

# YOUR COMPLETE GUIDE TO BOLTED JOINTS

Helping organizations develop a comprehensive understanding of bolted joints and the applicable standards for a better approach to design, engineering, construction and assembly.



ASME **L&D** LEARNING & DEVELOPMENT

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# BOLTED JOINT DESIGN

**Bolting is the process of fastening parts together to create structural integrity and strength allowing for disassembly of components if needed.**

The bolted joint can be gasketed as with a piping flange joint to connect piping segments to avoid leaks. Ungasketed joints have a similar function, but are not designed for pressure retaining and leak prevention.

Two of the most common types of bolted joints are tension and shear joints, both performing different functions within construction and machine design. These two kinds of bolted joints can be further defined into more specialized varieties used in different applications—such as pressurized bolted flange joints.

Being able to correctly design, specify, assemble, disassemble and maintain a bolted joint safely and effectively is a key responsibility for engineers as well as the assemblers.

An understanding of the various joint designs and how they can be applied to different projects and components can be beneficial. Equally as important is the understanding of different codes and standards that correspond to bolts, flanges, gaskets and bolted joints for added safety and durability.

This guide explores the applications of bolting and bolted joints in different industries, as well as uncovering the challenges that face designers and users. You'll also find out more about the ASME codes and standards that can be applied to bolted joint practices to ensure efficiency and safety with the design. Plus, you'll get the most frequently asked questions about bolted joints answered by our specialist.

# BOLTING IN THE REAL WORLD

**An understanding of bolting and fastening methods is one of the most fundamental aspects that applies to engineering and many different industries, making it a crucial aspect of any engineer's toolkit.**

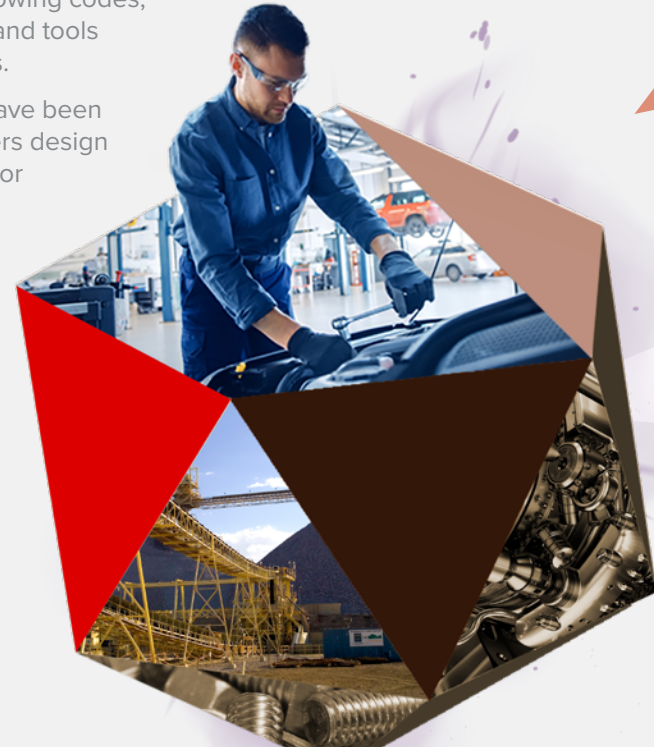
Many industries, such as aerospace, automotive, mining, medical, petrochemical, power plants, nuclear, marine make use of bolted joints. In a broader sense, we see the effects of bolting everywhere in our day-to-day lives, from the cars we drive and the bridges we cross on our way to work, along with the office buildings we spend our working hours in.

Assembling a bolted joint correctly, in accordance with the right standards, is the first and most critical step to ensuring a mechanism or system can operate reliably. Failing to do so can result in costly mistakes and downtime or possibly catastrophic failures.

Any system that is assembled using bolted joints can only function and be operated reliably if the bolting process is designed correctly.

Therefore, it's crucial that mechanical engineers are knowledgeable when it comes to designing and assembling components using bolting—that means knowing codes, standards, procedures and tools needed for bolted joints.

Codes and standards have been created to help engineers design bolting that works well for specific situations.



# BOLTING FUNDAMENTALS

**It's important for designers and assemblers to understand the different kinds of industrial bolted joints that are used for machinery, piping and structures.**

The three principal types of industrial bolted joints are:

## **Pressurized joints**

used mainly in flanges with gaskets for piping and pressurized vessels.

## **Structural joints**

used for the permanent joining of girders and beams.

## **Mechanical joints**

used for the component fastening without gaskets, for assembly/disassembly of equipment.

Pressurized bolted joints are used to keep gasketed joints leak-proof under any conditions. They do this by using interdependent bolts, gaskets and a standardized configuration system, utilizing materials that can stand up against all kinds of substances, including flammables and corrosives.

Mechanical bolting joints are used to assemble, align and disassemble equipment, working to ensure the machines they support are able to function properly, and allowing for them to be properly maintained. Unlike pressurized joints, they don't use gaskets and must be robust enough to stand severe vibration while the machine operates.

Structural joints are designed for buildings and structures, and they include girders and beams. These joints are not designed to be disassembled or removed, so their assembly is meant to be permanent. They need to be strong enough to bear the loads that the structure will take over time, such as cars across bridges for example.

Many features are shared across these three bolted joints, though there are certain elements that make each one, and their applications, very different. Trusted standards can ensure that bolts and bolted joints, wherever they are applied, are safely and securely implemented, whatever the type of joint.

# COMMON BOLTING CHALLENGES

Given the importance of bolting in mechanisms and structures, any defects can be a real cause of concern that can potentially have catastrophic effects. Being aware of these potential risks is key to ensuring the integrity and safety of bolted connections that prevent leakages and collapse.

## **Bolt thread stripping**

Stripped threads occur for many reasons, the most common being incorrect matching of bolts to nuts; Improper thread design, material choice, component assessment and assembling procedures can contribute to thread stripping.

## **Reduced joint clamp force**

Clamp force is the compressive force that holds a bolted joint together—reduced joint clamp force from embedment or elastic interaction can result in joint failure.

## **Bolt overloading**

Bolt overload occurs as a result of applied force being too high, causing the bolt to fail due to pressure and other loads—the bolt can deform or even fracture along its length.

## **Bolt fatigue**

Cyclic loading of bolts can have unintended failure consequences. A reduction in clamping force can increase the loading resulting in a fatigue bolt failure.



# KEY BENEFITS OF KNOWING ASME STANDARDS FOR BOLTED JOINTS

**As we've seen, incorrect bolting techniques can lead to serious problems for the integrity of mechanisms and structures.**

Working towards the standards set out by ASME can make all the difference when it comes to these techniques, ensuring that every bolt and every bolted joint you may design and assemble will have the longevity and reliability to last.

Here are some of the key benefits to knowing ASME bolted joint codes and standards:

## **Trusted quality assurance**

Engineers who follow ASME codes can assure customers that bolted joint construction, installation, application and maintenance are always of high quality.

## **Consistent, across-the-board bolting**

By using the same codes to design bolted joints every time, engineers, suppliers and manufacturers can be sure that the devices being made are all of the same industry-grade standard.

## **Avoiding costly mistakes**

Correctly applying codes and standards means that bolted joints can be designed and applied properly, avoiding costly equipment failures.



# FREQUENTLY ASKED QUESTIONS

**We gave some of our most commonly asked questions to one of our instructors, Patrick Cooper, who provided his thoughts about bolts and bolted joint design.**

## **How can ASME Standards help improve my bolting processes?**

The use of ASME standards associated with bolts, flanges and gaskets can provide a reliable bolted joint design to withstand the intended operational conditions. The ASME standards compile a wealth of information from committee members who create these documents assuring the latest

learnings are incorporated. Using the standards provides consistency with interchangeable parts and knowing that the parts are manufactured and adhere to strict quality procedures. In essence, the ASME standards, when used, can provide some assurance that the bolted joint has been designed and assembled well.

## **What are some examples of common mistakes that designers and assemblers make?**

The design of bolted joints is very complex without an understanding of all the variables that contribute to a reliable connection. A common mistake is not taking into account the variables that cause joints to relax such as embedment, elastic interaction of bolts, gasket creep and following a proven torquing pattern. Many designers rely on the assemblers to assemble the joint

without a procedure which leads to inconsistent results. An assembly procedure provides a consistent method of joint assembly resulting in a safe and reliable connection per the design.

## **What are the benefits of ASME training for bolted joints?**

Bolted joints are used throughout all industries. Having the knowledge of what codes and standards are required to design a bolted joint connection that is safe and reliable is one of the many benefits of ASME training. An organization that utilizes ASME training will benefit from knowing the latest codes and standards to apply in achieving a consistent bolted joint design and assembly. This benefit alone can justify preventing costly mistakes and unreliable bolted joints.



**Patrick Cooper, PE**

Patrick is one of ASME's instructors for bolted joints and flange design. As a mechanical engineer, his career spanned over several decades within the energy industry executing major projects along with specifying and optimizing rotating equipment reliability. Throughout his career, one thing remained constant and that was the use of bolted joints in many varied applications.

Patrick brings his knowledge and experience to the classroom to enhance the bolted joint learning experience. He has delivered many technical training courses for those involved with design, manufacturing, operation and maintenance of bolted joints in all facets of their facilities, equipment and products.

Find out more about our course instructors [here](#).



# ASME BOLTING COURSES

## Bolted Joints and Gasket Behavior (IPPD539)

In-person course  
Houston, TX,  
October 24-25, 2022

This course is designed to help engineers understand bolted flange joint fundamentals and gasketed joint torque factors, bolting patterns, and gasket behavior, tightness, selection and specification.

### Outline

- Part 1—Introduction to the bolted joint
- Part 2—Properties affecting in-service conditions
- Part 3—Stress and Strain Considerations
- Part 4—Gasket Behavior, Selection and Specification
- Part 5—Introduction to Assembly and Clamping Force
- Part 6—ASME PCC-1 Guidelines
- Part 7—Understanding and Preventing Gasket Failure
- Part 8—Joint Calculation Methods

### You will learn to:

- Explain how the bolted joint functions as a mechanical system that relies on the simultaneous interaction of the three primary components to successfully seal the connection
- Assess the mechanical stress and strain of a bolt and explain the challenges that one encounters when specifying an optimum bolt load
- Evaluate the total state of stress in bolts and how this effects the selection of a given bolt type and grade
- Describe the effects of in-service conditions and how they reduce or increase bolt load
- Describe the concept of leak tightness as a predictable value of gasket stress and how to use leak tightness as the basis of specifying bolt loads
- Identify conditions that create bolt failure
- Use ASME PCC-1 Guidelines for compliance to successful sealing of bolted, gasketed connections
- Discern how to use either stress or strain to select bolt load
- Evaluate the various methods of attaining bolt load.

# ASME BOLTING COURSES

## ASME PCC-1 Bolted Joints and Gaskets Design, Assembly, and Reliability Combo Course (VCPD601)

Virtual classroom / in-person course

This course is a combination of “Bolted Joints and Gasket Behavior” (VCPD539 / IPPD539), “Design of Bolted Flange Joints” (VCPD386) and “Bolted Joint Assembly Principles Per PCC-1 — 2019” (VCPD577).

Working as a combination, this course includes information on the fundamentals of bolted joints, whether gasketed or not, along with the design of different kinds of bolted flange joints, and the training and testing of bolted joint assembly—according to ASME codes and standards.

### **Courses included:**

- **Course 1: VCPD539—Bolted Joints and Gasket Behavior**
- **Course 2: VCPD386—Design of Bolted Flange Joints**
- **Course 3: VCPD577—Bolted Joint Assembly Principles per ASME PCC-1**

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

- Assess the mechanical stress and strain of a bolt and explain the challenges that one encounters when specifying an optimum bolt load
- Evaluate the total state of stress in bolts and how this affects the selection of a given bolt type and grade
- Use ASME PCC-1 Guidelines for compliance to successful sealing of bolted, gasketed connections
- Discern how to use either stress or strain to select bolt load
- Evaluate the various methods of attaining bolt load
- Develop an awareness of flange types and the ASME codes and standards applicable for bolted flange joint design
- Enhance your knowledge for designing and analyzing bolted flange joints
- Explain how the flange design interacts with bolts and gaskets to achieve a leak tight joint
- Identify the parameters that can affect flange sealing along with methods to troubleshoot and remediate flange leakage
- Identify factors affecting proper “load” and how to compensate for problems
- Identify the proper selection and installation of gaskets
- Describe the advantages and disadvantages of various bolting methods and where to use them

# ASME BOLTING COURSES

## Bolting specialist qualification program (LP109)

### On-demand learning path

This course is designed to train and evaluate an assembler's ability to inspect, assemble, disassemble and tighten bolted joints in an effective and safe manner.

### Outline

- **Part 1—Foundational knowledge on bolting principles and procedures**
- **Part 2—Bolting specialist application and final exam**
- **Part 3—Performance assessment led by an instructor**

### You will learn to:

- Explain the objectives and methods involved in bolting assembly
- Perform bolting tasks safely in compliance with applicable standards and procedures
- Identify and evaluate bolted joint problems
- Contribute to a safe work environment for bolting assembly