene torch set, or comparable equipment, with appropriate brazing tips	
Flame-retardant gloves (such as those used for GMAW or GTAW welding)		Module Review answer key		Soldering and brazing filler metals	
Proper footwear as designated by instructor or training facility provider		Copies of the Module Examination and answer key (for paper-based exams)		Copper tubing and fittings; ½" (12 mm) copper tubing is suggested for soldering. ¾" or 1" (22 or 28 mm) tubing is suggested for oxyacetylene brazing practice	
Hearing protection as designated by instructor or training facility provider		Performance Profile Sheets		Nitrogen cylinder with regulator (optional)	
Hard hat as designated by instructor or training facility provider		Sand cloth and/or abrasive pads		Accessories for nitrogen purging (optional)	
Fire extinguisher		Flux brushes		Tape measures	
Whiteboard/chalkboard		Tube-cutting tools		Tube brushes	
Markers/chalk					
A variety of standard marker sizes					
Pencils and paper					

To the extent possible, and as required for performance testing, provide a selection of the tools listed for each session; alternatively, photos may be used to teach tool identification.

