

YOUR COMPLETE GUIDE TO WELDING DESIGN

Helping organizations recognize welding
symbols and apply welding codes to designs.



ASME **L&D** LEARNING &
DEVELOPMENT

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WELDING DESIGN

Welding is a joining process that combines materials by heating them to the welding temperature, either with or without the application of pressure or the use of filler metal.

There are many types of welding processes. For example, shielded-metal arc welding is commonly used for pipe, pressure vessel and structural applications. Friction-stir welding is a solid state process, which works well for welding materials that are prone to solidification cracking, such as aluminum alloys.

Electric arc-welding, which requires the conversion of electrical energy into heat to join two metals together, is the most commonly used process for ASME applications. An electric arc creates an intense heat of around 6500°F, which melts the metal at the joint between the

two pieces. Working at extreme temperatures can be dangerous but, with the correct planning and training, designers and engineers can ensure safe and effective application of the correct process.

This guide explores the codes ASME recommends following for the selection of welding symbols and designing welds. Discover some common challenges for designing welds across multiple industries, as well as the benefits and fundamentals of following ASME codes. Plus, learn more from our expert, who answers some of the most frequently asked questions about welding.

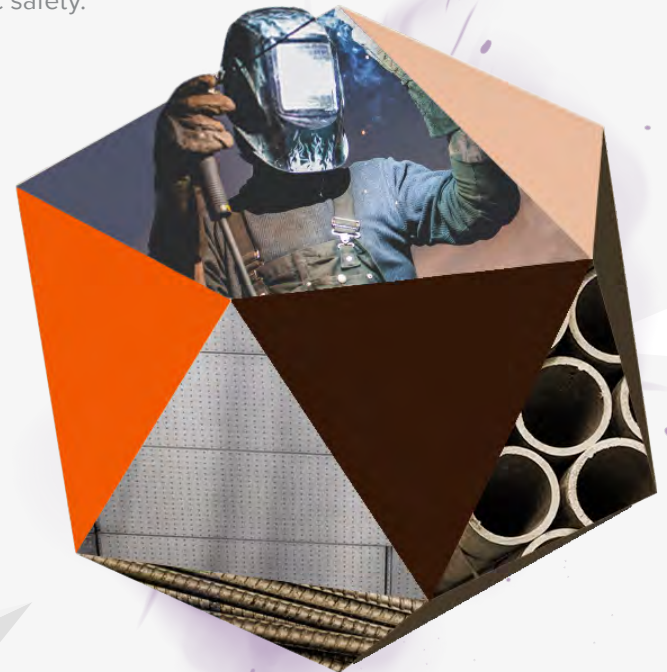
WELDING IN THE REAL WORLD

The job of a welder is to weld metals together, with the end goal of building a structure or fabricating a pressure-retaining component.

There are a huge number of industries that rely on welding in some form or another. Welding processes are commonly used across aerospace, automotive, energy and construction companies.

But it's not just industrial applications that rely on welding; almost all public infrastructure is made up of parts that have been welded together—think amusement park rides, parking structures and public transport. If the engineer has not planned the design carefully, with the appropriate considerations, the pipe, vessel or structure could contain defects that later result in part failure.

Therefore, it's crucial that welding engineers know what they're doing when it comes to specifying their welding requirements. Codes have been created to help engineers specify welding details that ensure public safety.



WELDING FUNDAMENTALS

Welding design is a detailed and intricate process, and there are several factors that must be considered in a fabrication design, such as aesthetics, strength and weight. Welding symbols are critical to the design process, enabling engineers to communicate their design intentions clearly and with ease. Engineers need to know not only what the symbols mean, but also the rules and principles of working with them.

For example, a welding symbol must always include:

1. An arrow line
2. A reference line
3. A weld symbol

GROOVE							
SQUARE	SCARF	V	BEVEL	U	J	FLARE-V	FLARE BEVEL
							
							

FILLET	PLUG OR SLOT	STUD	SPOT OR PROJECTION	SEAM	BACK OR BACKING	SURFACING	EDGE
							
							

NOTE: THE REFERENCE LINE IS SHOWN DASHED (----) FOR ILLUSTRATIVE PURPOSES.

COMMON WELDING DEFECTS

Weld failures are often caused by welding defects that can be easily avoided with the correct weld joint design, process selection and application. Failures are not only time-consuming and costly, but those that occur in load-bearing applications can also have potentially catastrophic consequences.

Here are some common welding defects:

Slag

Entrapped slag can be linear and, as such, can propagate like a crack under an applied transverse tensile stress. This defect can be prevented by simply cleaning slag from every weld bead, even temporary welds.

Cracks

Cold cracks in steels are caused by hydrogen, rapid cooling rates and brittle microstructures. Hot cracks in austenitic materials can be caused by low-melting temperature impurities and inadequate ferrite content. Cold cracking can be prevented by preheating the base metal to reduce the cooling rate of the weld, while correct filler metal selection will often prevent hot cracking.

Incomplete penetration

This flaw occurs when penetration through the joint thickness is not obtained. It can be caused by poor joint design, inadequate root opening, insufficient current, or excess travel speed. Proper root openings and careful welding variable selection will usually ensure the desired penetration.

KEY BENEFITS OF KNOWING THE ASME CODES FOR WELDING

Poor welding leads to defects. Correct and consistent application of welding codes can help engineers be sure that their weldments are safe and in compliance with the appropriate industry standards.

There are many defects that can arise as a result of poor welding, meaning there are huge benefits to be realized from applying globally-recognized codes to welding design.

Avoid costly mistakes

Correctly applying codes and standards means that processes and acceptance criteria suitable for the intended application can be specified and controlled.

Consistent approach

When engineers and designers are using recognized codes and standards to guide their designs, customers and engineering companies can be sure that welding is being done to the same industry-grade standard regardless of the fabrication site.

Quality assurance

Various sections of the ASME BPV IX Code provide explicit rules for qualifying joining procedures and personnel, so that fabricators can reassure their customers that they have complete control of their joining processes.



FREQUENTLY ASKED QUESTIONS

We asked our expert, Lynn Sturgill, some of our most frequently asked questions about welding design.

Why is it important for engineers to follow the ASME BPV IX Code when qualifying joining procedures?

Since production welds are rarely subject to 100% volumetric inspection, reliable qualification of joining procedures and personnel allows fabricators to assure their customers that they have control of their joining processes.

How does the ASME Code enable me to avoid making mistakes when welding?

ASME Section IX is the most widely used qualification code in the world today. It ensures that the procedures and personnel who use them meet minimum standards for weldment quality and personnel skill, respectively. Careful integration into the construction codes provides additional refinement and restriction when necessary.

What are the benefits of ASME group training for welding?

ASME group training provides the ability for students to interact with industry experts who are closely involved in writing the rules that govern modern production welding. Learning includes much more than the course content—it also includes the logic and industry events supporting the construction rules.

Lynn Sturgill

Lynn Sturgill is the owner and operator of Sturgill Welding & Code Consulting (SWCC), a privately-owned welding consulting company. Lynn has more than 30 years' experience in the manufacturing, welding, and inspection of metallic goods in the nuclear, aerospace, structural, petrochemical, military, food and dairy, and biopharmaceutical industries.

Read Lynn's full bio [here](#).

ASME WELDING COURSES

BPV Code, Section IX: Welding, Brazing & Fusing Qualifications

Virtual Classroom

Learn the layout, scope, and usage of Section IX of the ASME Boiler and Pressure Vessel Code, as well as the rules for qualification of welding, brazing and plastic fusing procedures and personnel.

Also available in [Guided Study format.](#)

Outline

- **Module 1: Code Basics**
- **Module 2: Welding Process Basics**
- **Module 3: Metallurgy & Welding**
- **Module 4: WPS Qualification Variables for SMAW**
- **Module 5: Developing a WPS**
- **Module 6: Qualifying Welding Personnel**
- **Module 7: Notch-Toughness & Supplementary Essential Variables**
- **Module 8: Brazing**
- **Module 9: Plastic Fusing**

By the end of the course, you'll be able to:

- Explain layout and scope of Section IX of the ASME Boiler & Pressure Vessel Code
- Identify basic rules for finding requirements in Section IX
- Describe practical, instructive welding procedures that are compliant with Section IX
- Describe the qualification of procedures and personnel
- Describe the basic features of the commonly used welding process
- Explain the concept of carbon equivalent and hardenability of steels
- Identify the nonessential variables and essential variables in the WPS
- Explain how to prepare and modify the PQR and WPS from fundamental data
- Identify supplementary essential variables

ASME WELDING COURSES

Practical Welding Technology

Virtual Classroom

This course employs in-class exercises to reinforce class lectures on the subjects of welding and NDE symbols, carbon equivalence, A-numbers, strength of welds, joint details, welding procedures, selection of filler metals, and preheat.

Outline

- **Module 1: Introduction**
- **Module 2: Terms and Definitions**
- **Module 3: Welding, Brazing and NDT Symbols**
- **Module 4: Welding Metallurgy**
- **Module 4a: Practical Welding Problems**
- **Module 5: Welding Processes**
- **Module 6: Common Construction Codes – scope and applications**
- **Module 7: Procedure and Performance Qualification**
- **Module 8: Weld Discontinuities and Defects**
- **Module 9: Designing Welds**
- **Module 10: Nondestructive Testing**

You will learn to:

- Explain welding terms and definitions
- Specify various weld types and nondestructive testing using standard AWS welding symbols
- Explain basic ferrous welding metallurgy
- Describe post weld heat treatments, residual stresses, and distortion control
- Evaluate welding processes typically used to fabricate pressure vessels and piping systems
- Clarify the interrelationship between AWS, ASME, and API codes and standards as they relate to pressure vessels, piping systems, and related facilities
- Explain welding procedure and performance qualification documentation and methodology applicable to pressure vessels and piping systems.
- Identify common weld defects, causes, and corrective actions
- Identify major considerations when designing a weld
- Identify common NDT used to examine welds
- Identify the elements of a cohesive welding program that includes design, purchasing, fabrication, inspections, and delivery

ASME WELDING COURSES

Principles of Welding

Understand introductory principles of welding technology, process of welding and how it affects welded materials and structures.

Outline

- **Module 1: What Is Welding and How Is It Accomplished?**
- **Module 2: What Are the Effects of Welding on the Welded Structure?**
- **Module 3: Welding Processes**
- **Module 4: Welding of Various Materials**
- **Module 5: Basics of Welding Design**
- **Module 6: Weld Examination & Quality Control**

You will learn how to:

- Explain how to use and application of common welding processes
- Describe basic weld design concepts, such as weld size determination and communication through weld and welding symbols on drawings
- Explain how welding affects various welded materials, including metallurgical and dimensional changes
- Describe the advantages and disadvantages of various arc-welding processes
- Identify basic electric circuits that are used to accomplish arc welding
- Identify weld inspection techniques, including non-destructive examination
- Identify common problems with welding processes and explain how to troubleshoot them

MORE DETAIL ABOUT OUR COURSES

ASME Learning & Development provides technical and management courses for individuals and teams across a range of engineering disciplines.

Courses are designed for technicians and engineers of all levels. They are essential resources for welders, welding inspectors, mechanical engineers and design engineers, process engineers and chemical engineers, reliability engineers and maintenance engineers, inspectors and testing engineers, as well as plant supervisors and managers.

All of our courses are delivered either virtually or in-person, with the ability to tailor content to include specific use cases and pain points for Corporate Training customers with 8 or more learners.



LET'S TALK ABOUT IT

We can help your team to consistently apply welding code to industry standards.

ASME is the go-to expert in both fundamentals and applications of welding standards, and our courses are designed to help professionals remain consistent in their welding design.

We can help you address your unique challenges with an expert in a private confidential setting. All ASME courses include real-world examples so that learnings can be applied to current projects.

From potentially standardizing your business processes with best practices and boosting productivity to improving engagement, we can help you maximize the potential of your workforce all while growing your organization's competitive edge.

Get in touch today to inquire about
ASME Corporate Training.

▶ learningsolutions@asme.org

▶ go.asme.org/evolve