Preface

Gas Tungsten Arc Welding is designed to impart the knowledge and skills required to begin a career in welding. The chapters lead you through GTAW principles and practices in a logical sequence. Topics include welding hazards and safety procedures; employment, qualification, and certification; power sources and auxiliary equipment; weld types and joint design; shielding gases and filler metals; tooling; and equipment setup and maintenance. The text also covers welding techniques and procedures for welding various types of ferrous and nonferrous metals, pipe welding, semiautomatic and automatic welding, and the inspection and testing of completed welds.

This text presents basic skills and proper procedures in easy-to-understand language. Welding terms used in the text comply with the AWS *Standard Welding Terms and Definitions* publication. Tables and charts within chapters offer useful data, including dimensions, information about materials, common welding problems, and corrective measures. Hundreds of illustrations help guide your learning, including many images of welds in the process of being made.

A Reference Section, located at the back of the text, contains many useful tables and charts. You will also find an extensive Glossary of welding terms, which contains the definitions of the key terms presented in each chapter.

Every weld you will make represents your skill as a welder. Take pride in your work and make each weld as if your career depends on it. *Gas Tungsten Arc Welding* will provide you with the information you need to make that weld.

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About the Author

Mark A. Prosser grew up in Michigan and learned how to weld in his father's collision/restoration business at a very young age. As a teenager, he attended a local vocational school and competed in SkillsUSA welding competitions, becoming one of the six finalists for the world competition in the early 1990s.

Mr. Prosser earned an associate's degree in welding technology from Delta College and another welding technology degree from Ferris State University. He transferred to Central Michigan University, where he obtained a bachelor's degree in industrial education and a master's degree in adult education.

For more than 20 years, Mr. Prosser has taught welding and fabrication professionally in private colleges, public colleges, and universities. He has worked in many industries, including automotive/motorsports, custom fabrication, and vessel construction. He has also worked in governmental contract shops and with structural steel and high-pressure piping for the chemical industry. In addition to *Gas Tungsten Arc Welding*, Mr. Prosser is the author of *Full-Bore Sheet Metal*, *Full-Bore Welding*, and *How to Read Shop Drawings*.

Mr. Prosser is currently the director of the School of Design and Manufacturing at Ferris State University in Big Rapids, Michigan. He is also an associate professor in the Welding Engineering program, where he teaches welding and fabrication courses. For the last 15 years, Mr. Prosser has run a small educational/welding consulting company called Question Mark. In addition to writing and teaching, he performs welding seminars; creates YouTube training videos; authors technical articles; and does guest appearances at events around the country to promote welding, welding education, and skill development.

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Reviewers

The author and publisher wish to thank the following industry and teaching professionals for their valuable input into the development of *Gas Tungsten Arc Welding*.

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Walhonde Tools, Inc.
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New to This Edition

The eighth edition of *Gas Tungsten Arc Welding* has been thoroughly revised by the author and carefully vetted by experts in the field of welding to make sure the material is technically accurate, up to date, and presented in the most logical and effective manner. Content has been updated throughout the text to feature the latest technology, techniques, tools, and equipment. Significant updates include the following:

- Content has been updated to align with the latest AWS SENSE Level I—Entry Welder standards.
- Content has been updated to align learning outcomes with sections and end-of-chapter review and assessment.
- Content includes expanded coverage of workplace skills, job searching, welding machine controls, blueprints, magnesium safety, and joint design and preparation for various ferrous and nonferrous metals.
- The exciting new interior design makes it easy to navigate and engage with content.
- Safety has been further emphasized with prominent and more frequent Warning and Caution boxes.
- Tech Tips have been added for helpful guidance in the shop.
- New images have been incorporated throughout the text to show the latest tools, equipment, and techniques. Illustrations have been updated or enhanced for clarity and an improved learning experience.
- End-of-chapter questions have been enhanced to include Know and Understand, Apply and Analyze, and Hands-On Activities.

In addition to the changes listed here, numerous small changes were made to each chapter of the eighth edition of *Gas Tungsten Arc Welding* to improve the organization and technical accuracy of the text.

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Features of the Textbook

The instructional design of this textbook includes student-focused learning tools to help you succeed. This visual guide highlights these features.

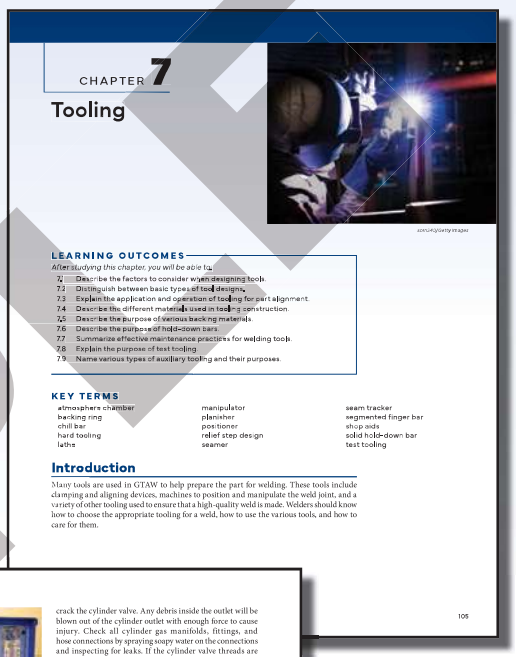
Chapter Opening Materials

Each chapter opener contains a list of learning outcomes, a list of key terms, and an introduction.

Learning Outcomes clearly identify the knowledge and skills to be gained when the chapter is completed. These outcomes are labeled and correlated to related assessment elements to facilitate reporting and remediation.

Key Terms list the key words to be learned in the chapter.

Introductions provide an overview and preview of the chapter content.


CHAPTER 7

Tooling

LEARNING OUTCOMES

After studying this chapter, you will be able to:

7.1 Describe the factors to consider when designing tools.
7.2 Distinguish between basic types of tool designs.
7.3 Explain the application and operation of tooling for part alignment.
7.4 Describe the different materials used in tooling construction.
7.5 Describe the purpose of various backing materials.
7.6 Describe the purpose of hold-down bars.
7.7 Summarize effective maintenance practices for welding tools.
7.8 Explain the purpose of test tooling.
7.9 Name various types of auxiliary tooling and their purposes.

KEY TERMS

atmosphere chamber, backing ring, chill bar, hard tooling, lathe, manipulator, planisher, positioner, relief step design, seamer, seam tracker, segmented finger bar, shop aids, solid hold-down bar, test tooling

Introduction

Many tools are used in GTAW to help prepare the part for welding. These tools include clamping and aligning devices, machines to position and manipulate the weld joint, and a variety of other tooling used to ensure that a high-quality weld is made. Welders should know how to choose the appropriate tooling for a weld, how to use the various tools, and how to care for them.

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Additional Features

Additional features are used throughout the body of each chapter to further learning and knowledge.

Warnings alert you to potentially dangerous materials and practices.

Cautions alert you to practices that could potentially damage equipment or instruments.

Tech Tips provide advice and guidance that is especially applicable for on-the-job situations.

Procedures provide clear, step-by-step instructions for hands-on learning.


Gas Tungsten Arc Welding

Figure 5–17. Portable analyzers measure the percentages of the individual gases.

5.4 Shielding Gas Safety

WARNING

CAUTION

When installing the regulator, make sure it is firmly attached. However, do not overtighten it. Regulators are made of brass and can be damaged by overtightening.

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Procedure 11–1: Fillet Weld on Stainless Steel, All Positions

Base metal: 16 gauge to 11 gauge 3XX stainless steel
Filler metal: ER3XX with a diameter of 1/16" to 3/32" (1.6 to 2.4 mm)
Machine setup: DCEN at 60 to 120 amps
Shielding gas: Argon at 15–25 CFH
Tungsten: Lanthanated, ceriated or rare earth electrodes, with a diameter of 3/32" (2.4 mm)

Procedure

1. Clean any oxide film on the weld joint and surrounding area down to bright metal.
2. Prior to welding, grind all fillet weld joints prepared by plasma arc cutting or carbon arc gouging to a bright metal finish. See Figure 11–15.
3. Remove grease, oil, dirt, and other contaminants with alcohol or acetone.
4. Select a compatible filler metal.
5. Create good head positioning and sight lines.
6. Create a comfortable position.
7. Maintain proper arc length, work angles, and travel angles.
8. Pause at the end of the weld to ensure complete gas coverage.

Inspection and Correction

Figure 11–16. A fillet weld made without chill bars has a wide HAZ. However, the weld has good colors due to proper gas coverage within the T-joint.

Procedure 11–2: Square-Groove Butt on Stainless Steel, Flat and Horizontal Positions

Base metal: 3/32" (2.4 mm) 3XX stainless steel
Filler metal: ER3XX with a diameter of 1/16" to 3/32" (1.6 to 2.4 mm)
Machine setup: DCEN at 60 to 120 amps
Shielding gas: Argon at 15–25 CFH
Tungsten: Lanthanated, ceriated, or rare earth, with a diameter of 3/32" (2.4 mm)

Procedure

1. Clean any oxide film on the weld joint and surrounding area down to bright metal.
2. Prior to welding, grind all groove weld joints prepared by plasma arc cutting or carbon arc gouging to a bright metal finish.
3. Remove grease, oil, dirt, and other contaminants with alcohol or acetone.
4. Select a filler metal.
5. Complete the weld using stringer beads. Do not make weave beads. Stringer beads minimize carbide precipitation. When stopping a weld, always maintain gas coverage from the torch nozzle until the weld cools. Proper gas coverage from the torch will result in a straw- or gold-colored weld.

TECH TIP

The colors in a stainless-steel weld indicate the level of contamination present in the weld. Straw or gold colors indicate low or no oxidation. Blue, purple, or red colors indicate significant oxidation, although light blue is sometimes acceptable.

Figure 11–15. Plasma arc cut material has a severe oxide film on the surface that must be removed down to bright metal prior to welding.

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Chapter 9 Manual Welding Techniques

welded, the tip of the electrode should be pointed slightly more toward the surface piece than the edge piece. The edges of a metal plate are not able to dissipate heat as quickly as the large surfaces of the plate. As a result, if the torch is pointed directly at the joint between the two plates, the edge of one piece heats up faster than the surface of the other, which can lead to undercutting at the edges of the joint. Pointing the torch slightly more toward the surface than the edge provides even heating through the entire joint. See **Figure 9-8.**

Welding Rods

When adding welding rod, the welder should grip the rod in the fingers as shown in **Figure 9-9.** The hand should be kept as close as possible to the arc to hold the rod steady. The rod should be moved in conjunction with the torch movement. When additional rod is required, it can be moved forward through the fingers using a forward movement of the thumb. Too much extension of the welding rod from the fingers results in a wobbly rod end, making addition to the weld pool very uneven. Adding rod to the pool requires steadiness and concentration in order to place the correct amount of material at the right place at exactly the right time. A 10°–20° entrance angle of the rod into the weld pool should always be maintained.

A

B

C

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Figure 9-7. Typical welding angles for welding a butt weld in the position. A—This butt joint is in the flat posi 90° work angle. The torch is tilted so the elec the direction the weld is progressing (travel in the horizontal position. C—A butt joint in t

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Gas Tungsten Arc Welding

Inspection and Correction

Inspect the completed welds and evaluate the results. **Figures 11-17** to **11-20** show stainless-steel butt joints made under various conditions. The butt joint in **Figure 11-17** was made using chill bar tooling to remove welding heat. Note the good gold and light blue coloration. **Figure 11-18** shows a butt joint made without the use of chill bar tooling. Note the enlarged HAZ and the purple and magenta hues surrounding the weld. The butt joint in **Figure 11-19** was made without any type of shielding on the penetration, resulting in oxidation. The oxidized material must be completely removed, and the joint must be rewelded. **Figure 11-20** shows a butt joint that was made with gas shielding on the penetration. This weld has good color and even penetration.

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Figure 11-17. Chill bars remove the welding heat rapidly, resulting in a weld with a good color and contour.

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Figure 11-18. If chill bars are not used, the welding heat moves out into the plate material. The crown has no color and is flatter.

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Figure 11-19. The unprotected penetration weld side of this joint is badly oxidized from the atmosphere. The weld has a poor bead contour and will not do the job intended. The oxidized material must be completely removed, and the joint must be rewelded.

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Figure 11-20. The penetration side of this weld was protected by an inert gas (argon). As a result, the weld has good color, shows even penetration, and will do the job intended.

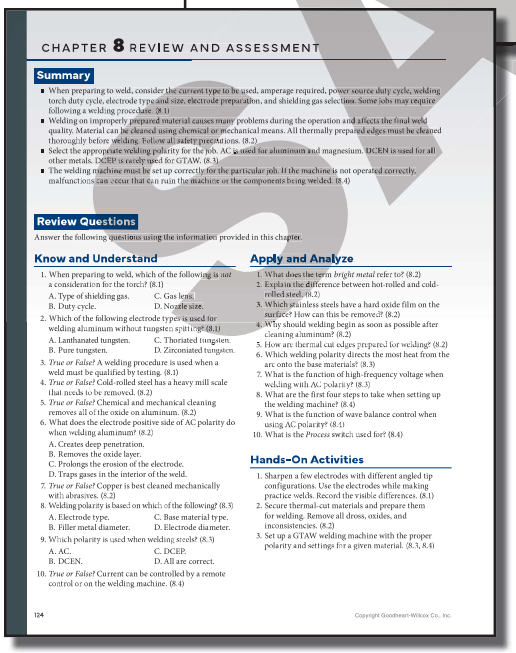
11.7 Postweld Treatment

During the welding of hardenable martensitic stainless steels, some martensite will form, regardless of preheating. If the weldment will not be fully hardened after welding, annealing is recommended. The annealing procedure is as follows:

1. After the welding is completed, heat the weldment to 1550°–1650°F (843°–899°C) and hold that temperature for two hours.
2. Furnace-cool the weldment to 1100°F (593°C) at a rate not to exceed 100°F (38°C) per hour.
3. Allow the weldment to cool to room temperature.

Specialty stainless steels and precipitation hardening alloys also require postweld treatment. These materials should be thermally treated to the manufacturer's recommendations to achieve full mechanical values.

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CHAPTER 8 REVIEW AND ASSESSMENT

Summary

- When preparing to weld, consider the current type to be used, amperage required, power source duty cycle, welding torch duty cycle, electrode type and size, electrode preparation, and shielding gas selection. Some jobs may require following a welding procedure. (8.1)
- Welding on improperly prepared material causes many problems during the operation and affects the final weld quality. Material can be cleaned using chemical or mechanical means. All thermally prepared edges must be cleaned thoroughly before welding. Follow all safety precautions. (8.2)
- Select the appropriate welding polarity for the job. AC is used for aluminum and magnesium. DCEN is used for all other metals. DCEP is rarely used for GTAW. (8.3)
- The welding machine must be set up correctly for the particular job. If the machine is not operated correctly, malfunctions can occur that can ruin the machine or the components being welded. (8.4)

Review Questions

Answer the following questions using the information provided in this chapter.

Know and Understand

1. When preparing to weld, which of the following is *not* a consideration for the torch? (8.1)
   A. Type of shielding gas. C. Gas lens.
   B. Duty cycle. D. Nozzle size.
2. Which of the following electrode types is used for welding aluminum without tungsten spitting? (8.1)
   A. Lanthanated tungsten. C. Thoriated tungsten.
   B. Pure tungsten. D. Zirconiated tungsten.
3. *True or False?* A welding procedure is used when a weld must be qualified by testing. (8.1)
4. *True or False?* Cold-rolled steel has a heavy mill scale that needs to be removed. (8.2)
5. *True or False?* Chemical and mechanical cleaning removes all of the oxide on aluminum. (8.2)
6. What does the electrode positive side of AC polarity do when welding aluminum? (8.2)
   A. Creates deep penetration.
   B. Removes the oxide layer.
   C. Prolongs the erosion of the electrode.
   D. Traps gases in the interior of the weld.
7. *True or False?* Copper is best cleaned mechanically with abrasives. (8.2)
8. Welding polarity is based on which of the following? (8.3)
   A. Electrode type. C. Base material type.
   B. Filler metal diameter. D. Electrode diameter.
9. Which polarity is used when welding steels? (8.3)
   A. AC. C. DCEP.
   B. DCEN. D. All are correct.
10. *True or False?* Current can be controlled by a remote control or on the welding machine. (8.4)

Apply and Analyze

1. What does the term *bright metal* refer to? (8.2)
2. Explain the difference between hot-rolled and cold-rolled steel. (8.2)
3. Which stainless steels have a hard oxide film on the surface? How can this be removed? (8.2)
4. Why should welding begin as soon as possible after cleaning aluminum? (8.2)
5. How are thermal cut edges prepared for welding? (8.2)
6. Which welding polarity directs the most heat from the arc onto the base materials? (8.3)
7. What is the function of high-frequency voltage when welding with AC polarity? (8.3)
8. What are the first four steps to take when setting up the welding machine? (8.4)
9. What is the function of wave balance control when using AC polarity? (8.4)
10. What is the *Process* switch used for? (8.4)

Hands-On Activities

1. Sharpen a few electrodes with different angled tip configurations. Use the electrodes while making practice welds. Record the visible differences. (8.1)
2. Secure thermal-cut materials and prepare them for welding. Remove all dross, oxides, and inconsistencies. (8.2)
3. Set up a GTAW welding machine with the proper polarity and settings for a given material. (8.3, 8.4)

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Illustrations

Illustrations have been designed to clearly and simply communicate the specific topic. Photographic images have been updated to show the latest equipment.

End-of-Chapter Content

End-of-chapter material provides an opportunity for review and application of concepts.

A concise **Summary** provides an additional review tool and reinforces key learning outcomes. This helps you focus on important concepts presented in the text.

Know and Understand questions enable you to demonstrate knowledge, identification, and comprehension of chapter material.

Apply and Analyze questions extend learning and develop your abilities to use learned material in new situations and to break down material into its component parts.

Hands-On Activities extend your learning and help you apply knowledge.

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