

Block D: Piping and Components



Plumbing Apprenticeship Program Level 1 Series

Block D: Piping and Components

BC Plumbing Apprenticeship, Level 1

SKILLEDTRADESBC

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CURRICULUM SUBCOMMITTEE; AND PAUL SIMPSON*

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Block D: Piping and Components of the Plumbing Apprenticeship Program Level 1 Series features Skilled Trades BC industry-authority content focused on the core installation skills that form the foundation of plumbing systems. This block emphasizes the practical knowledge and techniques apprentices use to assemble, connect, and integrate piping systems accurately and safely within residential, commercial, and institutional settings.

In Block D, apprentices learn how to install pipe and tubing, valves, and fittings, as well as how to safely and effectively penetrate building structures. These competencies support proper system function, durability, and compliance with codes and specifications, while reinforcing precision, planning, and coordination with other trades on the job site.

Plumbing Apprenticeship Program Level 1 Series

The *Plumbing Apprenticeship Program Level 1 Series* offers comprehensive training materials designed to build on foundational skills and knowledge. The series is divided into four main blocks, each focusing on critical areas of plumbing systems and installations.

Block A: Safety Related Functions

(<https://a-safetyfunctions-bcplumbingapprli.pressbooks.tru.ca>)

A-1: Workplace Hazards

A-2: WorkSafeBC Regulations

A-3: Safe Handling of Hazardous Materials

A-4: Personal Safety Practices

A-5: Fire Safety

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B-1: Use Hand Tools and Measuring Tools

B-2: Use Portable Power Tools and Use

B-3: Use Access Equipment

B-4: Use Rigging, Hoisting, Lifting and Positioning Equipment, and Rigging

B-5: Use Soldering and Brazing Equipment and Oxy-Fuel Cutting Equipment

B-6: Use Welding Equipment

Block C: Routine Trade Activities and Electrical Concepts

(<https://c-tradeactivities-electrical-bcplumbingapprli.pressbooks.tru.ca>)

C-1: Mathematics and Science

C-2: Electrical Concepts and Principles of Electricity

- C-3: Drawings and Specifications
- C-4: Codes, Regulations and Standards
- C-5: Manufacturer and Supplier Documentation

Block D: Piping and Components

(<https://d-pipingcomponents-bcplumbingapprli.pressbooks.tru.ca>)

- D-1: Install Pipe and Tubing
- D-2: Install Valves
- D-3: Install Fittings
- D-4: Penetrate Structures

Plumbing Apprenticeship Program Overview and Upcoming Resources

- **Plumbing Apprenticeship Program Level 1 Series** (<https://openpress.trubox.ca/2024/12/13/plumbing-apprentice-level-1/>) can be found in the TRU Open Press Collection.
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Safety Advisory

The current Standards and Regulation in BC can be obtained at the WorkSafeBC website: <http://www.worksafebc.com> (<http://www.worksafebc.com/>)

Please note that it is always the responsibility of any person using these materials to inform themselves about the Occupational Health and Safety Regulation pertaining to their areas of work.

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Symbol Legend



Important Information



Potentially Toxic/ Poisonous Situation



Required or Optional Resources



Potentially Flammable Situation



Complete a Self-Test



Possibly Explosive Situation



Use Protective Equipment



Potential Electric Shock

Acknowledgements

The development of the *Plumbing Apprenticeship Level 1* learning resources was a collaborative effort driven by a commitment to excellence in trades education. These resources were created to support apprentices and journeypersons in mastering the skills and knowledge essential to the piping trades. This achievement would not have been possible without the dedication and expertise of *Skilled Trades BC* and the *Piping Trades Articulation Committee*, whose contributions, leadership, and guidance have been instrumental in shaping high-quality, industry-aligned training resources. We extend our sincere gratitude for their contributions and ongoing stewardship in advancing the piping trades.

The content for *Block D: Piping and Components* (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/>) is adapted from the Piping Trades Apprenticeship Program from *SkilledTradesBC* (2019 Harmonized).

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- Trades Training BC

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If you are using a printed copy, you can scan the QR code with your digital device to go directly to the video: Introducing SkilledTradesBC (<https://www.youtube.com/watch?v=OQgwdP0rNog>)



Starting December 1, 2022, Industry Training Authority was officially renamed to SkilledTradesBC. Hear more in this video from SkilledTradesBC CEO, Shelley Gray, on what this means for the trades industry and British Columbians. Closed captioning and transcripts are available with this video, Introducing Skilled Trades BC (<https://www.youtube.com/watch?v=OQgwdP0rNog>) (2022) on YouTube.



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References

- Camosun College. (n.d.). *Line E – Electrical Fundamentals Competency*. BCcampus. <https://collection.bccampus.ca/textbook/Nf7jVbAg/>
- SkilledTradesBC. (2025). Plumber program outline (Implementation date: August 18, 2025; Last revised: December 16, 2025) [PDF]. Province of British Columbia. <https://skilledtradesbc.ca/media/2776/download>
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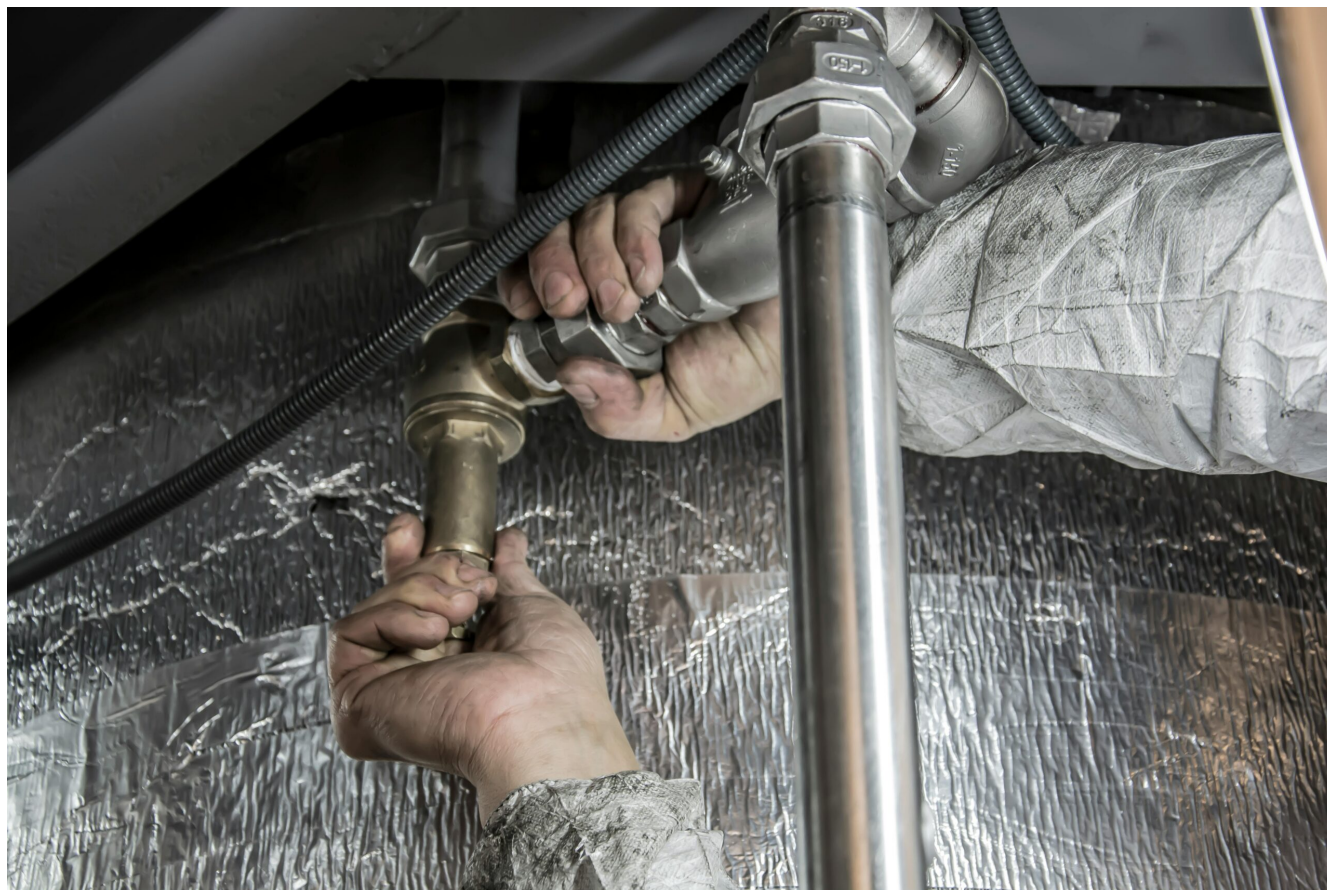
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PART I

D-1 INSTALL PIPE AND TUBING

Plumber Apprenticeship Program – Level 1



Close-up of a plumber's hands installing steel pipes indoors (<https://www.pexels.com/photo/plumber-installs-pipe-fittings-6419128/>).
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D-1 Install Pipe and Tubing Introduction

This section introduces the fundamental concepts and materials used in piping and tubing systems. You will learn key terminology and how to identify different types of pipe and tube, along with their distinct qualities, advantages, and limitations. Building on this foundation, the section explores a range of commonly used materials—including copper, cast iron, carbon and stainless steel, brass, thermoplastics, thermoset plastics, glass (Pyrex), and specialty materials—highlighting their properties and typical applications. By the end of this section, you will have the knowledge needed to recognize, compare, and select appropriate piping and tubing for a variety of practical situations.

After completing this section, you will be able to:

- Define pipe and tube terminology.
- Identify types of pipe and tube.
- Describe piping and tubing qualities, advantages and disadvantages.
- Describe piping and tubing materials:
 - ▶ Copper
 - ▶ Cast iron
 - ▶ Carbon and stainless steel
 - ▶ Brass
 - ▶ Thermoplastics
 - ▶ Thermoset plastic
 - ▶ Pyrex/glass
 - ▶ Specialty piping materials
- Describe the methods of pipe manufacture for:
 - Carbon and stainless steel
 - Cast iron pipe
 - Copper pipe and tubing
 - Thermoplastic pipe and tubing
- Identify the types and colour markings on copper tubing.
- Define the term “temper” as applied to copper tubing.
- Know the three methods used to manufacture cross-linked polyethylene (PEX) tubing.
- Identify hangers and supports.
- Identify pipe support anchors and expansion inserts.
- Select and install hangers and supports.
- Identify and select sway bracing, spring, and variable supports.
- Explain the purpose of seismic restraint.
- Identify seismic restraint components.
- Install seismic piping and equipment components, including cable brace attachments.
- Identify the factors leading to piping damage:
 - Corrosion
 - Frost
 - Ultraviolet
 - Physical
- Apply methods used to protect piping during transportation, storage, installation, and use, including:
 - Installing pipe in a heated structure
 - Installing pipe below the frost line
 - Insulating pipe

- Utilizing heat trace
 - Winterizing and draining
 - Constant circulation
- Inspect pipe and tubing before installation to locate potential defects.
 - Determine environmental effects.
 - Apply inspection techniques, including sounding of cast iron pipe and fittings.
 - Interpret markings on pipe and tubing and check against specifications.
 - Inspect pipe and tubing before installation to locate potential defects.
 - Determine environmental effects.
 - Apply inspection techniques, including sounding of cast iron pipe and fittings.
 - Interpret markings and check against specifications.
 - Identify and apply hazard safety procedures and tools used when installing and assembling pipe and tube (refer to Lines A and B).
 - Visually identify and name the various pipe and tube jointing methods.
 - Identify and apply the procedures for jointing various types of pipe and tube.
 - Identify the correct jointing procedures for specific piping and tubing applications.
 - Identify and apply measuring procedures, including inside and outside diameters and lengths.
 - Calculate measurements and offsets, applying fitting allowances.

Topic areas covered in this publication are in alignment with SkilledTradesBC Harmonized 2018 Program Outlines.



Resources

- You may be required to reference publications and videos available online at the WorkSafeBC (<https://www.worksafebc.com/en>) website.
- You may wish to have the IPT's Pipe Trades Training Manual (<https://iptbooks.com/product/pipe-trades-handbook/?v=5435c69ed3bc>) available as it is referred to throughout this section. This resource may also be useful to keep and refer to throughout your apprenticeship and into your career in the trades.

Terminology

The following terms may be used throughout this section. Note that some glossary terms may be in italics

throughout the section content but are not included in this list. A complete list of terms can be found in the **Glossary**.

- **ABS (acrylonitrile-butadiene-styrene):** A strong, lightweight plastic used to make pipes and fittings, especially for drainage, waste, and vent systems. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **annealed temper:** A soft and flexible type of copper tubing made by heating the metal and slowly cooling it. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **anode:** A metal through which current flows. (In an electrochemical reaction, the anode is the metal that corrodes.) (Section D-1.4 (#chapter-d-1-3-section-4))
- **armour conduit:** A protective tube or covering placed around piping or tubing to shield it from damage, such as impacts, abrasion, or punctures. (Section D-1.6 (#chapter-d-1-6-section-6))
- **authorities having jurisdiction (AHJ):** Organizations or officials (such as inspectors) who enforce codes and regulations and approve whether work meets required standards. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **billet:** A solid piece of metal that is heated and shaped into pipe or tubing. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **cathode:** A metal from which current flows. (Section D-1.4 (#chapter-d-1-3-section-4))
- **cathodic protection:** A method used to prevent corrosion by making a metal act as a cathode in an electrical process. (Section D-1.4 (#chapter-d-1-3-section-4))
- **cavitation:** The formation of air bubbles in a liquid that can damage pipes. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))
- **centrifugal casting process:** A method of making pipe by pouring molten metal into a spinning mould so it spreads evenly along the inside surface. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **corrosion:** The gradual destruction of material, usually metals, by chemical reaction with its environment. (Section D-1.4 (#chapter-d-1-3-section-4))
- **corrugated Stainless-Steel Tubing (CSST):** A flexible metal pipe used to carry natural gas or propane, designed with ridges so it can bend easily during installation. (Section D-1.6 (#chapter-d-1-6-section-6))
- **crossover method:** A way of tightening bolts in a crisscross pattern to ensure even pressure and a proper seal. (Section D-1.6 (#chapter-d-1-6-section-6))
- **deburring:** The process of removing rough edges from a cut pipe. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))
- **drawn temper:** A hard and strong type of copper tubing made by pulling the metal through a die without heating it. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **DWV (drainage, waste, and vent):** Pipes and fittings used to remove wastewater and allow air to flow in plumbing systems so drains work properly. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **electrochemical reaction:** A reaction caused or accompanied by the flow of electricity and the transfer of electrons between substances. (Section D-1.4 (#chapter-d-1-3-section-4))
- **ERW (electric resistance weld):** A method of making pipe by heating and welding the edges of steel together using electricity. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **expansion anchors (quick-bolts):** Fasteners that expand inside a hole to hold objects securely in place.

(Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

- **extrusion:** A process where heated material is pushed through a shaped opening to form pipe. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **friction loss:** The reduction of pressure in a pipe due to resistance as fluid flows. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))
- **hose:** Portable and flexible pipe made from flexible material such as natural rubber, synthetic rubbers, plastics and composites with metal reinforcing. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **interference fit:** A tight connection where a pipe is pressed into a fitting so the surfaces bond together, often using solvent cement that softens the material and allows it to fuse. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **IPS (iron pipe size):** Used to identify standard dimensions of a carbon steel pipe which is often referred to as “iron pipe.” (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **mandrel:** A tool placed inside a pipe during manufacturing to shape and size it. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **mechanical joint (zip coupling):** A pipe connection that uses a clamp and gasket tightened with bolts or screws to create a seal. (Section D-1.6 (#chapter-d-1-6-section-6))
- **NPS (nominal pipe size):** This is the approximate inside diameter. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **NPT (national pipe thread):** May be referred to as MPT (male pipe thread) for external threads, and FPT (female pipe thread) for internal threads. (Note that FPT and MPT are not authorized designations according to the ANSI standard.) (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **o-rings:** Round rubber seals placed between pipe parts to prevent leaks. (Section D-1.6 (#chapter-d-1-6-section-6))
- **out-of-round:** When a pipe is no longer perfectly circular in shape. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))
- **PEX (cross-linked polyethylene):** A flexible plastic pipe made stronger by a chemical bonding process. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **polyethylene (PE):** A type of plastic commonly used to make flexible and durable pipes. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **potable water:** Water safe for human consumption. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **pipe:** Pipe is generally specified by a nominal inside diameter with a constant outside diameter (OD) and a schedule rating that defines its thickness. Pipe is generally manufactured to one of several international and national industrial standards. In general, “pipe” is the more common term in most of the world, whereas “tube” is more widely used in the United States. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **pipe anchors:** Devices used to hold pipes firmly in place and prevent movement. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))
- **print-line:** The line of markings printed on a pipe that identifies its size, type, approvals, etc. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **PVC (polyvinyl chloride):** A strong plastic material used to make pipes for water and drainage systems. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **reaming:** The process of smoothing the inside edge of a pipe after cutting. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

- **rod hanger:** A threaded metal support used to hang pipes from a structure; other common names: hang-up anchors, Sammy super screws, vertigo anchors, hanger mates, and titan anchors. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))
- **sacrificial anode:** A metal that is designed to corrode instead of another metal to protect it. (Section D-1.4 (#chapter-d-1-3-section-4))
- **SDR (standard dimension ratio):** A number that compares a pipe's outside diameter to its wall thickness to show how strong it is and how much pressure it can handle. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **SDR number:** SDR number is determined by dividing the outside diameter of the tube or pipe by its minimum wall thickness. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **seamless (SMLS) steel pipe:** A type of steel pipe made from a solid piece of metal with no welded seams, making it strong and able to handle high pressure. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))
- **seismic restraint:** A system used to keep pipes and equipment secure during an earthquake. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))
- **standard:** A body of rules or principles established and agreed upon as valid and fundamental in a certain field or industry. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **stray current:** Electrical current that flows along unintended paths and can cause corrosion in pipes and metal components. (Section D-1.4 (#chapter-d-1-3-section-4))
- **sway brace:** A support that prevents pipes from moving side to side. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))
- **thermal expansion:** The increase in size of a material when it is heated. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))
- **thermoplastic:** A plastic capable of softening or fusing when heated and which hardens once cooled. Can be reheated and melted. Polyethylene and polyvinyl chloride (PVC) are examples of a thermoplastic. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **thermo-set:** A plastic capable of becoming permanently rigid when heated or cured. It cannot be reheated and re-melted. Fibreglass pipe is an example of a thermo-set plastic pipe. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **torque wrench:** A tool used to tighten bolts or nuts to a specific amount of force to ensure a proper and secure connection. (Section D-1.6 (#chapter-d-1-6-section-6))
- **tube:** Most often specified by the outside diameter (OD) and wall thickness, but may be specified by any two of OD, inside diameter (ID), and wall thickness. Although standards exist for tube, it's often made to custom sizes and a broad range of diameters and tolerances. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))
- **water hammer (hydraulic shock):** A pressure surge or high-pressure shockwave that occurs when water in motion is forced to stop or change direction suddenly. It produces a distinct banging or hammering sound, caused by the shockwave traveling back through the pipe. This effect can damage pipes, joints, and appliances. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

D-1.1 Describe Piping and Tubing Materials

It's important to be able to identify the piping and tubing you'll be working with. The key to this is recognizing the material from which it is made. Modern pipe is generally made from metal, metal alloys, and varieties of plastic. Other specialty piping materials include rubber, synthetic rubbers, glass silicates, and composite materials. In the past, pipe materials included asbestos cement, glazed clay, wood stave, or lead. You may encounter these pipes in older structures and underground, and it's important to be able to identify them. You'll also have to know how to repair, remove, or adapt new piping materials to older pipe.

Your customers will view you as an expert in your field. You can expect to be asked about the piping system you are using, and you will often have to make recommendations for your client.

Pipe versus Tube Terminology

In common usage, the words **pipe** and **tube** are the same thing. However, in industry and engineering, the terms are uniquely defined—a tube is a pipe with walls that are too thin to be threaded. Tube is typically defined by outside diameter and tighter tolerances, while pipe is defined by nominal inside diameter. Throughout this section, the words pipe and tube may be used interchangeably.

Definitions

It is helpful to know the following terminology when you talk about pipes and tubes:

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DWV (drainage, waste, and vent): Pipes and fittings used to remove wastewater and allow air to flow in plumbing systems so drains work properly.

hose: Portable and flexible pipe made from flexible material such as natural rubber, synthetic rubbers, plastics, and composites with metal reinforcing.

interference fit: The contact made as a plastic pipe is solvent-cemented into the fitting socket. When ABS or PVC plastic pipe and fittings are dry-fitted, the pipe will not easily slide to the bottom of the fitting socket. This is because the fitting socket is tapered slightly to a smaller inside diameter at the base of the socket. The taper causes enough pressure on the solvent-cemented surfaces to cause the ABS surfaces to fuse together. It's a misconception that ABS solvent cement is glue—it's actually a solvent that softens the surfaces it is in contact with. The interference fit forces the surfaces to fuse together.

IPS (iron pipe size): Used to identify standard dimensions of a carbon steel pipe, which is often referred to as “iron pipe.”

NPS: Nominal pipe size. This is the approximate inside diameter.

NPT: National pipe thread. May be referred to as MPT (male pipe thread) for external threads, and FPT (female pipe thread) for internal threads. (Note that FPT and MPT are not authorized designations according to the ANSI standard.)

potable water: Water safe for human consumption.

pipe: Pipe is generally specified by a nominal inside diameter with a constant outside diameter (OD) and a schedule rating that defines its thickness. Pipe is generally manufactured to one of several international and national industrial standards. In general, “pipe” is the more common term in most of the world, whereas “tube” is more widely used in the United States.

print-line: The line of markings printed on a pipe that identifies its size, type, approvals, etc.

SDR (standard dimension ratio): A number that compares a pipe's outside diameter to its wall thickness to show how strong it is and how much pressure it can handle.

SDR number: SDR number is determined by dividing the outside diameter of the tube or pipe by its minimum wall thickness. A lower SDR number means thicker pipe walls and higher pressure rating.

standard: A body of rules or principles established and agreed upon as valid and fundamental in a certain field or industry.

thermoplastic: A plastic capable of softening or fusing when heated and which hardens once cooled. Can be reheated and melted. Polyethylene and polyvinyl chloride (PVC) are examples of a thermoplastic.

thermoset: A plastic capable of becoming permanently rigid when heated or cured. It cannot be reheated and re-melted. Fibreglass pipe is an example of a thermo-set plastic pipe.

tube: Tube is most often specified by the outside diameter (OD) and wall thickness, but may be specified by any two of OD, inside diameter (ID), and wall thickness. Although standards exist for tube, it's often made to custom sizes and a broad range of diameters and tolerances.

Codes, Regulations, and Standards

Codes and regulations play a major role in all aspects of the piping trades. In BC, all plumbing installations must conform to the BC Plumbing Code (BCPC) (<https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/bc-codes/2024-bc-codes/plumbing>). Because the BCPC forms Part 7 of the BC Building Code (BCBC) (<https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/bc-codes/2024-bc-codes>), the parts of the BCBC that pertain to plumbing—but may not be found within the BCPC—must also be followed. Within the codes are references to standards that pipe, tube and fittings must conform to, and manufacturers build their products so that they can be used within the codes. For example, the BCPC lists Series 160 polyethylene as an acceptable material for water service piping, yet there are municipalities that do not allow anything other than copper tubing for that application. This requirement is applied through enactment of a bylaw specifically for that jurisdiction. All applicable codes, local bylaws, manufacturers' specifications, building specifications and site conditions must be considered when selecting an appropriate pipe material for installation.

Characteristics of pipe and tube must also be considered. These characteristics can include but are not limited to corrosion resistance, pressure rating, UV resistance, heat range, resistance to acids and alkalis, smoothness and

roughness, pipe weight and portability, compatibility with fluids, and cost. **Authorities having jurisdiction (AHJ)**, typically inspectors and engineers, routinely check that piping materials installed are correct in their application to the documents that they enforce.

Throughout all of the resource literature referred to in this section, we assume conformance to manufacturers' specifications and applicable codes and regulations in all applications of piping, tubing and fittings.

Metal Pipe and Tubing Standards (Including Steel Pipe Standards)

Nominal pipe size (NPS) is a North American set of standard sizes for pipes used for high or low pressures and temperatures.

Pipe size is specified with two non-dimensional numbers:

- A nominal pipe size (NPS) for diameter based on inches and a schedule (Sched. or Sch.) for wall thickness.
- NPS is often incorrectly called national pipe size, due to confusion with the term national pipe thread (NPT).
- The European designation equivalent to NPS is **DN (diameter nominal)**, in which sizes are measured in millimetres.
- The term **NB (nominal bore)** is also frequently used interchangeably with NPS.

Piping Dimension Standards

Piping and tubing are required to meet specific dimensional requirements. This ensures that piping and fittings will be interchangeable. There are three basic standards that determine the final dimensions of commonly used piping and tubing:

- Piping (plastic, metal, other)—iron pipe size (IPS)
- Copper water tubing—copper tubing size (CTS)
- Copper (ACR) air conditioning and refrigeration tubing

Piping and tubing are described by their *nominal pipe sizes* (NPS). Nominal pipe sizes are approximate inside diameters measured in inches. Piping and tubing may have the same NPS but have different actual dimensions depending on material. For example, a $\frac{1}{2}$ ” NPS iron pipe, $\frac{1}{2}$ ” NPS copper water tube, and $\frac{1}{2}$ ” NPS refrigeration tube will all have different outside diameters (OD).

For a given NPS, iron piping has the largest outside diameter to ensure that the wall thickness will allow threading (Figure 1).

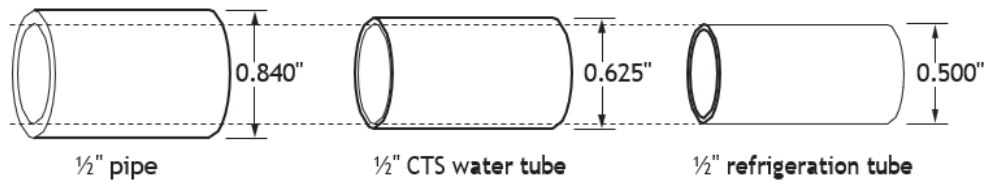


Figure 1 Actual sizes of NPS 1/2" piping and tubing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Size Standards

Steel and iron were the first materials used in the manufacture of piping. Iron pipe size (IPS) is the original standard developed for piping. It's still the basic standard for all pipe of any material (e.g., metal, plastic, vitreous clay) that has the same outside diameter and nominal size as the equivalent iron or steel pipe. Iron pipe size standards demand that the outside diameters of a pipe must be the same for all pipe of the same nominal size.

Pipe Thread Standards

Most piping is threaded, and the actual size, depth, angle, and pitch of threads for pipe are set by the **National Pipe Thread Tapered (NPT)** standard. This ensures that any pipe made to IPS standards will mate with the same threaded fittings.

You will find many different fittings and adapters to connect all types of piping. Copper, steel, and brass pipe (not tubing) as well as ABS and PVC plastic pipe may all be made to the same IPS standard. If the pipes are threaded, they can be joined to each other with IPS threaded fittings, regardless of each component's material. The effect of electrolytic action will still have to be considered when choosing a fitting to connect different metal pipes.

Unlike the straight thread pattern found on bolts, piping used for the delivery of gases or fluids under pressure has a threaded section that narrows to create a seal (Figure 2). This is called a "tapered thread". The seal provided by a threaded pipe joint depends upon the diminishing seal created by the threads and sometimes on the presence of a sealing coating, such as thread seal tape (Teflon tape), or a liquid or paste applicant such as "pipe dope". Pipe dopes and tapes are applied to male (external) threads to lubricate the mating of the threads. Pipe dopes and tapes reduce friction, allowing the joint to be properly tightened to specifications without binding.

Unlike straight threads, pipe threads are tapered to create a seal. Sealants such as thread tape or pipe compound are used to prevent leaks.

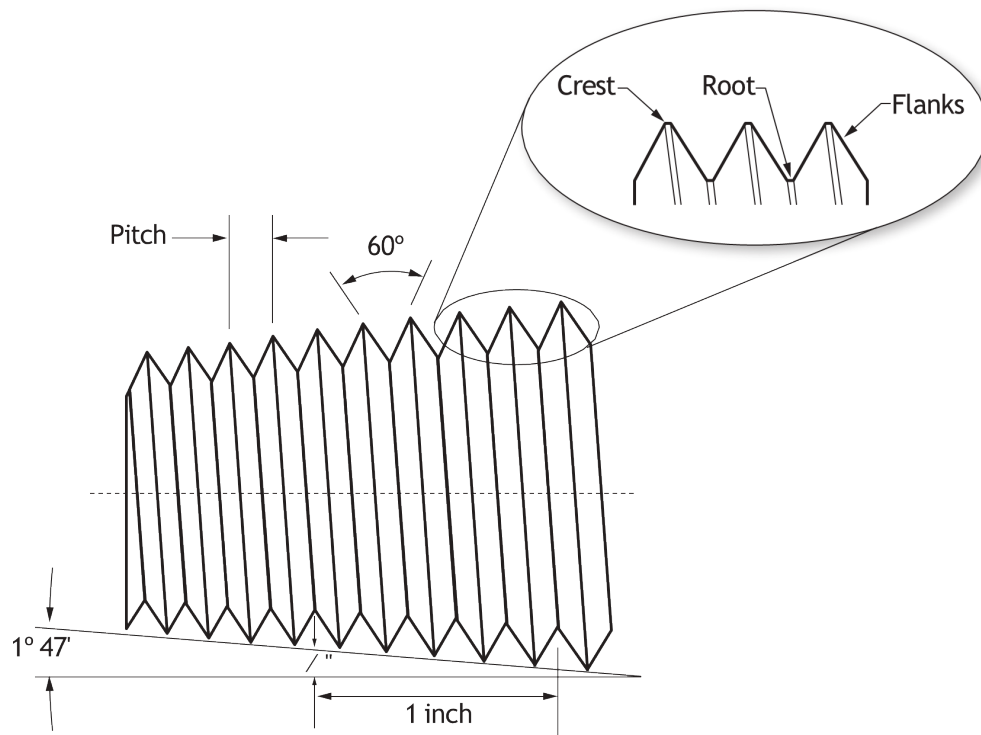


Figure 2 NPT tapered thread (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

National Pipe Thread

The standard developed in North America for tapered threads is ANSI/ASME standard B1.20.1 and is known as National Pipe Thread (NPT). It sometimes is still referred to as American Standard Pipe Thread (ASPT).

The rate of taper for all NPT threads is $\frac{1}{32}$ " per inch ($1^\circ 47'$), and the grooves that create the threads are formed at 60-degree angles. The thread pitch is measured in inches. The root and crest are flat to accommodate thread sealant.

Commonly used threaded pipe sizes are $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$ and 2 inch. Sizes smaller than $\frac{1}{8}$ are occasionally used for compressed air, while sizes larger than 2" are less common, due to the use of alternative methods of joining that are more common with these larger sizes.

The outside diameters of all pipe sizes up to 16" are listed in Table 1. Note that for nominal pipe sizes (NPS) greater than 12", the outside diameter is equal to the nominal pipe size.

Table 1: Standard Pipe Dimensions (inches)

NPS (inches)	Outside diameter	Wall thickness		
		Schedule 40	Schedule 80	Schedule 160
0.5	0.840	0.109	0.147	0.187
0.75	1.050	0.113	0.154	0.218
1	1.315	0.133	0.179	0.250
1.25	1.660	0.140	0.191	0.250
1.5	1.900	0.145	0.200	0.281
2	2.375	0.154	0.218	0.344
2.5	2.875	0.203	0.276	0.375
3	3.500	0.216	0.300	0.600
3.5	4.000	0.226	0.318	NA
4	4.500	0.237	0.337	0.531
5	5.563	0.281	0.375	0.625
6	6.625	0.280	0.432	0.719
8	8.625	0.322	0.500	0.906
10	10.750	0.365	0.594	1.125
12	12.750	0.406	0.688	1.312
14	14.000	0.438	0.750	1.406
16	16.000	0.500	0.844	1.594

You do not have to memorize the dimensions of each NPS category presented in these tables. Review the tables and notice the standard dimensions and how they vary across the different wall thickness standards and between NPS sizes. There are also standards that determine the weight of pipe per lineal foot. The dimensions and wall thickness noted in these tables are only allowed to vary a few percent from the established values.

Standard Wall Thickness

The NPS pipe sizes shown in Table 1 have varying wall thickness, with Schedule 40 pipe having the thinnest walls, and

Schedule 160 the thickest. There is also an increase in wall thickness for each larger pipe size. This is due to the need to increase wall thickness as the diameter increases to maintain the same pressure rating of the pipe.

Schedule numbers are modern classifications for the original weight classes of iron and steel pipe (Table 2). Originally, iron pipe was available in two standard weights, and steel piping was available in three weights. For example, cast iron soil pipe was initially sold in service weight (SW) and extra heavy (XH). Steel pipe was made in three weights: standard, extra-strong (heavy), and double extra-strong (extra-heavy). These weight classes were directly related to the wall thickness of the piping and the service application.

In an effort to standardize the increasing range of wall thickness in iron and steel piping, standards agencies developed schedule numbers from 5 to 160. These numbers indicate approximate values of the pressure-stress ratios times 1000. Standard weight steel pipe is equivalent to Schedule 40. Extra-heavy cast iron pipe is equivalent to Schedule 80.

Table 2: Oxygen Pressure-Temperature Comparison

Schedule Number	Weight Classification
40	standard weight
80	extra-strong (heavy)
160	double extra-strong (heavy)

Stainless steel piping in IPS sizes is classified by a separate class of schedule numbers that range from 5S to 80S.

A more versatile standard was developed that directly relates pipe dimensions to pressure ratings. This standard or rating system is called standard dimension ratio (SDR). SDR is the ratio of the average outside diameter to the minimum wall thickness measured in inches.

$$\text{SDR} = \frac{\text{outside diameter (OD)}}{\text{minimum wall thickness}}$$

Theoretically, different sizes of piping made of the same material, with the same SDR, should have the same pressure ratings. For example, 1" and 6" PVC pressure pipe with an SDR 26 rating are both suitable for 1.1 MPa (160 psi). Figure 3 shows a cross-sectional drawing of two different sizes of plastic pipe: NPS 1 and NPS 2. Each pipe is made of the same kind of plastic. Notice the increased wall thickness of the larger diameter pipe. When the outside diameter is divided by the wall thickness, the ratio or SDR is the same. Each pipe has an SDR of 11, which means that both sizes of pipe can be used at pressures up to 160 psi.

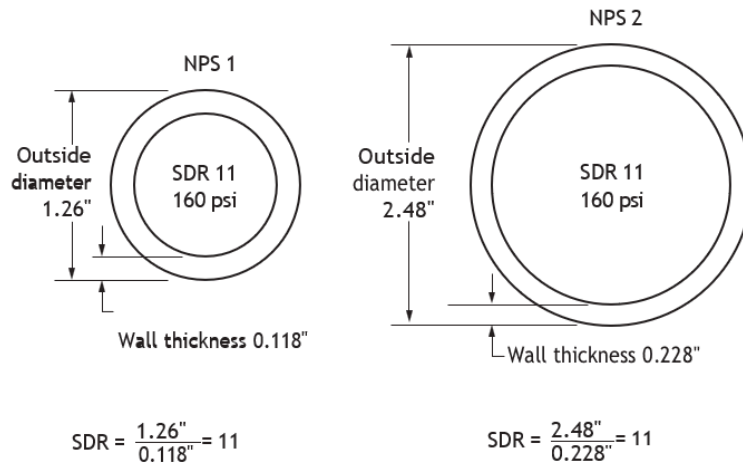


Figure 3 NPS 1 and NPS 2 plastic pipe, both SDR 11, rated for 1.1 MPa (160 psi) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Plastic pipe, such as CPVC and PVC, is sold in a wide range of wall thickness and pipe diameters. The standard schedule classifications are used for piping that matches the dimensions of iron or steel piping. For piping that does not match IPS standards, the SDR classification is preferred.

Each different SDR number has a corresponding pressure rating for each kind of material. For example, one type of polypropylene is available in three SDR ratios:

- SDR 32
- SDR 17.6
- SDR 11

Metal Piping

The previous sections described how pipe is identified and sized using systems such as IPS, schedule numbers, and SDR. These sizing systems apply across many different types of pipe, regardless of the material from which the pipe is made.

Once pipe has been identified by size and pressure rating, it is also classified by the material used in its manufacture. Different materials have different physical, chemical, and mechanical properties that affect their strength, durability, corrosion resistance, and suitability for specific applications.

The following sections introduce the common types of pipe materials used in the piping trades, beginning with metal piping and progressing to specific materials such as copper, steel, and plastics.

Metal piping may be made of pure elements or a mixture of elements called alloys. Alloys are used to improve pipe corrosion resistance, durability, strength, and other qualities.

Copper is an example of a pure metal. Copper tubing is claimed to be 99.9% pure copper.

Bronze is an alloy made of two elements: copper and tin. Brass is another alloy made primarily of copper and zinc.

Piping and Tubing and the Use of Alloying Metals

The chemical, physical, and mechanical properties of many metals are altered by the addition of alloying metals. The range of possible additions and proportions is virtually endless.

For example, iron may be mixed with varying amounts of carbon, silicon, manganese, sulphur and phosphorus to improve the pipe or tubing resistance to corrosion.

Nickel, chromium, magnesium, molybdenum, titanium and vanadium are all substances that will increase the hardness and tensile strength of a pipe. Chromium, nickel and titanium will increase an alloy's resistance to corrosion or staining. Tungsten and molybdenum will increase the melting point of all metals.

Copper Tubing

Copper piping and tubing is made from 99.9% pure copper. Copper piping is used in underground water service, hot and cold potable water systems, hot water heating systems, refrigeration and DWV systems.

Copper piping and tubing has the following characteristics:

- Does not rust
- Smoothness of interior (even at fittings)
- Manufactured with various wall thickness but standard outside diameters
- Available in hard tubing or available in soft (annealed) tubing that is very flexible
- Lightweight, malleable, and easy to work with
- Copper potable water tubing is available in sizes from $\frac{1}{4}$ " - 12"
- Copper DWV tubing is available in sizes from 1 $\frac{1}{4}$ " - 8"



See IPT's *Pipe Trades Handbook and Manual* for examples of other pipes with print lines.

Nickel and Nickel Alloys and Uses



Figure 4 Permendur (https://commons.wikimedia.org/wiki/File:Permendur_rod.jpg) (Nickel-cobalt alloy/Wikimedia Commons) CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/deed.en>)

Nickel and nickel alloys are used in heavy industry such as marine and ship building, pulp and paper manufacturing, medical gas systems, and chemical manufacturing. Nickel and copper nickel alloys come in several types.

The basic metals used are copper and nickel—other metals are added in varying proportions. The different alloys of copper nickel have different characteristics tailored to specific installation environments. The examples of nickel and copper nickel provided in this information are only a partial list of types and uses. Further information about alloys can be found on manufacturers' websites.

There are several grades of nickel piping including:

- Nickel pipe 200 ASTM/ASME SB standard
- Nickel pipe 201 ASTM/ASME SB standard
- Nickel pipe 205 ASTM/ASME SB standard

Monel is a nickel alloy and is produced in grades such as Monel 200, 400, and K 500 ASTM/ASME SB standard. Monel alloy uses include:

- Chemicals, fats, and fertilizers manufacturing
- Sugar mills and distilleries
- Cement industries
- Shipping
- Paper industries
- Pumps

Inconel is a nickel alloy and is produced in grades such as Inconel, 600, 601, and 825 ASTM/ASME SB standard. Inconel characteristics include:

- Nonmagnetic
- Corrosion- and oxidation-resistant
- Strong and durable structure

- Butt-weld and forged fittings available or can be manufactured with short lead times

Hastelloy is a nickel alloy and is produced in grades such C-22, C-276 (UNS N10276) standard pipe ASTM/ASME.

Hastelloy uses include:

- Marine, power, chemical processing, pollution control, paper processing, waste disposal
- Sour gas applications (NACE MR0175)
- Flue gas desulfurization (FGD) applications for scrubbers, dampers and ducts

Hastelloy C-22 tubing is available up 2" OD in welded and $\frac{1}{2}$ " OD seamless construction. Seamless pipe is available up to 6". Larger sizes are available in welded construction.

Copper Nickel Alloy Types

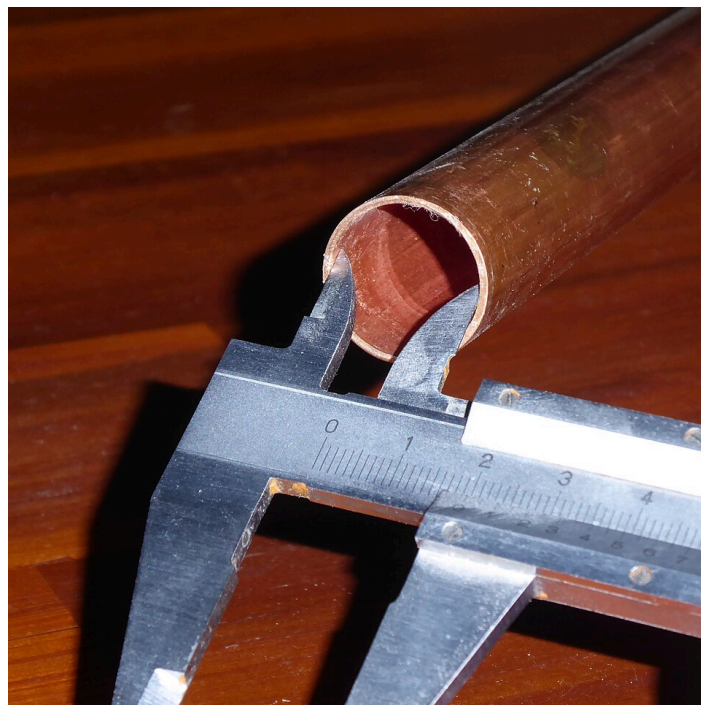


Figure 5 Copper pipe (https://commons.wikimedia.org/wiki/File:Messschieber_misst_Rohrinnendurchmesser.jpg) (Rhetos/Wikimedia Commons) CC0 1.0 Public Domain (<https://creativecommons.org/publicdomain/zero/1.0/deed.en>)

Copper nickel alloy type ASTM B111 90-10 is widely used in sea water applications. It has very good corrosion resistance to clean or moderately polluted water.

Copper Nickel Alloy Type

ASTM B111 70-30 is preferred for severe operating conditions. It has excellent resistance to impingement and erosion-corrosion by suspended solids in sea water. 70-30 copper nickel is virtually immune from stress-corrosion cracking. It can be sensitive to deposit attack and is therefore not recommended for stagnant or slow-moving water.

Copper Nickel Alloy Uses

Copper nickel alloy has the following uses:

- Water desalination plants, especially in the most critical areas such as the heat reject and brine heater stages of power station condensers
- Chemical, petrochemical, and food processing industries
- Applications where top surface corrosion resistance is required
- Sea water corrosion-resistant assemblies

Brass Pipe

Brass piping is made from varying proportions of copper and zinc. Brass piping is very expensive. It is used in some hot and cold water supply lines and some drainage systems.

Brass pipe has the following characteristics:

- Versatile
- Very soft so can be threaded easily
- Very resistant to corrosion and rust
- Smooth inner walls reduce blockages in piping
- Can withstand high pressures (up to 7 MPa or 1000 psi)
- Difficult to puncture
- More ductile than copper and bronze

Brass pipe is available in sizes ranging from $\frac{1}{8}$ – 12" (same sizing as steel piping) and standard lengths of 6 m (20').

Aluminum Pipe and Tubing



Figure 6 Aluminum Pipes (<https://www.pexels.com/photo/metal-tubes-on-stack-15508177/>) (Zakhar Vozhdaienko (<https://www.pexels.com/@zakhar/>)/Pexels) Pexels license (<https://www.pexels.com/license/>).

Seamless aluminum piping is inexpensive and used primarily in irrigation systems. It is permitted in drainage systems if it is lined with plastic and in above-ground venting systems. This pipe was used in DWV systems for a short time but is no longer acceptable according to current plumbing codes.

Aluminum DWV pipe:

- Must be protected from corrosion
- Has relatively high tensile strength
- Lightweight, malleable, and ductile

Cast Iron Piping (Cast Iron Soil DWV Pipe)



Figure 7 Cast iron (https://commons.wikimedia.org/wiki/File:Machines_de_Marly._D%C3%A9tail_tuyauterie_en_fonde_sur_la_colline_de_Bougival.jpg) (Moonik/Wikimedia Commons) CC BY-SA 3.0 (<https://creativecommons.org/licenses/by-sa/3.0/deed.en>)

Cast iron piping, sometimes referred to as mechanical joint or MJ, is an alloy of iron, carbon, and silicon. It may also contain varying amounts of manganese, sulphur and phosphorus to increase its corrosion resistance. Grey cast iron piping is used in drainage, sewer, and venting systems. Cast iron soil pipe cannot be used in a potable water system.

Cast iron piping qualities include:

- Resists corrosion; non-flammable
- Coated with pitch to protect from rust
- Durable and relatively inexpensive
- Does not easily transmit the sound of running water; much quieter than copper or plastic
- Heavier than plastic or copper
- Withstands high temperatures but not high pressures
- No-hub cast iron soil pipe is supplied in 3 m (10') lengths

Ductile Cast Iron Water Pipe (Ductile Water Main)



Figure 8 Ductile pipes for drinking water
(https://commons.wikimedia.org/wiki/File:Cast-iron_pipes_for_drinking_water.jpg) (Cjp24/Wikimedia Commons) CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/deed.en>)

Ductile iron pipe is a type of cast iron pipe used for potable water distribution. It's made from ductile iron. Ductile cast iron is produced by a technique known as centrifugal casting. The molten ductile iron is poured into a rapidly spinning water-cooled mold. Centrifugal force causes the molten iron to spread evenly around the circumference of the mold. Ductile iron will resist corrosion, however, over longer periods of time, the build-up of corrosion products inside the pipe can restrict the flow. Ductile cast iron water main is lined with a portland cement and sand mix mortar. The mortar is centrifugally applied during manufacturing. The mortar lining extends the life of the water main. A variety of other linings are available to reduce or eliminate corrosion including polyurethane and polyethylene. The exterior of the pipe is coated with bituminous coating to protect the pipe during shipping and installation.

In some jurisdictions, the ductile iron can be wrapped in a polyethylene sleeve. The sleeve of polyethylene completely wraps the pipe and the bell of any joints. The sleeve inhibits galvanic corrosion by physically separating the pipe from the surrounding soils.

Ductile water main characteristics:

- Very strong
- Fracture-resistant
- Nominal pipe sizes vary from 3 – 64", in increments of at least 1 inch
- Manufactured exclusively from scrap steel
- Can be recycled

Spigot and sockets involve a normal pipe end (the spigot) being inserted into the socket (or bell) of another pipe or fitting. This is called a "push-joint" or "slip-joint". A gasket and the pipe are lubricated before assembly. The joints provide some flexibility, allowing the pipe to resist ground movement stresses. Any bends, tees, or valves will require either a restrained joint or, thrust blocks.

Duriron Pipe

Duriron pipe is a high-silicon-content acid-resistant cast iron pipe. It's available in hub and spigot ends or mechanical joint no hub ends. Duriron pipe and fittings can be used wherever acids, solvents, bleaches, detergents, or otherwise aggressive fluids are present. Duriron is ideal for use in chemical processing plants, school, and industrial laboratories.

Duriron characteristics:

- Outstanding corrosion resistance
- Excellent resistance to sulfuric, nitric, hydrochloric and acetic acids
- Resistant to both oxidizing and reducing solutions
- Is not appreciably affected by either acid concentration or temperature
- Tensile strength is less than most metals
- Suitable for applications up to 500°F (260°C)
- High abrasion resistance
- Density and wall thickness muffles sound from drainage
- Bell & spigot pipe is available in 2-inch through 15-inch diameters
- Mechanical joint pipe and fittings is available in 1 $\frac{1}{2}$ -inch through 4-inch
- Available in a split flange design in sizes 1-inch to 8-inch

Duriron bell & spigot joints should be assembled using virgin lead and Red Stripe Sealite A312 acid-resistant rope packing. Mechanical joint couplings should be installed by alternately tightening the two nuts and bolts to a minimum of 9 ft-lbs and a maximum of 11 ft-lbs torque.

Wrought Iron Piping

Wrought iron pipe was used for water supply in older houses. It comes either “black” or galvanized. Joints are made by threading pipe into cast iron fittings—unlike screw threads, pipe threads are tapered. Wrought pipe can be identified by a raised cross-hatch pattern on one side or the other. Wrought iron pipe is no longer used in water systems.

Carbon Steel Pipe



Figure 9 Carbon pipes (<https://pixabay.com/photos/steel-pipes-steel-factory-6967964/>) (Bakhrom Tursunov/Pixabay)
Pixabay content license (<https://pixabay.com/service/license-summary/>)

Carbon steel is steel where carbon is the main alloy component. Carbon steel pipe is commonly referred on the job as “black iron pipe.” Carbon steel pipe manufactured with a zinc coating is called galvanized iron pipe. Carbon steel pipe can also be manufactured with a plastic coating for use in corrosive environments or underground. Carbon steel pipe is used in steam and hot water heating systems, fuel-gas piping systems and fire sprinkler systems.

Carbon Steel Types

ASTM A53 is a carbon steel alloy used for structural steel pipe. The alloy specifications are set by ASTM International, in specification ASTM A53/A53M [1]. A53 pipe is suitable for structural or pressure applications. A53 pipe comes in three types and two grades:

- A53 Type F is longitudinally furnace butt welded or continuous welded (Grade A only).
- A53 Type E is longitudinally electric resistance welded (Grades A and B).
- A53 Type S is seamless pipe, produced by hot working, and possibly cold finishing, the steel (Grades A and B).
ASTM A53 Type S is now currently an outdated specification and has been replaced by ASTM A106 specification for seamless carbon steel pipe.

► Available from $\frac{1}{8}$ ” – 48” diameter and larger, from stock, in Schedule 5 through Schedule 160, standard, extra-

heavy, and double extra-heavy.

► Threaded, bevelled, and grooved ends available from stock.

► Tube and tubing in carbon, stainless steel, aluminum and other alloys in sizes from hypodermic to 48” and larger. Available in rigid lengths and coils, depending on application.

Seamless Steel Pipe and Tubing



Figure 10 Seamless Steel Pipe (<https://www.pexels.com/photo/close-up-photo-of-stainless-steel-pipe-8853524/>) (Los Muertos Crew (<https://www.pexels.com/@cristian-rojas/>)/Pexels) Pexels license (<https://www.pexels.com/license/>)

Seamless (SMLS) steel pipe is made from a solid round steel billet that is heated and pushed or pulled over a form until the steel is shaped into a hollow tube. The seamless pipe is then finished to dimensional and wall thickness specifications. Seamless steel finishes include hot rolled, cold drawn, turned, and roto-rolled. After the end finishing is complete, all pipes are then pressure- tested. A final visual inspection and labelling is completed, and an external coating can then be applied.

Characteristics of seamless steel pipe:

- Used for steam boilers and pipelines for installations with high and supercritical steam conditions
- Used in oil and gas, chemical, and automotive industries
- Ultra strength and durability
- Can be used for corrosion-resisting applications
- In sizes from $\frac{1}{8}$ " – 26" OD
- ASTM A106/A106M – 10 standard specification for seamless carbon steel pipe for high- temperature service

Stainless Steel

Stainless steel is used primarily when corrosion or oxidation is a problem. Over 50 years ago, it was discovered that the addition of chromium to steel would impart corrosion and oxidation resistance to the steel.

Stainless steel is available from $\frac{1}{8}$ " – 24" diameter in Schedule 5 through to double extra-heavy and beyond. Also available is an inside diameter pulp and paper specified pipe.

Specialty grades are available, including high-nickel alloys such as Hastelloy C-276; carbon alloys such as Chrome-Moly P22, WPL6; aluminum alloys such as 6061T6, 5083H112; and stainless alloys such as 317L, 321, and 347.

Stainless steel alloys usually have a chromium content of at least 10%.

Grades of Stainless Steel

There are different grades of stainless steel:

- Austenitic: these grades (such as 302, 304, 308, 316, etc.) are also available with a lowered carbon content (designated with an “L”, such as 304L or 316L).
- Martensitic (such as 410 and 416).
- Ferritic (such as 409 and 430).

Depending on the grade, stainless steel is made up of iron and:

- Carbon (approximately 3–10%)
- Nickel (0–22%)
- Chromium (4–27%)
- Molybdenum (0 –4%)

Qualities of stainless steel:

- Corrosion-resistant
- Oxidation-resistant
- Heat-resistant
- Improved strength

Identify Stainless Steel Grades

Austenitic Grade of Stainless Steel (300 Series)

Austenitic grades are those alloys that are commonly in use for stainless applications. The austenitic grades are not magnetic. The most common austenitic alloys are iron-chromium- nickel steels, widely known as the 300 series. The austenitic stainless steels, because of their high chromium and nickel content, are the most corrosion-resistant of the stainless group, providing unusually fine mechanical properties. They cannot be hardened by heat treatment but can be hardened significantly by cold-working.

Straight Grades

The **straight grades** of austenitic stainless steel contain a maximum of 0.08% carbon. There is a misconception that

straight grades contain a minimum of 0.03% carbon, but the specification does not require this. As long as the material meets the physical requirements of straight grade, there is no minimum carbon requirement.

L Grades

L grades of austenitic stainless steel are used to provide extra corrosion resistance after welding. The letter L after a stainless steel type indicates low carbon (as in 304L). The carbon is kept to 0.03% or under to avoid carbide precipitation. Participation of carbon in stainless steel occurs when the steel is heated to temperatures in the critical range (800 – 1600°F). The carbon moves to the welded area and combines with the chromium resulting in reduced corrosion resistance of the welded joint.

- L grades are more expensive.
- L grades are used where annealing after welding is impractical, such as in the field where pipe and fittings are being welded.

H Grades

H grades of austenitic stainless steel contain a minimum of 0.04% and a maximum of 0.10% carbon and are designated by the letter H. H grades are primarily used when the material will be used at extreme temperatures, because the higher carbon helps the material retain strength at extreme temperatures.

Martensitic Grades of Stainless (400 Series)

The **martensitic grades** are straight chromium steels containing no nickel (414 has 2% nickel).

Martensitic grades of stainless steel were developed to provide a group of stainless alloys that would be corrosion-resistant and hardened by heat treating. They are magnetic.

The martensitic grades are mainly used where hardness, strength, and wear resistance are required.

Ferritic Grades of Stainless Steel (400 Series)

Ferritic grades have been developed to provide a group of stainless steel to resist corrosion and oxidation, while being highly resistant to stress corrosion cracking. These steels are magnetic but cannot be hardened or strengthened by heat treatment. They can be cold-worked and softened by annealing. As a group, they are more corrosion-resistant than the martensitic grades but are generally inferior to the austenitic grades. Like martensitic grades, these are straight chromium steels with no nickel. They are used for decorative trim, sinks, and automotive applications, particularly exhaust systems.

Corrugated Steel

This piping is used mainly for municipal applications such as storm sewers, storm water drainage, under-drains, culverts, and similar uses.

Corrugated pipes are not normally used for the conveyance of sanitary or industrial wastes.

Plastic Pipe and Tubing

It's important to be able to identify and install plastic pipe and tubing. Plastic piping is increasingly popular because of its versatility and ease of installation. Some codes limit its use in water supply piping within buildings. Plastic materials are generally divided into two groups: **thermoplastics** and **thermosetting resins**. Thermoplastics (such as ABS and PVC) can be repeatedly reformed by heating. Thermosetting resins (such as fibreglass) cannot be reshaped after they have been formed and cured. Most plastic piping materials are thermoplastics.

Polyethylene Plastics



Figure 11 Polyethylene Pipe lengths (https://commons.wikimedia.org/wiki/File:Polyethylene_Pipe_lengths.jpg) (GordonJ86/Wikimedia Commons) CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/deed.en>)

Polyethylene thermoplastic is made from petroleum. The method of processing determines the type of polyethylene used for different purposes including piping and tubing. Piping made from polyethylene is a cost-effective solution for a broad range of piping problems in municipal, industrial, marine, mining, landfill, duct, and agricultural applications. It has been tested and proven effective for above ground, surface, buried, floating, and sub-surface marine applications. Polyethylene (PE) is widely used in underground water and gas service and field irrigation systems. Cross-linked polyethylene tubing is used for water supply systems and hydronic heating.

Polyethylene piping has the following characteristics:

- Usually black (to prevent breakdown from sunlight) but also available in yellow or orange
- Extremely high-impact strength, yet flexible enough to be coiled
- High resistance to chemicals
- Low melting point and low temperature resistance, up to 54°C (130°F)

Polyethylene Pipe Qualities

In most piping systems, aging increases the pipe surface roughness, which increases flow resistance. Polyethylene (PE) pipe resists typical aging because it does not rust, rot, corrode, tuberculate, or support biological growth—it also resists the adherence of scale and deposits. In some cases, moderate flow velocities are sufficient to prevent deposits. For systems using a low velocity, it may be enough to introduce occasional high velocity flow in order to remove sediment and deposits.

Low-flow-rate gravity-flow pipelines can be cleaned with a water-jet or by forcing a soft (plastic foam) pig through the pipeline. Don't use bucket, wire, and scraper-type cleaning as these methods can damage PE pipe.

There are several types of polyethylene used to manufacture polyethylene pipe, including:

- High-density polyethylene (HDPE)
- Medium-density polyethylene (MDPE)
- Low-density polyethylene (LDPE)
- Linear low-density polyethylene (LLDPE)

You are not expected to memorize all types—focus on general properties and applications.

High-Density Polyethylene (HDPE)

High-density polyethylene or polyethylene high-density (PEHD) is a polyethylene thermoplastic made from petroleum. HDPE's plastic identification code (PIC) is 2. A plastic product's PIC is the small number printed within the recycling diagram somewhere on its surface. The HDPE has benefited from discussions about possible health and environmental problems caused by PVC and polycarbonate associated Bisphenol-A. HDPE's main use has been for underground gas piping.

Medium-Density Polyethylene (MDPE)

MDPE is less dense than HDPE. MDPE has good shock and drop-resistance properties. Stress cracking resistance is better than that of HDPE. MDPE is typically used in shrink film, packaging film, carrier bags, and screw closures. MDPE may be used for gas pipe and fittings when approved for that use.

Low-Density Polyethylene (LDPE)

LDPE is a thermoplastic made from petroleum. LDPE is commonly recycled and its “recycling number” (PIC) is 4. LDPE is used to manufacture juice and milk cartons, playground slides, and plastic wraps. LDPE is not used for piping.

Linear Low-Density Polyethylene (LLDPE)

LLDPE has penetrated almost all traditional markets for polyethylene—it’s used for plastic bags and sheets, plastic wrap, stretch wrap, pouches, toys, covers, lids, pipes, buckets and containers, covering of cables, and flexible tubing. (It can be made much thinner than LDPE.)

LLDPE can be recycled into other things such trash can liners, lumber, landscaping ties, floor tiles, compost bins and shipping envelopes.

The following are examples of polyethylene materials used in the piping industry. Refer to the manufacturer’s specifications for the product to ensure that the pipe you use meets the appropriate standards, applicable code requirements, and job specifications.

There are several categories of polyethylene pipe:

- CSA series, for building/plumbing code-related installations
- Standard series for non-CSA applications.
- Other polyethylene pipe products lines for specialty installations such as geothermal, ice rinks, submersible pump drop, irrigation, storm drainage, National Sanitation Foundation (NSF) uses, and utility uses

CSA Series Polyethylene Piping

The CSA series of polyethylene is general purpose pipe. It’s available in either low-density polyethylene (LDPE) or high-density polyethylene (HDPE) grades manufactured to CSA B137.1 standards.

CSA Series 75 PSI B137.1

This is a general light-duty service suitable for potable water.

Characteristics:

- Lightest wall thickness
- Black in colour
- Limited to 75 psi at 73.4°F
- Joined with gear clamps and insert type fittings
- Available in coils from 100’ – 500’ and reels up to 3000’
- Not allowable for use within the scope of the *Plumbing Code*

- Available in sizes $\frac{1}{2}$ -inch to 2-inch
- Carbon black pigment for ultraviolet protection

CSA Series 100 PSI B137.1

This is a general-duty service suitable for potable water. Characteristics:

- Heavier wall thickness than series 75 PSI
- Manufactured from LDPE
- Black in colour
- Limited to 100 psi at 73.4°F
- Joined with gear clamps and insert type fittings
- Available in coils from 100' – 500' and reels up to 3000'
- Not allowable for use within the scope of the Plumbing Code
- Available in sizes $\frac{1}{2}$ -inch to 2-inch
- Carbon black pigment for ultraviolet protection

CSA Series 160 PSI Copper Tube Size (CTS) B137.1 Municipal Water Service

CSA series 160 polyethylene pipe is specifically used for water service piping. Series 160 is copper tube size (CTS). It has its own size designation and will not accept normal polyethylene insert fittings, although fittings are available to adapt from one to the other. A yellow stripe that runs the full length of the pipe identifies some manufacturers' series 160 pipe. The yellow stripe is part of the pipe wall and permanently identifies it as the specific manufacturer's pipe.

In Canada, polyethylene water pipe and fittings must be certified to CAN/CSA-B137.1, Series 160, with a rated working pressure of 1034 kPa (150 psi).

Characteristics:

- Non-corroding and resists most acids, salt solutions, alkalis, fats, and oils
- Black or black with a yellow stripe
- Available in 100', 200', and 500' coils as well as in 1000' reels.
- Manufactured to copper tube size (CTS)
- Will not accommodate normal polyethylene insert fittings
- Resists decomposition, oxidation, tuberculation and microbiologically induced corrosion
- Connections of brass or plastic compression fittings are readily available
- Requires a stainless steel insert or a specially designed (copper tube size) plastic insert to reinforce the pipe joints
- Sequential markings every two feet
- Expansion rate is 0.87" per 100' of pipe for every 10°F change
- Rated at 160 psi @ 72°F cold water use only
- *Plumbing Code* restricts the use to a water service only

CSA Series 200 PSI Copper Tube Size (CTS) B137.1 Municipal Water Service

Characteristics:

- Non-corroding and resists most acids, salt solutions, alkalis, fats and oils
- Black in colour
- Manufactured from HDPE
- Available in 100', 200', and 500' coils as well as in 1000' reels
- Manufactured to copper tube size (CTS.)
- Will not accommodate normal polyethylene insert fittings
- Resists decomposition, oxidation, tuberculation and microbiologically induced corrosion
- Connections of brass or plastic compression fittings are readily available
- A stainless steel insert or a specially designed (copper tube size) plastic insert to reinforce the pipe joints
- Sequential markings every two feet

Non-CSA Standard Polyethylene Pipe

Non-CSA standard polyethylene is used in water distribution applications that do not require CSA approval.

Standard Series 75 PSI LDPE

Characteristics:

- Black in colour
- Manufactured from low-density polyethylene
- Available in sizes $\frac{1}{2}$ -inch to 2-inch
- Available in 100'–500' coils and 1000–3000' reels
- Limited to 75 psi at 73.4°F
- Joined with gear clamps and insert-type fittings

Standard Series 100 PSI LDPE

Characteristics:

- Black in colour
- Manufactured from low-density polyethylene
- Available in sizes $\frac{1}{2}$ -inch to 2-inch
- Available in 100'–500' coils and 1000–3000' reels
- Limited to 100 psi at 73.4°F

- Joined with gear clamps and insert-type fittings

Other Polyethylene Applications

The following describe some other polyethylene tubing applications.

Ice Rink PE Linear Low-Density Polyethylene or Low-Density Polyethylene

Manufactured using extrusion method in accordance with CSA-B137.1.

Characteristics:

- Working pressure 70 psi at 73.4°F (23°C)
- 1-inch diameter
- Black in colour
- Limited to 70 psi at 73.4°F
- Available in 2000'–5000' reels only
- Available in two wall thickness: standard wall and thin wall

Polyethylene Medium-Density Gas Pipe

Characteristics:

- Durable
- Corrosion resistance
- Not affected by hydrocarbons
- CSA B137.1 for water pipe and B137.4 for gas pipe
- Canadian General Standards Board CGSB 41 and 61 pipe polyethylene for transport of liquids
- NSF and Plastic Pipe Institute PPI PE 2406
- Available in a variety of sizes in coils or limited straight lengths
- Limited to 100 psi at 73.4°F
- Yellow in colour

Geothermal HDPE

Geothermal HDPE is manufactured by extrusion from high-density polyethylene (HDPE). Characteristics:

- Durability
- Stress crack resistance

- Sizes from $\frac{1}{2}$ -24"
- Pipes come in sticks, coils, and large reels
- Green in colour (black)
- Limited to 160 psi at 73.4°F
- NSF standard

Marking example for a geothermal HDPE pipe, printed with yellow permanent print stating the following:

- NSF geothermal logo
- Identification manufacturer
- The appropriate SDR rating
- Product trade name
- All relevant standards
- Manufacturing date
- Incremental footage marking every two feet
- Design temperature rating
- Production shift designation
- Identification of PE-3408 high-density resin

Pump Drop Polyethylene

Pump drop polyethylene pipe for submersible pump installations has two use designations:

LLDPE 200' Depth Installations

- Manufactured by extrusion to CSA B137.1 standard Series 75 and 100
- Up to 200' deep
- Available in coils from 300-1500 feet
- Available from $\frac{1}{2}$ -inch to 2-inch
- Blue in colour
- Pipe marking includes a printed count-down numbering on the pipe

MDPE 600' Depth Installations

- Manufactured by extrusion to CSA B137.1 standard Series 160
- Up to 600' deep
- Available in coils from 300-1500 feet
- Available from 1-inch to $1\frac{1}{4}$ -inch

- Blue in colour
- Pipe marking includes a printed count-down numbering on the pipe

Corrugated HDPE Municipal Storm Drainage

Dual-Wall HDPE Corrugated Pipe for Municipal Storm Drainage

HDPE corrugated municipal storm drainage pipe is manufactured from HDPE. It is available to move stormwater and wastewater.

Characteristics:

- Flexible pipe
- Durability
- Joint integrity
- Long-term cost-effectiveness
- Ability to support and distribute live and dead load Contact manufacturers for approval standards.

Cross-Linked Polyethylene (PEX Tubing)

Cross-linking is a chemical reaction that occurs between polyethylene polymer chains. Currently, three methods for producing cross-linked polyethylene (PEX) tubing exist:

- Engel or peroxide method (PEX-A)
- Silane method (PEX-B)
- E-beam (electron beam) or radiation method (PEX-C)

All three processes generate tubing that is cross-linked to varying degrees, and all meet the ASTM, NSF and CSA standards for use in potable water and heating applications.

Engel Method (PEX-A)

The PEX tubing industry considers this tubing superior because the cross-linking is done during the manufacturing process when polyethylene is in its amorphous state (above the crystalline melting point). Because of this, the degree of cross-linking reaches around 85%, resulting in a more uniform product with no weak links in the molecular chain.

Silane Method (PEX-B)

PEX-B tubing is crosslinked after the extrusion process by placing the tubing in a hot water bath or steam sauna. The

degree of crosslinking for PEX-B is typically around 65 to 70%. This method is not as evenly cross-linked as the PEX-A method, nor does it have the same degree of thermal memory, which allows kinked tubing to be reshaped with the use of a heat gun.

E-beam Method (PEX-C)

PEX-C uses an electron beam to change the molecular structure of the tubing (i.e., cross-link) after the extrusion process. The PEX-c method requires multiple passes under the beam to reach a 70 to 75% degree of cross-linking. Side effects of this process are discolouration due to oxidation (from natural white to yellow, unless other pigment is added), and a slightly stiffer product.

PEX-A Distinctions

The properties in PEX-A tubing make it the most flexible PEX on the market. This allows the tubing the tightest bend radius available—as little as $3 \frac{1}{2}$ ” for $\frac{1}{2}$ ” tubing. Its flexibility also greatly reduces the instance of kinked tubing. If there is the occurrence of kinked tubing, PEX-A tubing has thermal memory. This allows the repair of kinked tubing with a careful shot of heat from a heat gun. Shape memory allows PEX-A tubing to expand and then shrink back to normal size, this offers unique opportunity for various types of fitting connections.

Colour Coding of PEX Tubing

The colours used for PEX tubing vary from opaque, white, blue, red and variations of these colours. The best way to identify PEX is via the pipe markings. Typically, red PEX tubing is used for hot water while blue is used for cold.

PEX characteristics:

- Typically has less internal friction than metal pipe
- Less expensive than metal pipe
- Flexible and can be bent into a radius angle to provide less restrictive flow
- Expected lifetime of upward of 50 years
- Susceptible to ultraviolet degradation when exposed to direct sunlight See IPT's *Pipe Trades Handbook and Manual*.

Oxygen Barrier PEX

PEX tubing used in radiant heating system applications with ferrous metal parts was found to allow oxygen absorption through the PEX tubing wall. The solution to this problem is to apply an oxygen barrier shield during the manufacturing process. This shield is a thin layer of plastic film that slows down the rate of oxygen diffusion through the piping walls. It doesn't prevent diffusion. This PEX

tubing is identified by markings such as “OXY guard” or “Oxygen barrier.”

Composite Metal and Plastic Piping

Two kinds of composite metal and plastic piping are:

- Polyethylene/aluminum/polyethylene (PE/AL/PE)
- Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX/AL/PEX)

Both of these polyethylene composite pipes have three layers. The inside and outside layers are made of high-density polyethylene, tightly bonded with melt adhesive to the mid-layer, the longitudinally overlapped welded aluminum core. All layers are co-extruded in a one-step patented manufacturing process. The polyethylene inside and outside layers are hygienic, non-toxic and smooth. Its middle layer of aluminum serves as an oxygen barrier, stopping the oxygen diffusion through the cross-linked polyethylene layers.

Characteristics:

- Holds a bend better, because the shape memory of the PEX is offset by the aluminum.
- The pipe is available in $\frac{1}{2}$ -, $\frac{5}{8}$ -, $\frac{3}{4}$ - and 1-inch (14, 16, 20, and 25 mm) nominal diameter sizes.
- Available in 3.7 m (20') straight lengths or coils up to 305 m (1000').
- Hot-water piping is orange and cold-water piping is blue.
- Joints buried in concrete are not recommended—consult manufacturers' documentation.

Standards:

- PEX/AL/PEX pipe must comply with ASTM F 1281-98a.
- Produced from polyethylene compound complying with the requirements of ASTM D 1248 for P33, Class A material.
- Grade 3003 aluminum must comply with the requirements of ASTM B 209.
- Both PE/AL/PE and PEX/AL/PEX pipe and fittings used for potable water systems must conform to CAN/CSA-B137.9.
- PE/AL/PE pipe and fittings must not be used in a hot water system.

Pipe markings, at minimum 1.5 m (5') intervals, include:

- Manufacturer's name
- Product designation (name)
- Material designation (PEX/AL/PEX) or (PE/AL/PE)
- Nominal size
- Potable water designation
- Appropriate standard designation (CAN/CSA-B137.10)
- Pressure and temperature limitations

Polyamide

Polyamide (PA) is a newer thermoplastic piping material used for underground fuel gas distribution such as natural gas. The PA piping systems possess a higher hydrostatic stress rating than the traditional PE piping systems. Like PE piping systems, PA systems are available in a broad array of sizes and with a full complement of fittings. The PA piping systems are joined using heat fusion methods. PA is typically yellow in colour, which has become the standard for underground gas lines.

Standards: CSA B137.12-09 Polyamide-11 (PA-11) piping systems for gas services

Characteristics:

- Durable
- Available in straight lengths of 164 m (50') or in coils to more than 76 m (250')
- Extruded in diameters ranging from 2 – 6"
- Corrosion-free
- Chemical-resistant
- Suitable for use in hydrocarbon contaminated soils without de-rating
- Higher operation pressure than other plastic pipe
- Coiled pipe that can be ploughed or laid in trenches
- Ability to be squeezed off to stop flow
- Polyamide-11 (SDR 11)[GGA1] and polyamide-12 (SDR 12)[GGA2] are available for underground gas piping. A high SDR pipe has a low-pressure rating and low SDR pipe has a high-pressure rating.

Markings:

- Manufacturer's name
- Product designation (name)
- Material designation (polyamide PA-11)
- Nominal size
- SDR number
- Potable water designation
- Appropriate standard designation (CAN/CSA- 137.12-09)
- Pressure and temperature limitations

Polybutylene

Polybutylene (PB) plastic pipe is grey-coloured flexible tubing first introduced in the 1970s. Polybutylene was installed in many residential buildings. The pipe has since been discontinued, and PEX (cross-linked polyethylene) piping has taken its place. Polybutylene pipe is no longer manufactured. There were issues with it that resulted in class action lawsuits.

Polypropylene (PP)



Figure 12 Hdpe pipe installation (https://commons.wikimedia.org/wiki/File:Hdpe_pipe_installation.jpg) (Tomascastelazo/Wikimedia Commons) CC BY-SA 3.0 (<https://creativecommons.org/licenses/by-sa/3.0/deed.en>)

Polypropylene (PP) is used in piping systems where resistance to corrosion and chemical leeching is required. It's widely used in the petroleum industry for wastewater disposal lines, low-pressure gas gathering systems and crude oil flow piping. It's acid-resistant and is used for laboratory and industrial drainage piping. PP has resilience against most forms of physical damage, including impact and freezing, and is widely used where contents being transported need to maintain high purity.

Polypropylene characteristics:

- High strength and rigidity qualities for use in potable plumbing, hydronic heating, cooling and reclaimed water systems
- Environmental benefits
- May be joined by heat fusion rather than solvent cement
- Brown, white, blue or black in colour
- Corrosion- and chemical-resistant
- Suitable for high temperature, pressure and impact applications
- Brittle below -27°C (-10°F)
- Polypropylene is identified with "recycle number" 5
- CSA standard: B137.11-09

Acrylonitrile-butadiene-styrene

Acrylonitrile-butadiene-styrene (ABS) DWV is available in two types: solid wall schedule 40 and cellular core wall. ABS pipe is used for DWV plumbing systems in residential, commercial and some industrial buildings. It can be used both above and below ground. This pipe meets the requirements of CSA B181.1 and ASTM D 3965 standard.

ABS DWV Cellular Core and Solid Wall

Cellular core ABS has the same working characteristics as standard ABS solid wall DWV but is less expensive. This lightweight, inexpensive DWV pipe has pipe walls that are made up of small air pockets. The inside and outside diameter surfaces consist of a hard ABS shell.

ABS cellular core pipe does not appear any different than solid wall ABS pipe. The weight of each cellular core pipe is lighter than its respective solid wall partner. When looking at the ends of the cellular core pipe, you can see that it has air bubbles in the middle layer. ABS DWV solid pipe has no air bubbles in the pipe wall; consequently, it is heavier than ABS cellular core pipe.

Characteristics of ABS pipe:

- Black in colour
- Lower resistance to chemicals than polyvinyl chloride (PVC)
- Easy to cut and join
- Available in 1 $\frac{1}{4}$ " to 6" diameters and typically 3.7 m (12') lengths
- Strong at low temperatures
- Weaker than PVC
- Can be damaged by exposure to sunlight
- High temperature expansion ratio
- Canadian standard for ABS DWV pipe is CAN/CSA-B181.1, "ABS Drain, Waste, and Vent Pipe and Pipe Fittings."



There may be some restriction on the depth of burial of ABS cellular core, especially under vehicle traffic. You should consult the local authority having jurisdictions (AHJ) before installing in such situations.

Polyvinyl Chloride

Polyvinyl chloride (PVC) piping is a very popular thermoplastic used primarily in pressure systems such as water service, irrigation systems, and industrial process piping. Some PVC piping is used in DWV systems.

Characteristics:

- Available in various colours
- Will not react with many strong acids, alkalis, salt solutions, alcohol, and other chemicals
- No taste or odour added to substances carried by PVC
- Resistant to fungi, bacterial action, and corrosive effects of soil
- Withstands high pressures and temperatures
- High tensile strength
- Not permitted when pipes carry hot water

- PVC piping is not permitted for any compressed air application
- Canadian standard for PVC pipe is CSA B137.3-09
- Comes in Schedule and SDR sizing

Colour Codes

PVC materials can be made in many colours, as there is no established colour coding at this time. Always read the pipe markings to identify the correct use—do not rely on the colour of the pipe to indicate proper application.

Colours used include the following:

- White and grey used for irrigation and potable water systems
- Green and blue shades for water and sewer utility and service water lines
- Specific unique colours used by utility companies such as telephone or electrical (shades of orange/pink)

PVC Sewer Pipe



Figure 13 PVC nonpressure pipe (https://commons.wikimedia.org/wiki/File:PVC_nonpressure.jpg) (Стрелец Игорь/Wikimedia Commons) CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>)

PVC sewer pipe has thinner walls than Schedule 40 DWV PVC. PVC sewer pipe is available in standard length of 3 m (10') including the bell end. PVC sewer comes in sizes 3 – 6". PVC is available with solvent ends and with either solid or perforated walls. It is usually white in colour.

Solid wall PVC pipe is used to collect wastewater and storm water from the building drains and convey it to the municipal sewer lateral at the property line.

Perforated pipe is used in septic fields and for foundation perimeter drains or curtain drains to intercept ground water drainage. The perforation holes are $\frac{5}{8}$ " in diameter. The perforations are located at 4 o'clock and 8 o'clock (on 5" centres), and the print line is located at 12 o'clock. This allows you to ensure the perforations are oriented correctly.

Clear Plastic PVC

Typical applications for clear PVC include process, sight glass, and dual containment piping as found in chemical processing. Clear PVC is used for high-purity applications, food processing, pharmaceuticals, laboratory use, waste treatment and plating.

Applications and use:

- Used in applications involving fluid transfer where visual monitoring of process lines is required
- Generally corrosion-resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens
- Available in iron pipe sizes from $\frac{1}{4}$ " – 12"
- Can be used at temperatures up to and including 140°F
- Pressure rating varies with the schedule and pipe size from 70 – 570 psi
- Belled-end pipe has tapered sockets to create an interference type fit

Markings:

- Manufacturer's name
- Appropriate ASTM and or CSA standard
- Pipe size
- Schedule 40 or schedule 80
- Date and time of manufacture
- Temperature and pressure limitations

Chlorinated Polyvinyl Chloride

Chlorinated Polyvinyl Chloride (CPVC) is a thermoplastic used in process piping, hot water lines, and other applications where temperatures may exceed those that PVC piping can withstand.

Characteristics:

- Either cream, red, or green in colour
- High resistance to chemicals
- High impact strength
- High tensile strength: more than 13.7 MPa (2000 psi) at 100°C (212°F)
- Withstands high temperatures and pressures
- Canadian standard for CPVC pipe is: B137.6-09

CPVC for Fire Sprinklers

CPVC used for fire sprinkler systems must be a rigid chlorinated polyvinyl chloride compound, Type IV Grade I, with a cell classification of 23447 as defined in ASTM D1784. The compound and the finished product must be orange in colour and be approved by the National Sanitation Foundation (NSF) for use with potable water.

Corrosion-resistant fire sprinkler pipe, IPS sizes $\frac{3}{4}$ – 3", for use in wet automatic fire sprinkler systems.

When installed in accordance with the manufacturer's installation instructions, this pipe is listed by Underwriters Laboratories (UL) for use in: light hazard occupancies as defined in the *Standard for Installation of Sprinkler Systems* (NFPA 13); residential occupancies up to and including four storeys in height (NFPA 13R); and residential occupancies as defined in the *Standard for Sprinkler Systems in One and Two Family Dwellings and Mobile Homes* (NFPA 13D). CPVC fire sprinkler pipe is UL-listed for use in return air plenums (NFPA 90A), system risers per NFPA 13 *Light Hazard*, 13R and 13D, exposed installations, garages per NFPA 13R, and for use as underground fire service mains (NFPA 24) when installed in accordance with the manufacturer's installation instructions.

CPVC Dimensions

CPVC fire sprinkler pipe must be manufactured to standard dimension ratio (SDR) 13.5 dimensions in strict accordance to the requirements of ASTM F442 for physical dimensions and tolerances.

Each production run of pipe manufactured in compliance to this standard must also meet the test requirements for materials, workmanship, burst pressure, flattening, and extrusion quality defined in ASTM F442. Furthermore, this pipe must consistently meet or exceed the physical performance test requirements of the appropriate approval/listing agency(s) follow-up procedures established for the product.

Specialty Piping and Tubing

Piping may also be made from substances such as clay, borosilicate (glass), or fibreglass.

Glass Piping (Pyrex Pipe)

Glass piping is usually made of borosilicate glass, which is also used to manufacture tough, durable, chemical glassware. Glass pipe is used in industries such as food processing, chemical and pharmaceutical production, and pulp and paper manufacturing. Short lengths of glass piping may be inserted in opaque piping to serve as sight-flow indicators.

Glass piping qualities:

- Very breakable when dropped or over-tightened
- Extremely resistant to all chemicals (except hydrofluoric acid, phosphoric acid, and some strong alkalis)
- Withstands extremely high and low temperatures
- Very durable
- Has extremely smooth inside surfaces, which reduces pressure loss due to friction and discourages scale build-up

Fibreglass Pipe

Fibreglass-reinforced pipe (FRP) is made from vinyl ester and polyester resins, glass, and reinforcement materials. FRP piping materials are manufactured by winding processes that employ epoxy resins reinforced with continuous glass filaments. The resins used are thermosetting (they undergo chemical reactions as they cure that are irreversible), resulting in superior temperature capabilities, while the filament reinforcement makes the piping components far more capable mechanically than ordinary non-reinforced thermoplastics. The result is enhanced performance and lighter weight.

Fibreglass-reinforced plastic pipe (FRP) characteristics:

- Corrosion resistance
- Extremely hard surface that resists erosion
- Abrasion resistant barrier on the exterior of the pipe as well as the interior
- Durable, resists cracking and crazing of the resin when subjected to heavy design loads
- Heavy exterior coat of resin containing an ultraviolet stabilizer to impart long-term resistance to the effects of sunlight and other weathering elements
- Available in standard sizes 2" to 36" diameter
- Pressure ratings: 50, 100 and 150 psi
- Corrosion barrier: 0.100" (100 mils)
- Resin: corrosion-resistant vinyl ester

Fibreglass pipe uses:

- Motor fuel underground piping—available in diameters of 2–6".
- Municipal, chemical and industrial applications, including transmission of acids, caustics and solvents, and for cooling tower lines, wastewater treatment process lines, raw water inlet and discharge lines. Pipe diameters range depending on the manufacturer.
- Oil-field production lines, gas gathering lines, tank battery hookups, and salt water disposal/ injection. Standard diameters are available up to 16 inches with pressures up to 3500 psi.
- While sewer and drainage piping continues to be dominated by concrete, there are many areas where FRP is the preferred choice. For example, concrete pipe deteriorates rapidly in sewage due to hydrogen sulfide attack. Hydrogen sulfide erodes the upper surface of the pipe and will eventually cause a cave-in. FRP is unaffected by hydrogen sulfide or purging with caustic or hypochlorite to suppress sulfide odour. As a result, FRP pipe has been used as a liner in large diameter (48 "–60") concrete pipe.

Vitrified Clay Piping

Vitrified clay piping is no longer widely used but may still be found in building drains. Vitrified clay piping qualities:

- Extremely breakable
- Acid resistant (suitable for use in soil)

Plastic-lined Metal Piping

Plastic-lined piping is lined with thermoset plastics such as polytetrafluoroethylene (PTFE) or polyvinylidene fluoride (PVDF). It's quite expensive and is used primarily for transporting or containing highly-corrosive or ultra-pure fluids in chemical or pulp and paper plants.

Plastic-lined metal pipe qualities:

- Performs well over wide range of operating temperatures
- Very durable with high tensile strength

Asbestos-Cement Piping



Figure 14 Industrial Concrete Pipes in Rural Landscape
(<https://www.pexels.com/photo/industrial-concrete-pipes-in-rural-landscape-30762650/>) (Andy Coffie/Pexels) Pexels License (<https://www.pexels.com/license/>)

Asbestos-cement pipe is constructed by mixing asbestos fibres with cement. This pipe has been used for water mains, outside sewers, storm sewers, rainwater leaders, drainage and vent systems. Asbestos-cement is no longer available but may be found in existing systems.



Due to health concerns, before working on this type of piping, check WHMIS and WorkSafeBC regulations and follow provincial regulations for the handling of the product.

Corrugated Stainless Steel Tubing

Corrugated gas tubing is easily distinguished by a flexible yellow polyethylene jacket on the outside. Gas connectors will often have a coating on the outside—not a jacket. Corrugated stainless steel tubing (CSST) will also be identified as such on the jacket itself. The general rule for CSST is that it must be installed in accordance with the manufacturer's instructions. Before installing this CSST piping, you must first complete the manufacturer's training program.

Standards: ANSI LC1-2005, CSA 6.26-2006, "Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (CSST)."

Characteristics:

- Flexibility over rigid piping
- Does not require intermediate joints and is capable of being installed in one continuous run
- Easily avoids existing obstacles
- Well-suited for locations that are prone to seismic activity because the tubing is able to move as the ground or the structure shifts
- Must be properly bonded/grounded

Typical corrugated stainless steel tubing system (CSST) specifications:

- Made of type 304 alloy; ASTM A240.
- An annealing process tempers the steel, giving it added flexibility and ease of bending
- Suitable for use with elevated pressure systems
- The ANSI LC1 standard rates CSST for use at pressures up to 5 psi
- CSST fittings have standard NPT threads and may be used in combination with all approved fuel gas piping materials with the pipe threads as the interface
- System components such as manifolds, tees and stub-outs may be fabricated from other approved materials to be used with CSST flexible gas piping.

Corrugated stainless steel tubing manufacturers have also developed a lightning-resistant system. The product has a unique layer of metal mesh, designed to dissipate heat and electricity. The mesh is placed between two jackets of semi-conductive polymer. Fittings have been designed to ensure seamless continuity with the mesh with a feature that bites through the first layer of semi-conductive polymer and into the metal mesh. This creates electrical continuity throughout the system, eliminating the need for manufacturer required bonding.

Reinforced Hydraulic Tubing (Hydraulic Hose)

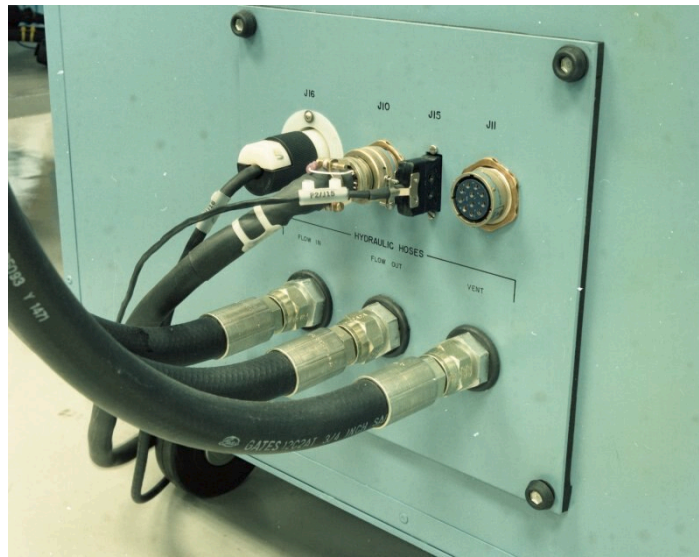


Figure 15 Hydraulic hose connection ([https://commons.wikimedia.org/wiki/File:23_0051283_Convair_Negative_Image_-_Hydraulic_hose_connection_points_\(53889743769\).jpg](https://commons.wikimedia.org/wiki/File:23_0051283_Convair_Negative_Image_-_Hydraulic_hose_connection_points_(53889743769).jpg)) (San Diego Air & Space Museum Archives/Wikimedia commons) No known copyright restrictions (<https://sandiegoairandspace.org/collection/image-collection>)

Unlike metal tubing, hose is flexible, so it is used primarily to allow relative motion between components at either end of the hose assembly and to simplify routing and installation. It's much easier to route a hose assembly over, under, around, or through a series of obstacles than it is to bend and install a rigid tubing assembly. Furthermore, replacing a hydraulic line by fabricating a rigid tube assembly often is more costly and time consuming than making a hose assembly.

A hydraulic hose is built up with rubber and steel layers. A rubber interior is surrounded by multiple layers of woven wire, for reinforcement, and rubber as shown in Figure 15. The exterior is designed for abrasion resistance. Hydraulic hoses generally have steel fittings swaged on the ends.

Reinforced hydraulic hose applications:

- Oil lines
- Hydraulic jacks
- Antifreeze and water fluids
- Natural and propane gas and liquids

Sample manufacturer's specifications for hydraulic hose:

- For high-pressure hydraulic oil lines
- Meets SAE 100R16 requirements and performance requirements of EN 857 2SC
- M2T hose has smaller exterior dimensions and significantly tighter bend radius
- Tube: black, oil resistant, synthetic rubber (Nitrile—Type C)
- Reinforcement: two braids of high-tensile steel wire
- Tubing cover: black; oil-, abrasion-, and weather-resistant; synthetic rubber (modified nitrile)
- Dual green stripe lay-line

- Temperature range: -40 °F to +212 °F (-40 °C to +100 °C)

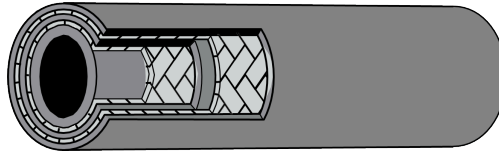


Figure 16 Hydraulic hose (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Self-Test D-I.I: Describe Piping and Tubing Materials

Complete Self-Test 1.1 and check your answers.

If you are using a printed copy, please find Self-Test D-1.1 (#chapter-self-test-d-1-1) and Answer Key (#chapter-answer-key-self-test-d-1-1) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1924#h5p-1> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1924#h5p-1>)

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- Plumber: Competency D-1 Prepare Pipe
- Steamfitter: Competency D-4 Layout and Install Piping and Tubing
- Sprinkler Fitter: Competency D-1 Prepare Pipe and Tubing

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D-1.2 Describe the Methods of Manufacture of Piping and Tubing

This section introduces the materials and manufacturing methods used to produce common piping and tubing in the trades. You will learn how pipes are made from carbon and stainless steel, cast iron, copper, and thermoplastic materials, and how these processes affect their strength, durability, and use. The section also explains how to identify different types of copper tubing, including their colour markings, and defines the term “temper” as it applies to copper. In addition, you will explore the three main methods used to manufacture cross-linked polyethylene (PEX) tubing, helping you understand how material properties relate to real-world applications in plumbing systems.

Carbon Steel Pipe

Schedule steel pipe and tube are types of steel pipe. Both are made from mild carbon steel and undergo similar manufacturing processes, in which strips of steel are passed through rollers until they form the desired shape. Then the seam is electrically welded. This process is shown in Figure 1. The tube is rolled at a high temperature, while the pipe is cold-rolled. Both tubing and pipe can be galvanized to protect them from corrosion.

The standard methods of manufacturing steel pipe are:

- Butt weld
- Electric resistance weld
- Seamless pipe
- Spiral weld pipe

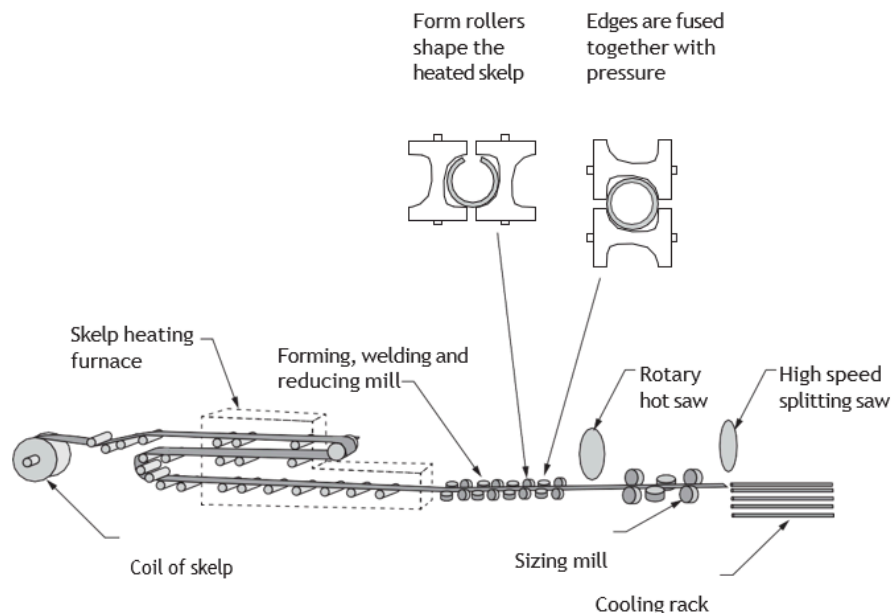


Figure 1 Procedure to form schedule steel pipes and tubes (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Electric Resistance Weld

The processing of **electric-resistance welded pipe (ERW)** starts with coiled ribbon of steel plate called a **skelp**. The ribbon is pulled through a series of rollers, which gradually form it into a cylindrical tube. As the edges of the plate come together, an electric charge is applied, heating the edges so they can be welded together. Electric resistance welded pipe is a high-speed production product that can be made in continuous lengths over 100 ft long.

Typically for light construction purposes, the ERW pipe is approximately 6.4 m (21 ft) long, plus or minus 25.4 mm (1 in).

Pipe can be ordered with end finishes. For example, it can be:

- Threaded and coupled
- Threaded without couplings
- Plain end
- Bevelled for welding
- With grooved ends
- Special order

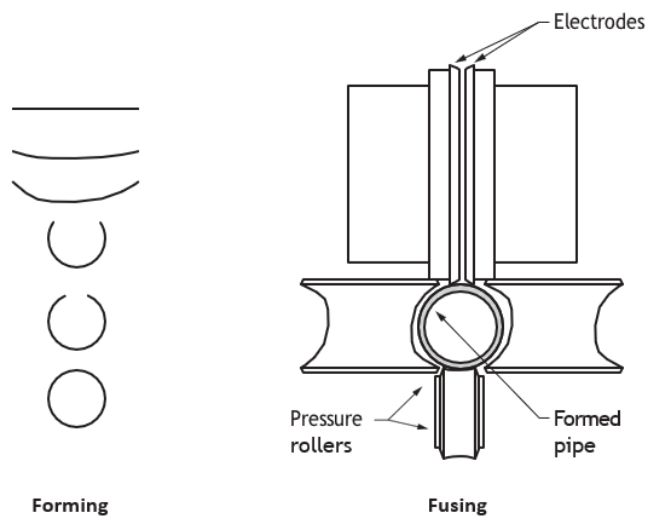


Figure 2 Electric resistance weld process (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



You can also refer to IPT's *Pipe Trades Handbook and Manual* for an image of the electric resistance weld.

Seamless Steel Pipe Manufacturing

Seamless pipe is made when steel in a solid, cylindrical shape, called a **billet** or a **tube round**, is heated and then either pushed or pulled (while being rapidly rotated) over a **mandrel** with a piercing point positioned in the centre. This produces a hollow tube or “shell.” The tube is then further finished until it becomes the desired size and wall thickness. Since the pipe is formed while heated, it is normalized and has a consistent steel cellular pattern (or microstructure) throughout its circumference.

Seamless pipe is made in sizes from $\frac{1}{8}$ - 26" and is widely used in the construction, oil refining, chemical, and petrochemical industries.

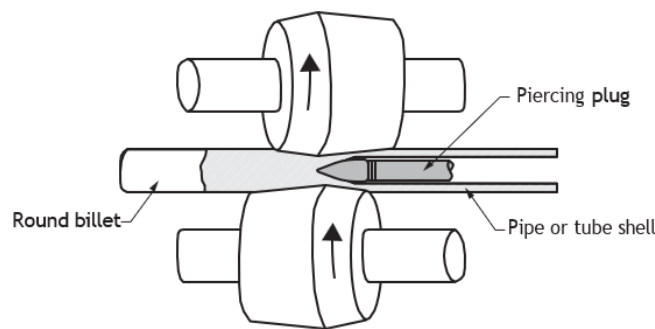


Figure 3 Seamless pipe piercing process (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

For larger sizes of seamless pipe (over 16 in - 400 mm) a rotary expander is used to enlarge the pipe.

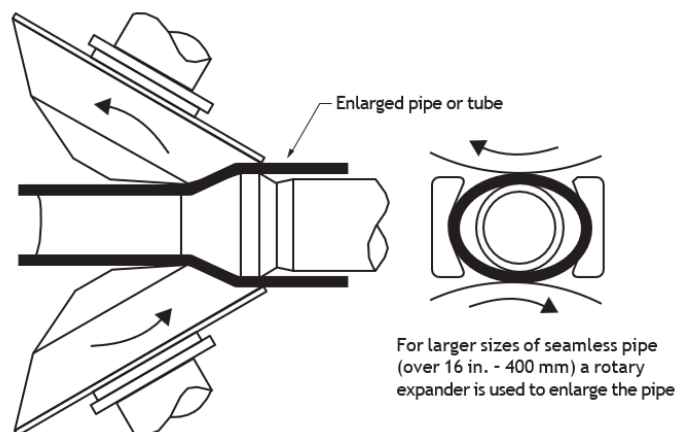


Figure 4 Seamless steel pipe process after being formed over a mandrel (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Fusion Welding Process

Another process for producing pipe is **fusion welding** (sometimes called “continuous weld”) and is produced in sizes

$\frac{1}{84.5}$ ”. Fusion-weld pipe begins as coiled steel ribbon (skelp). Successive coils of steel are welded end-to-end to form

a continuous ribbon of steel. The ribbon of steel is then flattened and straightened and then fed into a gas furnace, where it’s heated to the required temperature for forming and fusing. Forming rollers at the end of the furnace shape the heated skelp into an oval. The edges of the skelp are then firmly pressed together by the rollers, fusing the steel and creating a forged weld. Final sizing rollers form the pipe to its required dimensions.

Spiral-welding Process

Spiral-weld pipe is a steel pipe with a **double submerged arc weld (DSAW) seam** in a spiral form along the entire length of the pipe. This process allows for large-diameter pipe production. The outside diameter is determined by the angle of the de-coiled steel against the forming machine head. The more acute the angle, the greater the diameter. The production of large, hot-rolled coils of sufficient width and the development of dependable non-destructive testing methods has enabled this product to be placed in more demanding service. Spiral-weld pipe can be rolled in exact lengths up to 115 feet in either ID or OD dimensions up to 144 inches. There is a minimum tonnage required for rolling. Because the manufacturing process is slow, it gives the contractor an advantage of short term changes to the order. This same slow production can also be a disadvantage when large tonnages are needed with a short lead time. Spiral-weld pipe is produced to limited specifications.

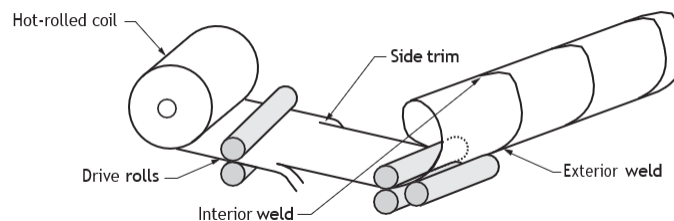


Figure 5 Spiral weld pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Double Submerged Arc Weld Process

Submerged arc welded (SAW) pipe derives its name from the process wherein the welding arc is submerged in **flux** while the welding takes place. The flux protects the steel in the weld area from any impurities or contaminants in the air when heated to welding temperatures. When both inside welds and outside welds are performed, the welding is accomplished in separate processes and the pipe is considered to be **double submerged arc welded (DSAW)** pipe.

There are three common types of pipe produced by the DSAW process.

- U&O process
- Rolled
- Spiral-weld

U&O Process

The **U&O process** uses a “U” press, then an “O” press to form a complete cylinder from 40’ long steel plates. The cylinder is then welded inside and outside by the submerged arc process by using as many as five welding wires. The primary use of this type of large pipe is gas and oil transmission fields.

Rolled and Welded Process

The **rolled and welded method** of manufacturing is also called the **pyramid roll method** because it uses three rolls arranged in a pyramidal structure. The steel plate is rolled back and forth between the pyramid rolls until the cylinder is formed. The cylinder is then moved to the welding stations. Most pyramid rolls are 20’ long or less. Greater lengths can be ordered. This process can produce large pipe diameters, either **ID** or **OD**.

Cast Iron Pipe and Fittings

The basic raw materials used to produce cast iron soil pipe and fittings are scrap iron, scrap steel, alloys, coke, and limestone. These materials are melted in a **cupola furnace** to produce molten iron.

The casting of melted cast iron from the furnace into soil pipe and fittings is done by pouring the molten cast iron into casting moulds for fittings and using a **centrifugal casting process** for pipe. Metal moulds used in centrifugal pipe casting machines are spun on rollers and externally cooled by water.

Coatings are applied to the metal mould’s surface preventing sticking of the molten cast iron. As the cylindrical metal moulds spin, specific amounts and weight of molten cast iron are poured in. Centrifugal force distributes the molten cast iron to the inside surfaces of the spinning cylinder. The molten cast iron is allowed to cool and is removed from the metal cylinder as cast iron pipe. The cast iron pipe and fittings are inspected, tested, and dip coated to provide a smooth finish and protective coating. The finished pipe and fittings are ready for storage for shipment.

Cast iron soil pipe fittings may be produced by two different static casting processes: one process casts fittings in sand moulds and the other method employs permanent metal moulds.

First, moulds are made, then molten cast iron is poured into each mould. After the cast iron has cooled, the fittings can be removed from the moulds. The fittings are cleaned, inspected, tested and coated the same way as the pipe.



Figure 6 Cast iron pipe and fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Copper Tube Manufacturing Process

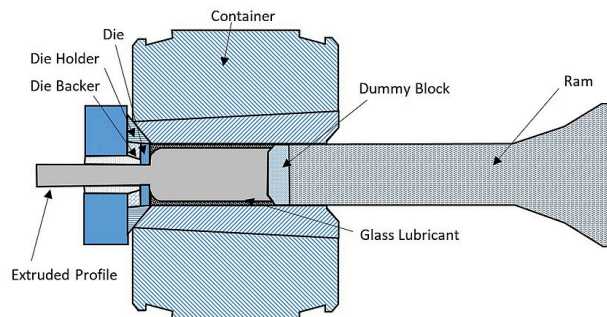


Figure 7 Schematic of metal extrusion process (https://commons.wikimedia.org/wiki/File:Schematic_of_metal_extrusion_process.jpg) (Vivekverma239/Wikimedia Commons) CC0 1.0 (<https://creativecommons.org/publicdomain/zero/1.0/deed.en>)

Copper and copper alloy tube is manufactured by the **extrusion method**. A headed copper billet is heated then forced through a die orifice and over a **mandrel** to form a hollow tube. The mandrel is held in position within the die orifice.

Another method uses **rotary piercing**. One end of a heated cylindrical billet is fed between rotating work rollers and is driven forward toward a piercing plug. In the mid-1960s, welded copper tube produced from strip without the use of a filler metal became commercialized.

Temper describes the strength and hardness of the tube. **Drawn temper** is often referred to as “hard,” while **annealed temper** is called “soft.”

Product Specifications (ASTM)

- Copper tube is a minimum of 99.9% pure copper.
- The copper used for tube supplied is deoxidized with phosphorus.

- Types K, L, M, DWV, and medical gas tube are designated by ASTM standard nominal inside diameter sizes. The actual outside diameter is always $\frac{1}{8}$," larger than the standard size designation.
- Copper used in medical gas and air conditioning and refrigeration systems is ordered degreased and capped. The plastic capped ends stay on the pipe until just before installation.
- Each copper tube type represents a series of sizes with different wall thicknesses. Type K tube has thicker walls than Type L tube, and Type L walls are thicker than Type M, for any given diameter. All inside diameters depend on tube size and wall thickness.
- Copper tube for air-conditioning and refrigeration field service (ACR) is designated by actual outside diameter.

“Temper” describes the strength and hardness of the tube. In the piping trades, drawn temper tube is often referred to as “hard” tube, and annealed as “soft” tube.

Table 1 identifies the six standard types of copper tube and their most common applications. The table also shows the ASTM standard appropriate to the use of each type along with a listing of its commercially available lengths, sizes and tempers.

Table 1: Standard Types of Copper Tube and Common applications

Tube Type	Colour Code	Standard	Application (See note 1)	Commercial Available Lengths (See note 2)		
Type K	Green	ASTM B 88 (See note 3)	- Domestic water service and distribution - Fire protection - Solar - Fuel/fuel oil - HVAC - Snow melting - Compressed air - Natural gas - Liquefied petroleum (LP) gas - Vacuum	Straight Lengths		
				0.25" to 8"	20'	20'
				10"	18'	18'
				12"	12'	12'
				Coils		
				0.25" and 1"	-	60'
					-	100'
				1.25" and 1.5"	-	60'
				2"	-	40'
					-	45'
Type L	Blue	ASTM B88	Domestic water service and distribution Fire protection Solar Fuel/fuel oil Natural gas Liquefied petroleum (LP) gas HVAC Snow melting Compressed air Vacuum	Straight Lengths		
				0.25" to 10"	20'	20'
				12"	18'	18'
				Coils		
				0.25" to 1"	-	60'
					-	100'
				1.25" to 1.5"	-	60'
				2"	-	40'
					-	45'

Type M	Red	ASTM B88	Domestic water service and distribution	Straight Lengths		
			Fire protection Solar Fuel/fuel oil HVAC Snow melting Vacuum	1.25" to 12"	20'	N/A
DWV	Yellow	ASTM B 280	Drain, waste, vent	Straight Lengths		
			HVAC Solar	0.25" to 8"	20'	N/A
ACR	Blue	ASTM B 280	Air conditioning Refrigeration Natural gas Liquefied petroleum (LP) gas Compressed air	Straight Lengths		
				$\frac{3}{8}$ " to $1\frac{1}{8}$ "	20'	N/A
				Coils		
				$\frac{1}{8}$ " to $1\frac{5}{8}$ "	20'	(See note 4)
OXY, MED OXY/MED OXY/ACR ACR/MED	K) Green (L) Blue	ASTM B 819	Medical gas	Straight Lengths		
			Compressed medical air Vacuum	$\frac{1}{4}$ " to 8"		
1. There are many other copper and copper alloy tubes and pipes available for specialized applications. For information on these products, contact the Copper Development Association, Inc. 2. Individual manufacturers may have commercially available lengths in addition to those shown in this table. 3. Tube made to other ASTM standards is also intended for plumbing applications, although ASTM B 88 is by far the most widely used. ASTM <i>Standard Classifications</i> B 698 lists six plumbing tube standards including B 88. 4. Available as special order only.						

Plastic Pipe Manufacturing

Acrylonitrile-Butadiene-Styrene (ABS)

Acrylonitrile-butadiene-styrene (ABS) cell core is made using an extruding head that allows air to be inserted in the middle of the pipe. It uses less resin and creates a less expensive pipe that doesn't affect the structure of the pipe and its resistance to pressure.

Polyethylene Pipe

Polyethylene (PE) pipe is produced by heating raw plastic pellets and forming them through an extrusion process. Colour pigments are added depending on the application (e.g., yellow for gas, black for general use). The essential steps of polyethylene (PE) pipe and fitting production are to heat the raw pellet material into a particular shape and hold that shape during the cooling process. This is necessary to produce solid wall and profile wall pipe as well as compression and injection moulded fittings. All diameters of solid wall PE pipe are continuously extruded through an annular die.

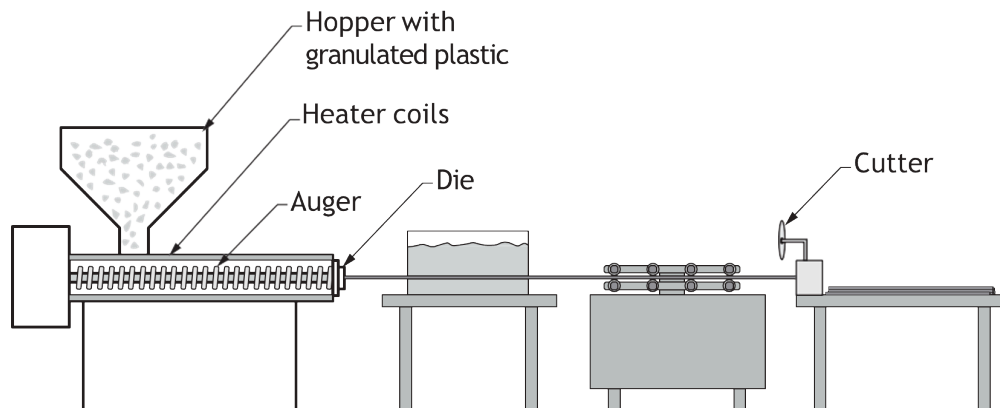


Figure 8 PE manufacture extrusion method (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The raw material is typically supplied to the pipe producer as non-pigmented pellets. PE pellets are stabilized for both heat and UV protection. Usually, colour pigment is added to the pipe at the producer's facility. In North America, the most common colours are black and yellow. The choice of colour will depend upon the intended application and the requirements of the pipe purchaser. Carbon black is the most common pigment used for water, industrial, sewer and above-ground uses. Yellow is reserved exclusively for natural gas applications, although black with yellow stripes is also permitted for this application. Other colours are used for telecommunications and other specialty markets.

Cross-Linked Polyethylene

Cross-linked polyethylene (PEX) is a polymeric material formed by chemically joining of individual polyethylene (PE) molecules in a process called **cross-linking**.

There are three main methods used to accomplish the molecular cross-linking:

- **PEX-A (peroxide method)** is produced by the peroxide (Engel) method. This method performs “hot” cross-linking, while the polyethylene is above its melting point before extrusion. The process takes slightly longer than the B and C methods because the molecular plastic polymer has to be kept at high temperature and pressure for long periods during the extrusion process. This PEX is the only type of PEX that can be kinked and fully repaired using low heat.
- **PEX-B (silane method)** is produced by the silane method, also called the “moisture cure” method. In this method, cross-linking is performed after the extrusion process, producing cross-links between a cross-linking silane related agents. After installation, PEX-B has the same properties as PEX-A.
- **PEX-C (electron beam method)** is produced through electron beam processing after extrusion in a “cold” cross-linking process. This process has lower uniformity of cross-linking than the PEX-A especially at tube diameters over one inch (2.5 cm). When the process is not controlled properly, the outer layer of the tube may become brittle. However, it’s the cleanest, most environmentally friendly method because it does not involve other chemicals to create the cross-linking.

PEX Piping Qualities

- PEX tubing and PEX fittings come in sizes ranging from $\frac{1}{4}$ ” – 2” in diameter in North America, whereas in Europe, PEX pipe is available in sizes up to 6”.
- Manufactured to copper tubing size OD controlled (CTS-OD) dimensions.
- Sold in coils and straight lengths.
- The wall thickness is based upon SDR 9 values, which yield pressure ratings of 160 psi at 73°F and 100 psi at 180°F.
- Some manufacturers have their tubing rated to 200°F with an 80 psi maximum working pressure.
- Some PEX fittings should only be joined to specific PEX tubing, as recommended by the pipe manufacturer.

PVC Pipe Manufacturing

The technology of the **Polyvinyl chloride (PVC)** pipe manufacturing processes is extensive and involved. It can be traced from oil or gas wells through petrochemical plants to the PVC compounding operations and finally to the automated extrusion, moulding and fabrication operations before a finished PVC product is ready for testing, inspection, and delivery.

The raw plastic PVC compounds are prepared and heated. The heated elastic plastic is extruded into the pipe-forming die under high pressure (2000–5000 psi). In the pipe extrusion die, the hot plastic material is moulded into a cylindrical shape. As it leaves the extrusion die at the exit orifice, the material is extremely hot (about 400°F), flexible, and pliable. In this state, the hot plastic is formed with dimensional accuracy into a finished product and then cooled into a solid state. The extruded PVC pipe is drawn away from the extruder into cooling tanks where it’s cooled by chilled water. By the time the pipe emerges from the end of the cooling tanks, it has cooled to a temperature where it can be handled without distortion. After leaving the cooling station, the pipe travels through a printing station. Pertinent product and process information is printed on the PVC pipe. Beyond the printer, the pipe is automatically cut to the correct length. The ends are trimmed to specifications depending on its intended use.



Self-Test D-1.2: Describe the Methods of Manufacture of Piping and Tubing

Complete Self-Test 2 and check your answers.

If you are using a printed copy, please find Self-Test D-1.2 (#chapter-self-test-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing) and Answer Key (#chapter-answer-key-self-test-d-1-2) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1926#h5p-2> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1926#h5p-2>)

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- Plumber: Competency D-1 Prepare Pipe
- Steamfitter: Competency D-4 Layout and Install Piping and Tubing

- Sprinkler Fitter: Competency D-1 Prepare Pipe and Tubing

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- **Figure 7** Schematic of metal extrusion process (https://commons.wikimedia.org/wiki/File:Schematic_of_metal_extrusion_process.jpg) by Vivekverma239 from Wikimedia Commons is used under a CC0 1.0 (<https://creativecommons.org/publicdomain/zero/1.0/deed.en>) public domain license.

D-1.3 Describe the Methods of Pipe and Tubing Support

Pipe Support

The installation of pipe and piping equipment requires proper support. Pipe support can be accomplished in a number of ways:

- Pipe hangers
- Pipe anchors
- Pipe guides
- Inserts and expansion shields
- Brackets and clamps
- Seismic braces (sway bracing)
- Accessories including sleeves, saddles, and shields
- Pipe slide-plates

Piping support must support the weight of the pipe and equipment, including the contents. Hangers and supports must be designed to accommodate pipe movement from expansion or contraction, as well as vibration seismic activity. The hangers and supports must keep the pipeline in alignment and maintain a specific position related to slope, level, plumb, or any other required design position.

Most piping installations are governed by codes and specifications. For example, requirements for hanger spacing, size, and **seismic restraint** are stated in various codes, including plumbing codes, fire sprinkler codes, and gas codes. In every case, the maximum allowable spacing of pipe hangers is clearly stated. Regardless of the maximum spacing allowed, when pipe sags, additional support should be added to ensure proper alignment and support. Job site engineered specifications and manufacturers' instructions should be followed where code regulations are not sufficient.

Pipe hangers and supports can be broadly classified into the following categories:

- Rigid hangers/supports
- Variable effort supports/hangers
- Constant effort supports/hangers
- Spring-loaded sway braces
- Dynamic restraints/rigid struts
- Snubbers/shock absorbers

Code Examples for General Hanger and Support Installation Guidelines

Pipe supports for nominally horizontal piping should be supported and sized as follows:

1. Where hangers are used to support nominally horizontal piping they shall be:

- a. Metal rods of not less than:
 - i. 6 mm diameter to support piping 2" or less in size
 - ii. 8 mm diameter to support piping 4" or less in size
 - iii. 13 mm diameter to support piping over 4" in size
- b. Solid or perforated metal straps of not less than:
 - i. 0.6 mm nominal thickness and 12 mm wide to support piping 2" less in size
 - ii. 0.8 mm nominal thickness and 18 mm wide to support piping 4" or less in size
2. Where a hanger is attached to concrete or masonry, it shall be fastened by metal or expansion- type plugs that are inserted or built into the concrete or masonry.
3. Underground horizontal piping shall be supported on a base that is firm and continuous under the whole of the pipe.
4. Underground horizontal piping that is not supported on a base that is firm and continuous under the whole of the pipe, may be installed using hangers fixed to a foundation or structural slab, provided that the hangers are capable of keeping the pipe in alignment and supporting the weight of the pipe, its contents, and the fill over the pipe.
5. Where a vent pipe that may be subject to misalignment terminates above the surface of a roof, it shall be supported or braced.
6. Piping shall be provided with support that is capable of keeping the pipe in alignment and bearing the weight of the pipe and its contents.
7. Nominally horizontal piping that is inside a building shall be braced to prevent swaying and buckling and to control the effects of thrust.
8. The design and installation of every piping system shall include means to accommodate its expansion and contraction caused by temperature changes, movement of the soil, and building shrinkage.
9. Where piping is installed underground, the backfill shall be carefully placed and tamped to a height of 300 mm.
10. Where asbestos-cement drainage pipe or vitrified clay is located less than 600 mm below a basement floor and the floor is constructed of other than 75 mm or more of concrete, the pipe shall be protected by a 75 mm layer of concrete installed above the pipe.
11. Where piping passes through or under a wall, it shall be installed so that the wall does not bear on the pipe.
12. Where piping may be exposed to freezing conditions, it shall be protected from the effects of freezing.
13. Plumbing, piping, and equipment exposed to mechanical damage shall be protected.
14. Piping may need to be protected against condensation.



Refer to the actual code related to your piping trade. Information not found in the code can be found by consulting the engineer-designed systems or the specific manufacturer's installation requirements.

Structural Restrictions for Hangers and Supports

The type of hangers and supports chosen will also depend upon the makeup of the building's structural components. When using "redi-rod" (threaded rod) for hangers within a wood-framed structure, you will undoubtedly require brackets and plates that are secured to the structure using wood screws. Concrete and steel structures, on the other hand, will have support components that are clamped onto steel or drilled into concrete.

Concrete buildings that are **post-tensioned** usually do not allow drilling into the underside or topside of suspended slabs, so the supports and holes for piping must be cast in place, requiring careful preplanning of piping routes to avoid interference with other trades. Drilling or coring into a post-tensioned structure can be extremely dangerous to anyone in the vicinity, and the associated hazards and prohibitions are normally explained on-site through a first-day orientation session for any workers new to the site.

General Installation Guidelines for Hangers and Supports

For each hanger piping installation, you'll be required to select and install the appropriate types of hangers and supports. Many factors must be considered when selecting these hangers, supports, and fasteners. General installation guidelines exist. However, you should always refer to the appropriate code requirements, job site specifications, and manufacturer's instructions.

Selecting Hangers, Supports, and Fasteners

Use the following general guidelines to select, install, and size hangers, supports, and fasteners:

- Refer to job specifications for the correct type of hanger.
- Consider pipe movement such as expansion, contraction, or vibration.
- Establish the type of pipe and the weight of the material and its contents.
- Identify the piping material regarding contact between the hanger and the material the hanger is made of. Contact between dissimilar metals can result in **electrolytic action** between hangers and piping.
- Consider whether the piping will be insulated.
- Identify the building structure material (e.g., concrete, steel, or wood).
- Select the correct fastener type and installation method. For example, wood screw, lag screw, bolts, or beam clamp.
- Refer to the manufacturer's maximum load capacity requirements for each hanger and fastener.
- Never exceed the maximum load capacity of the hanger or fastener.
- Refer to the job plans to determine the correct position of each hanger and support. In many cases, a chalk-line or string line can help establish hanger and fastener positions for long pipe line lengths.
- If seismic restraint/sway-bracing is required, determine the correct positioning as stated by governing codes such as the **Fire Sprinkler Code** (<https://www.nfpa.org/codes-and-standards/nfpa-13-standard-development/13>).
- Ensure that each hanger is tight to the pipe and supporting the pipe as it should be.
- For vertical piping, ensure vertical riser clamps or similar support is spaced and located as required by the code or job site specifications.
- Select hangers that can be adjusted when adjustment of piping heights is required.

Once you have a general idea of the type and size of hangers, supports, and fasteners you will require, consult the manufacturer's catalogues for further details. Most catalogues will include detailed sketches of the important dimensions to be considered when selecting each type of hanger.

Types of Pipe Support

The following images show common types of pipe support.



Figure 8 Fasteners and pipe supports (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Split-ring extension hanger



Adjustable swivel ring hanger



Clevis hanger



Riser clamp



Standard steel pipe clamp

Figure 9 *Non-insulated pipe hangers*



Figure 10 Pipe hangers and supports (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe saddles are used to support the pipe and protect the pipe insulation from being crushed by the pipe hanger. They also provide protection beneath the insulation. Standard lengths for pipe saddles range from 9" to 12". Custom radii, gauges, and lengths are available.

Sliding Pipe Saddle Insulation Protection

A sliding pipe saddle minimizes weather barrier damage caused from pipe movement.

- Inner saddle adheres to the insulation barrier and moves with the piping, while sliding on the **PTFE (poly-tetra-fluoro-ethylene)** surface below (see Figure 11, component C).
- Ribbed lower saddle remains stationary on the pipe hanger.

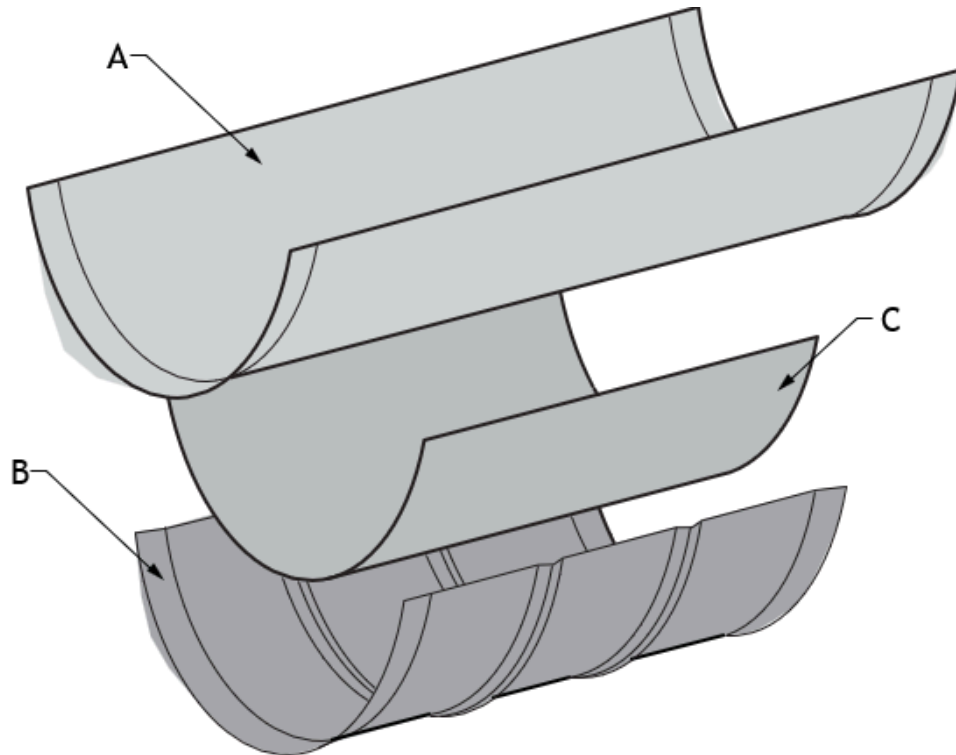


Figure 11 Sliding pipe saddle detail (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The PTFE layer is laminated to the lower saddle providing a minimal friction surface for the upper saddle to slide against.

Gliding Pipe Saddles

Figure 12 show the use of a gliding (sliding) pipe saddle on a large insulated exterior pipe line. The saddle allows the pipe to expand and contract easily over the pipe supports. This saddle reduces or eliminates damage to the pipe jacketing and the vapour barrier under it.

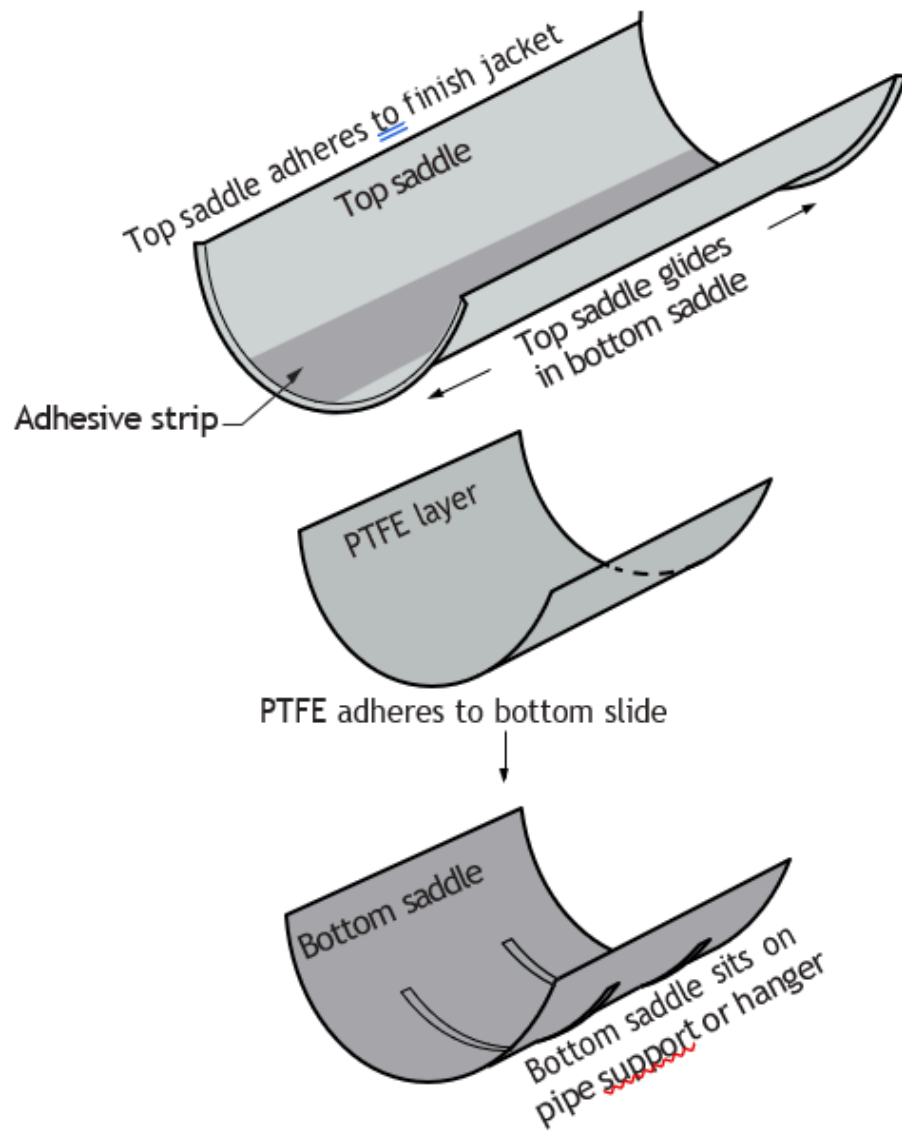


Figure 12 Gliding saddle components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 13 Sliding pipe saddle installation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Anchors

Pipe anchors are used to secure piping systems and prevent unwanted movement. Engineer specifications governing codes and manufacturers' instructions will dictate the correct use of pipe anchors. Various thread type and diameter sizes are available. Pre-drilling holes of the correct size is required before installation to insert the anchors. The required drill bit sizes are specified by the manufacturer's packaged instructions.

The following images show equipment for anchoring pipe.



Seismic expansion shield



Thunder-stud wedge anchor



Toggle bolt



Expansion shield

Figure 14 Pipe anchoring equipment (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Drop-in Anchor

The steel drop-in is a machine bolt anchor available zinc plated carbon steel in bolt sizes $\frac{1}{4}$ –

$\frac{3}{4}$. It can be used in solid concrete, hard stone (granite), and solid block. A hand setting tool is required.

Applications and uses of pipe anchors:

- Pipe hanger support
- Suspending conduit and lighting, cable trays and strut, and concrete formwork
- Can be installed flush-mounted or below the base material surface

Concrete drop-in anchor installation:

1. Confirm the location for the insert to be installed to ensure you're not drilling into concrete that has encased electrical or other components.



Figure 15 Drop in anchor (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

2. Drill hole into the concrete with a carbide tipped masonry drill matching the bit size with the outside diameter of the drop-in anchor being used. Check the hole for the correct depth.
3. Clean out concrete dust from the hole using a wire brush, compressed air, or a blowout bulb.
4. Thread the bolt into the anchor. Drive the anchor into the hole, flush with the surface of the concrete. Remove bolt.
5. Using the proper setting tool for the anchor, expand the anchor by inserting the setting tool into the anchor and setting it with several solid hammer blows. The anchor is set properly when shoulder of the setting tool is flush with the top of the anchor.
 - a. To set the anchor below the surface, drill the hole deeper than the anchor length. Thread the bolt into the anchor. Hammer the anchor into the hole until the bolt head is the desired depth. Remove the bolt and set the anchor with the setting tool, as described above.



Figure 16 Anchor-setting tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Drop-In Concrete Anchor Spacing

As a general rule, the expansion industry has established a minimum standard of ten anchor diameters for spacing between anchors and five anchor diameters from an unsupported edge. When vibration or sudden impact is part of the load condition, spacing between anchors should be increased.

Expansion Anchors

Expansion anchors, sometimes referred to as *quick-bolts* are threaded fastener studs, with specially formed ends, used to attach machinery components to concrete. A specifically sized hole is drilled into a concrete slab, and an anchor with its split collar is gently tapped into the hole. As the nut tightens onto the material that the bolt is meant to fasten to the concrete, the natural tendency is to pull the bolt back out of the hole. However, the split collar binds between the sides of the concrete hole and the tapered end of the bolt, causing the bolt/collar to bind and hold fast. Once the bolt/collar combination is embedded, it will not be possible to extract it, and it must be cut off using an angle grinder if removal is necessary. The use of a *quick-bolt* eliminates the need for a concrete anchor and threaded rod combination.

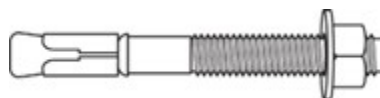


Figure 17 Quick-bolt (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Expansion Inserts

The single expansion insert is a single-action machine bolt expansion anchor. It can be used in solid concrete, hard stone (granite), and solid block and brick.

General applications and uses:

- Pipe hangers
- Suspending conduit and lighting
- Cable trays and strut



Figure 18 Single expansion insert (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Single expansion insert installation:

1. Confirm the location for the insert to be installed to ensure that you're not drilling into concrete that has encased electrical or other components.
2. Drill a hole using a carbide tip drill bit of the manufacturer-recommended diameter. The depth should be equal to, or slightly deeper than, the length of the expansion shield (anchor).
3. Clean out the hole of all dust and cuttings.
4. Place the single expansion insert, nut end first, into the hole. The top end of the anchor should be flush or slightly below the base material surface.
5. Place the object to be fastened over the anchor in the base material and bolt it into place. The bolt should engage $\frac{2}{3}$ of the threads of the anchor.

Precast Insert Hanger Anchors

The cast-in place insert is designed for pre-planned fastening in concrete. The insert provides rustproof threaded metal inserts in precast, pre-stressed or poured-in-place concrete. Install with bolts through holes in steel forms or by means of reusable concrete insert plugs on wood forms.



Figure 19 Pre-cast hanger anchor insert (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pre-cast anchor applications:

- Heavy machinery
- Pipe hangers support
- Duct work

Wood Form Cast-in-place Insert

The wood form concrete insert is installed onto wooden forms used to support newly poured concrete floor slabs, roof slabs, or walls. Refer to *D-4 Penetrate Structures* (#part-d-4-penetrate-structures) for information on use of this type of insert. The six-sided impact plate offers resistance to rotation within the concrete as the threaded rod is being installed.



Figure 20 Wood form cast-in-place insert (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 21 Installation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Wood form cast in-place insert applications and uses:

- Hanging pipe and sprinkler systems
- Overhead utilities
- HVAC ductwork
- Strut channels

Roof Deck Insert

Metal deck insert anchors are designed for installation through the pre-drilled metal composite deck used to support a newly poured concrete floor or roof slab. Depending upon the size chosen, the protective sleeve protrudes below the surface of the deck, allowing overhead attachment of threaded rod or bolts.

Roof deck insert applications and uses:

- Hanging pipe and sprinkler systems
- Overhead utilities
- HVAC ductwork
- Strut channels



Figure 22 Roof deck insert (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Rod Hangers

A **rod hanger** is an all-steel threaded anchor system for suspending threaded rod. These hangers can be used in a variety of base materials, including poured concrete, steel joists and beams, and wood frame columns and beams. Drill bits and installation tools are required as per manufacturer's specifications. (For example, carbide bits are required for drilling concrete.) Rod hangers have several other common names: hang-up anchors, Sammy super screws, vertigo anchors, hanger mates, and titan anchors.

Rod hanger applications and uses:

- Hanging pipe and sprinkler systems
- Lighting systems, suspended ceilings
- Suspended conduit and cable trays
- HVAC ductwork and strut channels
- Mounting security equipment



Vertical wood hang-up anchor



Horizontal wood hang-up anchor



Vertical concrete hang-up anchor



Vertical steel hang-up anchor

Figure 23 Rod hangers (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 24 The screw on the right is fluted to help thread into wood (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

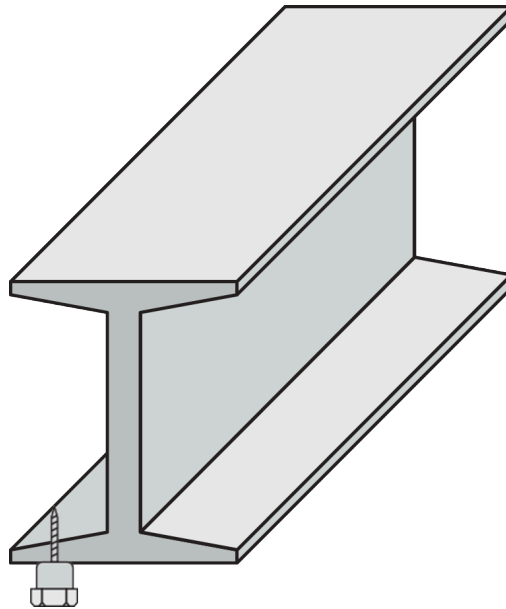


Figure 25 Rod hanger set vertically into steel (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

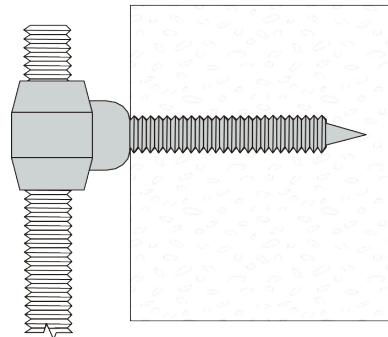


Figure 26 Rod hanger set horizontally into concrete (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Rod Hanger Installation

1. Drill a hole into the base material using the drill bit provided with the screws. The hole must be at least $\frac{1}{4}$ deeper than the anchor embedment.
2. Place the object to be fastened over the hole.
3. Insert the point of the anchor into the hole and drive the screw in using a nut drive or number 3 bit tip. Do not over-torque the screw.

Light-duty and Hollow Wall Anchors

Light-duty and hollow wall anchors have restricted use for supporting pipe and heavy equipment. In most cases, these anchors do not have the holding power of expansion or drop-in hangers. In the piping trade, these anchors can be used only for light-duty applications such as mounting light-weight components. They can be used in concrete, block, tile, wallboard and brick with a sheet metal, wood or lag screw.

Applications and uses:

- Mounting accessories such as control boxes or towel racks
- Attaching light-weight, small diameter piping to hollow block walls
- Wiring and similar attachments



Figure 27 Light-duty anchors

Self-Drilling Drywall Anchor Installation

1. Insert a Phillips screwdriver into head of the anchor.
2. Press the point of the anchor into the wallboard, while turning the anchor clockwise until it is seated flush with the wall.
3. Place the fixture over the hole and tighten the proper size sheet metal screw. A minimum thread engagement of 1" is recommended.

Residential Hanger Attachment Methods

Strap iron (often called *plumber's tape* or *metal hanger strap*) is a thin, flexible strip of metal (typically galvanized steel), used in plumbing to support and secure piping systems. It usually comes in rolls or flat lengths and features pre-punched holes along its length, allowing it to be easily fastened with screws, nails, or bolts. Strap iron is commonly used in residential and commercial plumbing installations where pipes need to be suspended, stabilized, or restrained.

Shown below are several methods of pipe support used in wood-frame buildings.

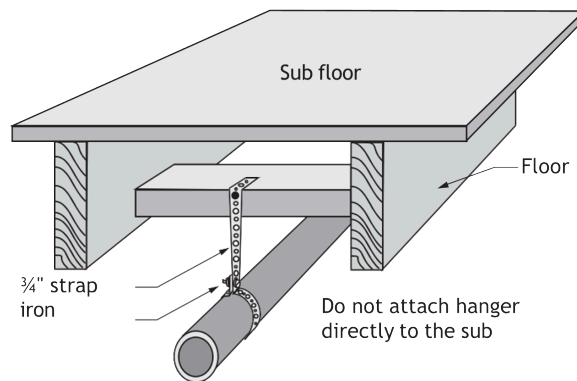


Figure 28 Pipe attached by a hanger to the wood blocking between the joist (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The Plumbing Code (<https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/bc-codes/2024-bc-codes/plumbing>) will designate the correct size and gauge of strap iron.

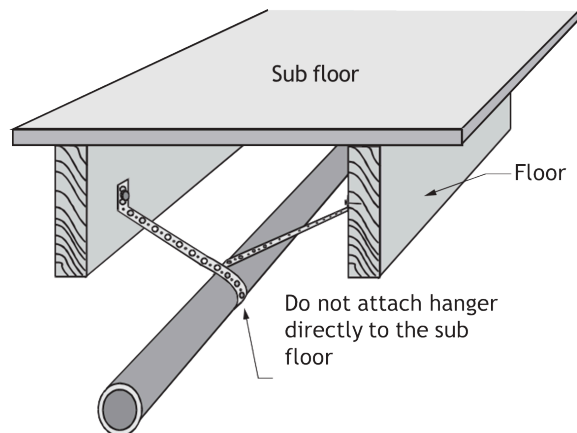


Figure 29 Pipe attached with hangers to the floor joists (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Although the method shown in Figure 29 is acceptable, it requires more strap iron than in the method shown in Figure 28.

Note: When using hanger strap iron to support piping in drop ceilings and crawl spaces, cross bracing is required to prevent the pipe from swaying.

Sometimes wood blocking is used to support the piping when the piping is located within the joist space, as shown in Figure 30.

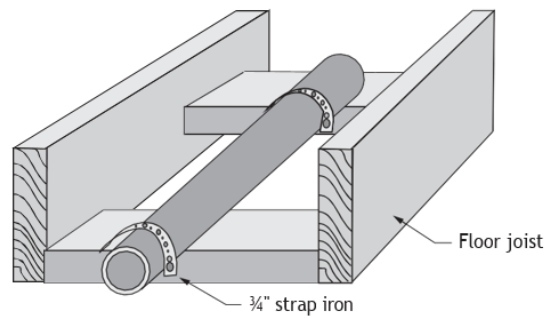


Figure 30 Wood blocking to support piping (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Hanger supports on residential applications of wood-frame construction are commonly applied with perforated hanger strap. This method is less expensive than using manufactured hanger supports. This strapping allows for flexibility in design of the support. The metal hanger strap installation must be capable of supporting the pipe and holding it in position.

Clevis Hanger with Double Nuts

Figure 31 shows a **clevis type hanger** with double nuts used on the hanger rod. The purpose of the double nuts is to reduce any swinging motion by holding the pipe more rigidly and reducing the tendency for vibration to loosen the nuts supporting the hanger.

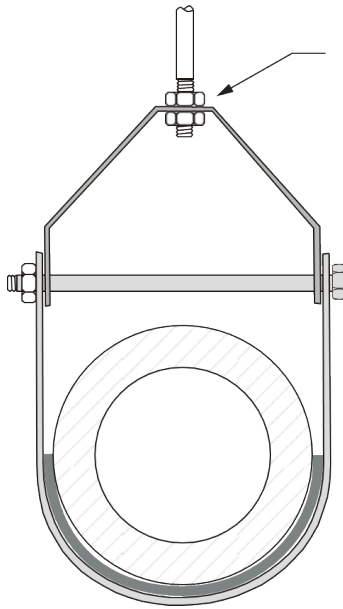


Figure 31 Clevis hanger with double nuts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

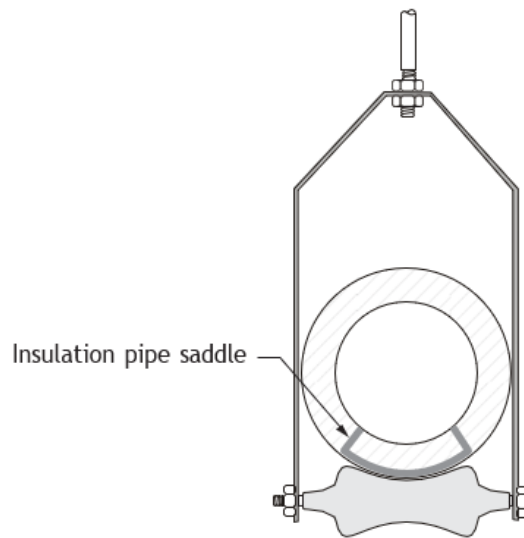


Figure 32 Insulation pipe saddle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The steel pipe saddle provides a solid surface for the pipe to move on the rollers without damaging the insulation.

Scissor Beam Clamp

A **scissor beam clamp** (Figure 33) is used to create a temporary overhead anchor point on steel beams for lifting and rigging applications, such as attaching hoists, lighting rigs, or pipework. It gets its name from the “scissor” action used

to clamp onto the beam's flanges, where twisting a spigot secures the clamp. This method allows for non-permanent installation, which avoids weakening the beam, and is ideal for lifting, construction, and industrial maintenance.



Figure 33 Scissor beam clamp (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Expansion and Contraction of Hangers and Supports

The movement and shifting of suspended pipe can cause damage or failure if not properly controlled. Detailed below are several methods for achieving this control.

- *Sway braces* are used to restrain pipe movement.
- A *spring sway brace* allows controlled movement and returns the pipe to its original position.
- A *hydraulic shock arrestor* protects piping from sudden forces such as water hammer or seismic activity.

Sway Braces

Sway braces are used for controlling and restraining pipe movement, as shown in Figure 34.



Figure 34 Basic sway brace designed to restrain movement in two directions (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Spring Sway Brace

A **spring sway brace** is a special type of variable effort restraint and is built around a standard or non-standard spring. It's used to restrain piping or equipment but is not intended to support. A swing sway brace has a pre-loaded spring, which allows both compression and extension movements of the pipe. By installing a spring sway brace, the pipe's position can move to accommodate forces acting upon it, then return to its neutral position once those forces have stopped.



Figure 35 Spring sway brace (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Hydraulic Shock Arrestor and Sway Suppressors

The **hydraulic shock arrestor** protects pipelines and equipment from the effect of shock loads caused by wind loads, pipe bursts, **seismic activity**, **water hammer**, and other sudden forces. When subjected to sudden movements, the shock arrestor “locks” momentarily and forms a rigid connection.



Figure 36 Hydraulic shock and sway suppressors (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Spring and Variable Supports

Spring supports are used to support piping and related components that are subject to **thermal expansion**. For minor vertical travel, a **variable spring support** (Figure 37) is typically used for relatively small displacements (up to about 75 mm). A **constant spring support** should be used for greater levels of thermal expansion (Figure 38).

The constant spring supports provide continuous support throughout the total movement of the pipe.



Figure 37: Variable spring supports (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Constant spring supports provide continuous support along the total travel of the pipe.

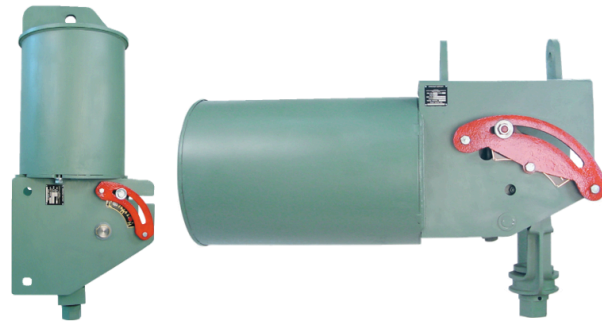


Figure 38 Constant spring support (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The constant spring support is designed and manufactured based on the principle of a compression spring working in conjunction with a **bell crank lever**, which balances the spring and load movements, resulting in a constant supporting effort throughout all pipe movement.

Model R lifting lugs:

To help alleviate the problem of lifting large size Constant Supports into position for installation, this product is available with lifting lugs (if requested) on sizes ten and larger.

Lifting Lugs (Figure 81-H): Not available on Type F.

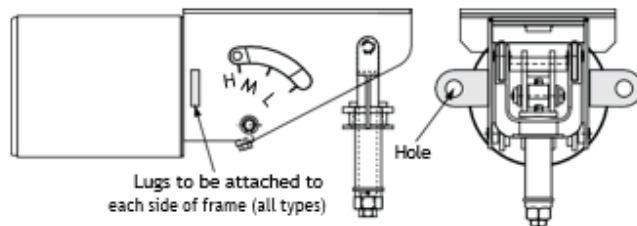
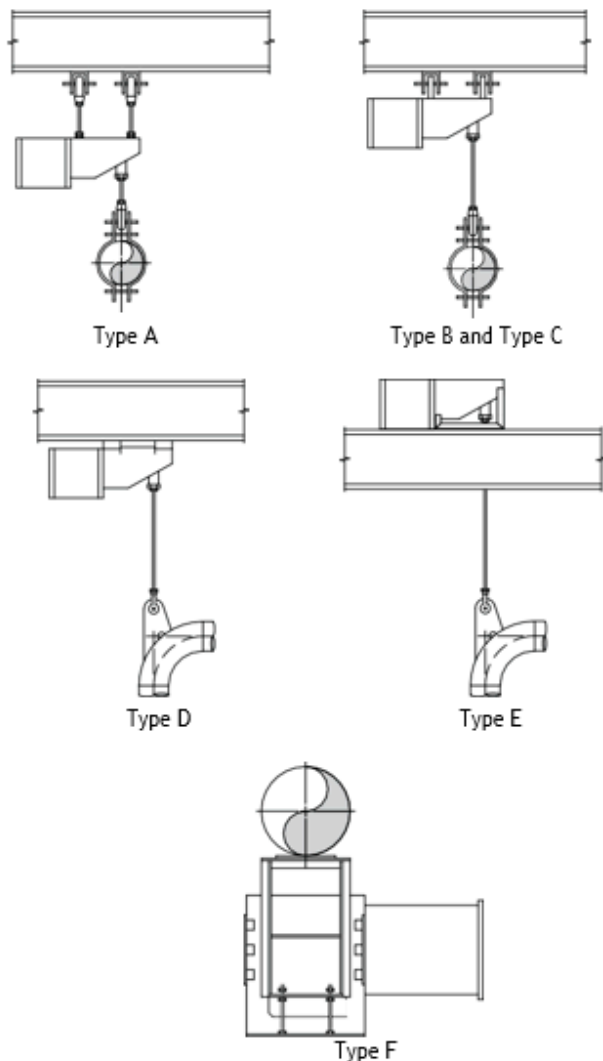


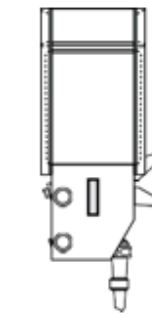
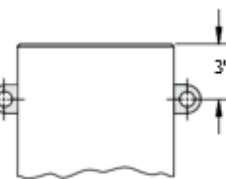
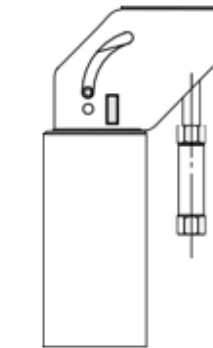
Fig. 81-H (Horizontal): Typical Applications



Lifting Lugs (Fig 80-V):

LUGS TO BE 90° FROM CHANNEL ON TYPE D

Types A, B, C, D, & E
sizes 10 thru 63



sizes 64 thru 83
Lugs to be attached to each side of frame and will need stabilizing rigging when being lifted

Fig. 80V (Vertical): Typical Applications

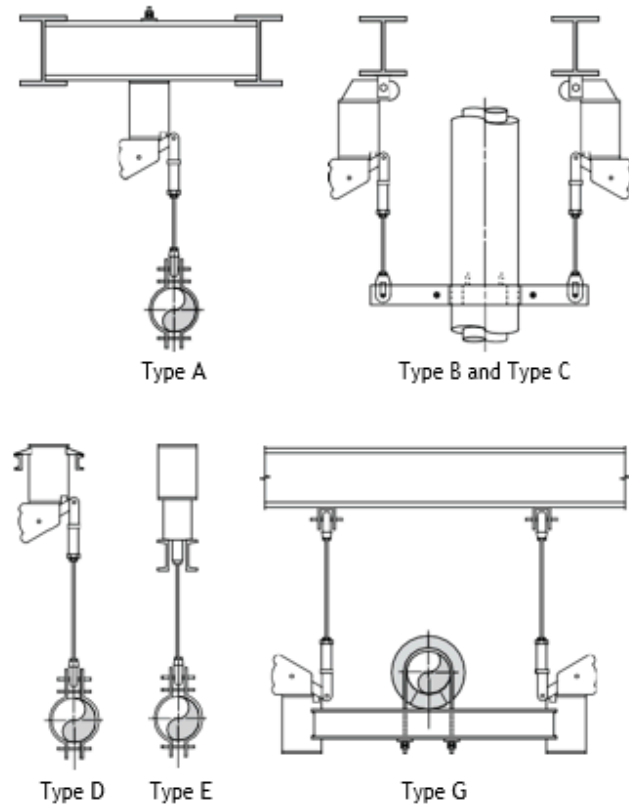


Figure 39 Constant spring support installation orientations (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Slide Plates

Slide plates are used to provide a surface with a low **coefficient of friction** so that it can be attached to a supporting structure. The slide plate provides support while allowing the supported equipment to move freely. Slide plates can consist of an upper slide plate and a lower slide plate component that work together as a unit. They can be manufactured for a variety of applications, including the support of piping, heavy equipment such as pressure vessels, and structural steel members.



Figure 40 Spring isolator supports under an outdoor refrigeration condenser unit (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Seismic Restraint of Mechanical, Electrical, and Plumbing Systems

During an earthquake, the shaking and rolling of the ground is transmitted to the building. The piping and equipment supported by the building's structure will be adversely affected by this movement. Unrestrained piping and equipment can rip apart, fail, or break loose. Fires, explosions, and flooding are common during earthquakes due to ruptured gas lines, fire sprinkler systems, and plumbing systems. As a tradesperson, you're responsible for the correct placement and installation of *seismic restraints*.

Seismic restraint refers to the components and systems used to keep mechanical, electrical, and plumbing systems secured in place while allowing movement with the building's structure. The goal is to maintain system operation during seismic activity, or at least until the structure itself fails.

Seismic Engineering Specification and Code Requirements

Building codes, plumbing codes, gas codes, and fire sprinkler codes all deal with support and seismic regulations. The *Fire Sprinkler Code* has extensive requirements for the installation and positioning of seismic restraints. Currently, plumbing and gas codes have more limited specific requirements. Where engineered systems are used, engineering practices and specifications must also be followed.

Basic seismic installation guidelines:

- Conform to *Building Code* requirements.
- Follow engineered job specifications.
- Follow manufacturer installation instructions.
- In the absence of regulations, follow proven trade practices.
- In **all** cases, check with the *authority having jurisdiction (AHJ)*.

Guidelines for seismic restraint:

- The seismic restraints' positions should be coordinated so as not to interfere with each other or the positing of building equipment and structural components.
- Seismic restraint attachments to the building structure must always be strong enough to carry the imposed loading by the piping during seismic activity.

Seismic Supports for Piping Systems and Equipment

Beam Clamp with Strap

A **beam clamp** with a restraint strap or safety strap prevents the clamp from walking (slipping) off the beam during seismic events. Restraint straps are required for sprinkler installations in all seismic regions.

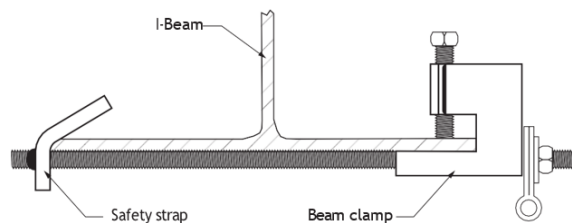


Figure 41 Beam clamp with safety strap (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figures 42–44 show acceptable ways and means of installing seismic attachments. It's important to note that engineered specifications, Code requirements, and manufacturer instructions must be adhered to.



Figure 42 Sway brace attached to riser clamp and concrete structure (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 43 Riser clamp on pipe attached to concrete wall structure (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 44 Pipe attachment to concrete by use of a spring hanger (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The hangers are close together so that each section of pipe is supported.

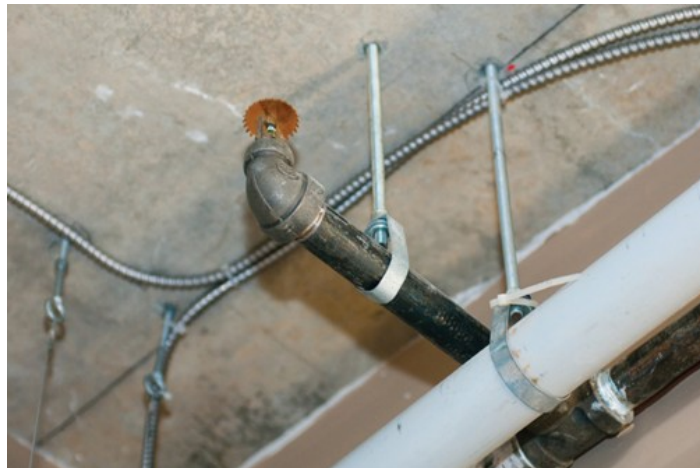


Figure 45 Ring hanger use below concrete slab in parking area (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Cable-Brace Attachment

Cable-brace attachments must be installed in a straight line between attachment points and must not bend or wrap around other components (Figure 46).



Figure 46 Seismic cable-bracing in a straight line between the anchor points and pipe attachment (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Power-actuated or *power-driven fasteners*, such as **powder shot pins**, must not be used for **tensile load applications** unless specifically approved for seismic use.

Proper attachment of the mechanical, electrical, and plumbing system components and their seismic restraints is important in order to maintain the building's functionality following an earthquake. It's your responsibility to ensure that seismic components, supports and restraints have been properly installed.



Figure 47 Cable attachment to pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Seismic Restraint Components

The following components are commonly used to support and anchor pipes (Figures 48–52):

- Sway brace
- U-clamp
- Clevis bracket



Figure 48 Sway brace attachment to threaded pipe sway brace (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 49 U-clamp pipe to sway brace attachment (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 50 U-clamp on a pipe and sway brace pipe and attachment assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

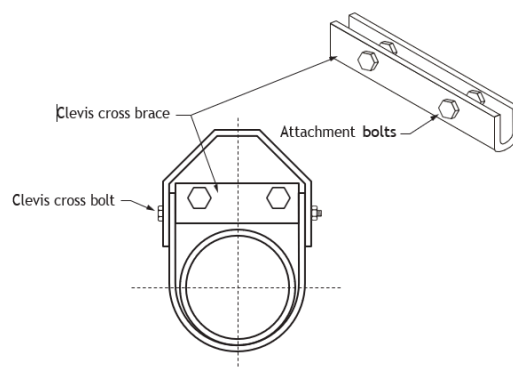


Figure 51 Clevis cross brace bracket (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 52 Sway brace on a fire sprinkler system (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Support and Anchor Accessories

The following images show accessories used in supporting and anchoring pipes.



Figure 53 U-bolt (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

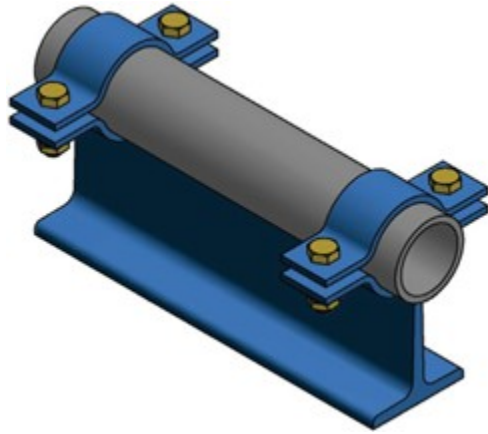


Figure 54 Pipe shoe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 55 Rod connector (turnbuckle) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 56 Top attachment support

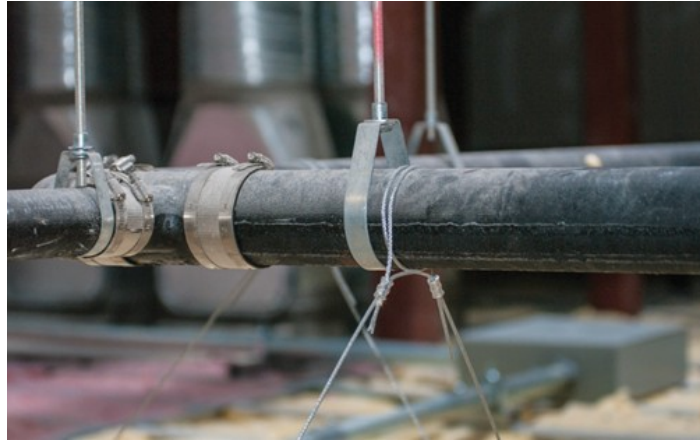


Figure 57 Seismic suspension and restraint cables (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

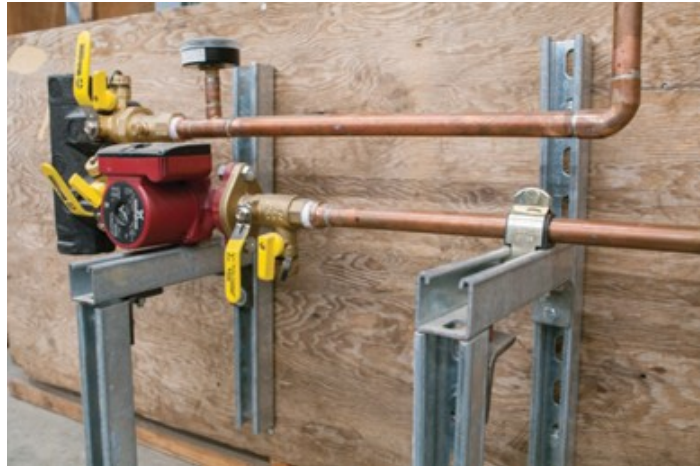


Figure 58 Site-fabricated (Unistrut) channel bar floor pipe support (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Seismic Bracing of Water Storage Heaters

Suggested guidelines for hot water storage heaters:

- Consult the **authority having jurisdiction (AHJ)** for any local requirements.
- Secure both the top and bottom of the hot water storage heater using heavy-gauge metal strapping.
- Position the tank so that there is approximately 25–50 mm (1–2 in) between the water heater and the wall. If the distance is greater than 50 mm, attach a wooden block to the wall studs with long lag screws to prevent the heater from sliding backwards.
- Wrap heavy-gauge metal strapping $1 \frac{1}{2}$ times around the tank:
 - Start by placing the strapping at the back of the tank.
 - Bring it to the front and then take it back to the wall.
 - Secure this strapping to the wall studs or the wood block using longer lag screws with oversized washers. (If securing into concrete, use expansion bolts.)
- Replace all copper and metal piping with flexible natural gas and water line connectors.
- The gas and water lines should have flexible pipes—these may be safer than rigid pipes during an earthquake.
- Remind the customer to check the straps regularly for tightness.



Figure 59 Hot water storage heater with seismic restraint using manufactured strapping (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 60 Close up of seismic strap connection (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Residential Applications of Pipe Support

You are responsible for designing simple methods to provide adequate support and seismic restraint where possible. The *Building Code* does not specifically address every situation that occurs on a job site. You need to consider the effects of wood shrinkage and final settlement over time as the structure ages, particularly for wood-frame structures.



Figure 61 Residential application of pipe clips used to support and hold PEX tubing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 62 Wood-frame installation showing the use of stub-out supports (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 63 shows the use of strap iron to support the ABS trap arm.



Figure 63 Strap iron support (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 64 Tub spout stub-out with wingback 90 deg elbow (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

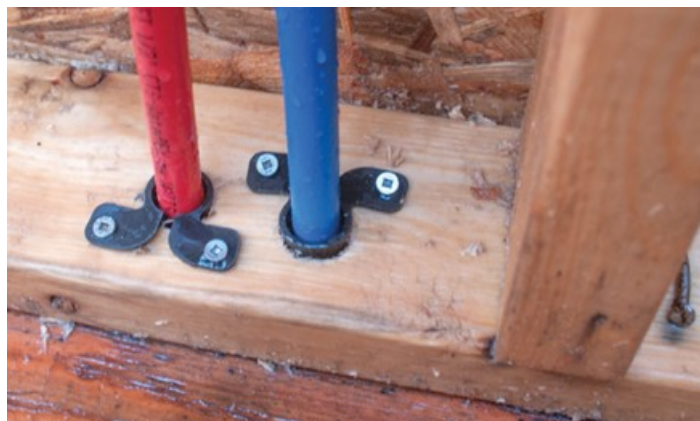


Figure 65 Plastic clips used to prevent rattling of pipes (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 65 shows the use of **plastic clips and grommets**. The plastic grommet protects the pipe from contact with the sharp edges of the metal stud framing. Avoiding contact between dissimilar metals is important to prevent **galvanic corrosion** that can occur in the presence of moisture.



Figure 66 Copper clips (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 66 shows the use of plastic tape wrap to isolate the copper trap arm from the dissimilar steel stud. Also shown is the use of a rise clamp to support the vertical cast iron soil pipe.



Figure 67 Plastic tape wrap and rise clamp (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Hangers and supports guidelines for ABS piping:

- Hangers and straps shall not compress, distort, cut, or abrade the piping and shall allow free movement of pipe.
- Pipe exposed to damage by sharp surfaces shall be protected.
- Support all ABS piping at intervals of not more than 4' (1219 mm), at end of branches, and at change of direction or elevation.
- Supports shall allow free movement but shall restrict upward movement of lateral runs so as not to create reverse

grade.

- Vertical piping shall be supported at each storey or floor level.
- Alignment of vertical piping shall be maintained between floors with the use of a mid-storey guide.
- Support trap arms in excess of 3' (914 mm) in length as close as possible to the trap.
- Water closet rings shall be securely fastened with corrosive resistant fasteners to the floor with the top surface

$\frac{1}{4}$ " (6.4 mm) above the finished floor.



Self-Test D-I.3: Describe the Methods of Pipe and Tubing Support

Complete Self-Test 1.3 and check your answers.

If you are using a printed copy, please find Self-Test D-1.3 (#chapter-self-test-d-1-3-describe-the-methods-of-pipe-and-tubing-support) and Answer Key (#chapter-answer-key-self-test-d-1-3) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1929#h5p-3> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1929#h5p-3>)



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1929#h5p-15> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1929#h5p-15>)

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- Plumber: Competency D-1 Prepare Pipe
 - Steamfitter: Competency D-4 Layout and Install Piping and Tubing
 - Sprinkler Fitter: Competency D-1 Prepare Pipe and Tubing
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Media Attributions

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D-1.4 Describe the Methods of Protecting Piping

It's important to understand the factors that can cause damage to piping. A damaged pipe results in reduced life expectancy (of the pipe) or failure of the piping system. Pipe can deteriorate for many reasons, including installation practices, environmental conditions, and the contents being transported. This damage can be reduced by protecting the pipe through the proper selection and installation of piping systems.

Factors Leading to the Need for Pipe Protection

Piping systems need to be protected from damage caused by the following:

- Mechanical damage during storage, handling, and installation
- Improper burial and trenching, vehicle traffic above ground, and **buoyancy** issues
- Freezing or excessive heat
- Environmental conditions such as corrosive soil, air pollutants, oxidation, electrolysis, and exposure to sunlight
- Damage as a result of the type of fluids being conveyed (internal damage)

Basic Methods Used to Protect Piping and Piping Systems

- Pipe coatings
- Pipe tapes and wraps
- Geotextile pipe protection
- Protective casings (a pipe placed inside a larger pipe)
- Electrolysis (galvanic) protection and dielectric protection
- Freeze protection through insulation, heat tracing, frost boxes, and circulation lines
- Protective plates and pipe sleeves

Pipe can also be protected by selecting the appropriate pipe material (e.g., steel, copper-nickel, cast iron, plastic). Each pipe material has unique characteristics that help it resist specific working conditions.

Preventing mechanical damage from seismic activity, pipe **expansion**, and vibration is covered in D-1.5 Describe the Inspection of Pipes and Tube Before Installation (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation).

Corrosion Protection: Internal and External Pipe Coatings

Typical regulations and specifications require that pipelines are treated with coatings that:

- Electrically isolate the external surface of the pipeline from its environment
- Have sufficient adhesion to resist under-film migration of electrolyte
- Are sufficiently ductile to resist cracking

- Resist damage from soil stress and normal handling
- Are compatible with cathodic protection
- Resist deterioration due to the environmental conditions and service temperature
- Resist harmful rays such as ultraviolet light

Internal and External Pipe Protection

Internal pipe protection is accomplished by applying protective coatings such as:

- Polyethylene lining
- Internal polymer coating
- Cement/sand coating
- Corrosion inhibitors

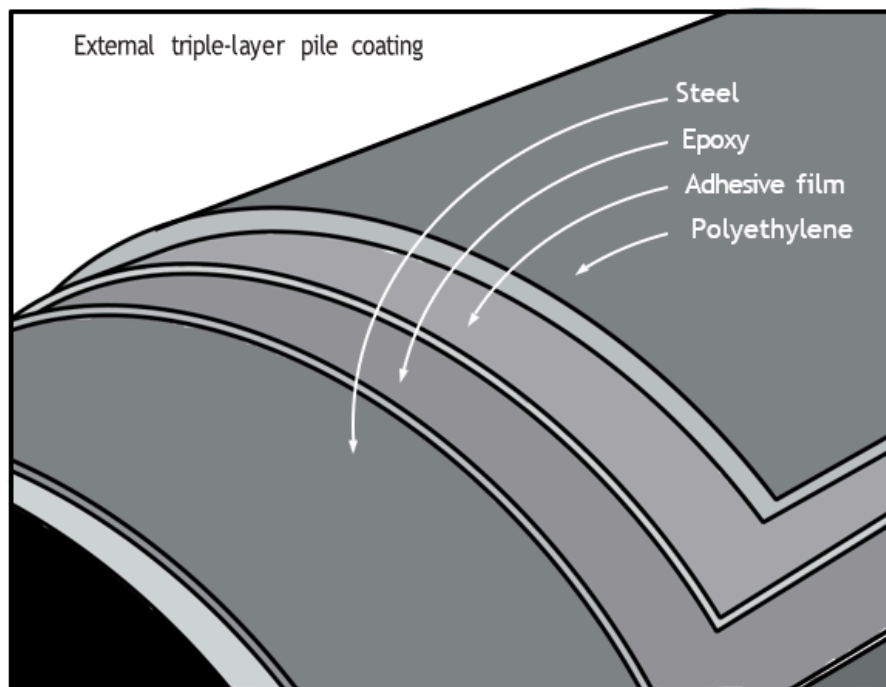


Figure 1 External pipe coating tape/wrap (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Coating Types and Methods

Liquid Coatings

Liquid coatings have the following uses and advantages:

- Ideal for pipeline rehabilitation and coating repairs

- Suitable for field applications such as large recoating projects or short pipe sections
- Available in formulations that are 100% solids with no **volatile organic compounds (VOCs)**
- Often do not require a primer and allow for **high-build single-coat application**
- Can be applied with either spray or brush

The selection of pipe coatings is usually done by project design engineers.

Pipe coatings are applied to piping to protect the pipe from the degrading effects of the environment they are installed in. The types of protective coatings and the materials that make up the composition of the coating depend on the type of pipe and the damage that the pipe is going to be subject to. The methods used when applying these coatings is dependent on the manufacturer's application instructions and the type of pipe material it is applied to.

Mastic elastomeric coatings (soils saturated with oil and gasoline) may be used as a general-purpose coating for underground **corrosion** protection of all fabricated steel products, such as pipes, tanks, conduits, cylinder casings, and structural steel.

Other Mastic Coatings

Coal-tar-based epoxy combines the superior moisture resistance of coal tar with the excellent chemical and abrasion resistance of epoxy. Environments include chemical plants, flood gates, locks and dams, sewage plants, bridge and piling structures, and pipelines. Coal-tar-based is also used for immersion service and in atmospheric conditions where abrasion and chemical resistance are needed. It is used in industries such as sewage and water treatment, chemical processing, marine, offshore exploration, oil and gas distribution, and public utilities.

Rubberized mastic is a cold-applied coating with high electrical resistivity designed to protect underground steel pipes, tanks and other structures against corrosion.

Tape and Wrap Coatings

The external surfaces of steel pipe can be protected from corrosion by external pipe coatings. Pipe coatings include both liquid and powder coatings, pipe wraps and tapes, and can be applied at the factory or on the job. Factory-applied coatings are usually more reliable since they're applied in a controlled environment.



Figure 2 Moisture sealing a pipe casing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Geotextile Pipe Protection



Figure 3 Geotextile-GSI (<https://commons.wikimedia.org/wiki/File:Geotextile-GSI.JPG>) (Marilyn475/Wikimedia Commons) Public Domain (https://en.wikipedia.org/wiki/en:public_domain)

Geotextile sacrificial wrap provides protection for surface coating during backfilling operations and is often placed around the pipe prior to placement in the **trench**.

Pipe Casing



Figure 4 Steel casing pipe (https://pxhere.com/en/photo/1607653#google_vignette) (annawaldl/Pixabay) Content License (<https://pixabay.com/service/license-summary/>)

Pipe casing is a method to protect a pipe by encasing the transporting pipe within a larger pipe. Pipeline casing filler is a petrolatum-based corrosion-preventative compound used to fill the void between the transporting and external pipes. It prevents corrosion by displacing water that is present in the casing and by preventing water from re-entering the casing.

Rock Guards

Rock guards are used to protect pipe protective coating from damage from soils with rocky backfill. The product is available in rolls or pads for varying diameters of pipe.

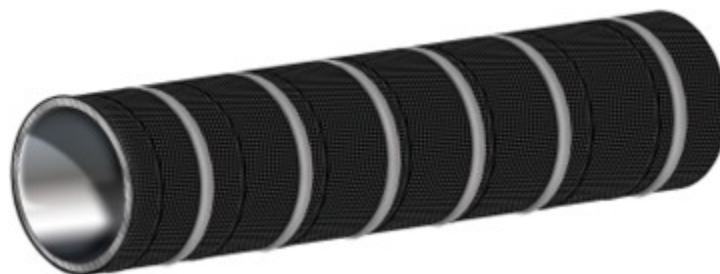


Figure 5 Rock guard (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Transmission Sleeve

A transmission sleeve is used for field application at a joint in a pipe with existing pipe protection. (For example, an

underground welded gas line.) The transmission type sleeve system provides corrosion protection and bonding on pipelines ranging from operating temperatures up to specified temperatures. They are designed to bond to the existing pipe protection.

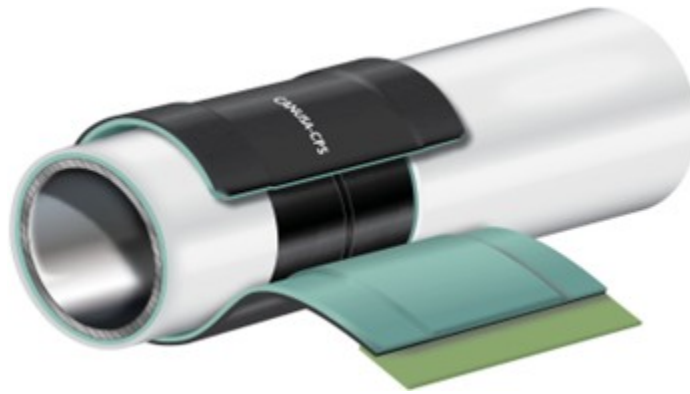


Figure 6 Transmission sleeve Canusa-CPS (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Freeze Protection

Exposure of piping systems to freezing conditions will cause water and similar low freezing point fluids to freeze. The expansion of the fluid (water) as it freezes can rupture the pipe. When the water thaws the resulting water damage can be extensive.

Several methods can prevent freezing damage, including:

- Installing piping within a heated structure
- Applying insulation or enclosing the pipe (e.g., boxing, tenting, spray foam)
- Installing piping on the heated side of building insulation
- Draining or blowing out the system during cold weather
- Adding antifreeze solution
- Using hot boxes
- Installing heat trace systems
- For buried piping, installing the piping below the frost line or insulating and heat tracing
- Using constant circulation

The easiest way to prevent a piping system from freezing is to install the system within a heated structure. Building standards will often not allow potable water systems to be installed in exterior walls, especially in regions subject to freezing conditions without specific **freeze protection**. Fire sprinkler systems installed in areas subject to freezing may be designed to be a dry pipe system, for example, parking garages and warehouses. The use of low-point drains are examples of frost-protection measures. Constructing an insulated box around piping or installing the pipe on the warm side of the building **insulation** is an acceptable way to insulate piping.

Piping installed in attic spaces, such as the case with residential fire systems, must be protected from freezing. Fire codes have standards on the methods of application of insulation in residential fire sprinkler systems.

Irrigation systems are often designed with compressed air blow out connections and low point drains. Irrigation systems are usually winterized by simply shutting down the systems and draining for the winter season.

Underground piping that can't be installed below the local frost line can't be insulated using materials that would crush under the weight of the compacted fill. Because of this, you might need to install a frost box. A frost box is the term given to one of three accepted assemblies (see the accompanying diagram):

1. An inverted U made of treated wood planks that is installed over the pipe and that maintains an air space between the pipe and planks. Freezing time would be longer due to the absence of physical contact between the pipe and the planks.
2. A pipe installed inside a much larger pipe. The outer pipe reduces contact between the pipe and the frozen earth around it.
3. High-density styrofoam used to separate the pipe and the fill above it. This method requires very high compaction of the fill around the pipe, and the Styrofoam must be of dense construction.

As long as water is moving, it is unlikely to freeze. Leaving a faucet dribbling to a drain can sometimes be effective to prevent freezing, but it wastes a lot of water. This adds cost to owners on a metered system and adds volume to a private septic or a municipal treatment system.

Using a pump to keep water circulating within a closed system, much the same as in a domestic hot water recirculation system, can effectively reduce the threat of freezing and prevent wasting water. Water at the end of the piping run is pumped back to its starting point through a separate pipeline. It is important that these systems are sized correctly to avoid unnecessary erosion of the pipe walls from excessive flow velocities.

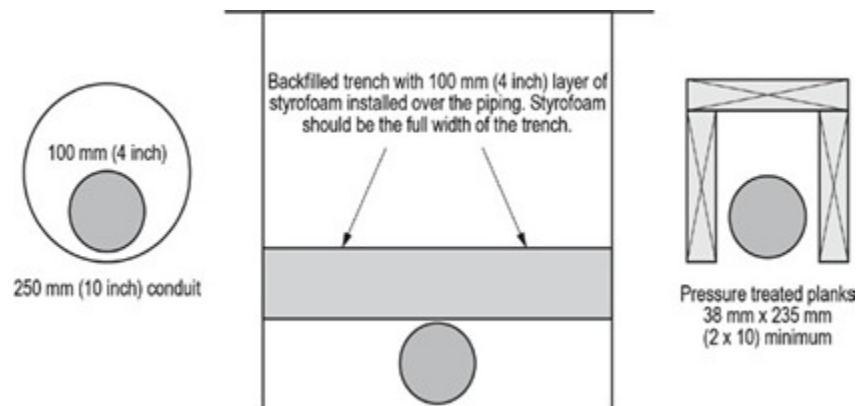


Figure 7 Frost protection (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Piping Materials and Frost Protection Considerations

Different piping materials respond differently to freezing conditions, which has important implications for system design, installation, and maintenance in cold climates.

Compared to copper piping, PVC plastic pipe generally takes longer to freeze due to its lower thermal conductivity. However, once freezing occurs, PVC is more rigid and brittle, causing it to burst at a lower internal pressure when ice

expands inside the pipe. This makes PVC particularly vulnerable to sudden failure during freeze–thaw cycles, especially in unheated spaces or exterior installations.

Polyethylene (PE) and cross-linked polyethylene (PEX) piping offer greater resistance to freeze-related damage. These materials have a higher degree of flexibility than copper, allowing them to expand slightly as water freezes. This flexibility enables PE and PEX pipes to better absorb the internal pressure caused by ice formation, often preventing the pipe from bursting. In many cases, these pipes can return to their original shape once thawed, provided the freezing was not prolonged or extreme.

Copper pipe, while strong and durable under normal conditions, is relatively rigid and has little ability to expand. When water freezes inside a copper pipe, the expanding ice can generate significant pressure, leading to splitting or rupturing of the pipe, particularly at fittings or soldered joints.

Because of these material characteristics, frost protection measures—such as proper insulation, heat tracing, adequate pipe sizing, and strategic routing away from exterior walls—are critical regardless of the piping material used. However, material selection can play a significant role in reducing the likelihood and severity of freeze damage, especially in residential and light commercial applications.

Applying Freeze Protection

When pipe is installed where it is subject to freezing, the first solution is to apply pipe insulation. The goal is to maintain the temperature of the pipe and contents above the freezing point.

There are many types of insulation pipe wraps available. In many cases, batt fibreglass insulation is simply packed around the pipe in question. Pipe is often boxed in, and insulation is placed in the box surrounding the pipe. Often insulation is not protected from moisture and the environment. Water-soaked insulation does not provide good insulation.

In-ground valve and meter boxes are installed with some method to prevent freezing. Installation of piping below the frost level is a good solution. Where this is not possible, the piping can be covered with light-weight material with insulation qualities. Sawdust and wood chips and shavings can work in dry environments for limited amounts of time before needing to be replaced.

The application of freeze protection requires consideration of the type of insulation and its thickness. It's difficult to know how much insulation is required. How cold will an unheated crawl space, attic, or outside wall get? How long is the ambient temperature going to stay below freezing? Will additional **heat trace** cable be required? If the pipe freezes, the resulting damages can be costly. Given this, it's better to be safe than sorry.

Factors affecting heat loss include:

- Thickness of installation
- Ambient temperature
- The size of pipe and the amount of residual heat
- Wind speed (for pipes exposed to wind)

Types of pipe insulation include:

- Flexible closed-cell polyethylene
- Fibreglass
- Mineral wool

- Natural insulation
- Foam



Figure 8 Fibreglass pipe insulation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Flexible closed-cell polyethylene or elastomeric insulation are often used for insulating plumbing, both residential and commercial. These lines are found in crawl spaces, walls, attics, parking garages, and unheated warehouses. The closed cell has excellent range of properties, including low thermal conductivity, water vapour permeability, and ease of installation. There is no need for additional water vapour barrier.



Figure 9 Closed-cell polyethylene foam pipe insulation used for frost protection

Styrofoam Insulation

Styrofoam insulation is a rigid, closed-cell foam pipe insulation. This insulation has a dense, compact structure ensuring resistance to water, water vapour, and wet freeze-thaw cycling.

Using insulation by itself may be satisfactory in climates where freezing temperatures are rare and for short periods of time only. Where climate temperatures drop below freezing and last for extended periods of time, insulation and heat tracing is recommended.

Heat Trace

Heat tracing protects pipe from freezing by applying a heat-producing source, such as an electrical heat trace cable. The effectiveness of such heat trace or cable depends on correct selection and proper installation.

Heating cable systems can be controlled either manually or by thermostatic control. Self-regulating and all heating cables should be Underwriters Laboratory (UL) Listed, Canadian Standards Approval (CSA) certified, or Factory Mutual

(FM) approved for their use. The most common thickness for heat trace is $\frac{1}{4}$ ”, and the insulation’s inside diameter must be sized properly to fit over both the pipe and the tape. This is done to ensure the insulation seam will close tight and stay tight.

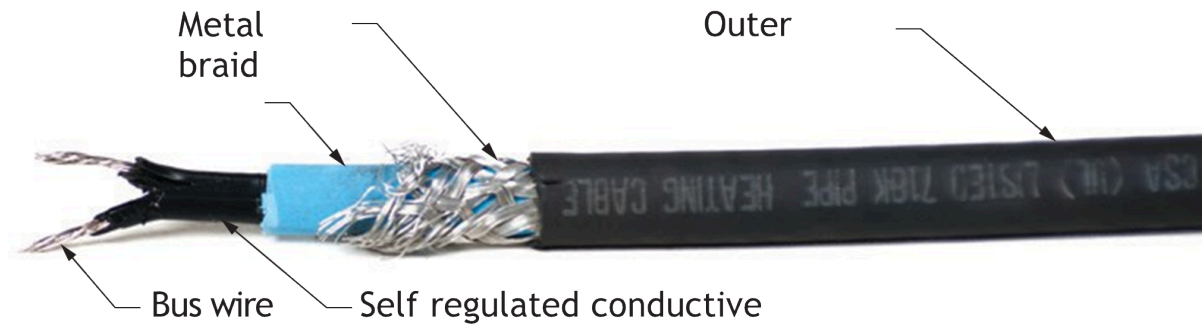


Figure 10 An example of one type of heat trace cable (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Heat trace frost protection cable is constructed of several layers. The inner layer of the cable contains two conductor wires that supply electrical power to the heat tape. Surrounding the two wires is a special polymer that generates heat when electrical current flows through it.

Some manufacturers supply heat trace cable in coils that may be cut to the exact length needed for a job. Cable connectors and end seals are supplied to terminate the cut ends.

Heat trace cable is also supplied in specific lengths. These pre-cut lengths should not be further cut unless specifically allowed by the manufacturer.



Figure 11 Coil of heat trace with ground fault plug (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Thermostats

Heat tracing systems may be controlled either manually or through thermostatic control. Manual control requires the

operator to turn the power to the heating cable on or off as needed, relying on judgment and monitoring of ambient conditions.

Thermostatic control uses a temperature-sensing switch to automatically energize or de-energize the heating cable at preset temperatures. This method provides more consistent freeze protection and improved energy efficiency by ensuring the system operates only when required.



Figure 12 Example of heat trace thermostatic control (©2014 Environmental Technology Inc.) Used with permission

Aluminum Foil Tape

When required, aluminum foil tape is applied to the pipe under the heat trace. This will provide better conductivity to the pipe, particularly for plastic piping. Aluminum tape can also be used to attach the heat trace tight to the pipe and keep insulation from getting under the heat trace.



Figure 13 Aluminum tape (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Heat trace cable is available thermostatically controlled or self-regulating. Self-regulating cable consists of a polymer in the cable that has a resistance that changes with the temperature. For example, one manufacturer states that their cable uses about 3.5 watts per foot at 4.4°C (40°F). At -17.7°C (0°F), the power usage increases to about 5 watts per foot. The heat trace cable is simply plugged in or turned on for the winter season and unplugged or turned off at the end of the cold season.

Heat Trace Safety

The following are some considerations for heat trace safety:

- Do not use heat trace cables below ground unless specifically approved for such use.
- Heat trace should be plugged into a grounded electrical receptacle in a dry area.
- Ground fault interruption may be required (consult electrical codes).
- Do not cut or splice heat trace cable unless specifically approved by the manufacturer and electrical codes.
- Heat trace should not be enclosed in walls, ceilings or floors.
- Heat trace must be visible for inspection (under pipe insulation is permitted if specified by the manufacturer's installation instructions).

Heat Trace Selection

Factors to consider when selecting and installing a heat trace cable include:

- Pipe diameter
- Pipe length
- Minimum ambient temperature (worst-case scenario)
- Temperature rating of the fluid being transported
- Manufacturer's sizing tables

Note: A typical maintained temperature of 5°C (40°F) is acceptable. This maintained temperature is used to determine the maximum length of the tracer circuit and the size of the electrical breaker.

Recommended Heat Trace Installation Practices

- The pipe and heat trace cable should extend into the building approximately 300 mm as the pipe enters the building and well below the frost line if the pipe exits or enters the ground.
- For short branches run off a main, you can double-trace (down and back) to eliminate the need for splicing.
- Avoid running heat trace cables through open air from pipe to pipe. Use a conduit extension to protect the cable.
- Select the cable wattage conservatively, allowing a slightly higher wattage output, per foot of cable, than required.

- Insulate all heat sinks in the heat tracing system. Allow sufficient cable to trace additional heat sinks.
- Avoid wrapping heat trace cable around a valve so the valve cannot be easily removed or repaired.
- The better insulation value of the pipe insulation, the less wattage required and the longer the runs.
- Larger pipe may require more than one heat trace cable.
- Place aluminum foil tape over the heat trace cable before applying spray on insulation—this will improve heat transfer to the pipe.
- Avoid contacting heat trace cable with steam from steam cleaning operations—the high temperature can damage the cable.

Electrical Considerations

- Design the heat tracing system using the most commonly expected start-up temperature. Maintaining the higher start-up temperature uses less power and allows longer heat trace circuits and smaller circuit breakers. Breaker tripping may occur if the heating system starts at a lower temperature than it was designed for.
- The maximum lengths and breaker should be in conformance with the manufacturer's specifications and *Electrical Code* requirements.
- All heating cable systems require ground fault protection as required by the *National* and *Canadian Electrical Code*.

For the required wattage given the pipe diameter, the ambient temperature, and the amount of insulation, use the tables provided by the heat trace manufacturer.

Methods Used to Install Heat Trace

Methods used to attach heat trace to pipe include flexible nylon straps and flexible heat trace tape. When attaching heat trace, ensure that the tape or strapping is rated for the temperature of the piping when in use. Do not use metal strapping or tie wire. It's important that the heat trace makes positive continual contact with the pipe surface to provide the best results.

Temporary Attachment

Starting at the end of the circuit and working back towards the power source, attach the heat trace temporarily. Allow extra tracer cable for final attachment to valves, flanges, elbows, and at pipe supports. Also allow extra cable for the power connection and for any splicing that may be required. Pipe supports can act as a heat sink, so on sizes over 2" in diameter, extra heat trace may be required.

Permanent Attachment of Heat Trace

For instructions applying to large diameter industrial piping or residential application, see the manufacturers' instruction

Ultraviolet Light (Sunlight) Protection

When thinking about UV protection, there are different considerations for different types of pipe and tubing.

ABS Pipe Protection

ABS piping should not be exposed to direct sunlight. An exception is a vent pipe passing through a roof. Vent piping exposed to sunlight must be protected by water-based synthetic latex paints.

Adequate support must be provided where ABS piping is exposed to wind, snow, and ice loading.

Piping passing through wood studs or plates must be protected from puncture by steel nail plates of not less than 18-gauge.

PVC Pipe Protection

PVC does not readily degrade when exposed to sunlight due to natural UV inhibitors present in the material. Short-term exposure of PVC to sunlight during construction is typically not a problem. PVC piping installed outdoors can be painted with a light coloured water-based acrylic or latex paint that is chemically compatible with PVC.

PEX Pipe Protection

PEX tubing is not intended for use outdoors. The tubing must be stored and used in a concealed environment. Some PEX manufacturers produce PEX with varying resistances to ultraviolet light. PEX tubing should not be exposed to ultraviolet light for extended periods of time. PEX tubing can handle ultraviolet light during the installation period; however, you should always consult the manufacturer's specifications.

Note: Plastic piping should be protected from contact with concrete form release oils and foundation emulsions.

Fibreglass Pipe Protection

The effect of ultraviolet light on fibreglass pipe is limited to surface discolouration. Fibreglass pipe degradation is limited to the outer 0.005–0.01" of the pipe. You may protect fibreglass pipe from the ultraviolet rays by painting with a heavily pigmented industrial coating or by coating with an ultraviolet absorbing agent.

Pipe Condensation Protection

Pipes that operate below the ambient temperature of the surrounding air are subject to condensation. The moisture in the surrounding air condenses on the cold pipe surface. This accumulation of moisture may contribute to the corrosion

of the pipe and/or its support. Moisture accumulation can contribute to damages to the surrounding building structure. Mould and bacteria growth can cause visual damage or promote rot in wood structures.

Typical examples of piping subject to condensation include:

- Cold water piping
- Storm and rain water drainage piping leading from roof areas and passing through the heated structure
- Piping installed in cold storage facilities or freezers

Damage caused by this condensation may include:

- Staining of building surfaces
- Mildew and bacterial growth
- Decay of structural components
- Promotion of electrolysis causing damage to pipe and supports
- Oxidation of exterior pipe walls



Figure 14 Condensation on a pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Methods used to prevent condensation include:

- Pipe insulation
- Reduction of moisture content through the use of heat recovery ventilation systems or dehumidifiers
- Use of a vapour barrier to eliminate air infiltration through openings surrounding the pipe

Physical and Mechanical Pipe Damage Protection

There are different sources of damage to pipes, requiring protection.

Steel piping installed parallel to or through wood frame members rarely needs protection from punctures by nails or screws. Plastic and copper tubing, however, is not as robust and therefore needs to be protected from this threat.

Protective prescriptions for gas piping or tubing are laid out in the CSA B149.1 Code for the installation of natural gas and propane systems, but protection of water lines is not really addressed quite as specifically in the plumbing codes. Following the gas code references for tubing protection should ensure adequate protection for water pipe installations.

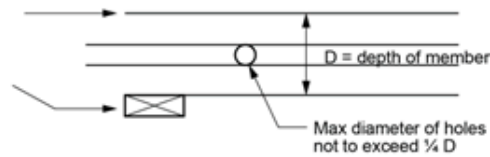
When the tube is installed within joist spaces and parallel to the joists, keep the tube face at least $1 \frac{3}{4}$," (43 mm) above the face of the joist to prevent contact with drywall nails or screws. When run through holes in joists or studs, maintain that same $1 \frac{3}{4}$," (43 mm) distance between the face of the stud or joist and the edge of the tube. If that minimum separation cannot be maintained, use protective plates or sleeve.

Article 9.23.5 of the National Building Code of Canada specifies the permissible notching and drilling of wood framing members.

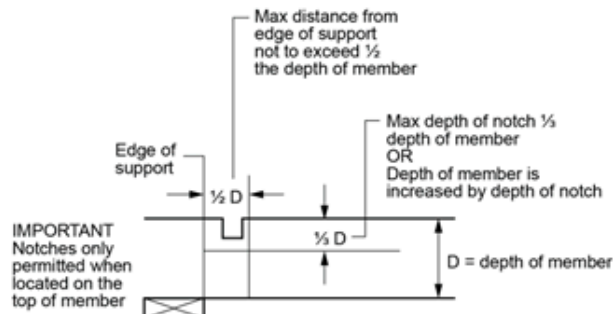
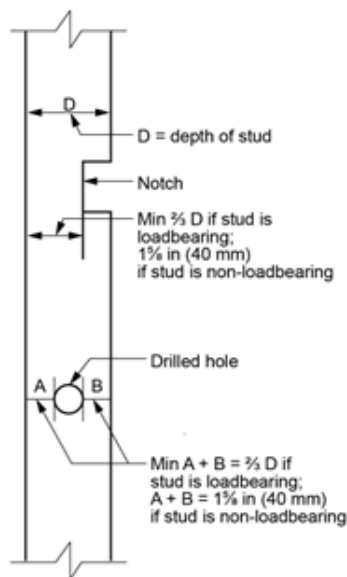
The figures and tables on this page summarize these requirements.

For materials such as concrete and steel, obtain advice from a structural engineer prior to notching or drilling any structural members.

Holes must be located a min of 2 in (50 mm) from edge of member
OR
depth of member must be increased by size of hole



Horizontal Member Size	Maximum Hole Diameter
2 × 4 in (38 × 89 mm)	Not permitted
2 × 6 in (38 × 140 mm)	1 1/4 in (35 mm)
2 × 8 in (38 × 184 mm)	1 1/4 in (46 mm)
2 × 10 in (38 × 235 mm)	2 1/4 in (58 mm)
2 × 12 in (38 × 286 mm)	2 1/4 in (71 mm)



IMPORTANT
Notches only
permitted when
located on the
top of member

Stud	Loadbearing	Non-loadbearing
2 × 4 in (38 × 89 mm)	1 1/4 in (30 mm)	1 1/4 in (48 mm)
2 × 6 in (38 × 140 mm)	1 1/4 in (46 mm)	3 1/4 in (98 mm)

Member Size	Maximum Distance from Edge of Support	Maximum Depth of Notch
2 × 4 in (38 × 89 mm)	1 1/4 in (44 mm)	1 1/4 in (30 mm)
2 × 6 in (38 × 140 mm)	2 1/4 in (44 mm)	1 1/4 in (46 mm)
2 × 8 in (38 × 184 mm)	3 1/4 in (92 mm)	2 1/4 in (61 mm)
2 × 10 in (38 × 235 mm)	4 1/4 in (117 mm)	3 in (78 mm)
2 × 12 in (38 × 286 mm)	5 1/4 in (143 mm)	3 1/4 in (95 mm)

Figure 15 Example from CSA B149.1 Handbook. Used with permission.

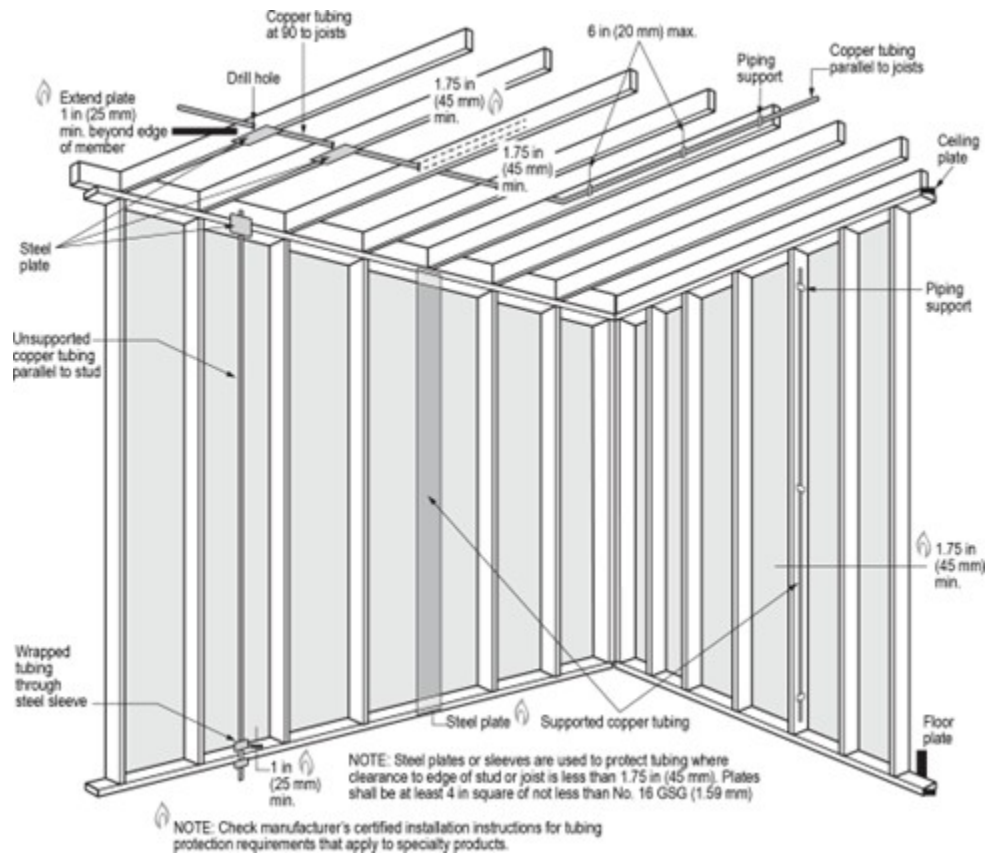


Figure 16 Example from CSA B149.1 Handbook. Used with permission.

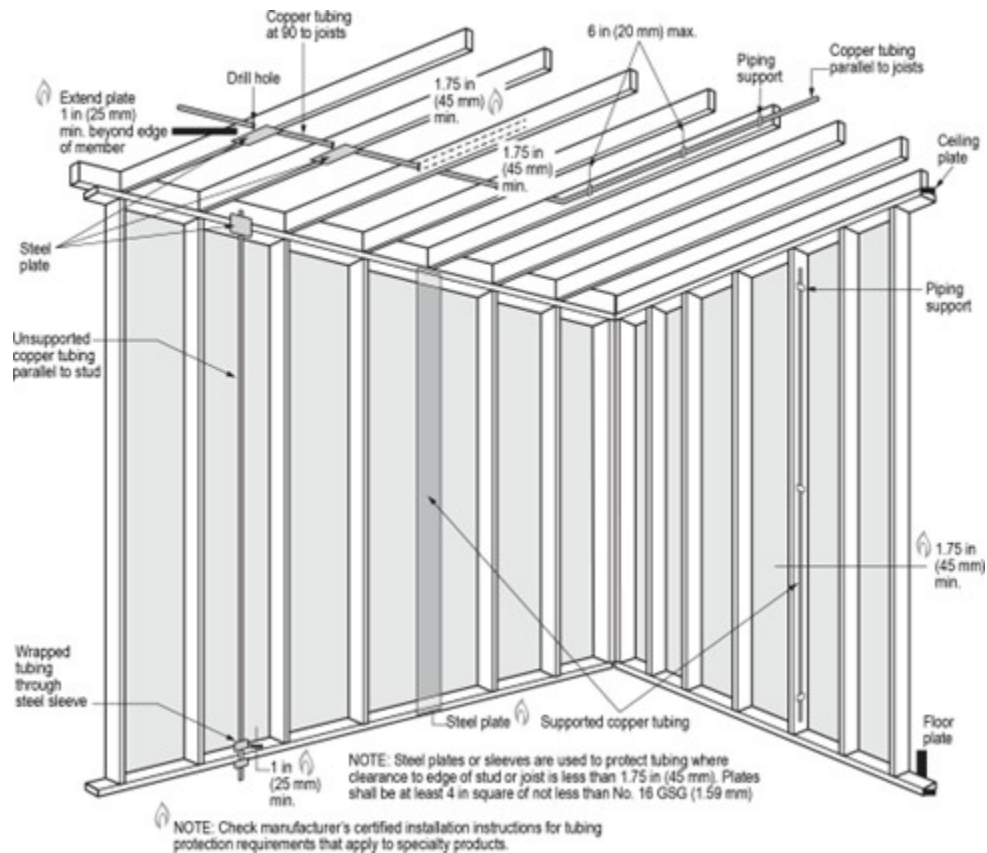


Figure 17 Tubing protection requirement—Example from CSA B149.1 Handbook. Used with permission.

A small diameter pipe run through oversized holes drilled through the centre of 2 x 6 studs usually maintains that minimum separation. Oversized holes allow the pipe to deflect if hit. In drilling the holes, however, make sure to not compromise the structural integrity of the stud. If running piping through a 2 x 4 stud wall, the minimum separation usually cannot be met, so it would require that heavy gauge steel protection plates be attached to the stud face. This method usually causes the drywall to bulge outward at that point, so an alternative method would be to run the pipe or tube through short sleeves of electrical metallic tubing (EMT) that are larger than the water line. The sleeves are meant to be fitted tightly into the drilled holes so they can't fall out, and the pipe or tube must be wrapped with a dielectric such as electrician's tape to prevent galvanic corrosion between the pipe and the pipe sleeves. Also make sure to ream the cut ends of the pipe sleeves to prevent abrasion of the tubing running through them.

Expansion and Contraction of Piping

Pipe expansion and contraction occurs when the piping is subject to temperature changes. The temperature changes can be a result of internal fluid temperature or external temperature caused by the surrounding environment. When piping heats up, it will expand. When piping cools down, it will contract. Continued uncontrolled expansion and contraction of piping can result in damage or failure of the pipe or the components of the piping system.

Damage to the building structure can occur when expanded piping has not been controlled. Uncontrolled expansion and contraction stresses applied to connected appliances and equipment can result in damage. It is your responsibility to recognize the expansion and contraction issues and apply installation practices to control it. Providing proper

clearances from building structural components and the use of piping fittings and piping design layout can effectively limit and control the forces of expansion and contraction.

Expansion Control for Metallic Piping

Manufactured Expansion Joints

Manufactured expansion joints are used to protect metallic piping. There are different kinds.

A single bellows expansion joint is simply a bellows element with end connections. It will deflect in any direction—to keep the pipe and bellows in line, the joint is controlled with pipe guides or anchors.



Figure 18 Bellows-type expansion joint with shipping bars. (Do not remove bars until after installation.) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Slip-Type Expansion Joints

Slip-type expansion joints are used when the primary problem is large axial movement. The design is basically an inside and outside barrel (sleeve), with a mechanical seal between them that slides back and forth as the pipe expands and contracts.

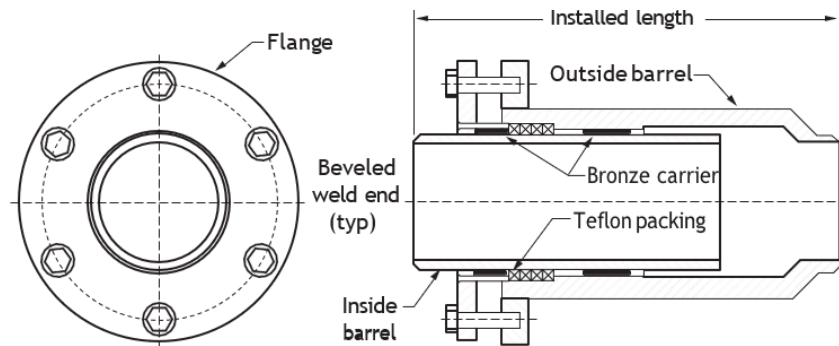


Figure 19 Cross section of slip-type expansion joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Installation Practices for Manufactured Expansion Joints

The following summarizes installation practices for manufactured expansion joints.

- Follow the manufacturer's precautions.
- Inspect for damage during shipment. i.e., dents, broken hardware, water marks on carton, etc.
- Store in clean dry area where it will not be exposed to heavy traffic or damaging environment.
- Use only designated lifting lugs.
- Make the piping systems fit the expansion joint, rather than the other way around.
- Leave one flange loose until the expansion joint has been fitted into position. Make necessary adjustment of loose flange before welding.
- Install joint with arrow pointing in the direction of flow.
- Install single Van Stone liners, pointing in the direction of flow. Be sure to install a gasket between the mating flange and liner.
- With telescoping Van Stone liners, install the smallest ID liner pointing in the direction of flow.
- Remove all shipping devices after the installation is complete and before any pressure test of the fully installed system.
- Remove any foreign material that may have become lodged between the convolutions.
- Refer to appropriate standards for proper guide spacing and anchor recommendations.
- Do not drop or strike the delivery carton.
- Do not remove shipping bars until installation is complete.
- Do not remove any moisture-absorbing desiccant bags or protective coatings until ready for installation.
- Do not use hanger lugs as lifting lugs without approval of manufacturer.
- Do not use chains or any lifting device directly on the bellows or bellows cover.
- Do not allow weld splatter to hit unprotected bellows. Protect with wet chloride-free insulation.
- Do not use cleaning agents that contain chlorides.
- Do not use steel wool or wire brushes on bellows.
- Do not force-rotate one end of an expansion joint for alignment of bolt holes. Ordinary bellows are not capable of absorbing torque.
- Do not hydrostatic pressure-test or evacuate the system before installation of all pipe guides and anchors. Pipe hangers are not adequate guides.
- Do not exceed a pressure test of 1.5 times the rated working pressure of the expansion joint.

Bellows Misalignment

During the installation of the piping systems, the accuracy of the location of equipment, pipe supports, structure, and the piping itself is often not perfect. The expansion joint is usually far more easily deflected than any of these other components. The use of the expansion joint to correct imperfections in piping alignment is not recommended. The expansion joints will arrive from the factory with rigid restraints that maintain their length and ends in the position and dimensions of the specification. Do not remove prior to, or during, installation.

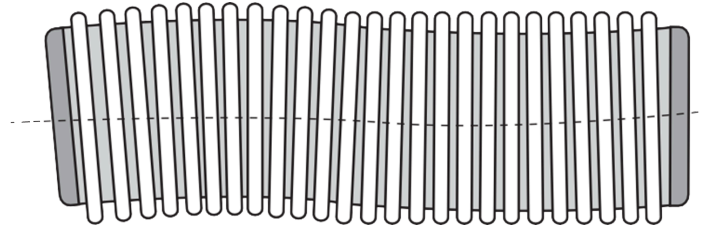


Figure 20 “Bellows squirm” (damage caused by misalignment) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Rubber Expansion Joint

A rubber expansion joint, illustrated:

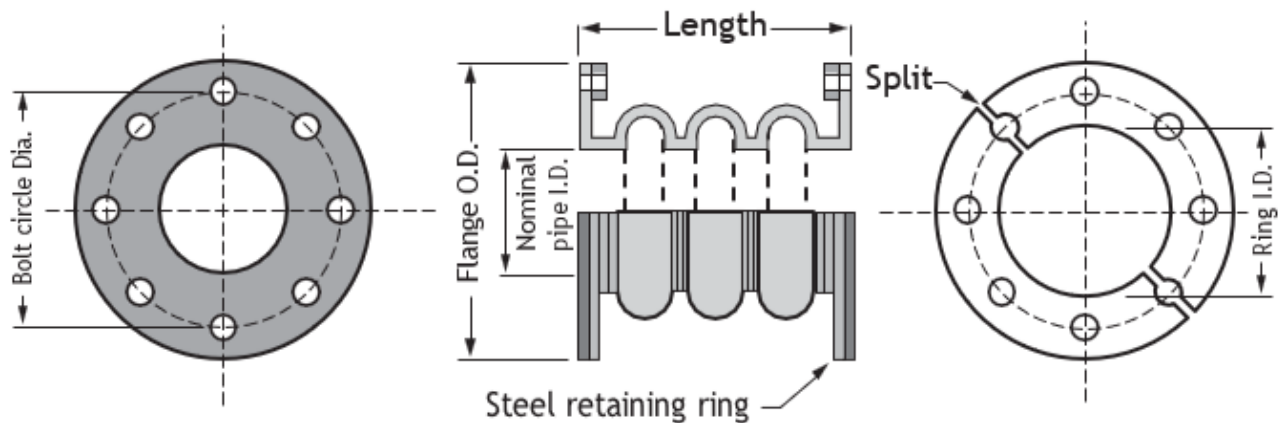


Figure 21 Rubber expansion joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Roller Hangers, Expansion Loops, and Supports

The following illustrations show common roller hangers, expansions loops and supports.

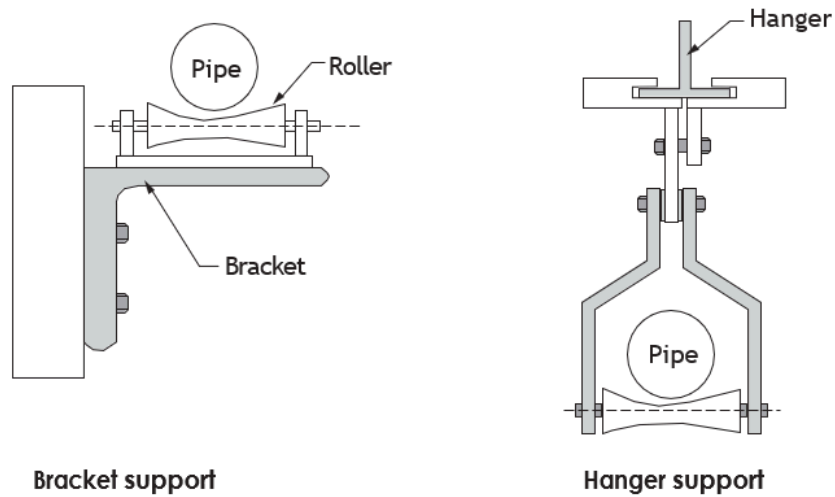


Figure 22 Roller hanger and brackets (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

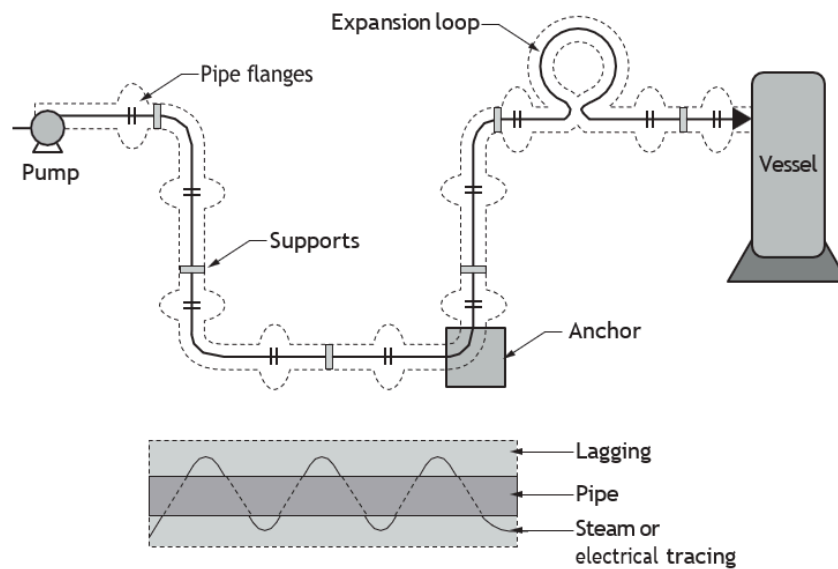


Figure 23 Expansion loop application (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Guides

Pipe guides ensure that the thermal expansion of the pipeline is properly directed into the expansion joint and to prevent buckling of the line. Additional guides located adjacent to the expansion joint are necessary because of the inherent flexibility of the bellows and the compressive loading on the pipe caused by the pressure thrust of the expansion joint.

The first guide must be located within a distance of four pipe diameters from the expansion joint, and the second

guide within fourteen pipe diameters of the first guide. Additional guides should be located in accordance with the manufacturer's guidelines.

In Figure 21, below, two pipe guides allow pipe to move and are kept in line by the large guide sleeve. Sections bolted to pipe keep the pipe centred in the guide sleeve. The guide sleeves are anchored solidly to the building structure.



Figure 24 Pipe guides (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

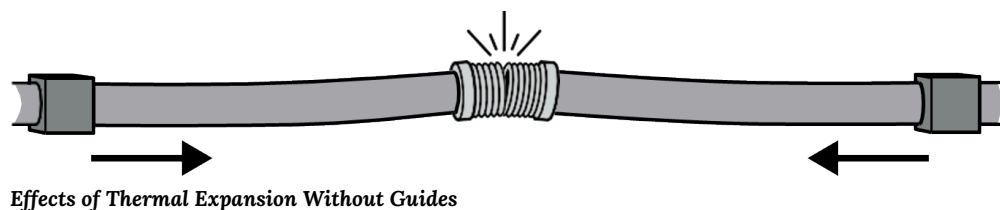
Pipe Guide and Pipe Anchor Placement

Proper pipe guiding is essential to an installation of expansion joints or pipe expansion loops. Properly located pipe guides and anchors keep the pipe in line and reduce or eliminate excessive misaligning forces on the expansion joint.

Guides normally permit axial movement of the pipe, while restraining both lateral and angular movement. Pipe guides support the pipe and guide the pipe expansion.

The location and number of pipe guides and anchors is dependent upon:

- Proximity of the expansion joint to an anchor
- Diameter of the pipe
- Length of the pipe run



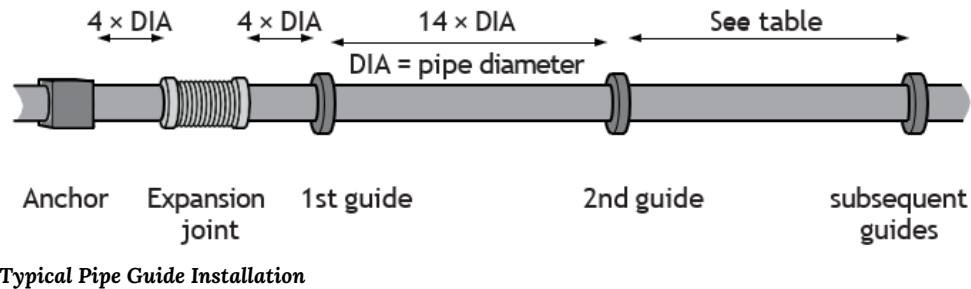


Figure 25 Location of pipe guides and anchors on straight pipe lengths (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 23 shows the placement of pipe guides and anchors for an expansion loop.

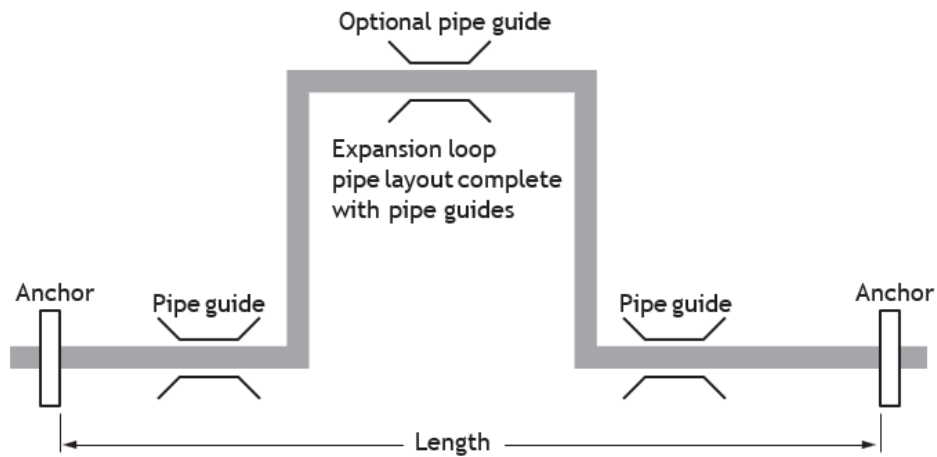


Figure 26 Expansion loop showing typical pipe guide placement and pipe anchor positions (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Offsets and Changes of Direction to Maintain Piping System Flexibility

Piping flexibility is probably the least understood function of piping design. Although not often thought about in residential applications, it's an important application in larger commercial applications, industrial, and process piping. It's preferable to provide adequate flexibility in piping systems by using elbows to create additional changes of directions in the piping layout. Where space is limited or cost considerations apply, manufactured expansion joints may be used. A good expansion design will provide the maximum flexibility using a minimum number of fittings.

As with any pipe expansion provisions, the use of pipe guides to keep the pipe in line and pipe anchors to direct the expansion is required. An anchor placed near the centre of the run will direct expansion by forcing 50% of the expansion to either side of and away from the anchor point. Remember that pipe guides are used to keep the pipe in alignment.

The design of pipe expansion provisions is normally the work of the design engineer. However, as an installer, it's useful to recognize the basic piping design configurations used to provide for pipe flexibility and expansion movement.

Figures 24-27 illustrate the various piping arrangements used to provide flexibility and accommodate expansion in industrial and process piping applications.

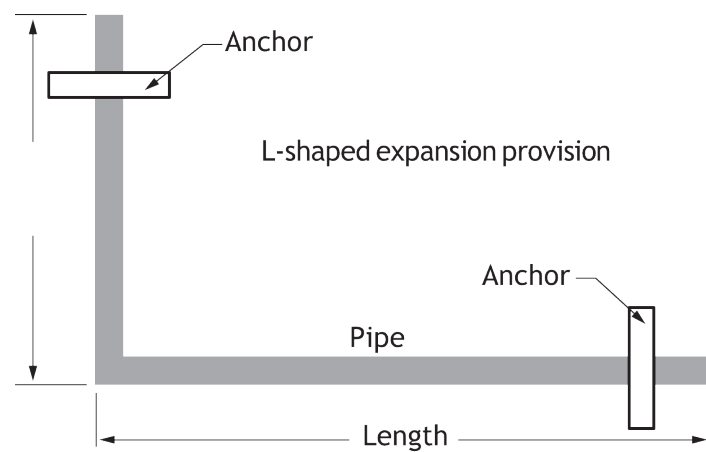


Figure 27 L-shaped pipe configuration provides flexibility (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Design engineers calculate the flexibility and expansion required. They can then design the piping layout and the required dimensions of L and H to accommodate system flexibility and expansion.

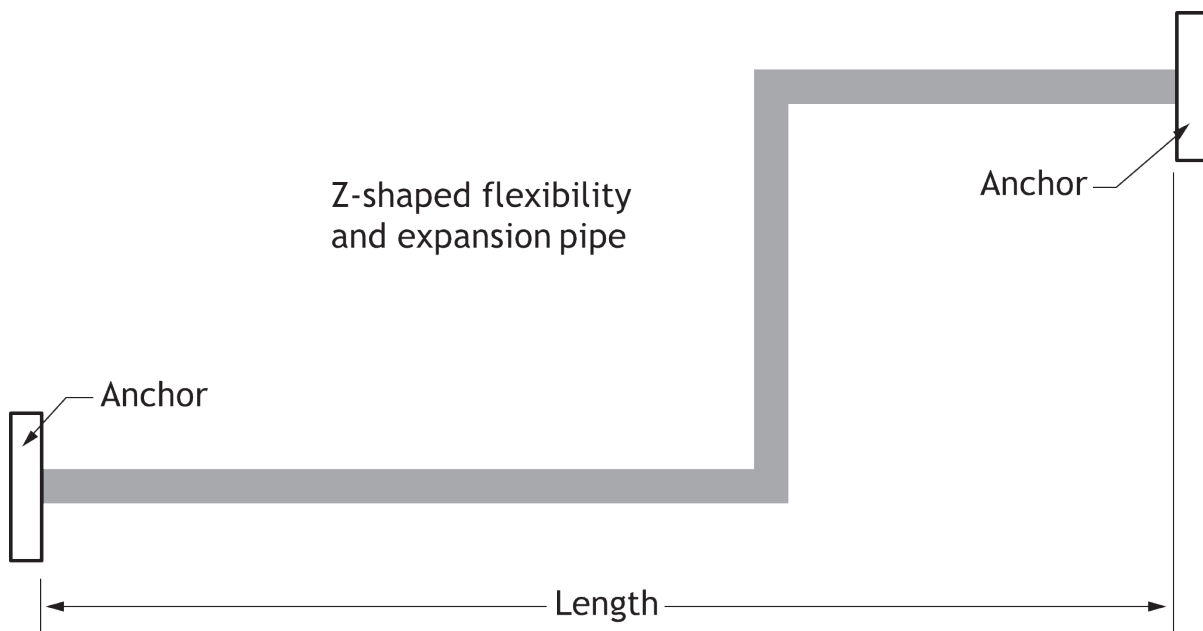


Figure 28 Z-shaped pipe configuration (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

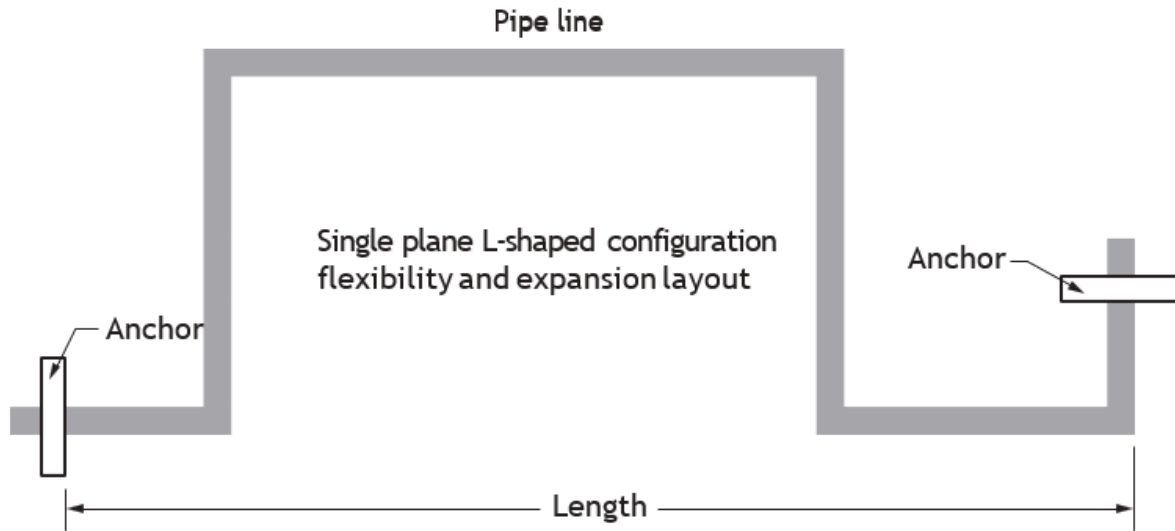


Figure 29 Single-plane L-shaped configuration (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

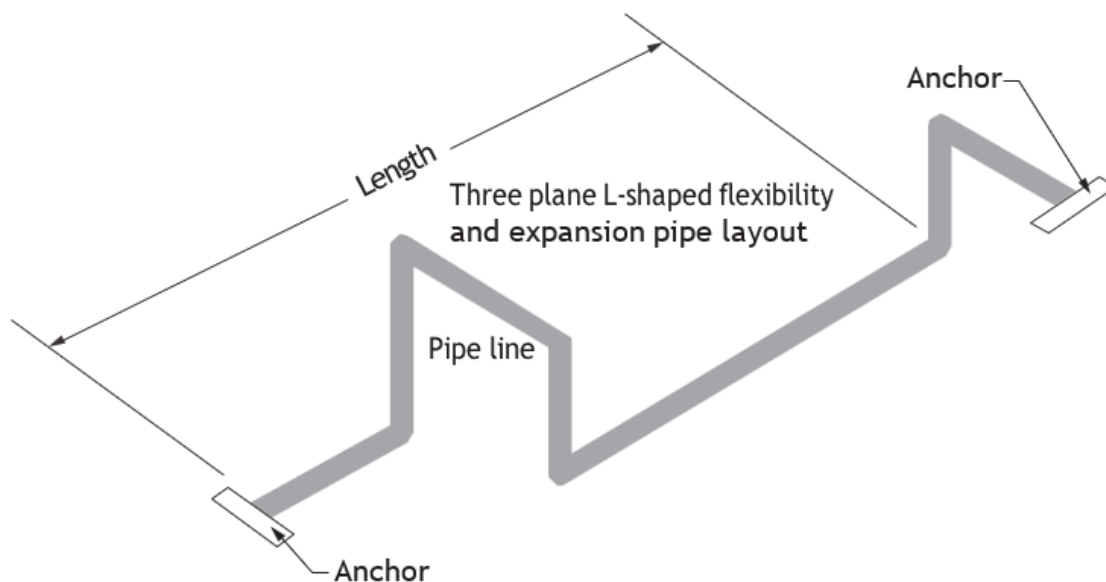


Figure 30 3-plane L-shaped configuration (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Cold Spring in Piping

Cold spring is the allowance made during installation of the piping to accommodate for the final pipe position after expansion has occurred. Cold spring is applied to piping systems for these basic reasons:

- When required by a design engineer's detailed stress analysis
- To maintain adequate pipe spacing in rack, parallel pipe installations

- To prevent visual misalignment with adjacent piping or structure Figures 28–30 show the theory behind cold spring:

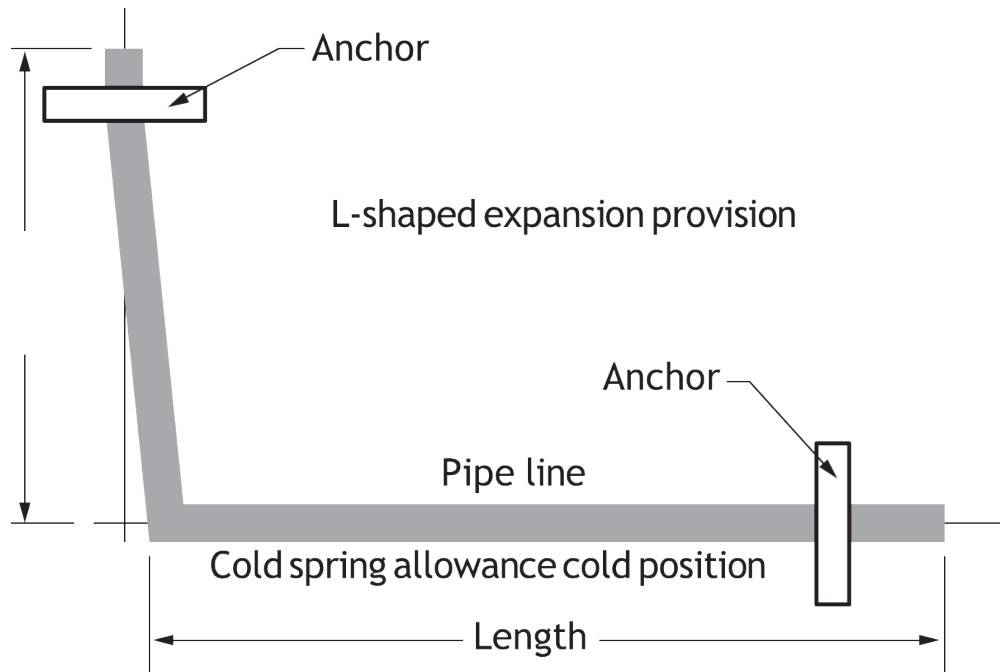


Figure 31 Pipe configuration before expansion (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

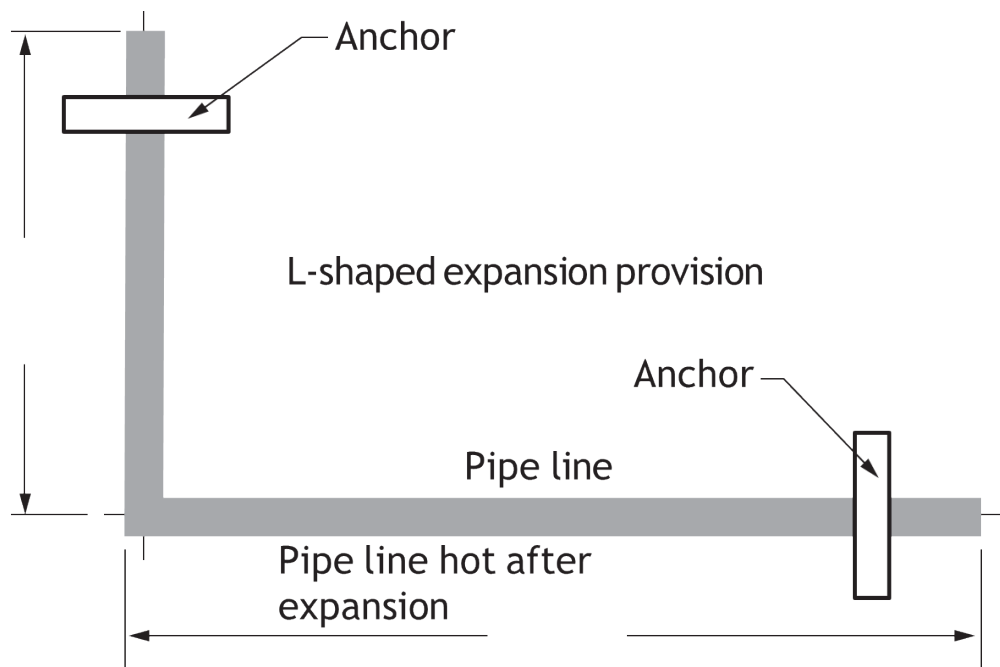


Figure 32 Pipe configuration after expansion (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

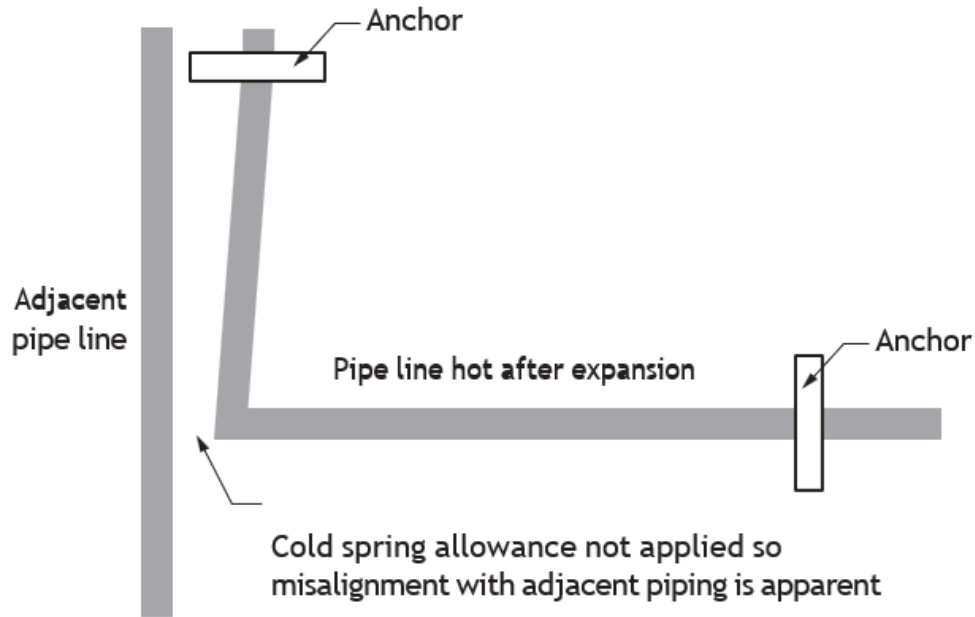


Figure 33 Pipe configuration after expansion if cold spring allowance is not made (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Piping Fittings that Provide Provisions for Expansion Within Piping Systems

Various types of plumbing and piping fittings that have flexible joints can reduce the stresses of pipe expansion. Fittings designed for joining grooved fittings and pipe use flexible composite rubber seals that, when clamped to the pipe, provide some degree of movement. Typical brand names include Victaulic, Groove Lock, and Press Fit.

Flexible Mechanical and Grooved Type Joints

Flexible mechanical joints can be used in expansion loops without inducing stress in pipes, elbow, or joints. These flexible couplings and fittings have the ability to allow thermal expansion and contraction to be absorbed at elbows and fittings. Pipe configurations can be reduced in size when using these types of fittings (Figure 31).

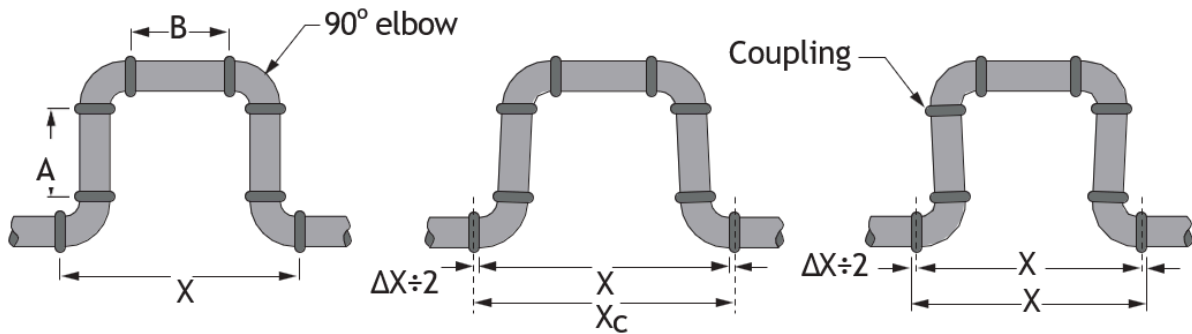


Figure 34 Pipe configuration using flexible fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 35 Flexible grooved pipe coupling (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 36 Limited flexibility grooved pipe coupling (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 37 Flexible soil pipe coupling
(BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
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Swing Joints and Spring Pieces

Swing joints are piping configuration that allow for flexibility, expansion and contraction. The piping configuration for a swing joint includes the use of a minimum of three elbows, as well as a change

in direction and plane. Swing joints are used when connecting equipment such as heat transfer units, gas utility meters, irrigation heads and so on. Swing joints can align piping to the attached equipment and ease the stresses and strains on the equipment connection point.

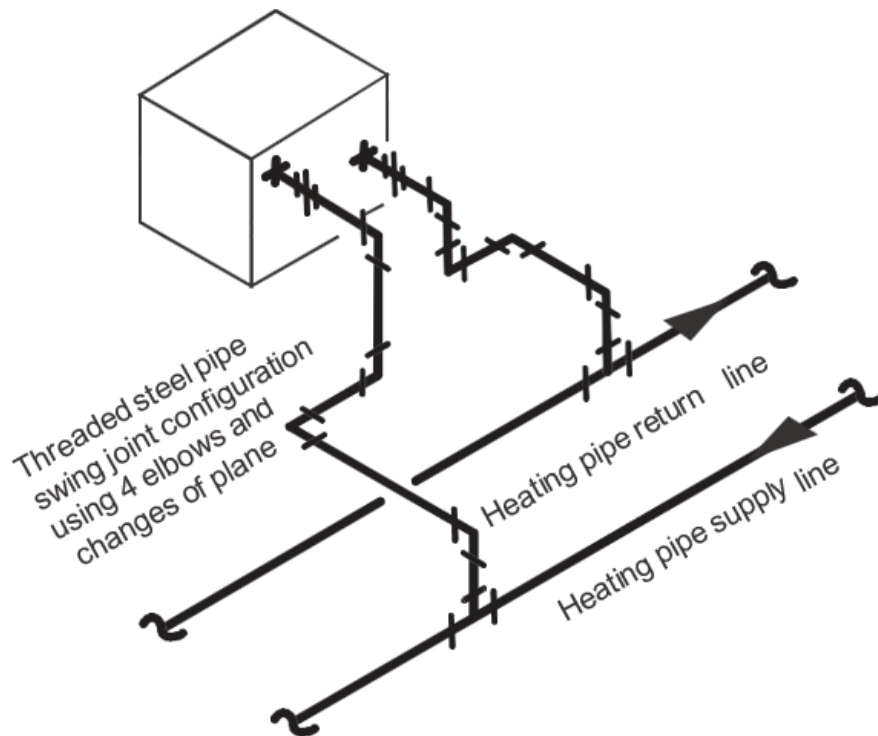


Figure 38 Swing joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
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Spring Pieces

Spring pieces are section of pipe that, because of their size, length and material, can flex, dispersing any forces and strain along their length. Anchors may be required to reduce stresses on connected equipment. Swing pieces can be applied when fitting joint methods that do not provide flexibility or movement, such as soldered, brazed, or welded fittings.

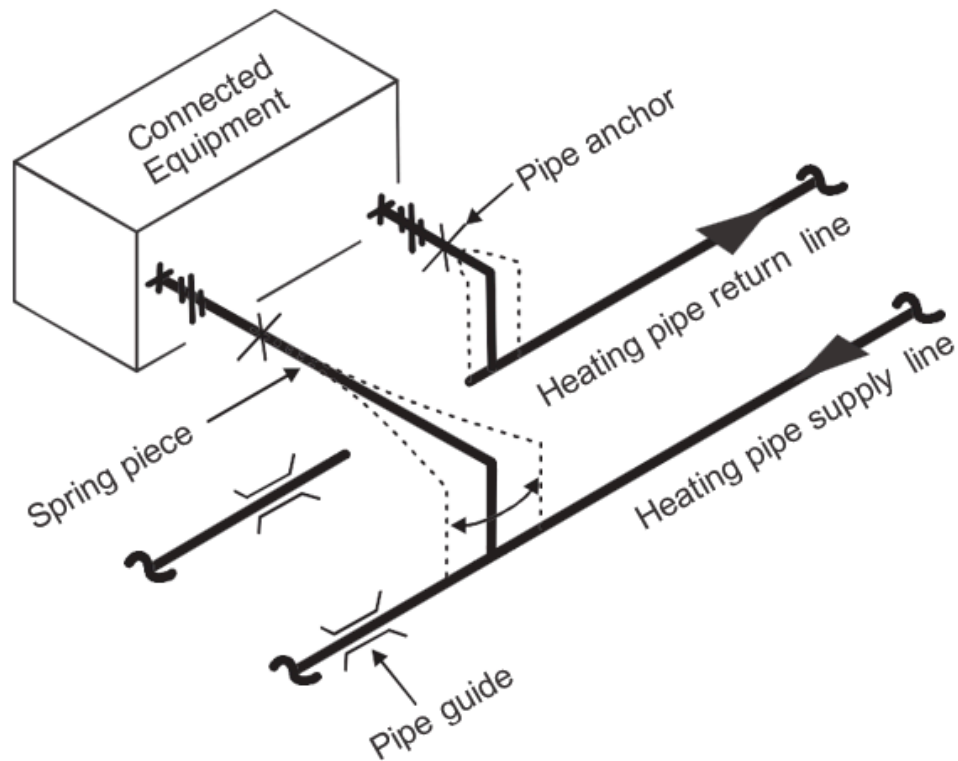


Figure 39 Spring piece (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

ABS and PVC Plastic Piping Expansion Protection

Expansion within ABS and PVC piping systems is an important issue. Hot and cold wastewater flowing in plastic piping causes the plastic pipe to expand and contract. In residential wood-frame construction, there is often shrinkage of the wood-frame itself. This shrinkage will cause stress on the ABS pipe if it has been rigidly attached to the structure.



Figure 40 ABS expansion joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

ABS DWV and PVC piping has a relatively high rate of expansion when exposed to heat. The linear expansion of ABS is approximately 13 mm ($\frac{1}{2}$ ") for each 5°C (10°F) change for each 30 m of pipe (100'). ABS piping is often controlled by the naturally occurring piping offsets and changes of directions in a residential building. ABS expansion joints are typically applied in residential applications when a vertical ABS drainage pipe passes through two floor levels. Vertically installed expansion joints will also provide for naturally occurring shrinkage in wood-frame structures.

Failure to allow for expansion, contraction and shrinkage may result in:

- loss of pipe slope
- pipe bowing
- stress breakage of fittings
- noises caused by plastic piping rubbing against the building structure

Placing ABS drainage piping in walls other than living rooms, dining rooms, studies and video viewing rooms is a good practice.

Guidelines for Installation of ABS Drainage Waste and Vent Piping

Thermal expansion and contraction of plastic drain waste and vent systems must be taken into consideration. Thermal expansion and contraction may be controlled with several methods, including:

- installing expansion joints on vertical ABS drainage pipe
- installing structural penetrations (holes) so they are large enough to provide free movement of the pipe without binding
- providing adequate support without rigidly restraining piping at changes of direction
- designing appropriate changes in piping direction, or offsetting the pipe

PVC Expansion Joint Installation

The travel of expansion joints is typically up to approximately 75 mm (3"). Set the expansion joint approximately mid-point of its full travel. Make sure that the expansion joint is anchored at one end and that the upper piping is guided

to maintain straight alignment with the expansion joint. Failure to guide the pipe straight into the expansion joint can result in leakage of the joint. PVC expansion joints are typically placed close to the base of vertical stacks of drainage systems in residential applications. The seal is maintained by lubricated internal O-rings.



Figure 41 Installed PVC expansion joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Dielectric and Cathodic Corrosion Protection

Electrochemical corrosion occurs when two dissimilar metals are in contact with each other in a moist environment. Although this can happen anywhere, it's especially problematic for buried pipe. One metal becomes a **cathode**, and the other (usually the pipe) becomes an **anode** that corrodes and develops a leak. **Cathodic protection** reduces corrosion by forcing the pipe to act as the cathode. It is your responsibility to ensure that **dielectric (cathodic) protection** of pipe is used.

Cathodic Protection Applications

Cathodic protection systems are used to protect a wide range of metallic structures in various environments, including:

- Steel water or fuel pipelines
- Storage tanks such as home water heaters
- Steel pier piles, ship and boat hulls

- Offshore oil platforms
- Onshore oil well casings
- Metal reinforcement bars in concrete buildings and structures

Corrosion is the deterioration of metal pipe. Corrosion can be caused by an electrical reaction between the metallic pipe and its surroundings. As a result, the pipe deteriorates and may eventually leak. Although corrosion cannot be eliminated, it can be substantially reduced with cathodic protection.

All metals have a unique voltage stored within them. When two different metals such as copper and steel are connected together, the voltage difference between them will cause a DC electric current (electrons) to flow from the higher voltage to the lower.

Buried Piping Corrosion

Dissimilar soils create an environment that enhances corrosion in buried pipelines. The chemical makeup of the soil and the moisture present allow the soil to become a path for electrons to travel from the negatively charged area of a pipe (anode) to a positively charged area of the pipe (cathode). The movement of electrons away from the anode causes the pipe to corrode.

Definition of Terms

corrosion: The gradual destruction of material, usually metals, by chemical reaction with its environment. Typically, it refers to the electrochemical reaction with an oxidant such as oxygen.

electrochemical reaction: A reaction either caused or accompanied, by the passage of an electric current and involving the transfer of electrons between two substances.

electrode: An electrical conductor used to make contact with a part of a circuit. In an electrochemical cell, the electrode is referred to as either an anode or a cathode. Each electrode can be either the anode or the cathode depending on the current direction.

anode: A metal through which current flows. (In an electrochemical reaction, the anode is the metal that corrodes.)

sacrificial anode: A metallic anode intended to be dissolved to protect other metal components.

cathode: A metal from which current flows.

cathodic protection: A method used to control the corrosion of a metal surface by ensuring that the metal is the cathode in an electrochemical process. Normally, this process requires attaching or connecting the metal to a less-noble metal.

dielectric: A substance with a small amount of electrical conductivity.

disbondment: The separation of a protective coating from a pipe's surface. Disbondment is accelerated when cathodic protection systems are operated with excessively polarized negative potentials, especially in systems operating at high temperatures.

rectifier: An electrical device that changes alternating current (AC) into direct current (DC). This current is then impressed on an underground metallic piping system to protect it against corrosion.

stray current: The portion of a current that flows over a path other than the intended path. There are two types of stray current: direct current (DC) and alternating current (AC). Stray currents found in the ground and in water promote corrosion of piping and metal components.

noble: Possessing outstanding qualities.

galvanic series: A list that indicates the relative stability of different metals and alloys in seawater, based on the measurement of corrosion potentials.

It's important to note the rank of metals and alloys from least to most noble because when pairs of these metals are in contact with each other, the least noble one (i.e., the one highest on the list) will act as the anode, the metal that corrodes in an electrochemical reaction. Since magnesium and zinc are at the top of the list, they make very good sacrificial anodes.

In order for corrosion to occur, there must be four elements present:

- Electrolyte
- Anode
- Cathode
- A complete circuit

Corrosion will occur at the anode.

Methods of Cathodic Corrosion Protection

There are two basic methods of cathodic protection:

- Passive galvanic anode system
- Impressed current system

The simplest method of cathodic protection is to connect the protected metal with a sacrificial metal that acts as the anode in the electrochemical cell. The sacrificial metal corrodes instead of the protected metal.

Passive Galvanic Anode System

Anodes are usually installed near the pipe and connected to the pipe with an insulated conductor. They are sacrificed (corroded) instead of the pipe. Anodes are “sized” to meet the electrical current requirements of the soil. Anodes are made of materials such as magnesium (Mg), zinc (Zn), or aluminum (Al).

Galvanized (zinc) coatings used on pipe are durable in most environments and can provide a small localized degree of electrochemical corrosion protection. The zinc acts as the sacrificial anode, but only in the immediate location.

A proper corrosion protection system requires a sacrificial anode separate from the protected metal but connected by cables. This protects the entire system rather than just a localized section of pipe.

Galvanic Passive Anodes

The sacrificial anode consists of a bag containing either magnesium or zinc ingot and other chemicals and is connected by wire to an underground metal piping system. It functions as a battery that induces a direct current on the piping system to retard corrosion.

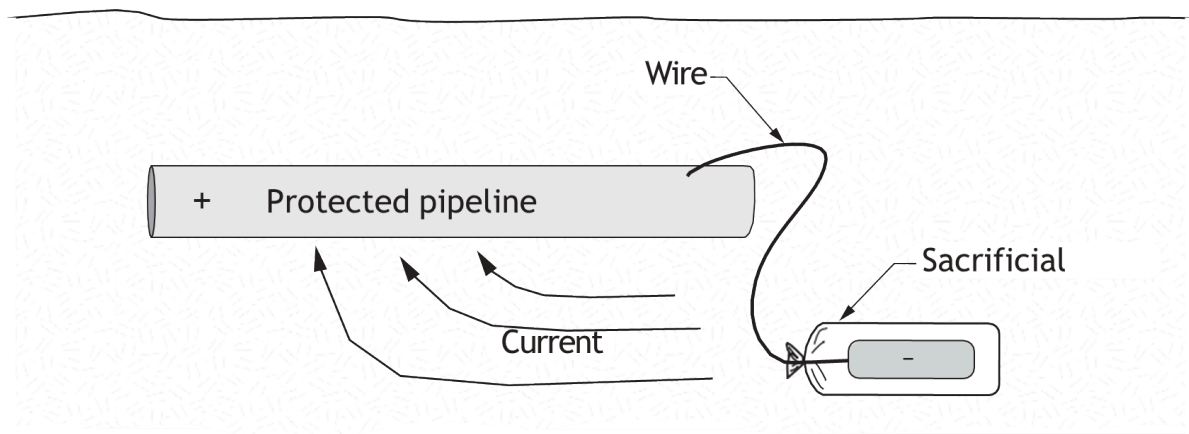


Figure 42 Sacrificial anode (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Impressed Current Systems

For structures where passive galvanic corrosion protection is inadequate (e.g., long pipelines), an external DC electrical power source is used to provide current. This direct current is induced onto the pipe by means of a rectifier.

These systems are normally used along transmission pipelines where there is less likelihood of interference with other pipelines. Anodes made of corrosion-resistant material such as graphite, high-silicon cast iron, lead-silver alloy, platinum, or scrap steel are used to disperse the electric current. The DC rectifier will typically have a DC output of between 10 and 50 amperes and 50 volts, depending on the system requirements.



Figure 43 An air-cooled cathode protection rectifier connected to a pipeline (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

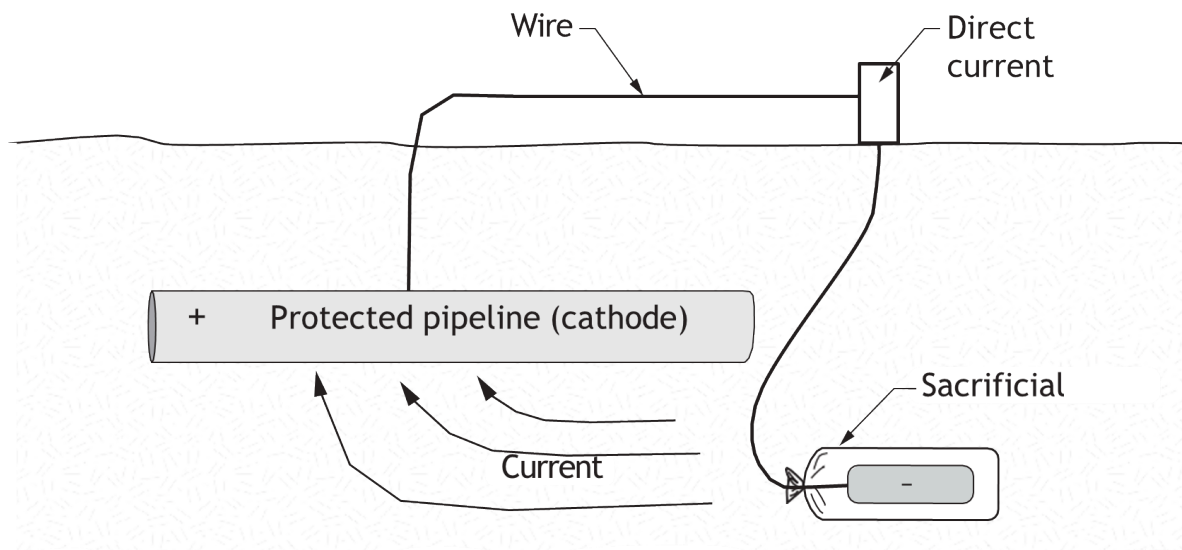


Figure 44 Impressed current system (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Impressed Corrosion Protection Installation

The rectifier is connected by a cable to the anodes in the system. The other negative cable of the rectifier is connected to the pipeline.



Figure 45 Thermo weld tool with mold (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Anodes for cathodic protection system are often placed in a vertical hole or trench and then backfilled with conductive materials that improve the performance and life of the anodes. Installation factors also include the location and soil resistivity.

Figure 42 shows the equipment used to attach the anode wire to the pipe using the thermite weld method.

A flint striker gun must be used to ignite the starting powder. This will ignite the copper oxide flakes of the weld powder. The heat from the burning powder fuses the copper wire to the pipe. When the weld has cooled, the mold is removed and any exposed metal is coated with protective mastic.

Rectifier Safety

Rectifier safety is a concern to those who are responsible for rectifier installation, maintenance and repair. Rectifiers should be installed in compliance with appropriate electrical codes and the manufacturer's instructions. Advances in rectifier design include safety features such as touch-safe features, advanced microprocessor technology, electronic fusing, and multiple access doors.

Stopping Galvanic Corrosion with Dielectric Fittings

Dielectric fittings are specialty fittings used to connect two dissimilar metals together. Without them, electrolysis can damage the weaker pipe.

Dielectric fittings are generally installed above ground to provide electrical isolation in piping systems. They can control stray electrical currents and cathodic protection current, and prevent the occurrence of dissimilar metal corrosion. Piping systems with a cathodic protection current should be regulated to follow a specific electrical path. The installation of dielectric unions is a method for electrically isolating cathodically protected piping systems.



Figure 46 Dielectric union (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

To prevent electrolytic corrosion in dissimilar piping connections, dielectric unions and fittings are used. The dielectric fitting prevents contact between the dissimilar metals interrupting the electric current that would otherwise cause corrosion.

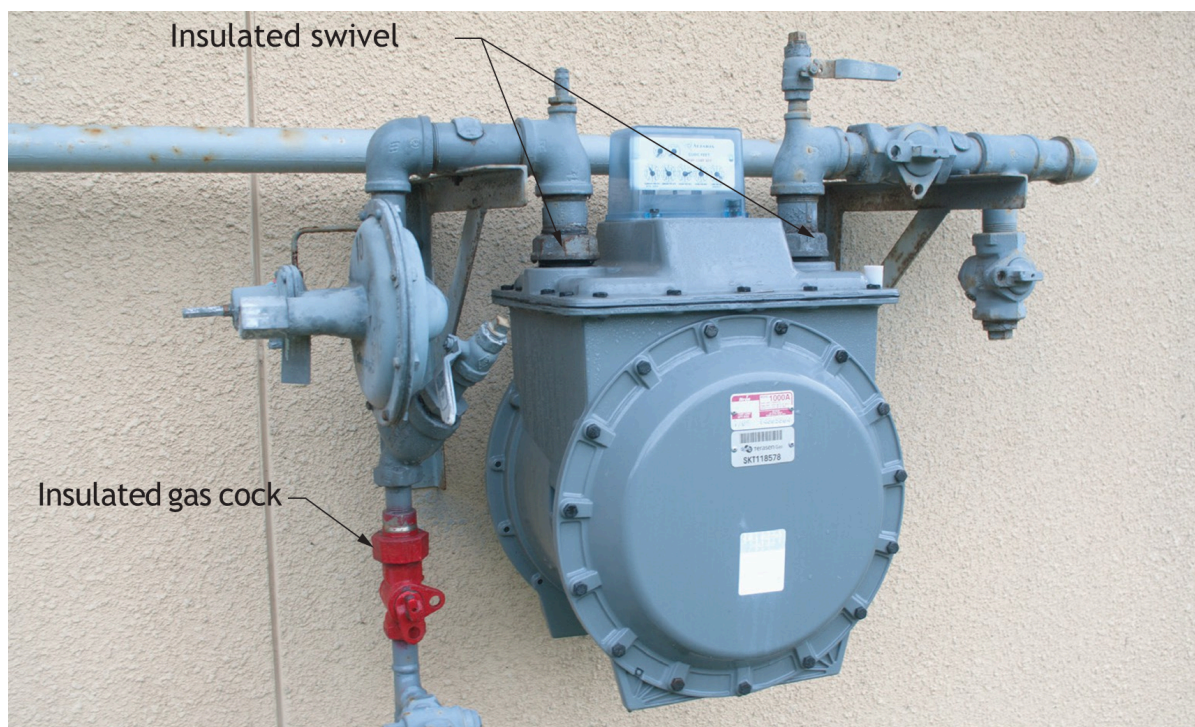


Figure 47 Gas meter installation showing where dielectric fittings can be installed (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Underground storage tanks and their piping must be electrically isolated from any dissimilar buried metal piping.

Dielectric unions can be made of various metals, such as malleable iron or forged steel, which is either galvanized or black-metal coated.

Dielectric Flange

The **dielectric flanged pipe fitting** shown in Figure 45 is installed between pipes of dissimilar metal, in this case copper tube and steel pipe. The flange has an isolative gasket and bolt isolative bushings. It effectively interrupts the electrical current flow that causes corrosion.



Caution: Metal piping in buildings is grounded according to *Electrical Code* requirements.

When a dielectric fitting is installed, it interrupts the grounding safety provided by the grounding connection. This creates a dangerous situation in the remaining piping system downstream of the dielectric fitting.

Additional piping system grounding (bonding) is required, in accordance with the *Electrical Code*.



Figure 48 Dielectric flange fitting (Image courtesy of Watts). Used with permission.

Marine and Ship Cathodic Protection

In the marine and ship industry, cathodic protection is applied to shipboard piping systems and also the ship hull itself. Galvanic anodes are attached to ship hulls rather than impressed cathodic protection. Anodes are removed and replaced as regular ship maintenance. Smaller craft boats with non-metallic hulls also use galvanic anodes. However, an electrical conductor connection between the anode and the protected equipment is required.

Water Heater and Water Connections



Figure 49 Gas water heater tank
https://commons.wikimedia.org/wiki/File:Rheem_home_gas_water_heater_tank_-_newly_installed.jpg (Tim Evanson/Wikimedia Commons) CC BY-SA 2.0
<https://creativecommons.org/licenses/by-sa/2.0/deed.en>

Hot water storage heaters come equipped with internal sacrificial anodes, which should be inspected at regular intervals, as recommended by the manufacturer—typically once a year. Hot water storage heaters can also come with plastic-lined connection pipe nipples. These pipe nipples serve as a dielectric connection to the tank. If the hot water storage heater is equipped with a sacrificial anode and dielectric nipples that provide cathodic protection, then dielectric unions aren't needed.

Precaution must be taken to not melt the plastic in the pipe nipple when making a soldered connection to copper piping.

Stray Electrical Currents and Pipe Corrosion

The third prong on a standard electric plug is the grounding pin. This grounding pin is a safety component that protects the user from shock in the event of a fault in the tool or equipment. The grounding circuit will dissipate any electrical voltage to an earth-to-ground-rod located in the building's electrical system. This voltage is dissipated into the ground. The electrical system circuitry itself includes a neutral conductor that is connected at the service panel to the earth-to-ground-rod system. Typically, there is always some small current flow in the earth-to-ground-rod



Figure 50 Dielectric pipe nipple with plastic lining
 (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
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connection. These stray currents can cause in-ground metal piping systems to suffer from accelerated rates of electrolytic corrosion. Any assessment of passive or impressed protection must consider this increased corrosion.

Stray electrical currents and voltages are expected in existing piping systems when the metal piping system is grounded (Figure 51).



Figure 51 Stray current accelerating corrosion of a copper pipe

Protective coatings on the buried pipe help reduce corrosion of in-ground piping. Pipe tape insulation, either on the hanger or around the pipe, can eliminate current flow and prevent corrosion.



Figure 52 Pipe support with isolative capability

Safety Issue with Stray Electrical Currents

Stray current is any voltage or current other than what you are expecting. For example, you would not expect a shock from a pipeline from which you have just removed a valve.

Electrical shocks have been documented when service personnel have removed valves, water meters, and other components. To reduce the possibility of shock from these piping systems, install a jumper cable from the pipe to a

proper earth ground. This is especially important if the piping system is serving as a pathway for stray current back to the building ground rod.

When a grounding system has been removed or improperly installed, the possibility for shock injury is increased. An individual touching an ungrounded metal piping system will become the conductor for any stray currents. The potential for shock is high. The intensity of the shock depends on a number of conditions including the stray current voltage, amperage, conductivity of the individual, and moisture. Always install a temporary jumper ground.

Field Test for Stray Voltage

There are standard test procedures for detecting stray currents and voltages. These tests should be carried out by a qualified electrician and are not part of this competency.

A quick check for your own safety should be completed with a multimeter with milliamp capability. A common **electrical tester pen** will also work.

In a properly grounded system, you should not see electrical currents higher than a few milliamps, and the voltage should be less than 10. If you have any doubt, or suspect stray current, contact a qualified electrician.

Water Treatment Pipe Protection

Pipe systems used in hot water heating or steam heating are often treated to avoid pipe corrosion and for greater efficiency.

Pure water (H₂O) is tasteless, odourless, and colourless in its pure state. However, pure water is very uncommon—natural waters contain various impurities. If not treated, these impurities can form deposits on heat transfer surfaces in boilers and heating piping.

Untreated boiler water may cause the following:

- Metal corrosion
- Reduced heat transfer rates, leading to overheating and loss of mechanical strength

Typical Impurities Found in Water

pH: This is a measurement of the acidity or alkalinity of a substance. You may need to adjust the pH level of water in a hydronic heating system by adding an acid to stabilize a condition that is too alkaline or by adding a base (alkali) if the solution is too acidic. Hot water boiler manufacturers normally suggest a solution that is very mildly alkaline (pH of approximately 7.8) rather than neutral (pH of 7) to prevent corrosion caused by acidic water.

Dissolved solids: These are substances that will dissolve in water. The principal ones are the carbonates and sulphates of calcium and magnesium, which are scale-forming when heated. There are other dissolved solids, which are non-scale forming. In practice, any salts forming scale within the boiler should be chemically altered so that they produce suspended solids, or sludge, rather than scale.

Suspended solids: These are substances that exist in water as suspended particles. They are usually mineral or organic in origin. These substances are not generally a problem as they can be filtered out.

Dissolved gases: Oxygen and carbon dioxide can be readily dissolved by water. These gases are aggressive instigators of corrosion.

Scum-forming substances: The use of water softeners, iron filters, UV-sterilization and other water treatment devices may be necessary in order to correct any conditions that are undesirable for the water's intended use. Mineral impurities that foam or scum: usually soda in the form of a carbonate, chloride or sulphate.

Corrosion in Fire Sprinkler Systems

Wet and dry fire sprinkler systems are primarily composed of metal pipe, water, and trapped or compressed air. Any environment that has oxygen, metal, and untreated water in prolonged contact with each other is subject to corrosion (i.e., rust). Bacteria and other corrosion mechanisms can accelerate existing corrosion in fire sprinkler systems.

Microbiologically Influenced Corrosion

Microbiologically influenced corrosion (MIC) is an **electrochemical process** involving bacteria that can accelerate previously occurring corrosion in both wet and dry fire sprinkler systems. MIC always involves bacteria but does not occur by itself. In recent years, thin-wall piping has been introduced, so the effects of corrosion appear more quickly.

Oxygen corrosion is also common in fire sprinkler systems. Evidence of high corrosion exists especially at the air/water interface at high points in the fire sprinkler system where air accumulates.

The prevention of sprinkler pipe corrosion is becoming a major issue in this trade.

Corrosion Indications in a Fire Sprinkler System

Pinhole leaks can be caused by a variety of corrosion mechanisms but are most often attributed to microbiologically influenced corrosion.

To prevent corrosion in fire sprinkler systems:

- Complete an assessment of the system to determine if a corrosion situation exists
- Treat the system with water treatment chemicals
- Install air vents to remove oxygen

Chemical Treatment

Portable chemical injection systems can be used for injecting corrosion inhibitors into fire sprinkler systems to prevent corrosion caused by MIC.



Figure 53 Portable injection pump for a fire sprinkler system (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Removing Air (Oxygen)

Air removal means are used to reduce corrosion in a fire sprinkler system.



Figure 54 Air vent for pressurized fire sprinkler system (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

An **air vent** will reduce the amount of air trapped in a pressurized fire sprinkler system. Reducing the amount of air reduces the effects of oxygen corrosion. Air vents should be installed at the collection point for air in the high points in the sprinkler system.

Internal Protection Using Chemical Treatment

Chemicals used in fire sprinkler systems should be environmentally safe. One example of a chemical that is designed specifically for fire protection systems is Potter's Pipe-Shield®, a patented, biostatic, environmentally friendly corrosion inhibitor. This pipe shield protects wet, dry, and pre-action fire sprinkler systems from both microbiologically influenced corrosion and oxygen corrosion, and is completely nonhazardous and biodegradable, with a neutral **pH**. It does not contain biocides and pesticides commonly used to control or kill bacteria, so it is safe for the environment.

Protection of Buried Pipe Against Flotation Damage

Pipe buoyancy must be considered whenever there is a risk of **flotation**. When the **water table** is above the bottom (invert) of the pipe, the surrounding water creates an upward (buoyant) force. This force is equal to the weight of the water displaced by the pipe. If the upward force is greater than the combined weight of the pipe and its contents, the pipe will float.

Conditions that can lead to a pipe floating out of a trench include the following:

- Pipelines installed in ground with a high water table or where flooding is a possibility
- Pipelines installed under lakes, oceans, etc.
- Flooding of trench before and after backfilling

To avoid flotation buoyancy of pipe, proper installation and/or anchoring of the pipe are critical. The uplift buoyancy of a buried pipeline depends upon the:

- Weight of the pipe material
- Weight of the volume of water displaced by the pipe
- Weight of the liquid load carried by the pipe
- Weight of the backfill material
- Specific gravity of the pipe material and the volume of water displaced

When considering the buoyancy of sanitary and storm lines, you must first determine buoyant force when the pipe is empty, which is when the buoyant force would be the greatest.

To prevent flotation, proper installation and/or anchoring is required. Methods may include:

- Adequate backfill
- Concrete weights or collars
- Ground screw anchors

Flotation Buoyancy Protection Methods

The weight of backfill material is usually sufficient to prevent uplift of piping and hold the pipe in the ground. When backfill alone is not heavy enough, additional methods such as concrete weights or ground screw anchors can be used. Weights such as concrete collars of sufficient size and weight can be positioned on the pipe to prevent flotation. The pipe can also be strapped to concrete pads placed in the trench.

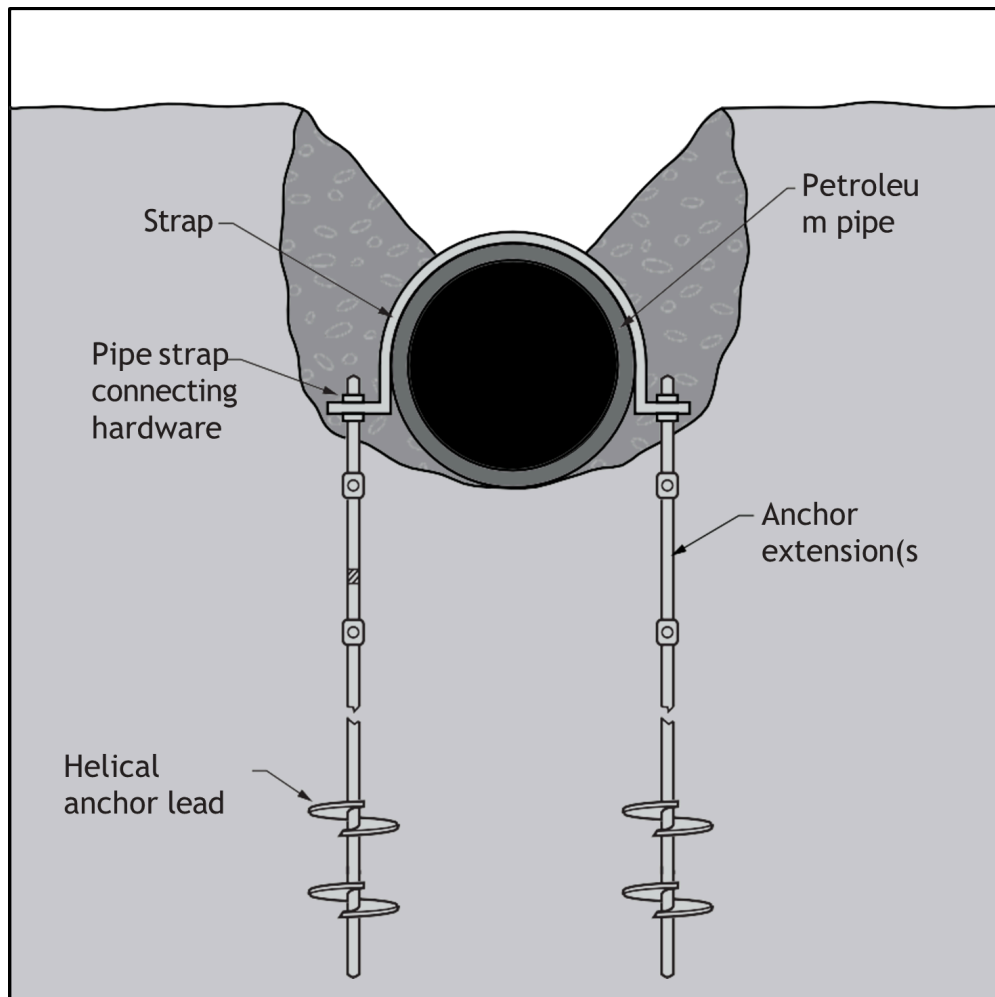


Figure 55 Buoyancy-restraint screw anchor system on an oil pipeline (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Flotation Protection During Trench Installation

Piping installed in a trench often has to be inspected before backfilling. Proper bedding is required, and the pipe is tested under pressure for leaks. The tests may include pressurizing with air, inert gas and/or water. The pipe cannot be completely backfilled and must be left visible for inspection for a period of time. During this time, the exposed trench might be inundated with groundwater or rainfall runoff. Buoyant upward forces on the pipe may be sufficient to lift the pipe out of the bedding materials. When pipe grades are disturbed, the pipe must be repositioned, which can be costly. Pipe flotation restraint may be accomplished simply with adequate backfill. In cases where adequate cover cannot be achieved, alternate methods for restraining the pipe are available.

To reduce the chances of pipe flotation, it may be acceptable to partially backfill portions of the piping with enough weight to resist flotation before inspections are completed. You should consult with the authority having jurisdiction before backfilling prior to inspection.

Buoyancy of Other Underground Equipment

Buoyancy also applies to storage tanks installed below ground; for example, septic tanks before they are filled with water and underground gasoline and oil storage tanks. Septic tanks should be filled at the time of installation if flotation is a concern. Underground storage tanks are normally braced against flotation buoyancy using in-ground anchor systems such as strapping the tank to a concrete pad.



Figure 56 A properly restrained tank strapped to a concrete slab (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Expansion from Sunlight

The exposed top of bedded piping can expand when heated by direct sunlight. The expansion may cause the pipe to warp and arch up and lift out of the bedding material. Bedding material such as sand can then fall under the arched portion of the pipe. When the pipe cools, it cannot settle back into its original position, and repositioning is required. To prevent this situation from occurring, lightly cover the pipe with just enough backfill to prevent sunlight exposure. The light cover can be brushed back to expose the pipe markings for the inspection authority and to check that plastic pipe, such as ABS (black surface) and PVC, have high coefficients of expansion and are susceptible to expansion and degradation caused by sunlight exposure. Pipe installed above ground and exposed to direct sunlight may need to be protected by insulation, protective pipe wraps, or shielding.

Refer to *D-4 Penetrate Structures* (#part-d-4-penetrate-structures) for information on pipe wrap and shielding.

Pipe Storage, Shipping, and Handling

Pipes can be distorted and damaged by improper storage, including:

- Improper handling and stacking
- Exposure to sunlight

- Excessive heat or cold

Pipes and fittings stored outdoors for an extended period should be protected according to the manufacturer's instructions.

General Pipe Storage Conditions

The following give guidelines for pipe storage conditions:

- Exposure to excessive heat should be avoided to reduce the risk of pipe distortion.
- If plastic pipes or fittings are to be stored outdoors for extended periods of time, they should be protected as directed by the manufacturer. Plastic pipes may be affected by exposure to sunlight, especially if exposed for extended time periods and outside of protective cover. Bowing of the pipe can also occur.
- Correct stacking of some pipe can result in bowing and distortion (out of round). It can be difficult to attain correct even and continuous grade during installation if the drainage pipe is bowed. You may be able to correct a bow by exposing the opposite side of the pipe to sunlight before installation. However, it is best not to purchase bowed pipe.
- When purchasing pipe, check for damage such as deep scratches, cracked ends, out of round, etc.
- When stacking pipe at the job site, set the pipe on evenly spaced, level runners to prevent sagging. Place wedges or blocking to stop the pipe from rolling off the runners.
- Pipe delivered on pallets is often banded. Be sure that cutting the band does not cause the pipe stack to collapse uncontrolled. If the pipe is not on a supporting cradle, block the stack before cutting the banding.
- When stacking pipe that has hub ends, alternate the hub and spigot ends with the ends protruding so that the pipe barrels will lie flat.
- When unloading alongside a trench, stack the pipe on the opposite side of the trench from the excavated soil pile. Installing large and heavy pipe will be easier from the clean side of the trench.

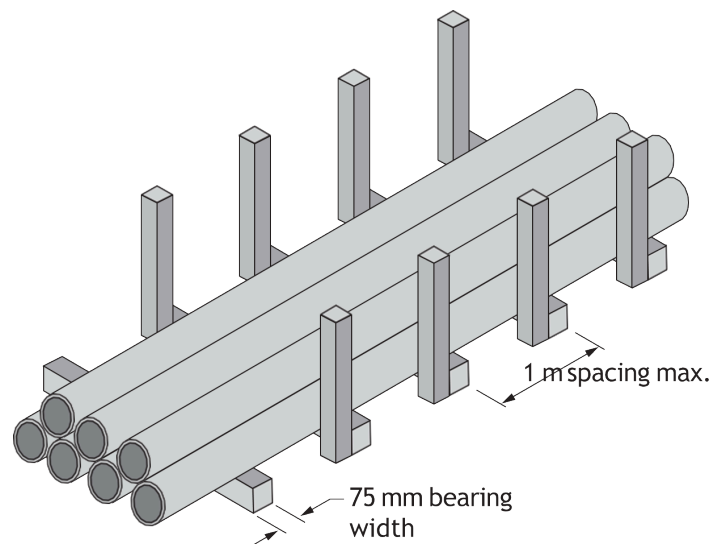


Figure 57 Storing pipe at job site (BC Industry Training Authority, 2019).
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Trench Depths and Pipe Protection

Buried pipes must be able to withstand the forces trying to damage or crush the pipe. Pipe leaks can be serious, especially when combustible liquids and gases, sewage and water supplies are involved. Pipe protection and proper burial are important to prevent pipe damage during installation and regular use.

Factors affecting the depth of a trench and the protection of the installed pipe include the following:

- Type of pipe and schedule (wall thickness strength)
- Job site terrain
- Job specifications
- Code regulations
- Required slope
- Vehicle traffic
- Weight of the fill material
- Proper compaction of the soil below and surrounding the pipe

General Trenching Guidelines

You must consult job specifications and code regulations within the area jurisdiction.

For details on trench depth for plastic pipe, refer to code books and manufacturers' documentation.

Trenching Pipe Protection

Normally, you need to follow the job site excavation engineering specifications, plans and the local code requirement. The following information is non-specific but will give you an idea of the typical requirements for trench construction to protect buried piping.

Typically, a trench would be constructed as follows:

- As narrow as practicable at the pipe depth
- Wide enough to provide space to work on the pipe and proper jointing
- Where soil conditions are unstable, trenches may need to be wider to the depth where the trench is unstable and narrow at the pipe depth where the soil is undisturbed and stable. Trench walls may need to be shored.

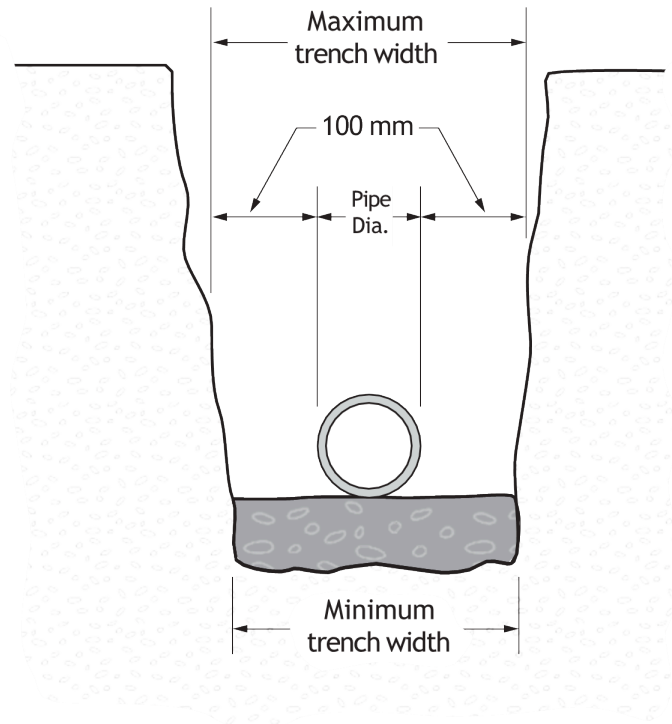


Figure 58 Trench dimensions in stable soil (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

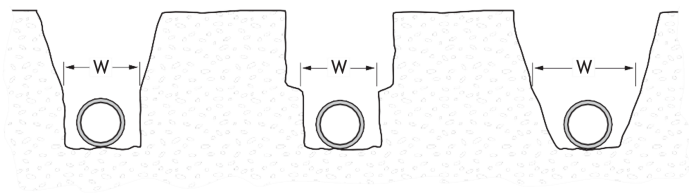


Figure 59 Trench dimensions in unstable soil (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Table 1 lists examples of trench measurements under stable conditions.

Table 1: Pipe Diameter and Trench Width in Stable Soil

Pipe Diameter	Normal Trench Width
100 mm (4 in.)	400 mm (16 in.)
150–200 mm (6–8 in.)	600 mm (24 in.)
225–300 mm (9–12 in.)	750 mm (30 in.)
375 mm (15 in.)	900 mm (36 in.)

Backfill Material and Compaction of the Soil

Pipe bedding and backfilling material should not:

- Be placed in a ditch where standing water is present
- Include large stones, boulders, cinders, frozen earth or building site debris.

The pipe should:

- Not rest on solid rock without suitable bedding protection
- Be laid on compacted level bedding that supports the full length of the pipe barrel (sand, gravel, crushed rock or good natural sandy soil; no large boulders, etc.)
- Be covered in sand, gravel, crushed rock or good natural soil (no large boulders, etc.) compacted to a minimum of 300 mm (12 in.) above the pipe
- Be covered with natural excavated soil consistent with the surrounding soil for the remaining backfill material

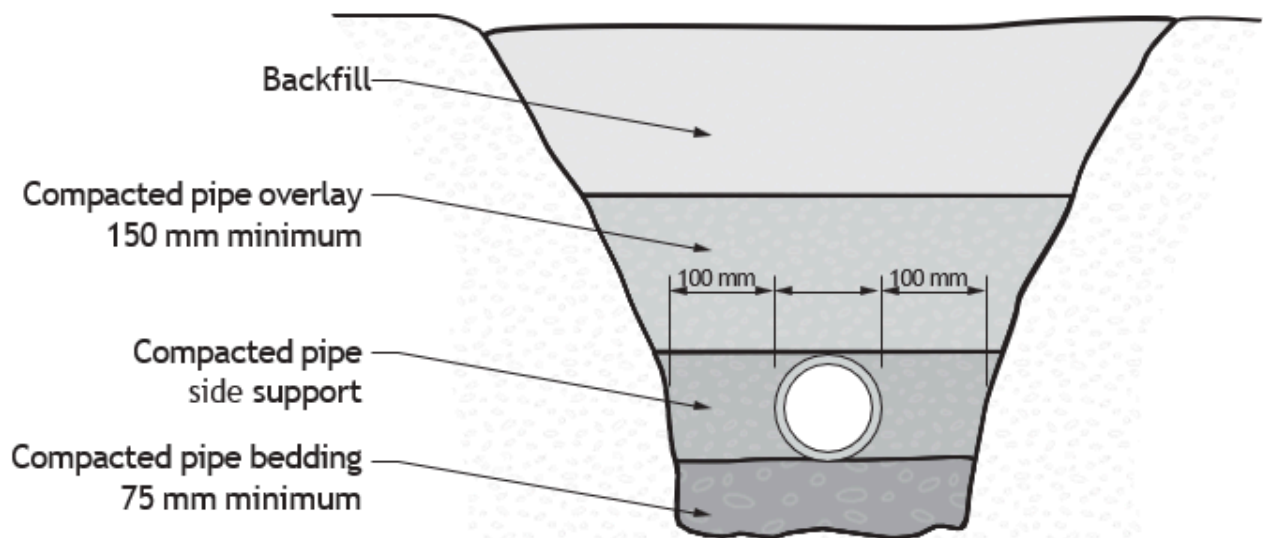


Figure 60 Example of a manufacturer's trenching requirements for PVC (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Protecting Pipe During Backfilling

- Bedding may not be required in all cases. Soil conditions at the trench bottom may be adequate to support the pipe continuously without additional bedding.
- When bedding is required, the bedding must be compacted before the pipe is laid.
- Pipe overlay backfill is best hand-shovelled around the pipe and continually tamped snugly to the pipe.
- Before covering the pipe, it is tested and inspected as soon as possible.
- Shortly after inspection and approval, overlay backfill is carefully added by shovel or machine. Care must be taken that no heavy rocks are dropped on the pipe.
- Overlay backfill and compacting continues to a depth of approximately 150 to 300 mm (6–12 in.) over the pipe.

Plumbing codes may require a minimum of 300 mm (12 in.) coverage above the pipe.

Compacting provides continuous support for the pipe. Final backfill is complete and compacted. Limited amounts of water can aid compaction.

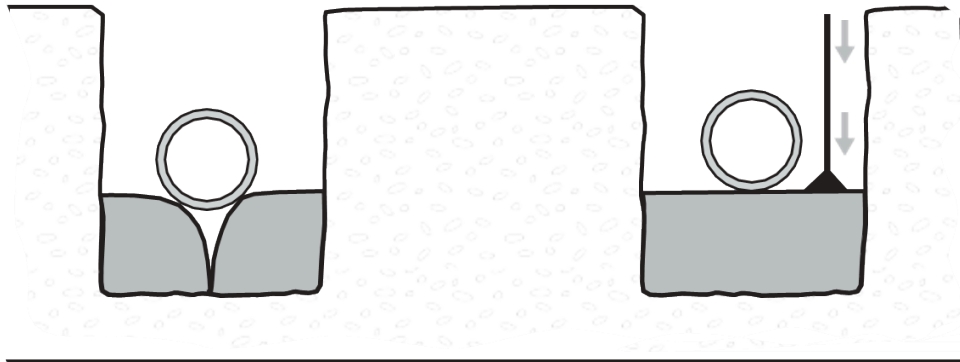


Figure 61 Correct tamping of bedding (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

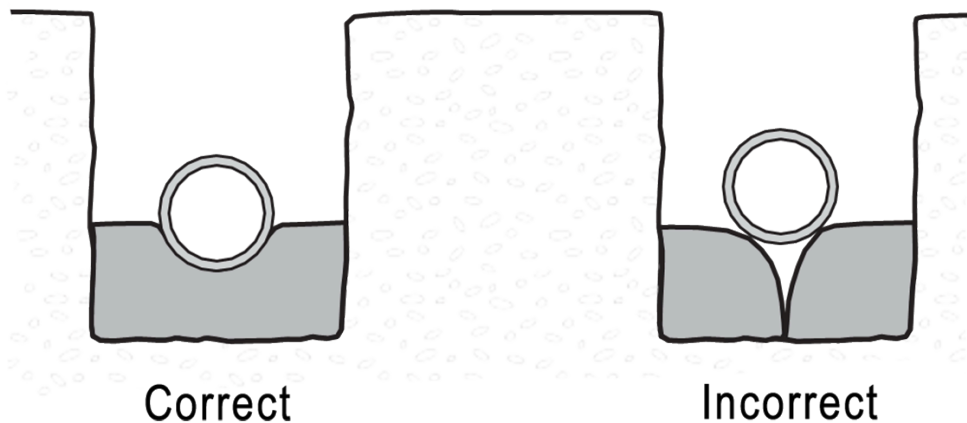


Figure 62 Left: Correctly placed bedding. Right: **Incorrect:** Bedding not pushed entirely under the pipe. (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Damage from Vehicles

Damage to piping due to contact with vehicular traffic occurs in locations where services enter a building, such as above-ground gas services. Damage to piping occurs in parking garages or warehouse facilities frequented by vehicular traffic. Protection methods include barriers such as bollards or curbs. These barriers must be constructed to take the force of contact away from the pipe.

The location and design of barriers to protect pipe from vehicular traffic is often done by the design engineers and, in many cases, is addressed in building code regulations.



Figure 63 Pipe bollards filled with concrete and placed to prevent vehicle damage to the gas service entry and meter located in a driveway. (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Self-Test D-1.4: Describe the Methods of Manufacture of Piping and Tubing

Complete Self-Test D-1.4 and check your answers.

If you are using a printed copy, please find Self-Test D-1.4 (#chapter-self-test-d-1-4-describe-the-methods-of-protecting-piping) and Answer Key (#chapter-answer-key-self-test-d-1-4) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1931#h5p-4> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1931#h5p-4>)

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- Plumber: Competency D-1 Prepare Pipe
- Steamfitter: Competency D-4 Layout and Install Piping and Tubing
- Sprinkler Fitter: Competency D-1 Prepare Pipe and Tubing

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D-1.5 Describe the Inspection of Pipes and Tube Before Installation

Before installing a piping system, you need to be aware that new piping materials can have **defects**. Defects can occur during manufacturing, and most manufacturers have strict procedures for inspecting and testing the pipe before it leaves the factory. Freight damage can occur during shipping and transit to the wholesale distributor. Cast iron pipe can crack or break when handled roughly. Plastic piping can be damaged if not stored properly or if exposed to direct sunlight for extended periods. Soft metal tubing can be bent or pushed out of round, making installation difficult. Rough handling of pipe at the job site can also result in damage. Open ends of pipe can collect debris during shipping and before or during installation. You need to inspect for and identify these types of damage before you install pipe and tubing.

Inspect Pipe for Defects

Despite quality assurances, piping can arrive at the job site with damage. It is important that you take the time to inspect each pipe or fitting carefully before you install it. Discovering a defect after the pipe has been installed and is under test is costly and time-consuming or, at best, irritating. Time is wasted by removing test pressure, draining the system, repairing the defect, reassembling, and finally, retesting.

Once the pipe has been cut and **reamed**, inspect the pipe ends for signs of deformity or damage. Any splitting, **out-of-round** shape, or excessive burring on either the inside or the outside of the pipe should be corrected or replaced before attempting to join the piping. **Deburring** is referenced in most pipe assembly instructions and cannot be over-emphasized. Once the pipe end has been formed, it is extremely difficult, if not impossible, to ream it without damaging it beyond further use. Besides causing possible leaks, failure to ream piping and tubing will result in **cavitation**, **friction loss**, **noise**, and **erosion**.

Detecting Defects

When a defect is found, you can either reject the product or cut out the defect (damaged section) and use the undamaged section of the pipe. You would expect to pay less for a damaged product. Accepting a damaged pipe means you have chosen to accept defective materials. Before doing this, you must consider pride in your workmanship and the reliability and safety of the product for as long as the system is in use. Equally important is that using defective piping might invalidate manufacturer warranties.

When the pipe has been received, visually inspect each pipe for the following:

- Is the pipe straight? Look along the length of the pipe. Is it curved or bent? You will need to decide whether you can use the pipe. A bent drainage pipe will present issues when you try to lay the pipe at a specific even and continuous slope.
- Are the pipe ends damaged or out of round? If the end is damaged, it will have to be removed before you can make a good connection.
- Inspect the circumference of coiled copper tubing to see if it has been pinched or flattened.
- Inspect cast iron drainage pipe for cracked ends or pinholes in the casting. Tap the end of the pipe with something

solid or on the ground. Listen closely for a rattling sound, which indicates a crack of some kind.

- Cast iron pipe can also have ridges and depressions caused by uneven casting that won't be evident by "sounding." Ideally you can detect these irregularities by feel before the pipe is installed by running a hand along the outside of the pipe. But most often, these irregularities are discovered through failed pressure testing caused by being out-of-round or otherwise defective and should be removed and replaced upon discovery.
- When receiving steel pipe with bevelled, grooved, or threaded ends, inspect the grooved and threaded end sealing surfaces for scratches, gouges, nicks, or other damage.
- If piping is coated for permanent **corrosion** protection and not just for not shipping, check to see if the coatings have been damaged. You may have to repair or cut out the damaged sections. Refer to the manufacturer's specific instructions on repair of damaged products.
- Inspect the pipe **bore** for blockages or debris on receiving and immediately before installation. Tilting the pipe toward the vertical will allow any loose debris to fall out of the pipe. Debris in a pipe can cause no end of problems when the system is put into service.
- Plastic piping can be seriously damaged by extended exposure to the **ultraviolet rays** in sunlight, especially if the pipe does not have ultraviolet protection.
- Check PVC plastic for cracks, discoloration, gouges, and scratches.
- Check PE and PEX for discoloration, gouges, and scratches.

Determine Environmental Effects

Both environmental conditions and faulty, defective materials can contribute to piping installation problems. Here are some environmental factors to consider before installing piping.

- Will the constituents contained in the soil have a detrimental effect on the pipe? High salt content necessitates the installation of pipe materials with better resistance to corrosion.
- Is the ground boggy? If so, there might be too much settlement for a normal installation, and piping may have to be supported using hangers imbedded in the slab-on-grade or suspended from the edge of the footing. Also, cast iron pipe installed underground in these conditions could crack, so plastic pipe may be a more acceptable choice.
- Is the atmosphere around the piping likely to be corrosive? If so, plastic rather than metal piping may be better.
- If the finished installation will be subjected to a lot of moisture, the pipe and the hardware used to support it may need to have a higher corrosion-resistance rating than normal. Outdoor exposed piping is an example of this.
- Check to see if there is going to be excessively high or low temperatures surrounding the pipe. Wide swings in ambient temperatures can necessitate alternative pipe types.
- If piping is installed in areas where there is a lot of paint and coatings being applied close to the pipe, it may be a good idea to check the pipe's compatibility with the coatings.
- If the installed piping is going to be in direct sunlight, the effects of expansion/contraction and of UV rays will be an issue. ABS pipe installed in direct sunlight will undergo a lot of expansion and warping, which can cause problems with grade in drainage systems. PEX tubing should never be exposed to direct sunlight for extended periods, either before or after installation, and pipe failure could result if not protected.
- Has the plastic pipe been stored in direct sunlight? If so, check with the manufacturer to ensure that the pipe can still be installed without threat of failure or of voiding warranties.

Inspect Pipe for Proper Markings

The various codes that pipe installations must conform to will typically specify pipe or tube according to the standard that it was manufactured to. For instance, the National Plumbing Code of Canada (<https://nrc-publications.canada.ca/eng/view/object/?id=c97ac796-01fc-4383-9c68-b271db2802cf>) specifies both in the body of the Code (2.2.6.1 (1); 2-8 Division B) and in Table A-2.2.5., 2.2.6. and 2.2.7 “Summary of Pipe and Fitting Applications” (2-80 Division B) that cast iron soil pipe used in a drainage or a venting system must conform to the CSA B70:19 (R2024) – Cast iron soil pipe, fittings, and means of joining (<https://www.csagroup.org/store/product/CSA%20B70%3A19/>) standard. Because there is enough space on the pipe itself, a reference to that standard is painted or indelibly marked onto the pipe, and inspectors will look for that marking for acceptance. If it's not evident, they may not accept the installation. Cast iron pipe is fairly easily recognizable, so is rarely, if ever, mistaken for anything else.

Where copper tube is concerned, there are at least five different grades available on the market that could be installed, and the pipe/tube marking becomes more of an issue. The various codes may say that the markings have to be visible after installation so that an inspector can readily determine if the grade of copper used is correct for the application. Besides having the relevant standard applied in ink to the pipe or tube, the colour of the ink is also used to differentiate between the grades. Further to that, copper tube is embossed (etched), indicating the grade at specific points along its length, in case the inking isn't identifiable.

Installers may be required to access codes and manufacturers' literature to determine that the proposed pipe type is in fact correct for the application. In some instances, the type of pipe chosen may not be acceptable to the building specifications, even though it conforms to the plumbing code. Remember that building specifications can be and sometimes are more stringent than the codes involved. Always consult local codes, as well as building specifications and manufacturers' literature, before installing any pipe or tube.



Self-Test D-1.5: Describe the Methods of Manufacture of Piping and Tubing

Complete Self-Test 1.5 and check your answers.

If you are using a printed copy, please find Self-Test D-1.5 (#chapter-self-test-d-1-5-describe-the-methods-of-manufacture-of-piping-and-tubing) and Answer Key (#chapter-answer-key-self-test-d-1-5) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1934#h5p-5> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1934#h5p-5>)

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BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S

- Plumber: Competency D-1 Prepare Pipe
- Steamfitter: Competency D-4 Layout and Install Piping and Tubing
- Sprinkler Fitter: Competency D-1 Prepare Pipe and Tubing

CSA Group. (2019). CSA B70:19 (R2024): *Cast iron soil pipe, fittings, and means of joining*. <https://www.csagroup.org/store/product/CSA%20B70%3A19/>

National Research Council Canada. (2025). *National plumbing code of Canada: 2025*. Government of Canada. <https://nrc-publications.canada.ca/eng/view/object/?id=c97ac796-01fc-4383-9c68-b271db2802cf>

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D-1.6 Install Tubing and Pipe

As a qualified pipe trade worker, you will be expected to install various types of piping systems, including different types of piping and tubing. The methods used to assemble and install piping systems depend largely on the manufacturer's installation instructions and the design engineer's specifications. Codes such as those for plumbing, gas, fire sprinkler systems, etc., also contain selection, installation, and **jointing** (commonly referred to as *joining*) requirements for piping and tubing. The study of detailed code requirements is not part of this section.

In this section, the focus is on jointing methods for the installation of various types of pipe. Detailed installation requirements for the piping system as a whole are covered in other sections and training levels.

Piping Installation Layout

No matter what type of piping system is being planned, it will be installed within some form of a structure. Laying out the piping route involves reading drawings and relating the information to actual site conditions.

The procedures to follow when laying out a carbon steel piping system are similar to those used when planning a drainage and venting system for plumbing fixtures. Critical information that is key to any installation will be found in the "Book of Specifications" for the project (assuming the project is large enough to warrant this literature). In it you will find information on the appliances and equipment that you will be connecting to, as well as the types of hangers and supports to use along with all other aspects of the materials mandated for the job. Once those key pieces of information are collected and considered, the next step will be the actual layout of the piping routes.

There is a logical order to the events required in order to lay out the proposed piping system. The order of steps can change, but they are all important to the successful completion of the installation.

1. **Review the architectural drawing:** On it you will find the location of fixtures and equipment relative to the building. Make a note of the finish planned for walls and floors in order to estimate finished thicknesses. Check ceiling heights and finishes, and check the architectural plan that shows an upside-down view of the finished ceiling (known as a "reflected ceiling plan"). Make sure your piping won't conflict with light fixtures, air grilles and sprinkler heads. Look for the number of appliances/equipment/fixtures planned and their approximate locations. Check the model and manufacturer of each item and familiarize yourself with any key pieces of information that might affect your pipe installation.
2. **Review the mechanical drawing:** Check for pipe sizes and look for the path of travel for your piping as well as that for any other such as sprinkler or gas. Check the equipment literature and mark on it the connections required. Also check the mechanical drawing for HVAC ductwork. The location of sheet metal ductwork is the most difficult aspect of the entire mechanical system to alter, due to its physical size, so the ductwork location usually takes precedence. Altering the paths of pipes and electrical wiring are much easier to accomplish when there are interferences to consider, and it is always better to identify conflicts with other trades' work on paper before they actually occur. As a matter of fact, most building plans will state that it is the responsibility of the contractor or installer to identify and deal with any interference prior to installation.
3. **Review the electrical and structural drawing:** Make sure the planned piping connections will not interfere with electrical lines or outlets or require you to compromise or weaken supporting structural members. Check for necessary penetrations in suspended slabs and floors and identify any holes that may need to be cored or sawn through them. Remember that penetrations through structural slabs may have to be X-rayed in order to avoid

embedded conduits or cables.

4. **Locate manufacturers' rough-in literature or suppliers' rough-in sheets:** These are known as “shop drawings” for the equipment identified in the architect's information. Check the important dimensions for pipe connections and supports. Measure at the intended installation location to confirm actual points of connections and that clearances are adequate. With accurate measurements, changing piping routes can be avoided.
5. **Refer to relevant code requirements for your work:** Check that your planned piping connections and equipment supports will not conflict with any regulations. Also check the elevations that your piping will be installed at. Any liquid system, such as a hydronic heating system, will need high point vents and low point drains. Try to avoid too many changes in elevation, as these drains and vents may be difficult to locate in a finished ceiling space without the added expense of access doors to conceal them.
6. **Check with your local Authority Having Jurisdiction (AHJ):** Check for any special requirements regarding inspections. Also check if there are any local bylaws that may affect the installation.
7. **Prepare a piping isometric drawing for either the entire installation (if it is small) or for sections of piping (if a large installation):** They assist in visualizing just how the piping is expected to be installed. From these drawings, items such as number and type of fittings, pipe lengths and material lists can be formulated and ordered. The creation of isometric drawings is normally the responsibility of either the installer or their supervisor if there are particulars to the installation that are atypical.

Once these items listed above have been considered, the piping installation can proceed.

Pipe Installation Guideline

When installing pipe:

- Make sure piping is not distorted, so you can bring it into alignment for joint assembly.
- Don't use wedges to laterally contain or position pipe for closure **fit-ups**.
- Ensure the amount and direction of **cold spring** (the intentional deformation of piping during assembly to produce a desired initial displacement and stress) matches the design values.
- Confirm support locations, type, and restraint direction are as specified in the design drawing.
- Ensure pipe slope has been maintained in the direction specified by the slope arrow and/or work point elevation indicated on the design drawing.
- Ensure changes in piping elevation have not impacted slope requirements, high-point vents, or low-point drains.
- Upon completion of installation, record the as-installed piping geometry on the design documents. Typical tolerances for **erection (field installation)** are the larger of 152 mm (6 in) or D/2 for safety-related piping or 300 mm (12 in) or D/2 for non-safety-related piping, while maintaining code, design, and vendor alignment and slope requirements. Tolerance must not affect the sequential location of components and fittings or the centreline lengths.
- Ensure valves and other components are oriented as shown in design documents or manufacturer's requirements.
- Check that insulation is installed as specified.
- Ensure there are no visible defects, or missing or damaged parts in piping, components, or piping.

Specialized Pipe and Tubing Joint and Assembly

Certain types of pipe or tube may have joining methods that will require you to receive specialized training and

certification from the product manufacturer. In such cases, you must follow the manufacturer's joining, assembly, and installation procedures. If these procedures conflict with code regulation, resolve the differences with the **AHJ** before you start the job. As the installer, you may be responsible for any damages and liabilities caused by joint failure.

Identify Safety Hazards

Apply the appropriate safety practices when joining pipe and fittings.

Calculations

Pipe or tube is almost always installed between fittings or valves. When cutting pipe to length, you need to calculate for cut lengths by using fittings at hand or by consulting fitting catalogues. Either way, terms such as **pipe or thread engagements**, **centre-to-face**, **centre-to-centre**, and **fitting allowance** will need to be understood and applied.

Measurements for **makeup-type joints** that require *fitting allowance (takeoff) calculations* are those involving soldered or brazed connections, compression joints, socket weld, solvent-cemented plastic fittings, threaded connections, pressed connections, and insert/push fittings for PEX and polyethylene piping. **Non-makeup type joints**, which butt together and would therefore not need fitting allowance calculations are those such as hubless mechanical joint cast iron, butt weld steel, groove-and-shoulder and butt fusion of plastics.

Centre-to-centre measurements of fittings that use a 90-degree change of direction can be calculated quite easily using simple subtraction and conversion of fractions. Centre-to-centre measurements using **wyes** and 45-degree fittings tend to be a little more challenging in that the offset multiplier of 1.414 must be factored into the calculations before a length of pipe can be cut. Always remember to measure/calculate twice to ensure that you only cut once.

Common Pipe and Tubing Joining Methods

There are several methods of joining piping. These have been established to suit the material being joined, with the goal of creating a joint that has the same integrity as the pipe itself. Different pipe and tubing materials are better suited for a particular joining method.

Basic types of piping joints include the following:

- Soldered and brazed
- Extracted tees
- Flared
- Compression
- Flanged
- Clamped
- Slip-on
- Threaded
- Solvent welded
- Welded

- Fusion welded
- Other

Design features of a piping or tubing joint may include the following:

- Type of material: copper, steel, cast iron, plastic, etc.
- Strength
- Tightness against leakage
- Ease of assembly
- Rigidity or flexibility

Methods for Joining Copper and Copper Alloys

Plastic has become the material of choice for piping and tubing in many residential applications. However, it is still important to be able to solder and braze high-quality joints. Copper tubing and fittings are still used extensively in commercial and industrial applications.

Copper tube and fittings may be joined in a number of ways, depending on the purpose of the system. Methods used for joining copper tube include:

- Soldering and brazing fittings
- Extracted tee connections
- Flare joints
- Compression joints
- Press-fit joints
- Grooved joints
- Push-on joints
- Flared joints

The following images will help you visually identify the methods of joining copper tube.

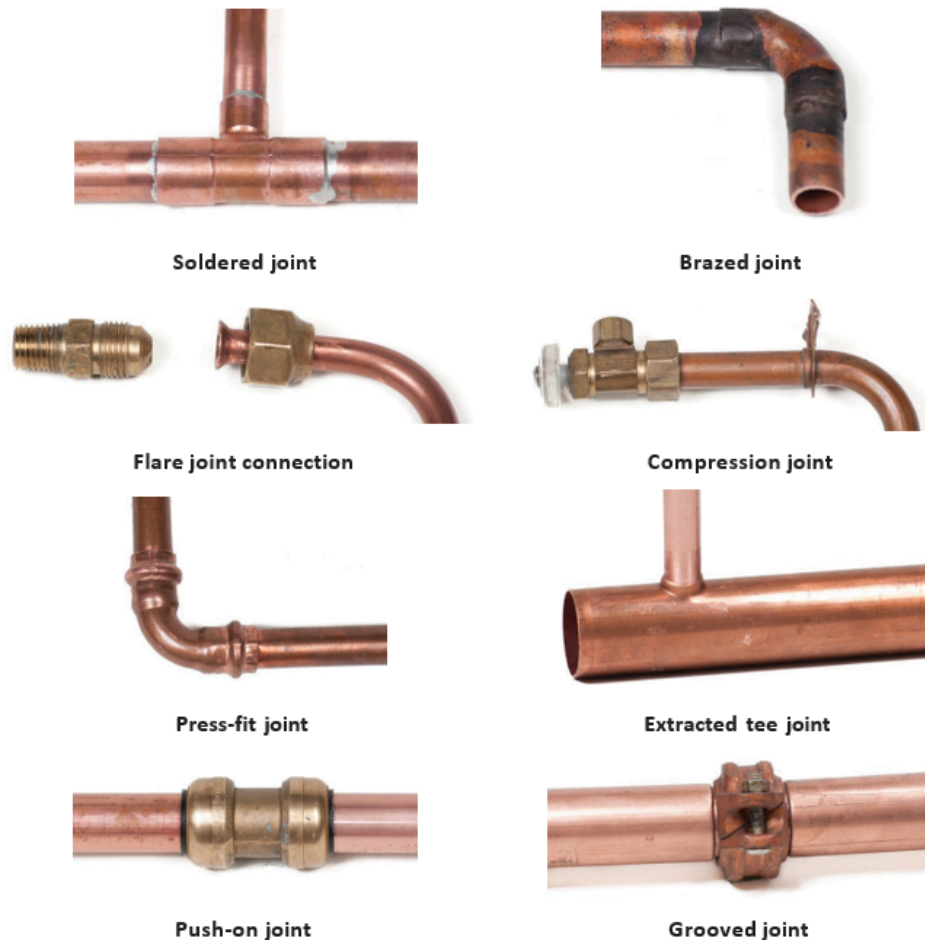


Figure 1 Copper tube joining (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Soldering and Brazing Copper Jointing

The ability to make complete soldered or brazed jointing in copper tubing systems is essential for the tradesperson.

Soldering and brazing jointing is used in the following:

- Potable water systems (residential, commercial and industrial)
- Refrigeration tubing (silver brazing only; no soft soldering)
- Extracted tee joints in fire sprinkler systems
- Drainage, waste, and venting (DWV) systems
- Medical gas systems (brazing only; no soft soldering)

Soldering and Brazing Definitions

capillary action: The action by which liquid solder is drawn into the annular space between the inside fitting wall and

the tubing outside wall due to attraction between the copper and the liquid solder molecules. This attraction is a result of the forces of adhesion, cohesion, and surface tension.

Capillary action is most effective when the space between surfaces to be joined is between 0.05 mm and 0.013 mm (0.002 in and 0.005 in). A certain amount of looseness of fit can be tolerated, but too loose a fit can cause difficulties with larger size fittings.

Solder joints depend on capillary action to draw free-flowing molten solder into the narrow clearance between the fitting and the tube. This occurs regardless of whether the solder flow is upward, downward, or horizontal.

soft soldering: Soldering at temperatures below 450°C (840°F).

hard soldering (brazing): Brazing at temperatures above 450°C (840°F).

solidus: The temperature at which 100% of the alloy is in a solid, crystalline form but starts to melt when additional heat is applied. Soldering begins upon reaching the solidus.

liquidus: The temperature at which 100% of the alloy is in a fluid, non-crystalline form. The liquidus temperature is the minimum temperature at which soldering or brazing will take place.

plastic range: The temperature range between the solidus and liquidus, where some portion of the alloy is solid but the majority is liquid. Also called the melting (pasty) range. It may be of importance when selecting a filler metal. It indicates the width of the working range for the filler metal and the speed with which the filler metal will become fully solid after brazing. Filler metals with narrow ranges, with or without silver, solidify more quickly and therefore require careful application of heat.

eutectic: A mixture having the lowest liquefaction point possible with a tin/lead mix. Alloys are eutectic when the solidus and liquidus are the same.

Soldering and Brazing Abbreviations

- Sn: tin
- Pb: lead
- Ag: silver
- Ni: nickel
- Cu: copper
- Sb: antimony
- Cd: cadmium
- Zn: zinc

Soldering and Brazing Materials

The following describes soldering and brazing materials.

Soft-Solder Filler Metals

Soft-solder filler metals belong to a group of filler metals with melting temperatures below 427°C (800°F). They are available in 1-pound spools in diameters of $\frac{3}{64}$ ”, $\frac{1}{16}$ ”, $\frac{3}{32}$ ”, and $\frac{1}{8}$ ”. Other diameters and spool sizes are available on request.

Tin/Lead 50/50, 40/60, 60/40 Soft Solders

With some exceptions, the tin/lead solders can be used to solder copper and most copper alloys, lead, nickel alloys, and steel.

Tin/lead solders are not recommended in the cooling industry for joints subject to high stress or vibration due to their lack of sufficient elongation properties. It is illegal to use lead alloys in connection with potable water systems. (Refer to lead-free solder information.) These solders (40/60, 60/40, 50/50 – numbers referring to the percentage mix of metals) are available with rosin or acid cores.

Tin/Antimony 95/5

Tin/antimony 95/5 lead-free solder is useful for applications where moderately elevated temperatures are present. With higher electrical conductivity and high fluidity, 95/5 is recommended for lead-free installation of small-diameter, tight-fitting connections. Tin/antimony solders are not recommended for use on brass.

Lead-free Solders

Lead-free solders were developed to conform to regulations banning the use of solders containing over 0.2% lead in potable water systems. These solders may contain some or all of the following metals: specific amounts of silver (Ag), antimony (Sb), copper (Cu), nickel (Ni) and/or tin (Sn). The strength of a lead-free solder joint normally exceeds the pressure at which copper tubing will burst.

Silver Brazing Filler Metal (Hard Soldering)

There are two general categories of silver brazing alloys:

- BAg—containing varying amounts of mainly silver and copper, with lesser amounts of other elements
- BCuP—similar to BAg, but with added phosphorus that acts as a flux

Selecting Solders or Brazing Alloys

The choice between soldering or brazing depends on operating conditions. Solder joints are generally used where the service temperature does not exceed 121°C (250°F), while brazed joints are used where greater **tensile strength** is required to resist vibration, pressure, or temperature cycling, or where system temperatures reach as high as 177°C (350°F).

Tube and Fittings Made for Soldering and Brazing

Copper tube and solder-type pressure fittings are accurately manufactured for compatibility. The tolerances permitted for each ensure the capillary space remains within the limits required for a strong enough joint.

Brazing Silver Copper Filler Alloys (BAg)

B (Brazing) and Ag (Silver) Element 47

These alloys are usually available in diameters of $\frac{1}{32}$ „ , $\frac{3}{64}$ „ , $\frac{1}{16}$ „ , $\frac{3}{32}$ „ and $\frac{1}{8}$ „ as wire, bare rod, or flux-coated rod, in straight lengths, coils, strips, rings, and other forms.

Sil-56

This high silver content (56%) alloy makes first-quality brazes. It is free-flowing with unequalled capillary attraction and deep penetration. **Ductility** is high, and corrosion resistance is suitable for most applications, except strong chemical environments. Sil-56 offers the highest elongation of silver brazing alloys, and is suitable for use in the food-processing industry. The silver colour is an excellent match for stainless steel and silverware applications.

Sil-45

This is an excellent general-purpose non-toxic brazing alloy. It has good ductility and capillary flow, and is often specified for government use. Its colour ranges from silver to light yellow, similar to polished brass.

Sil-25

This is a lower-cost brazing filler metal with good flow properties at relatively low brazing temperatures.

Brazing Copper Phosphorous Alloys (BCuP)

Phosphorous-copper and silver-phosphorous-copper alloys are used to braze copper-to-copper and copper-to-brass joints. The phosphorus content in these alloys makes them self-fluxing on copper. When brazing brass or copper to brass, use brazing flux. These alloys are not recommended for brazing steel or other ferrous metals.

Typical examples and usage of BCuP include medical gas systems, refrigeration systems, and other systems where flux is not permitted into the system. Available in stick form approximately 610 mm (24 in) long.

Fluxes

Soldering fluxes are classified as corrosive, intermediate, or non-corrosive. The selection depends on the metals being joined, the melting range of the solder, and whether residues will be removed after soldering.

Fluxes are either petroleum-based or water-based. Soft-solder joints require a flux to be applied to the metal surfaces prior to heating.

The purpose of a flux is to:

- Remove mild oxides
- Prevent oxides from forming (oxidation) while heating
- Wet the metal to permit the solder to flow smoothly over the surfaces and aid in capillary action

Different fluxes perform these duties differently at different temperatures. Therefore, the choice of flux depends on the metal being used and the temperature of the flow point of the solder.

Petroleum-Based Soft-Soldering Paste Flux

Petroleum-based paste fluxes are made of organic chlorides, zinc, bromides, fluorides, and ammonium chlorides mixed in a petroleum grease base. They are slightly corrosive, which helps clean the surface during soldering. Therefore, you must limit the amount of flux entering the joint and thoroughly clean the exterior after soldering to avoid visible discoloration and a poor, “shabby” appearance.

Water-Based Soft-Soldering Paste Flux

Water-based fluxes are a newer development. Experimenting with these new fluxes on the job may require changes to work practices. Many of these new fluxes are more sensitive to heat within the temperature ranges typically used for petroleum-based fluxes. Water-based fluxes may burn away, leaving residue and oxidation that can result in leaks once the system is activated (in service). Some begin reacting immediately upon application and do not allow for delays between fluxing and soldering. They contain chlorides and have an active soldering temperature range of 93 to 315°C (200 to 600°F).

Water-Based Brazing Fluxes

White brazing paste flux is good for use with silver-brazing most ferrous and non-ferrous metals, except aluminum, magnesium, and titanium. Recommended filler metals for use with white brazing flux include those in the BAg and BCuP classifications. White brazing paste flux contains water, boric acid, and potassium fluorides, and has an active temperature range of 566 to 871°C (1050 to 1600°F).

The shelf life of these types of fluxes is approximately one year from the time of manufacture.

Solder Joints and Brazed Joints

Methods of forming joints include soldering, brazing, and electric resistance soldering.

- Soldered joints, using capillary fittings, are used in plumbing for water lines and sanitary drainage.
- Brazed joints, using capillary fittings, are used where greater joint strength is required or where service temperatures may reach 177°C (350°F).
- Electric resistance soldering can be used for most soldering applications and is especially helpful when you need to bring the intended joint to temperature rapidly to avoid thermal damage to surrounding components.

Soldering and brazing can be defined as a group of joining processes that join materials together by heating them to a required soldering or brazing temperature and using a filler metal (solder).

Solder generally has a liquidus temperature not exceeding 450°C (840°F) and below the solidus of the base metals. In actual practice, most soldering is done at temperatures from about 177 to 315°C (350 to 600°F). Brazing temperatures range from approximately 566 to 871°C (1050 to 1600°F).

Soldering and Brazing Specifications

Selection of Soldering Filler Metal

The selection of a solder depends primarily on the pressure and temperature at which the system will operate. Consideration should also be given to stresses on joints caused by thermal expansion and contraction. However, this may not be necessary when a tube length is short or when an expansion loop is used in a long tube run. In such cases, the stresses caused by a temperature change are usually insignificant.

When joining copper tube to soldered valves, follow the manufacturer's instructions. The valve should be partially open before applying heat, and heat should be applied primarily to the tube. Commercially available heat-sink materials can also be used to protect temperature-sensitive components during the joining operation.

Copper tube and solder-type fittings are accurately manufactured to work together. The tolerances permitted for each ensure the capillary space will be within the limits necessary for a joint of satisfactory strength. Soldered joints rely on capillary action to draw free-flowing molten solder into the gap between the fitting and the tube. Flux acts as a wetting agent and, when properly applied, permits uniform spreading of the molten solder over the surfaces to be joined.

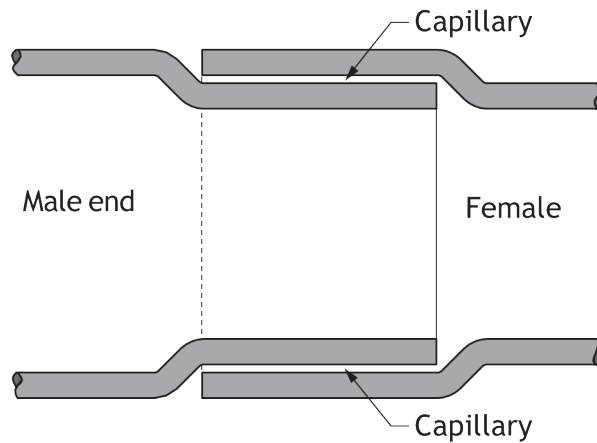


Figure 2 Capillary space (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The 50/50 tin-lead solder is suitable for moderate pressures and temperatures. For higher pressures or where greater joint strength is required, 95/5 tin-antimony solder can be used. For continuous operation at temperatures exceeding 121°C (250°F) or where the highest joint strength is required, brazing filler metals should be used.

Solder alloys that meet ASTM B32, *Standard Specification for Solder Metal* (a standard that defines requirements for solder materials), can be used to join copper tube and fittings in potable water systems. Solders containing lead at concentrations of greater than 0.2% are banned for potable water systems. Some jurisdictions may allow the use of 50/50 tin-lead solder in some HVAC, drainage, and other piping system applications.

Always refer to manufacturers' documentation and applicable code regulations.

Soldering and Brazing Procedures

To consistently make satisfactory joints, the following sequence of joint preparation and operations, based on ASTM Standard Practice B 828, should be followed.

First Preparation Procedures: Measuring and Cutting

Soldering and brazing to produce a solid, leak-proof joint begin with accurately measuring the length of each tube segment (Figure 3). Inaccurate measurements can compromise joint quality. If the tube is too short, it will not fully enter the fitting cup, and a proper joint cannot be made. If the tube segment is too long, system strain may be introduced, which can affect service life.



Figure 3 Measure carefully (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Cut the tube to the measured length. There are a number of different methods to produce a satisfactory squared end. The tube can be cut with a disk-type tube cutter, a hacksaw, an abrasive wheel, or a stationary or portable bandsaw. Care must be taken that the tube is not deformed during cutting. Regardless of the method used, the cut must be square to the **run of the tube** (the straight direction or alignment of the pipe) so that it seats properly in the fitting cup.



Figure 4 Using a tube cutter (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Reaming

Ream all cut tube ends to the full inside diameter of the tube to remove burrs created during cutting. If this rough inside edge is not removed by reaming, erosion-corrosion may occur due to local turbulence and increased local flow velocity in the tube. A properly reamed piece of tube provides a smooth internal surface for better flow.



Figure 5 Ream file (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Remove any burrs on the outside of the tube ends that were created during the cutting operation, to ensure proper insertion of the tube into the fitting cup.

Tools used to ream tube ends include the reaming blade on the tube cutter, half-round or round files, and suitable deburring tools. With soft tubing, care must be taken to avoid deforming the tube end by applying too much pressure.

Soft temper tube, if deformed, can be brought back to roundness with a sizing tool. This tool consists of a plug and sizing ring.



Figure 6 De-burring tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Cleaning

The removal of all oxides and surface soil and contaminants from the tube ends and fitting cups is crucial for proper solder flow into the joint. If not removed, they can interfere with capillary action, lessening the strength of the joint and causing failure.

Lightly abrade (clean) the tube ends using sand cloth or nylon abrasive pads to a distance slightly greater than the depth of the fitting cup.

Clean the fitting cups using abrasive cloth, abrasive pads, or a properly sized fitting brush.



Figure 7 Clean tube end with sand cloth (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 8 Wipe off tube end (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 9 Clean inside fitting with fitting brush (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Do not touch the cleaned surface with bare hands or oily gloves. Skin oils, lubricating oils, and grease can impair the soldering process.

Copper is a relatively soft metal. If too much material is removed from the tube end or fitting cup, a loose fit may result, leading to a poor joint. The capillary space between tube and fitting is approximately 0.1 mm (0.004 in). This spacing is critical for the solder metal to flow into the gap and form a strong joint.

Applying Flux

Use care in applying flux. Careless workmanship can cause problems long after the system has been installed. First, apply a thin, even coating of flux to the tube using a brush, then apply a smaller amount to the inside of the fitting hub. Flux the fitting as soon as possible after cleaning. If you apply too much flux inside the hub, the excess will get pushed into the pipe. Excessive flux can leave residue that may cause corrosion. In extreme cases, this corrosion could perforate the wall of the tube, fitting, or both.



Figure 10 Flux pipe end (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 11 Flux the fitting (do not overload the fitting with flux) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Assembly and Support

Insert the tube end into the fitting cup, making sure that the tube is seated against the base of the fitting. A slight twisting motion helps distribute the flux evenly. Remove excess flux from the exterior of the joint with a clean cotton rag.



Figure 12 Insert and twist fitting fully (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

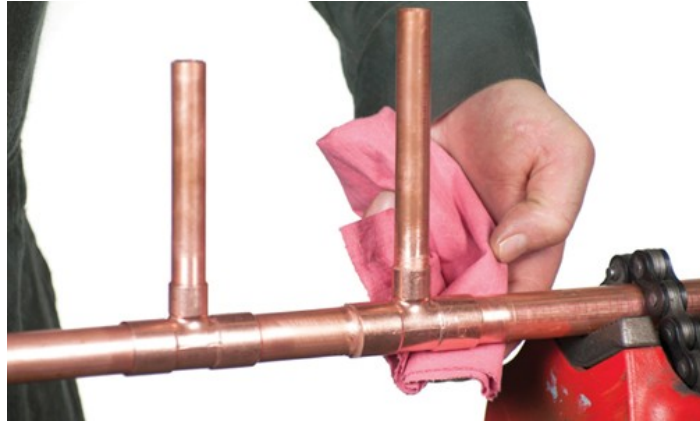


Figure 13 Remove excess flux (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Support the tube and fitting assembly to maintain a uniform capillary space around the entire circumference of the joint. Uniformity of capillary space will ensure good capillary flow of the molten-solder metal. Excessive joint clearance may lead to solder metal cracking under conditions of stress or vibration. The joint is now ready for soldering.

Joints should be soldered the same day they are prepared and not left overnight.

Heating

Begin heating with the flame at right angles to the tube (Figure 14). The copper tube conducts the initial heat into the fitting cup to produce even distribution of heat in the joint area. The extent of this preheating depends upon the size of the joint. Preheating of the assembly should include the entire circumference of the tube in order to bring the entire assembly up to a suitable preheat condition. For horizontal joints, avoid directly preheating the top of the joint to avoid burning the soldering flux. The natural tendency for heat to rise will ensure adequate preheat of the top of the assembly. Practice and experience will indicate the amount of heat and the time needed.



Figure 14 Preheat the tube (position 1 in Figure 15, right). (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

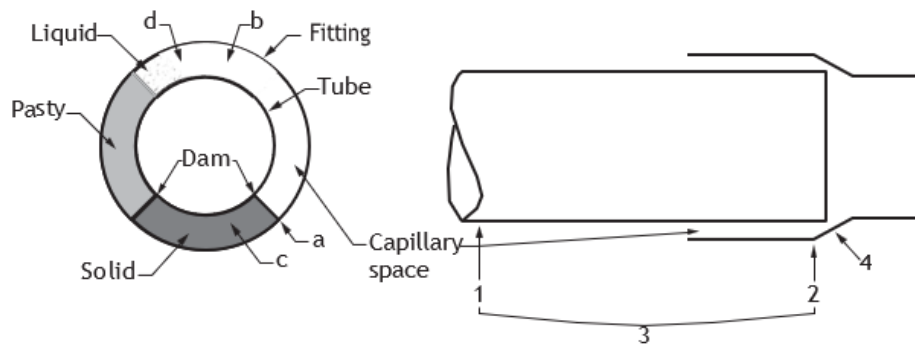


Figure 15 Heating positions (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Next, move the flame onto the fitting cup (Figure 16, position 2). Sweep the flame alternately between the fitting cup and the tube approximately a distance equal to the depth of the fitting cup (Figure 15, right, position 3). Again, preheat the circumference of the assembly as described above, with the torch at the base of the fitting cup (Figure 15, right, position 4). Touch the solder to the joint. If the solder does not melt, remove it and continue heating.



Figure 16 Preheat the fitting cup (position 2) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Do not overheat the joint or direct the flame into the face of the fitting cup.
CAUTION:Overheating could burn the flux, which will destroy its effectiveness, and the solder will not enter the joint properly.

Applying Solder

Continue heating while touching the solder to the joint. When the solder melts, apply heat to the base of the fitting cup to aid capillary action in drawing the molten solder into the cup toward the heat source. For joints in the horizontal position, start applying the solder metal slightly off-centre at the bottom of the joint (Figure 15, left, position a, and Figure 17). When the solder begins to melt from the heat of the tube and fitting, push the solder straight into the joint while keeping the torch at the base of the fitting and slightly ahead of the point of application of the solder. Continue this technique across the bottom of the fitting and up one side to the top of the fitting (Figure 15, left, position b).



Figure 17 Applying solder (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Return to the point of beginning, overlapping slightly (Figure 15, left, position c), and proceed up the uncompleted side to the top, again overlapping slightly (position d). While soldering, small drops may appear behind the point of solder application. These indicate that the joint is full to that point and will take no more solder. During this process, solder transitions through solid, pasty, and liquid states.

The now-solidified solder at the bottom of the joint has created an effective dam or barrier that will prevent the molten solder from running out of the joint as the side and top of the joint are being filled.

For joints in the vertical position, make a similar sequence of overlapping passes, starting wherever is convenient.

Cooling and Cleaning

Allow the completed joint to cool naturally. Shock cooling with water may stress the joint. When cool, clean off any remaining flux residue with a wet rag (Figure 18). Whenever possible, based on end use, flush the system to remove excess or residual flux and debris.

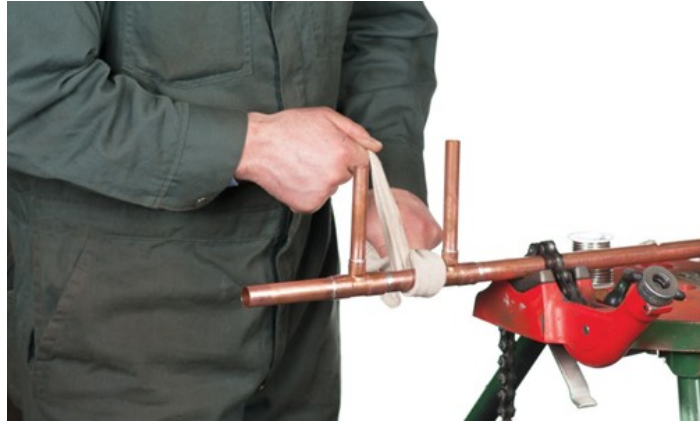


Figure 18 Clean off flux residue (BC Industry Training Authority, 2019).
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Testing

Test all completed assemblies for joint integrity. Follow the testing procedure prescribed by applicable codes governing the intended service.

Visual Examination

The finished joint shall be visually inspected. The following conditions shall be considered unacceptable:

- Excess solder drips on the outside of the tube and/or fitting
- Cracks in the tube or fitting
- Cracks in the solder filler metal

Brazed Joints

Brazing Filler Metal Alloys

Brazing filler metals are used in plumbing, HVAC, refrigeration, and fire sprinkler systems. For joining copper tube, any of these filler metals will provide the necessary strength when used with standard solder-type fittings or commercially available short-cup brazing fittings. Brazing filler metals are sometimes referred to as “hard solders” or “silver solders.” These confusing terms should be avoided.

There are two classes of brazing filler metals suitable for joining copper tube:

- BCuP series alloys containing phosphorus: brazing (B), copper (Cu) phosphorous (P)
- BAg series alloys containing a high silver content: brazing (B), silver (Ag)

The two classes of brazing metals differ in their melting, fluxing, and flowing characteristics, and this should be considered when you are selecting a filler metal.

Each class of filler metal comes in variations for specific uses:

- BCuP-2: used for close tolerances
- BCuP-3, BCuP-4 and BCuP-5: used where close tolerances cannot be held
- BAg-1, BAg-5 and BAg-7: used when the specific characteristics of the BAg alloy are required

Brazing alloy key characteristics:

- BAg filler metals are used for joining dissimilar metals.
- The BCuP series filler metals are less expensive than the BAg series.
- BCuP alloys are better suited for general piping applications.
- The strength of the brazed joint will meet or exceed that of the tube and fitting being joined.
- Depending on the composition of either BAg or BCuP alloys, they melt at temperatures between 590 and 815°C (1100 to 1500°F).
- Brazing filler metals can form strong, leak-tight brazed connections for copper tube.
- The temperature at which a filler metal starts to melt on heating is the solidus temperature; the liquidus temperature is the higher temperature at which the filler metal is completely melted. The liquidus temperature is the minimum temperature at which brazing will take place.
- The difference between solidus and liquidus is the melting (pasty) range and may be of importance when selecting a filler metal. It indicates the width of the working range for the filler metal and the speed with which the filler metal will become fully solid after brazing. Filler metals with narrow ranges, with or without silver, solidify more quickly and therefore require careful application of heat.

For details about brazing filler metal composition, use the manufacturers' documentation.

Strength of Brazed Joint

The strength of a brazed copper tube joint does not vary much with the different filler metals. The joint strength depends mainly on maintaining the proper clearance between the outside of the tube and the cup of the fitting.

Brazing Flux

The fluxes used for brazing copper joints are different in composition from soldering fluxes. The two types must not be used interchangeably.

Unlike soldering fluxes, brazing fluxes are water-based. However, brazing fluxes perform the same functions as soldering fluxes:

- Dissolve and remove residual oxides from the metal surface
- Protect the metal from re-oxidation during heating
- Promote wetting of the surfaces to be joined by the brazing filler metal

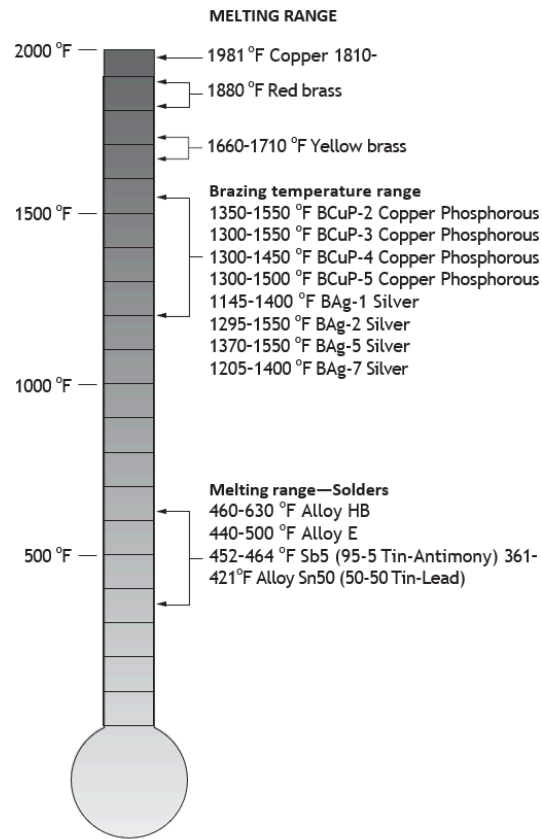


Figure 19 Melting ranges of solders, brazing filler metals, and base metals (°F) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Brazing fluxes also provide an indication of temperature (Figure 20).

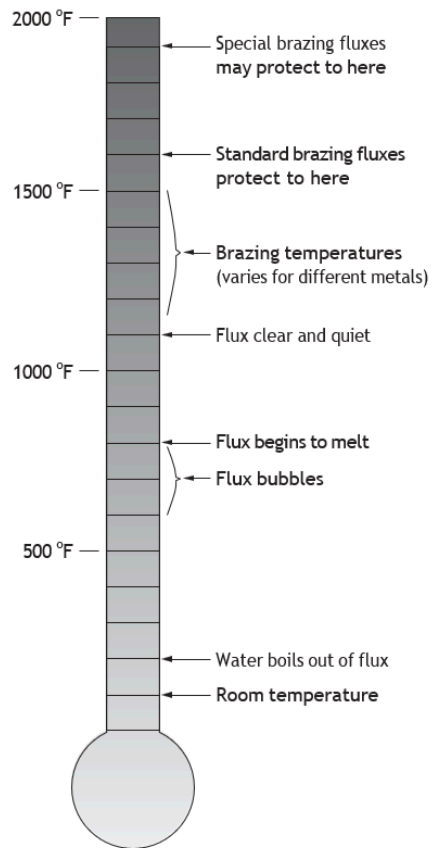


Figure 20 Temperature behaviour of flux during brazing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The flux can be used as a guide as to how long to heat the tube.

By observing the flux reaction during soldering or brazing, you can judge the temperature and avoid overheating. Excessive oxidation will be minimized, and the appearance of the joint will be greatly improved.

For information about flux requirements based on tube, filler metal, and fitting type, refer to manufacturer documentation.

Brazing Procedures

The procedures for measuring, cutting, de-burring, cleaning, fluxing, and assembly are the same as for soldering. The following brazing procedures start once heat is applied to the joint being brazed.



When brazing, selecting the right size of tip and torch is important. A torch tip that is too small will produce insufficient heat and take longer to reach and maintain the brazing temperature. Normally, a single B-size acetylene tank will be adequate for smaller diameter copper tubing. On larger joints over 2.5 cm (1 in), an oxy-acetylene system may be required. Experience will guide the selection of heat source and tip size.

When brazing larger diameters, a B tank will work with a larger tip, or multiple B tanks could be used. However, an oxy-acetylene fuel torch with a neutral to slightly **carburizing flame** is preferred.

Apply Heat

Heat the tube first, beginning about 2.5 cm (1 in) from the edge of the fitting and sweeping the flame around the tube in short strokes at right angles to the axis of the tube (Figure 21, right, position 1).

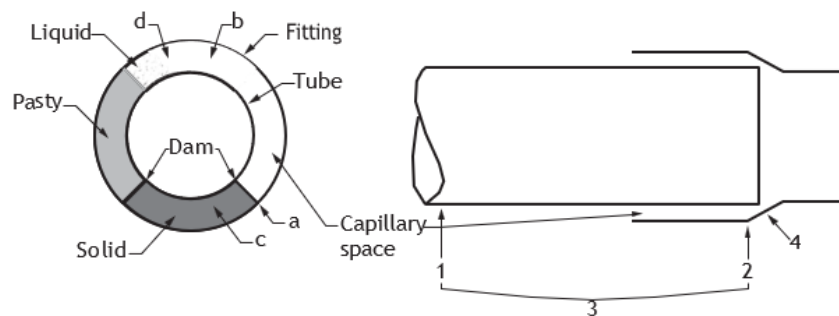


Figure 21 Heating positions of a brazed joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

It is very important that the flame remain in motion and not stay in one spot long enough to damage the tube.

Switch the flame to the fitting at the base of the cup (Figure 21, right, position 2). Heat uniformly, sweeping the flame from the fitting to the tube until the flux on the fitting becomes quiet (stops bubbling and becomes smooth). Avoid excessive heating of cast fittings, as this may cause cracking.

When the flux appears liquid and transparent, start sweeping the flame back and forth along the axis of the joint to maintain heat on the parts to be joined, especially toward the base of the cup of the fitting (Figure 21, right, position 3). The flame must be kept moving to avoid melting the tube or fitting.

For tube sizes 2.5 cm (1 in) or larger, it may be difficult to bring the whole joint up to temperature at one time. It frequently will be found desirable to use an oxy-fuel, multiple-orifice heating tip to maintain a more uniform temperature over a large area. A mild preheating of the entire fitting is recommended for larger sizes, and the use of a

second torch to retain a uniform preheating of the entire fitting assembly may be necessary in larger diameters. Heating can then proceed as outlined in the steps above.

Applying the Brazing Filler Metal

Apply the brazing filler metal at a point where the tube enters the fitting socket. When the correct temperature is reached, the filler metal will flow readily into the space between the tube and fitting socket, drawn in by the natural force of capillary action.

Keep the flame away from the filler metal itself as it is fed into the joint. The temperature of the tube and fitting at the joint should be hot enough to melt the filler metal.

Keep both the fitting and tube heated by moving the flame back and forth from one to the other as the filler metal is drawn into the joint. When the joint is properly made, filler metal will be drawn into the fitting socket by capillary action, and a continuous **fillet** of filler metal will be visible completely around the joint. To aid in the development of this fillet during brazing, the flame should be kept slightly ahead of the point of filler metal application.

Horizontal and Vertical Joints

When brazing horizontal joints, it is preferable to first apply the filler metal slightly off-centre at the bottom of the joint, proceeding across the bottom of the joint, and continuing up the side to the top of the joint. Return to the beginning point, overlapping slightly, and proceed up the uncompleted side to the top, again, overlapping slightly. This procedure is identical to that used for soldering.

Also, similar to the soldering process, make sure the operations overlap. On vertical joints, it is immaterial where the start is made. If the opening of the socket is pointing down, avoid overheating the tube, as this may cause the brazing filler metal to run down the outside of the tube.

Removing Residue

After the brazed joint has cooled, remove flux residue using a clean cloth, brush, or swab with warm water. Remove all flux residue to avoid the risk of the hardened flux temporarily retaining pressure and masking an imperfectly brazed joint. Wrought fittings cool faster than cast fittings, but all fittings should be allowed to cool naturally before wetting and cleaning.

Techniques for troubleshooting brazing include:

- If the filler metal fails to flow or has a tendency to ball up or **bead**, it indicates oxidation on the metal surfaces or insufficient heat on the parts to be joined.
- If the tube or fitting starts to oxidize during heating, insufficient flux has been used.
- If the filler metal does not enter the joint and tends to flow over the outside of either member of the joint, it indicates one part is overheated or the other underheated.

Testing

Test all completed assemblies for joint integrity. Follow the testing procedure prescribed by applicable codes governing the intended service.

Purging

Some installations (such as medical gas, high-purity gas, and ACR systems), require the use of an inert gas during the brazing process. The **purge gas** (usually nitrogen) displaces oxygen from the interior of the pipe system while it is being subjected to the high temperatures of brazing and therefore eliminates the possibility of oxide formation (oxidation) on the interior tube surface during heating.

Purge gas flow rates and methods of application should be included in the *Brazing Procedure Specifications* of these applications.

Visual Examination

The finished joint should be visually inspected. The following conditions shall be considered unacceptable:

- Excess filler metal on the outside of the tube and/or fitting
- Cracks in the tube or fitting
- Cracks in the filler metal

Copper Swaging

The Canadian Oxford Dictionary (2004) defines the term “**swage**” as “A tool, die, or stamp for bending and shaping wrought iron, etc., by hammering or pressure.” A pipe swage for copper is a tool that expands the end of an annealed piece of copper tube to form a **coupling**.

One type of swaging tool uses a hand-held steel pin or mandrel that is driven into the tube end by repeated hammer blows, thereby expanding the inside diameter of the tube. Each size of tube requires a different size of swage.

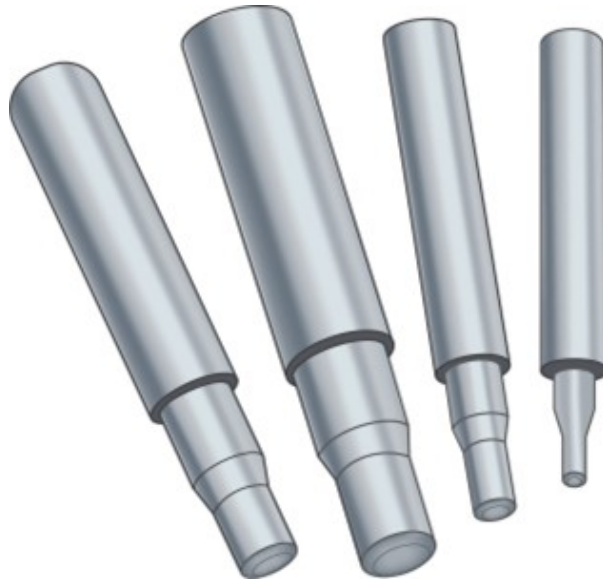


Figure 22 Swaging tool kit (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Another type of swage uses handles that are pumped to expand a die. The die is placed into the pipe end and, when the handles are opened and closed repeatedly, the die expands and forms the coupling. Like the hand swage, each pipe size requires a different die head.



Figure 23 Tube expander kit (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

This variety of swage is more commonly known as a tube expander, and can also be found using an electric motor to power the swaging movement.

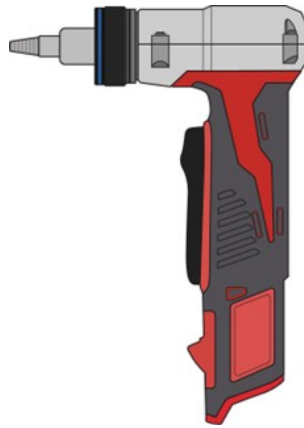


Figure 24 Milwaukee expander kit (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

To be an acceptable joint, pipe swage manufacturers usually specify that the newly formed expanded connection should be brazed rather than soldered.

Extracted Tee Joints

Extracted tee joints are a tested and effective method for joining copper tubes. In this method, the tool forms a raised collar on the pipe to which another tube is brazed. Soldering is not permitted, because the joint would not be strong enough.

Power or hand tools quickly form an extracted tee connection in a run of copper tube, reducing the number of soldered or brazed joints. The process is faster than individual tees piped together (because there are fewer joints) and can reduce installation costs. This method may be used for general plumbing, HVAC, refrigeration, fire sprinkler, and service projects.

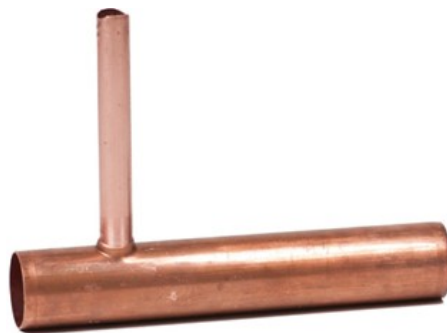


Figure 25 Extracted tee joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Typical Code Regulations

Extracted tees can be formed from Type K and Type L copper used in water distribution systems, provided the following requirements are met:

- A tool specifically designed to form the joint is used.
- The branch line size is at least one size smaller than the tube in which the tee is formed (the main tube).
- The end of the branch incorporates a means to prevent the branch from penetrating into the run of the tube and obstructing the flow.
- The joint is brazed using filler metal with a melting temperature of at least 540°C (1004°F).



Although manufacturers may suggest that extracted tees can be formed with Type M copper, code regulations may not permit it. Refer to manufacturer instructions and authorities having jurisdiction for these applications.

Figure 26 shows a tube end preparation tool that forms the end of a branch pipe to match the inner curve of the tube. The tool simultaneously presses two dimples in the end of the branch tube. One acts as a depth stop, and the other is used to inspect branch alignment after brazing.



Figure 26 End prep tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

On larger tube sizes and/or heavier wall thicknesses, the area for forming the tee outlet must be annealed before preparing an extracted tee joint. Refer to manufacturer instructions when working with these sizes.

Installation Steps

The following procedure is typical for forming and brazing 12.5 to 31.75 mm ($\frac{1}{2}$ to $1\frac{1}{4}$ in) outlets using power-operated equipment. Although there are specific steps to follow, the tee-forming and brazing process takes little time and is quickly repeatable. Follow the manufacturer's operating instructions for all tube sizes.

1. Select and adjust the drill head and forming pins according to the manufacturer's instructions. The drill bit and pins are quite sharp, so be careful when handling them.
2. Insert the drill head into the chuck (Figure 27) and extend the forming pins (Figure 28).



Figure 27 Insert drill head (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 28 Extend forming pins (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

3. Lubricate the drill head and forming pins (Figure 29).



Figure 29 Lubricate drill head (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

4. Pull out the support legs (Figure 30).



Figure 30 Pull out the support legs (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

5. Press in the conical cover and rotate counter-clockwise to retract the forming pins (Figure 31).



Figure 31 Retract the pins (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

6. Place the tube support firmly at the point where the tee is to be formed on the tube. Then twist the machine counter-clockwise using the handle to centre the drill head on the tube. The support legs will centre and stabilize the drill while absorbing rotational torque (Figure 32).



Figure 32 Position the drill tip and ensure a snug fit of the support legs (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

7. Start the tool by squeezing the trigger and drill until the bit has fully penetrated into the tube. Then release the trigger to stop the drill. **Do not extend the forming pins while the motor is running.**
8. Extend the forming pins on the drill head by pressing the cover toward the tool and rotating it counter-clockwise until the head locks in the tee-forming position (Figure 33).



Figure 33 Stop drill and extend the forming pins (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

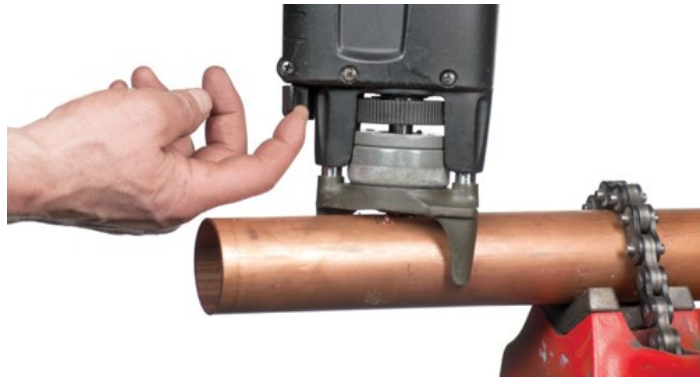


Figure 34 Engage support legs (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

9. Turn the speed selector control to the slowest position (typical) and engage the feed mechanism. You may need to rotate the motor by giving a nudge on the trigger to engage it.
10. Squeeze the trigger to start forming the outlet and continue until the drill head exits completely out of the tube (Figure 35). Maintain a slight downward pressure on the drill to ensure a firm contact with the tube. The rotation of the forming pins causes a backflow and thickening of the metal around the lower circumference of the outlet. It is important to release the drill trigger as soon as the drill head clears the rim of the outlet. **Note:** Removing the drill head from the tube before it emerges will result in an oval or imperfect outlet.



Figure 35 Form the outlet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

11. Select the appropriate branch-size die on the tube-end notcher to notch and dimple the sides of the branch tube end. Proper notching and dimpling must be performed to meet code requirements and to ensure that the branch does not protrude into the tube and obstruct flow.



Figure 36 Using the notching and dimpling tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

12. Ream or de-burr the branch tube end.



Figure 37 Ream the branch tube end (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 38 Proper notching (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

13. Remove any excess lubricant from inside the outlet and use a sand cloth to clean the inside of the outlet rim.

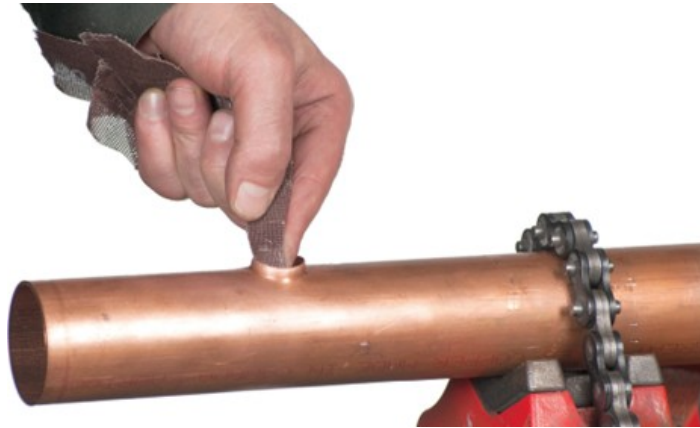


Figure 39 Clean the inside rim surface (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

14. Insert the branch tube into the outlet up to the first dimple and align the dimples with the run of the tube.



Figure 40 Align the dimples with the run of the tube (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

15. Align the joint for brazing and complete the brazing process using the specified filler metal and following the normal joint procedures.



Figure 41 Align the joint ready for brazing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Testing the Extracted Tee Joint System

All drilling residue and debris must be flushed out before the system is placed in service.

Final pressure testing of the completed piping system is accomplished by using pressurized air or water as required by local codes or project specifications. Test pressures should never exceed the maximum operating pressure specified by the manufacturer of the fitting system.

Push-Connect Joints

Push-connect joints use an integral **elastomeric gasket** or seal (such as **EPDM**) and a stainless-steel grab ring to produce a strong, leak-free joint connection. This push-on method of joining of copper and copper alloy tube is fast and may be economical in specific applications.

There are two common types of **push-connect** fitting: removable and permanent. Both create strong, permanent joints. However, one allows easy removal after installation (Figure 42) to permit equipment service, while the second type cannot be easily removed once the fitting is installed.



Figure 42 Removable push-connect fitting (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Examine the tube to ensure that it has no dents, deep scratches, dirt, oils, paint, grease, or other surface imperfections.



Figure 43 Examine pipe ends for damage (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Push-On Fitting Installation Procedure

1. Measure and cut the tube square, perpendicular to the run of tube, using an appropriate tubing cutter.
2. Remove burrs from the inside diameter (ID) and the outside diameter (OD) of the cut tube end by reaming the ID and **chamfering** the OD using the appropriate tools.

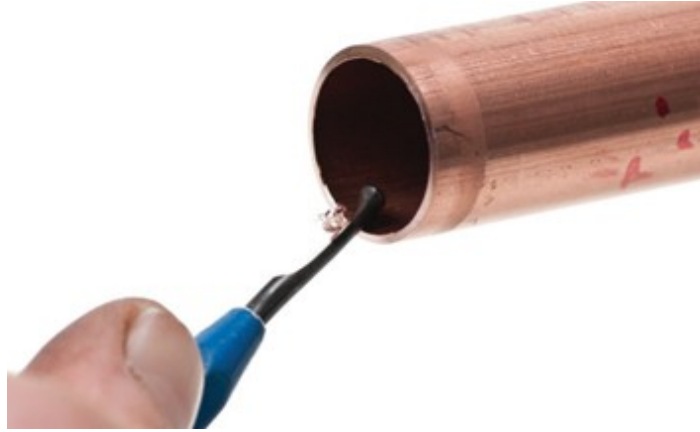


Figure 44 Deburring tube (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

3. The cut tube end must be chamfered to reduce the possibility of gasket damage when the tube is being inserted. Cleaning the chamfered tube end with emery paper, abrasive nylon cloth, or plumber's cloth will ensure that there are no sharp edges or nicks that might damage the sealing gasket when the tube is inserted into the fitting.



Figure 45 Chamfered OD of tube (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

4. Examine the fitting to ensure that the sealing gasket and gripper ring are properly positioned and not damaged.



Figure 46 Examine gasket and gripper (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

5. Mark the depth of insertion on the tube before inserting it into the fitting to ensure that it will socket to the back of the fitting cup.



Figure 47 Mark the insert depth (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Note: Lubrication of the tube end may or may not be required. Follow the manufacturer's installation recommendations related to pre-lubrication of the tube end.

6. Align the tube so that it is straight and in line with the fitting. Using a firm pushing and twisting motion, insert the tube into the fitting and push the tube and fitting together until the tube is seated at the back of the fitting cup, as evidenced by the pre-marked tube insertion depth line.



Figure 48 Align tube and fitting, push and twist together (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

7. Test the completed piping system using pressurized air or water as required by local codes or project specifications. Test pressures should never exceed the maximum operating pressure specified by the manufacturer of the fitting system. Refer to manufacturers' instructions.

Press-Fit Joints

The **press-connect** joining method and associated fittings and tools were introduced in North America in the late 1990s. Also known as *press-fit*, this method has been used successfully in Europe since it was patented there in the late 1950s.

Press-fit joints rely on the sealing capability of a special fitting that contains an elastomeric gasket or seal (such as EPDM) (Figure 49).

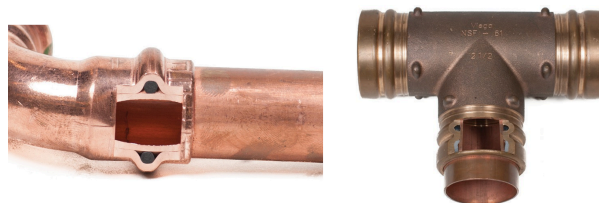


Figure 49 Cutaway of press-connect fitting with elastomeric gasket (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The joint is formed using an approved pressing tool and jaws (Figure 50). Typical ranges of pressure-temperature ratings for these no-flame joints can be found in the manufacturers' documentation.



Figure 50 Press tools and jaws (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Several manufacturers offer full product lines of press-connect fittings, valves, and specialty items (Figure 51). Tubing is available with an integrally formed press-connect end.



Figure 51 Samples of available fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Examine the tube to ensure there are no dents, deep scratches, dirt, oils, grease, or other surface imperfections.

Press-connect Fitting Installation Procedure

1. Measure tubing accurately to ensure it sockets completely to the base of the fitting cup.



Figure 52 Measure (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

2. Cut the tubing square, perpendicular to the run of tube, using an appropriate tube cutter.



Figure 53 Cut the tube square (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

3. Deburr the tubing. Burrs must be removed from the ID and OD of the cut tube end.
4. Chamfer the cut tube end to reduce the possibility of gasket damage when inserting the tube. Clean the chamfered tube end with emery paper, nylon abrasive cloth, or plumber's cloth to ensure there are no sharp edges or nicks that might damage the sealing gasket when the tube is inserted into the fitting.
5. Examine the fitting to be used to ensure the sealing gasket is properly positioned and is not damaged.
6. Mark the depth of insertion on the tube before inserting the tube into the fitting.
7. Select the proper size of the appropriate pressing jaw and insert it into the pressing tool.
8. Ensure that the tube is completely inserted to the fitting stop (appropriate depth) and squared with the fitting before applying the pressing jaws onto the fitting.
9. Place the pressing jaw over the bead on the fitting and ensure the tool and jaws are at a 90° angle (perpendicular) to the centreline of the tube.

10. Depress the pressing tool trigger to begin the pressing cycle.
11. When the pressing cycle is complete, release the pressing jaw and visually inspect the joint.



Figure 54 Fitting prepared for pressing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

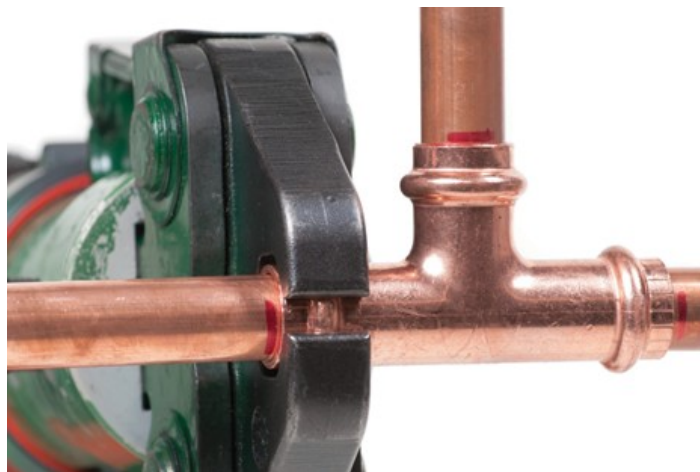


Figure 55 Properly positioned press tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 56 Completed installation of a press-connect joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Testing the System Joints

Test the completed piping system using pressurized air or water. When the test pressure is relatively high, use

hydro-pneumatic testing. The test pressures should never exceed the maximum operating pressure specified by the manufacturer of the fitting system. Check the documentation they provide and always follow manufacturer specifications and applicable codes.

Roll Groove Joints

Since 1925, the **grooved-end piping** method has been used reliably to join steel and iron pipe in HVAC, fire protection, process piping, and related applications.

This method of mechanical joining is also available in a system for copper tube in sizes from 5 to 20 cm (2 to 8 in). Included are couplings, gaskets, and a myriad of fitting configurations. The system offers a practical alternative to soldering and brazing larger-diameter copper tube—and most importantly, it requires no heat or open flame.

Copper **roll groove joining** takes advantage of copper's excellent **malleability** and its increased strength when **cold-worked**. The joints rely on the sealing capability of a special clamping system that contains an EPDM gasket and a specially designed clamp. Several manufacturers offer roll groove tools, gaskets, clamps, and fittings (Figure 57).



Figure 57 Copper roll groove fittings and clamps (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Roll Groove Copper Tube Joining Procedures

Proper selection of the correct roll grooving tool and heads for each type of tube to be prepared is essential. Manufacturers' recommendations must be followed to ensure safe, trouble-free tube preparation.

1. Examine the tube to ensure there are no dents, deep scratches, dirt, oils, grease or other surface imperfections.
2. Measure the tube length accurately.
3. Cut the tube end square (perpendicular to the run of the tube).
4. Remove burrs (de-burr) from the ID and the OD of the tube end by reaming the ID and chamfering the OD.
5. Roll groove the tubing to the proper dimensions, as required by the fitting manufacturer.

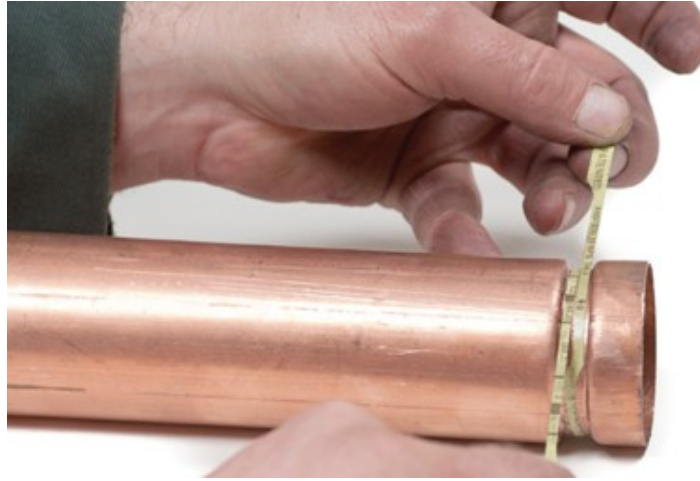


Figure 58 Check the dimensions (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

6. Examine the fittings, gaskets, and clamps to ensure the proper gasket is inserted into the clamp and the fitting end is not damaged.
7. Inspect the clamping surfaces to ensure they are clean and free from construction debris.
8. Lubricate the gasket according to the manufacturers' recommendations.



Figure 59 Apply lubrication (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

9. Assemble the clamp and pipe, ensuring that the gasket and groove and sealing surfaces align and seal correctly.



Figure 60 Assembled joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

10. Tighten the clamp evenly.



Figure 61 Tighten the clamp (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

11. Visually inspect the completed joint alignment, etc.



Figure 62 Inspect clamping surfaces (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

12. Test the completed piping system using pressurized air or water. When the test pressure is relatively high, hydro-pneumatic testing may be used. Test pressures should never exceed the maximum operating pressure specified by the manufacturer of the fitting system. Test pressures are determined by the job specifications and regulations standards such as the plumbing code, fire sprinkler code, or other applicable codes.

Bending of Pipe and Tubing

Most pipe and tube can be bent. There are several benefits to bending, including:

- Reduced or eliminated unnecessary joints and connections, resulting in fewer leaks
- Greater flexibility of pipe when bends rather than fittings are used
- The ability to create offsets at angles not available with manufactured fittings

This basic bending information section focuses on tube bending only.

Tube bending is used in refrigeration and other piping systems, including, but not limited to, gas fitting applications, residential fuel oil systems, pneumatic control piping, and small-diameter water lines to plumbing fixtures.

When copper tube is properly bent, it will not collapse on the outside nor buckle the inside of the bend. Because copper is readily formed, expansion loops and other bends necessary in an assembly can be made quickly and efficiently. A well-constructed system of exposed tubing will also present a more professional appearance when bends are used instead of fittings.

Both **annealed** and **hard-drawn tube** can be bent using the appropriate hand benders. Use the proper size of bender for each tube size. Refer to manufacturers' guides for a list of each tool's typical bend radii.

Aside from brittle pipe materials, such as cast and ductile iron, both ferrous and non-ferrous pipe can be bent using machines. Machine bending methods include **draw bending**, **compression bending**, **roll bending**, **ram bending**, and **stretch bending**. The use of dies and rolls helps prevent the pipe from distortion that could cause pipe failure or difficulty connecting to other pipes or fittings. *Cold and hot bending, bend radius, bend angle, throat-of-bend, back-of-bend, bend arc, inner curvature, outer curvature, thinning, stretching and shortening* are some of the terminology that will be used in pipe bending theory for steel pipe, which will be covered in detail in future levels of your apprenticeship training.

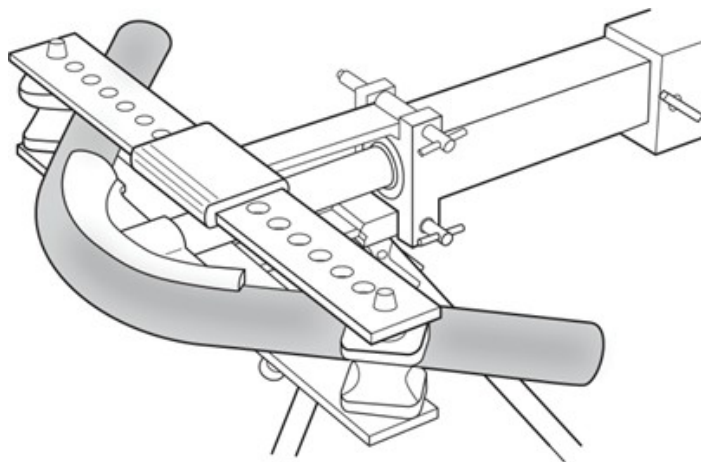


Figure 63 Rothenberge pipe bender (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Plastic Fusion Welding Jointing Methods

Thermoplastic pipe is increasingly used in many industries, such as gas, water, and mining. The advantages over traditional materials (e.g., steel and cast iron) include lower cost, resistance to corrosion, lighter weight, and ease of joining. Ease of joining is only applicable if installation is done by qualified personnel following correct procedures and pipe and fitting tolerances.

The information, procedures, and equipment described here are generic and do not represent any specific manufacturer. Fusion welding of plastic pipe may require specific training and certification by a particular manufacturer to conform to the product they are providing.

Fusion welding is a type of welding that uses hot air or heating plates to fuse certain types of plastic piping. For example:

- Plain-end pipe: joined by **butt fusion**
- **Hub-to-spigot** pipe: joined by socket fusion
- Branch connections (tees): often formed by saddle fusion

Polyethylene piping can be heat welded by socket fusion.

Heat fusion welding of **high-density polyethylene pipe (HDPE)** employs specially designed heating elements along with appropriate forming blocks, cutting tools, and clamping devices to fusion weld the pipe joint.

The heating element heats the pipe and fitting components to a temperature at which the HDPE material begins to soften and melt. At a specified temperature, the heating element is removed, the opposing joint surfaces are brought together, and a specific force is held on the joint, forcing the two heated surfaces to mix and become one. As they cool, the joint forms a single continuous material with strength comparable to the original pipe.

General Safety Specific to Fusion Welding and Machines

Follow all safety requirements.

Before adjusting or attempting maintenance, disconnect the machine from the power source. The heater is hot and will burn clothing and skin. Keep the heater in its insulated heater stand or blanket when not in use and use care when heating the pipe.

Use only a clean, natural-fibre cloth (such as a cotton) to clean heater plates.

Basic Fusion Welding Equipment

The subtopics describe some basic fusion welding equipment to be familiar with.

Heating Irons

Specially shaped **heating irons (also called heaters)** are used to:

- Heat pipe ends for butt fusion
- Heat the inside of fittings and the outer surface of the end of a pipe for socket fusion
- Heat the exterior wall of a pipe and its mating surface on a fitting for saddle fusion

With all types of joining with heating irons, the heating iron is applied to the surface of the mating components until each surface melts but does not burn.

The length of time required to heat a joint is determined from the manufacturer's specifications and used for heating the joints systematically.

When irons have seen a lot of use, the protective non-stick coating can be damaged. At some point, this will allow the melted plastic to stick and interfere with the actual joint. Replacement adapters would need to be purchased. Some irons have temperature gauge and temperature adjustment screws. Check the fitting manufacturer's instructions for appropriate temperature settings.

Coated heater adapters are available for all fusion applications. Heater adapters are installed with stainless steel cap screws. Ensure that the heater adapters are seated on the heater body and that there is no foreign matter trapped between these surfaces. Do not over-tighten the bolts. The surface of the heater adapters are coated with an anti-stick coating. Only install heater adapters when the heater is cool. Check manufacturer's tightening instructions.



Figure 64 A regular plastic pipe cutter with a plastic cutter wheel can be used to cut the pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The following figure shows an example of a large-diameter poly pipe fusion machine.



Figure 65 Large portable fusion machine (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Other Fusion Welding Equipment

Pyrometer

Incorrect heating temperature can result in poor fusion joints. Periodically check heater plate surface temperature with a properly calibrated **pyrometer** and make necessary adjustments. The thermometer on fusion heaters indicates internal temperature and should be used as a reference only.



Figure 66 Pyrometer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

You can use a **Tempilstik** to check the heating element surface temperature. Simply apply the end of the stick to the surface of the heater. Never touch the stick to the surface being melted, as you could contaminate the joint.



Figure 67 Tempilstik (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Fusion-Welding Assembly

Figure 68 shows a small-diameter fusion assembly used for fusion-welding poly pipe.

This assembly holds the pipe tight with built-in cold-clamping rings (A). The cold clamps are tightened around the pipe using a handle (C).

The system can be used for butt fusion or saddle connections. For pipe saddles, the chains wrap around the pipe and hook into the latches (B).

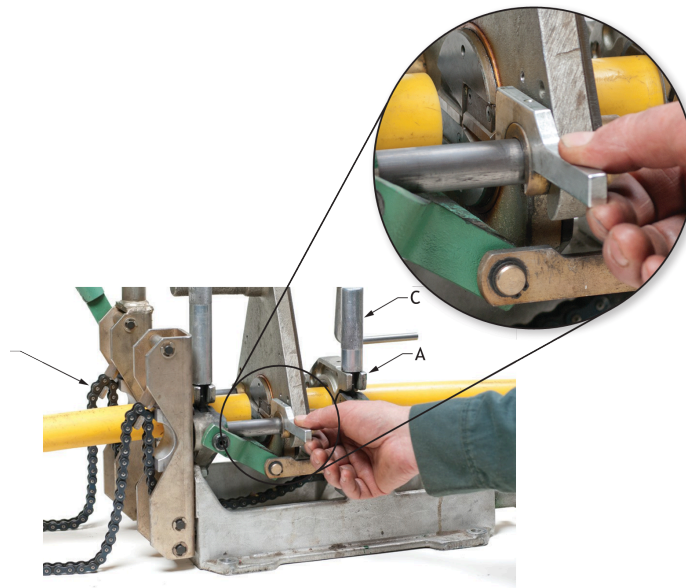


Figure 68 Facer not locked onto the rail (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 68 shows the pipe facer mounted on the fusion machine. The pipe ends have been lined up for a butt fusion weld. The facer/trimmer has been lowered into place to trim the ends of each pipe. The operator is holding the locking lever ready to swing it up to the locked position.



Figure 69 Vice-grip cold-clamping ring (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Facer

A **pipe facer (trimmer)** fits onto the fusion assembly and is used to trim the ends of the poly pipe square for butt fusion welding. Before using the facer, also known as a trimmer, make sure the pipe ends are aligned with each other by checking the outside diameters for perfect circumference alignment. The figures below show the facer being installed.



Figure 70 Pipe facer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In Figure 71, the facer/trimmer locking lever has been swung up and locked into position. The facer is now ready to trim the ends of the pipe perfectly square and smooth. The cold-clamp handles have been tightened on both pipes on both sides of the facer/trimmer.

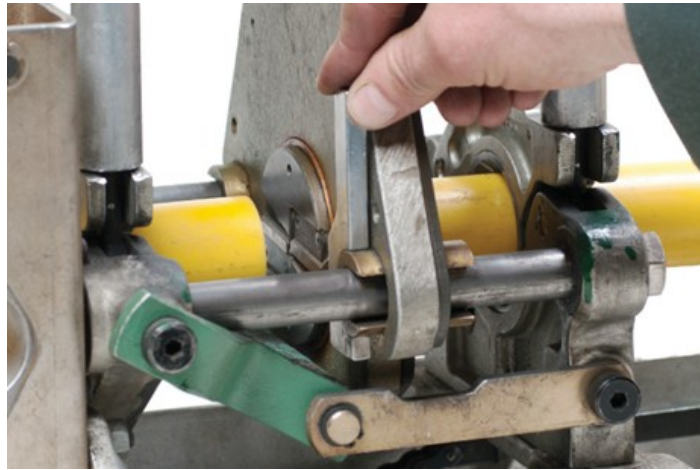


Figure 71 Facer locked onto the rail (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Trimming for Butt Fusion

The facing cutter is used to square up the ends of the poly pipe after first aligning and clamping the pipe. The pipe ends must be aligned perfectly over the entire circumference of each end. After facing, recheck for proper alignment and resurface if necessary.

To face the pipe end, rotate the facer trimmer handle, applying just enough pressure to cause the cutter to cut into the pipe (Figure 72). Continue to rotate the handle until a continuous ribbon is produced from each end of the pipes being faced. As you finish up the trimming, ease off the pressure so as not to leave nicks in the ends of the pipe.



Figure 72 Facing the pipe end (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 73 shows the operator checking the final alignment of the pipe ends after facing. Alignment is critical and should be perfect, with no gap between the pipe ends.

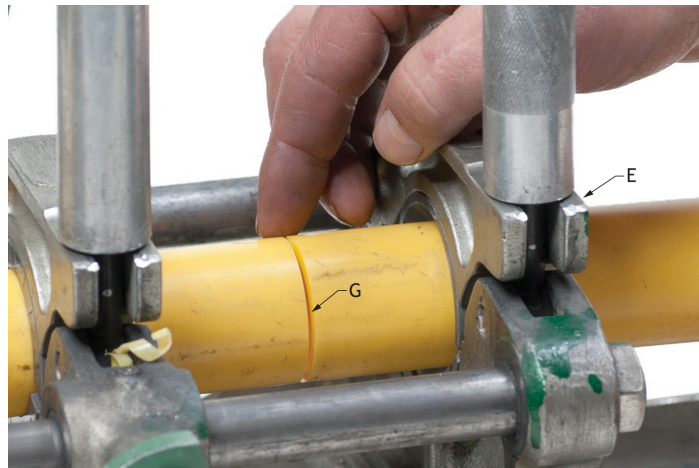


Figure 73 Pipe ends in alignment (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

- Note the following in the above figure: the clamps (E) are positioned close to the joint.
- The pipe ends are aligned and ready for the heating iron (G).

Fusion Welding Procedure

Before proceeding with the weld, do the following:

- Make sure you have cleaned the ends of the pipe with a clean, non-synthetic cloth or paper towel. Remove burrs and debris from inside the pipe ends.
- Recheck the alignment. There should be no gaps, nicks, etc.
- Check the tightness of the cold clamps. Do not overtighten.
- Make one last check for proper alignment.
- You are now ready to install the fusion heater.

The fitting and pipe must be clean and dry. Use a clean cloth to wipe the mating surfaces. Do not touch the surfaces with your hands.



Figure 74 Cold-clamping ring being used in preparation for fusion welding hands-free without the fusion assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The procedures shown here are for education purposes only. Always follow manufacturer specifications, standards, and procedures. Fusion welding procedures are found in the manufacturer's specification or in recognized approved and accepted standards. Follow the procedure carefully and adhere to all specified parameters. Failure to follow the pipe manufacturer's procedure could result in a defective joint.

Basic Procedures

Following are general, non-specific fusion welding procedures:

1. **Clamping:** The pipe and fitting must be held firmly to allow all subsequent operations to take place.
2. **Cleaning:** The area of pipe that the fitting will contact must be cleaned.
3. **Aligning:** The fitting must be properly seated on the pipe for proper alignment.
4. **Heating:** A melt pattern must be formed that penetrates into the pipe and into the fitting.
5. **Joining:** The pipe and fitting must be joined and the pipe fully seated within the fitting.
6. **Holding:** The molten joint must be held immobile until adequately cooled.
7. **Inspecting:** Visually examine the entire circumference of the joint for compliance with standards established by your company, customer, industry or local regulations.

Procedures for Butt Joint Fusion Welding

1. Plug in the heater and confirm that it reaches the correct temperature according to the manufacturer's specifications. This is normally $260^{\circ}\text{C} \pm 4^{\circ}\text{C}$ ($500^{\circ}\text{F} \pm 7^{\circ}\text{F}$). Also check the surface temperature using a Tempilstik.



Figure 75 Temperature at 260°C (500°F) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

2. Place the heater into the assembly and bring both pipe ends into contact with the heater surface. Do not apply any pressure.



Figure 76 Pipe contacting heater (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

3. Allow the pipe ends to form a bead (melt pattern), approximately 3 to 4 mm (0.12 to 0.16 in) in size.

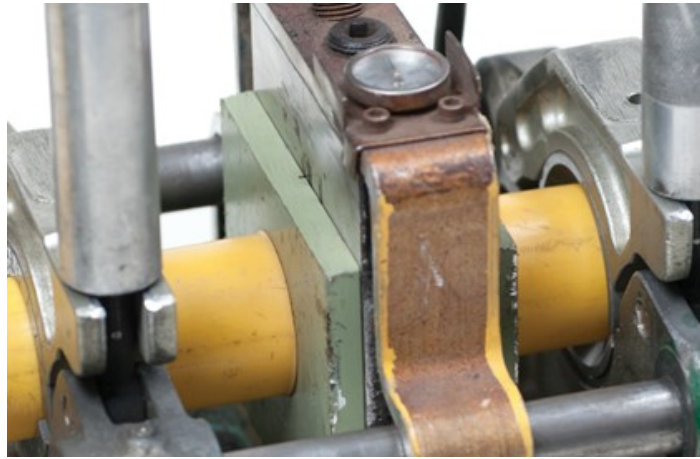


Figure 77 Melt pattern on pipe end (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

4. Move the ends of the pipe away from the heater and remove the heating plate quickly. Bring the ends of the pipe together rapidly without slamming. Use just enough force to form a **double roll-back bead**. Too much force will push melt away from the bead, resulting in a poor fusion. Hold in position until you can touch with your finger comfortably. Wait for approximately 10 minutes before applying any stress to the joint.

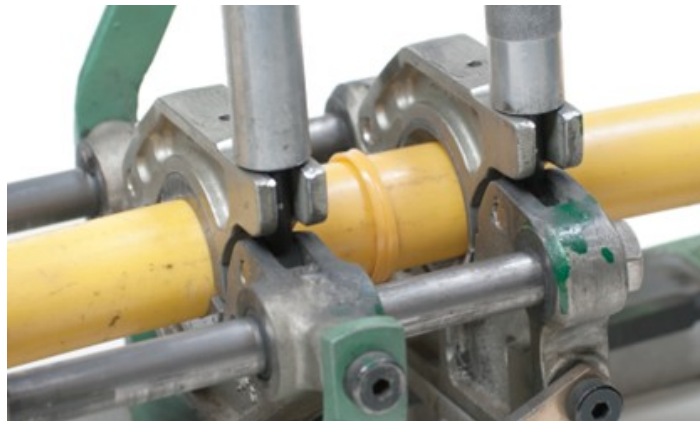


Figure 78 Double bead (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Temperature, applied pressure, and melt and cooling times are critical factors in creating a good fusion joint. With practice, you will learn when and how much pressure to apply to complete a fusion joint.

Safety Precautions for Butt Joint Fusion Welding

The heater is not explosion-proof. Take safety precautions when operating the heater in hazardous environments to prevent explosion, injury, or death. Bring the heater up to temperature in a safe environment, then unplug it before entering the hazardous environment to perform the weld. Use a clean, natural-fibre cloth to clean the heater adapter surfaces.

Clearly mark all hot surfaces to indicate they are hot. Store the heated iron in the appropriate holder to stay hot when in use or to cool off when not in use.

Precautions for Cold Weather Butt Fusion Welding

Follow these precautions when butt fusing pipe in cold weather:

1. Avoid hitting the pipe ends on hard surfaces. Cold temperatures make plastic more brittle and susceptible to damage from mechanical abuse, such as impact.
2. Carefully remove, by light tapping and scraping, any snow, ice, or frost from inside and outside the open ends and the areas to be clamped in the joiner. Failure to remove ice and snow could lead to incomplete fusion at the joint and slippage of the jaws.
3. Use tape or paper **shims** if needed to prevent clamps from slipping during cold weather. Clamping inserts are usually more than adequate to prevent pipe slippage, but slippage can still occur when pipes contract in low temperatures.
4. Follow the standard butt fusion steps, giving particular emphasis to the fusion steps. The time required for an initial melt bead to form will be longer than usual. Do not apply greater than normal pressure to the pipe ends.
5. Bring the pipe ends together quickly after removing the heater plate from between them. Do not slam the pipe ends together.
6. Protect and shelter the heating and fusion tools from high winds or rain to prevent excessive heat loss and to keep the heating tool dry at all times. The melt area should also be sheltered to reduce heat loss from the melted ends and to prevent rain or moisture from contaminating the fusion area.

Saddle Fitting with a Built-in Hole Cutter

Some saddle fittings have a built-in cutter. After fusion, the cutter can be advanced to cut the hole in the pipe. The removed cut-out section from the hole is held in the cutter, and the cutter is then repositioned at the top of the saddle. The cap is then reinstalled. The fitting may also function as a shut-off valve.



Figure 79 Saddle fitting with built-in cutter (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 80 Cap removed to show cutter head (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Saddle Fusion Procedure

Saddle fusion (also called *sidewall fusion*), is used when installing polyethylene service saddles onto compatible polyethylene pipe mains.

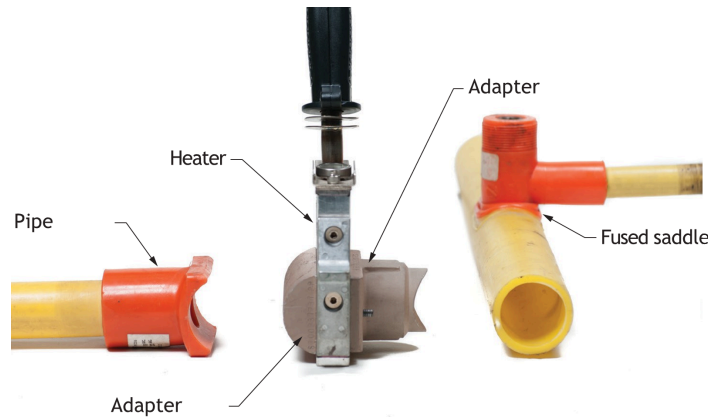


Figure 81 Saddle fusion components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 82 Installed saddle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Follow this procedure when saddle fusing pipe:

1. Clean the pipe surface so that it is free of dirt, oil, and water. Remove any printed ink lettering with a clean cloth.
2. Install the fusion machine on the main. Ensure that the machine is adequately supported in the desired position and that it is firmly attached to the pipe.
3. Prepare the surface of the pipe and fitting by first roughing with coarse emery cloth then brushing away any loose material.
4. Align the fitting on the main, then tighten the fitting while applying slight pressure on the movable clamp handle.
5. Check the saddle base for square alignment on the main.
6. Use a Tempilstik to check the heating iron temperature, which should be $260^{\circ}\text{C} \pm 4^{\circ}\text{C}$ ($500^{\circ}\text{F} \pm 7^{\circ}\text{F}$). Take care not to contaminate the actual fusion surface with Tempilstik residue.
7. Quickly place the heater onto the main and remove it. Check for evidence that the heater has contacted all areas of the main. Two to three seconds of heating time should indicate this. If the main is not contacting the heater properly, the most probable reason is that the pipe is out of roundness. This can sometimes be corrected by either tightening or loosening the clamp knobs. The heater must be proven to make full contact with the main before fusion can be started.
8. Place the heater between the fitting and the main. Apply firm (but not excessive) pressure while heating. Ensure that the heater is centred under the fitting. Continue to heat until a bead has formed on the pipe and on the fitting all the way around the heater. The last place that the bead should form is on the pipe, in the middle of the heating

iron face

9. Once the bead is at least 1.6 mm ($\frac{1}{16}$ in) all the way around, snap the fitting and main apart and snap the heater free. Be careful not to damage the pipe or the fitting while removing the heater. Care must be taken not to over-melt the main, as there is a risk of a blowout if the main is under pressure. The recommended maximum time for the heater to contact the main is 30 seconds.
10. Bring the melted surfaces together quickly, but do not slam the surfaces together. Apply continuous progressive pressure until a proper fusion bead is formed. Maintain pressure until the joint has cooled sufficiently to allow your finger to remain comfortably on the bead.
11. Remove the saddle fusion unit and inspect the fusion. The joint should have a uniform, well-aligned appearance all around. There should appear to be three beads at the fusion joint. Inspect the joint for gaps or voids or other evidence of incomplete fusion.
12. Do not subject the fitting to any abnormal stresses until the fusion is sufficiently cooled, which should be in approximately 10 minutes.
13. Do not drill or tap through the main until the pipe is sufficiently cool.

Precautions for Cold Weather Saddle Fusion

Follow these precautions when saddle fusing pipe in cold temperatures:

- The length of time necessary to obtain a complete melt pattern will depend not only on the outdoor (pipe) temperature, but also on wind conditions, pipe tolerances, and operator variation.
- If possible, store the fittings at room temperature before use. This will make it easier to place the fittings on the heating iron, because fittings shrink when subjected to low temperature.

After observing the above precautions, follow normal saddle fusion procedures.

Socket Fusion Welding Procedure

Follow this procedure when **socket fusing** pipe:

1. Cut the pipe square using shear-type cutters or pipe cutters fitted with special plastic pipe cutting wheels.
2. Chamfer pipe sizes 31.75 and 50.8 mm (1- $\frac{1}{4}$ and 2 in). Smaller sizes do not require chamfering.



Figure 83 Chamfering tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

3. Remove any oil or dirt from the surfaces to be joined. Sand pipe ends with emery cloth and then remove any loose material with a clean dry cloth or paper towel.
4. Place the depth gauge on the end of the pipe to allow for correct positioning of the cold ring. Position the cold ring on the pipe and remove the depth gauge.



Figure 84 Setting cold ring depth (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

5. Use a Tempilstik to check the heating iron temperature, which should be $260^{\circ}\text{C} \pm 4^{\circ}\text{C}$ ($500^{\circ}\text{F} \pm 7^{\circ}\text{F}$). Take care not to contaminate the actual fusion surface with Tempilstik residue.
6. Push the socket fitting into the heating iron until it bottoms out, and then place the heating iron on the pipe until it bottoms against the cold ring. Hold it there until the surfaces melt, about 5 to 40 seconds, depending upon the diameter and the temperature of the heating iron.
7. Quickly remove the fitting and the pipe from the heating iron. Immediately push the fitting squarely onto the pipe until it bottoms against the cold ring. Do not twist or rotate the pipe in the socket. Hold the fitting onto the pipe for the duration of the cooling cycle (see manufacturers' documentation).



Figure 85 Socket fusion weld (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Additional Considerations

- Do not subject the joint to any externally applied stresses (pulling or bending) until it is completely cool, generally in about 10 minutes.
- Inspect the joint for evidence of complete fusion. This is shown by a flat melt bead pattern on the fitting that completely encircles the pipe.
- Clean the heating iron of any residue after use.

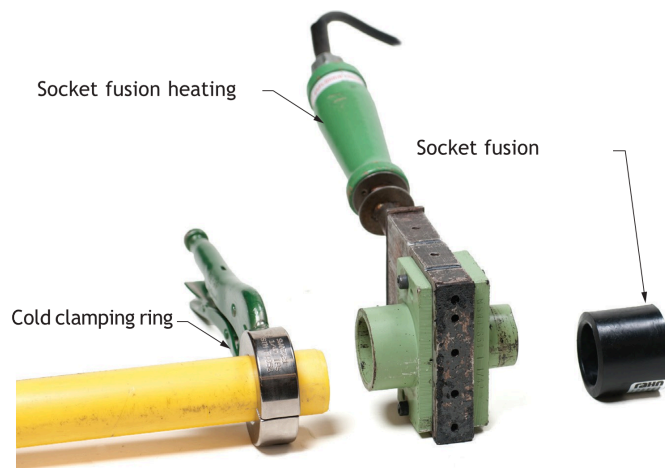


Figure 86 Socket fusion components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Precautions for Cold Weather Socket Fusion

Follow these precautions when socket fusing pipe in cold weather:

1. Remember that the length of time necessary to obtain a complete melt pattern will depend on the outdoor (pipe) temperature, wind conditions, pipe tolerances, and operator variation.
2. If possible, store fittings at room temperature before use. This makes it easier to place fittings on the heating iron because fittings shrink when subjected to low temperatures.
3. The pipe also contracts in cold conditions, which may result in loose or slipping cold-clamp rings. For best results, clamp one cold-clamp ring in its normal position directly below the depth gauge, then place **shim** material (a piece of paper or tape) around the inside diameter of a second cold-clamp ring and clamp it directly behind the first cold-clamp ring to prevent slippage. The first cold-clamp ring will allow the fused portion of pipe to expand to its normal diameter during heating.
4. Under abnormal or extreme weather conditions, use the following method to determine melt times for socket fusion:
 - a. Place the heater onto a pipe test piece and begin timing when the cold-clamp ring bottoms out.
 - b. After a chosen heating time, quickly remove the pipe from the heater and gouge the outer pipe wall with a screwdriver or other sharp object. The correct heating time is achieved when half of the wall thickness can be gouged out in this manner. If less than half of the wall thickness can be gouged out, increase the heating time; if more than half can be gouged out, decrease the heating time.
 - c. Discard all gouged test pieces.
5. After observing the above precautions, follow normal socket fusion procedures.

Solvent Welding Plastic Piping



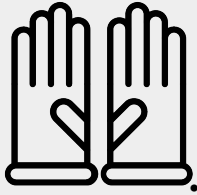
Figure 87 Glueing lengths of pipes
([https://commons.wikimedia.org/wiki/File:David_Caldwell_glueing_lengths_of_pipe_\(12366938823\).jpg](https://commons.wikimedia.org/wiki/File:David_Caldwell_glueing_lengths_of_pipe_(12366938823).jpg)) (USFWS/Southeast/Wikimedia Commons) CC BY 2.0
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Solvent cementing is the process of fusing plastic pipe and fittings by the use of an adhesive containing a suitable active solvent system and an appropriate resin. This process is referred to as **solvent welding**.

Plastic piping systems are easy to install, but larger sizes (more than 50 mm or 2 in) require a degree of expertise to produce a leak-free joint.

Most plastics are joined by inserting **plain-ended piping** into fittings and solvent welding them together. PVC and chlorinated poly-vinyl chloride (CPVC) piping and fittings are joined with a different type of solvent cement than acrylonitrile butadiene styrene (ABS).

Consult the manufacturer's detailed directions on the solvent cement container. Environmental conditions, such as temperature and moisture, will affect the time required for the joint to set.



Safety Precautions for Solvent Cements

• Ensure there are no ignition sources in the area you are working, as solvent cements are flammable.

- Ensure that the work area has adequate ventilation, or wear a respirator.
- Wear protective eyewear and avoid contact of solvent cement or cleaner with your skin.
- Read the manufacturer's Material Safety Data Sheet (MSDS) before using the solvent cement.

Solvent Cementing Joining Procedures



Figure 88 Plastic Pipes joint
(<https://www.pexels.com/photo/plastic-pipes-on-wall-12142829/>) (Bùi Hoàng Long/Pexels) Pexels license
(<https://www.pexels.com/license/>).

These procedures apply to all types of plastic: ABS, PVC, and CPVC.

1. Pipe preparation

- a. **Cutting:** Cut pipe square using a hand hacksaw and miter box, a power circular or hand saw with a

suitable guide, or a rotary cutter if the cutting wheel is specifically designed for cutting plastic pipe.

- b. **De-burring and bevelling:** Using a knife, de-burring tool, or coarse file, remove all burrs and sharp edges from the pipe. All pipe ends should be bevelled with a coarse file or bevelling tool. This will minimize the chance of wiping the solvent cement from the fitting socket during installation, which could result in a leaking joint. Do not use sandpaper on plastic pipes. It may remove too much material for successful joining.

2. **Fitting preparation:** Before solvent cementing, all fittings should be inspected for cracks or damages. Fittings should be exposed to the same temperature as the pipe for at least an hour, to ensure that they are thermally balanced before joining.

3. **Cleaning:** Clean the pipe end and fitting socket thoroughly. The surfaces to be joined must be clean, dry, and free of dirt and grease. Some plastics may recommend a liquid cleaner be used.

4. **Dry fitting:** Solvent cement joints are designed so that there will generally be interference of pipe wall with the

fitting socket before the pipe is fully inserted. Usually this occurs when the pipe is inserted $\frac{1}{3}$ to $\frac{2}{3}$ of the socket

depth during dry fitting. Therefore, do not use this step to check your measured lengths. Sometimes, when the pipe and fittings are at their tolerance extremes or when Schedule 80 pipe is used, it may be possible to fully insert the dry pipe into the fitting until it bottoms. If this occurs, the fit should be snug. If the fit is loose or wobbly other fittings or pipe should be selected to give a proper fit.

5. **Priming:** ABS, PVC, and CPVC are different materials. Although their cementing procedures are similar, they are different and are outlined separately below.

- a. **ABS:** Cleaner may be used to prime the mating surfaces. However, in most cases, experienced installers can achieve successful bonding without the use of a primer.
- b. **PVC and CPVC:** The use of a primer is recommended and is mandatory for all pressure applications. Our PVC-1, which is a one-step cement, does not require the use of a primer and can only be used on non-pressure applications. The function of the primer is to penetrate and soften the bonding surfaces, especially the high-gloss and hard-glaze surfaces of the pipe and fittings, before applying the cement. Apply primer to the fitting with a dauber or brush.

“One step” cement can be used when installing CPVC fire sprinkler piping.

6. Solvent cementing:

- a. Choose the proper CSA-certified solvent cement.
- b. Using an applicator, evenly apply a heavy coating of solvent cement to the pipe and a light coating to the socket. Now apply a second coating to the pipe, ensuring that sufficient material is present to fill all gaps.
- c. Making certain that the cement on the pipe and fitting is still “wet,” insert the pipe into the fitting until it

bottoms in the socket. Then give it a $\frac{1}{4}$ turn to ensure complete and even distribution of the cement. Make

sure that the joint is positioned correctly, as the cement sets in a few seconds.

- d. If the pipe does not insert smoothly or does not twist easily, take the joint apart immediately. Apply more cement and rejoin. The use of a cleaner or primer will extend the open time and setting time.
- e. Hold the joint together until the cement has set. This may take up to two minutes depending upon pipe size. Avoid disturbing the joint until it is fully cured.
- f. Immediately after joining, wipe off all excess cement. A properly made joint will show a bead around its entire perimeter. Gaps may indicate a defective assembly resulting from insufficient cement.

Joint Integrity



Figure 89 Outdoor pipes (<https://pixabay.com/photos/tap-water-pipes-closed-water-pipe-5142411/>) by (Alexei other/Pixabay)
Pixabay Content License (<https://pixabay.com/service/license-summary/>).

Joint integrity depends upon a tremendously wide variety of product and environmental conditions. These include size of pipe, ambient temperature, surface temperature of the joint, humidity, dry joint interference fit, and others. In general, drying times will be faster with smaller diameter pipe, higher surface temperatures, tighter interference fits, and lower humidity. Drying times will be slower when the opposite conditions exist.

Recommendations

1. Avoid joining at atmospheric temperatures below 5°C (41°F) or above 32°C (90°F) when exposed to direct sunlight. For work outside of this preferred range, refer to the sections below on hot-, cold- and wet-weather cementing.
2. Allow at least 48 hours of joint drying time before a joint is moved or subjected to any internal or external pressure. When in doubt about proper cementing techniques under particular conditions, contact the solvent cement manufacturer for expert advice.

Cementing Under Wet Conditions

Moisture inhibits the bonding of plastic pipes and fittings. In failed joints a white film or residue often appears, indicating the presence of water during the joining process. Cementing can be done in wet weather and in wet environments but it is imperative that the mating surfaces be dry when the joint is made.

The following suggestions may help in wet situations:

1. Work under a cover or canopy to keep rain off the pipe and fittings.
2. Use a cleaner or primer to aid in the removal of moisture.
3. Work quickly after drying the pipe and fitting to avoid condensation.

4. Use a very fast-drying and fast-setting cement to limit the period of time when the joint is vulnerable to moisture. A fast-setting cement requires the worker to apply more cement and to work very quickly to ensure that the cement is still fluid when the pipe is inserted into the fitting.
5. Allow a longer cure time before the system is tested or used.

Hot Weather Cementing

When atmospheric temperatures are above 32°C (90°F), certain precautions have to be taken to avoid excessive solvent evaporation from the cement. Such evaporation may cause the cement to set prematurely and adversely affect joint integrity.

The following steps can reduce these challenges:

1. The surface temperature of the mating surfaces should not exceed 45°C (113°F) at the time of assembly. Shade or shelter the joint surfaces from direct sunlight for at least an hour prior to joining and also during the joining process. Swabbing the surface to be cemented with cleaner may reduce the pipe temperature; wet rags may also be used, provided the parts are thoroughly dried before primer or cement are applied.
2. Make cement joints during the cooler, early morning hours.
3. Apply cement quickly. On 15 cm (6 in) and larger pipe we recommend that two workers apply cement to the pipe surface while a third applies it to the fitting socket.
4. Join pipe to the fitting as quickly as possible after applying cement.
5. To minimize solvent loss, keep cement container closed or covered when not in use.

Cold-Weather Cementing

Working in freezing temperatures is never easy. However, if the job of solvent cement welding is necessary, you can do it successfully with proper solvent cements. By following the manufacturer's standard instructions and using a little extra care and patience, successful solvent cemented joints can be made at temperatures even as low as -26°C (-14.8°F). In cold weather, solvents penetrate and soften the plastic pipe and fitting surfaces more slowly than in warm weather. In addition, the plastic is more resistant to solvent attack, making it more important to pre-soften surfaces with an aggressive primer. Because of the slower evaporation, a longer cure time is necessary. Cure schedules provided by the manufacturer will allow a margin for safety, but for colder weather, more time should be allowed.

Suggestions for Quality Joints in Cold Weather

1. Prefabricate as much of the system as is possible in a heated work area.
2. Store cements, cleaners and primers in a warmer area when not in use and make sure they remain fluid.
3. Joints that must be made outside should be protected with a portable shelter and heated with indirect heat to surface temperatures above 5°C (41°F) before joining. The shelter and heat should remain in place for at least two hours after joint assembly.
4. Although PVC-1 (one-step) cement can be used in cold weather, it is extremely important that extra care be taken when applying the cement, so that proper penetration and softening of the pipe and fitting surfaces are achieved.

The use of a primer when using PVC-1 during an extreme cold-weather installation will be beneficial to the final results if shelters and heating set-ups cannot be done in the welding area.

5. Take special care to remove moisture including ice and snow from the surfaces to be joined. On PVC and CPVC pipe and fittings the surfaces must be cleaned with a manufacturer-approved cleaner.
6. Before assembly, after the pipe has been cut, cleaned and dry-fitted as per the instructions on the label, primer must be used to soften the joining surfaces on PVC or CPVC installations before applying cement. On ABS installations, cleaner may be used as the primer. More than one application may be necessary.
7. Allow a longer cure period before the system is used. A heat blanket may be used to speed up the set and cure times.
8. It is extremely important to read and follow all of the manufacturer's directions carefully before installation. For all practical purposes, good solvent-cemented joints can be made in very cold conditions, with proper care.



Caution: Do not attempt to speed the setting or drying of the cement by applying direct heat to the solvent-welded joint. Forced rapid drying by heating will cause the cement solvents to boil off, forming porosity, bubbles and blisters in the cement film.

Estimating Solvent Cement Requirements

The actual number of joints can vary considerably due to installation conditions and techniques, tolerance variations, and socket depths. Since the cement is the least expensive material being used, it is better to use too much cement than not enough.

Refer to manufacturer documentation.

Set Times and Cure Schedules

During the initial setting of the cement (approximately 2 minutes), the joint should not be moved or disturbed. Numerous factors, such as application conditions and the specific cement used, affect the actual cure rates, which may be faster or slower than the times indicated. In damp or humid weather, allow 50% more set time and cure time; extended set times are required for chemical applications.



Refer to manufacturer documentation for exact curing schedules. The initial set schedule is the necessary time needed before the joint can be carefully handled.

PVC and ABS Testing

For testing, refer to manufacturer documentation and applicable local code requirements.

Joining ABS to PVC Piping

Transition solvent cement is solvent cement used to join ABS drainage and PVC drainage pipe and fittings. This solvent cement is white in colour and is typically used only for a single transition joint within a system. You are not permitted to switch back and forth from ABS to PVC several times. This solvent cement is often used to connect ABS DWV pipe to PVC sewer pipe after the ABS pipe leaves the building. Procedures for joining are the same as for ABS and PVC.

Threaded Piping Connections

Various types of iron, steel, heavy copper, and plastic piping may have threaded ends. The most common type uses external threads that are joined with internally threaded fittings.

Threading pipe is an essential skill in the piping trades. Pipe threads are widely used to join pipe and fittings. You must be able to produce high-quality threads and assemble leak-proof joints. Poor threading can lead to serious problems, especially in gas or pressurized systems.

A common question is, “How tight do you tighten the pipe and fittings?” The answer is: tight enough to prevent leaks, but not so tight that the fitting is damaged. Over-tightening may stretch a malleable fitting or crack a cast iron fitting. The correct feel is developed through experience.

The number of pipe threads that remain exposed after you have finished tightening the fitting onto the pipe will give some indication of the joint quality. Typically, two to three threads should remain visible. If no threads are visible, the joint may be over-tightened. If too many threads are visible, the joint may be under-tightened.



Figure 90 Correctly threaded joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Procedures for Threaded Jointing

Installation of threaded joints involves the cutting of threads and assembling the joint. Threads may be cut using a power threader or by hand. When cutting threads by hand, follow these steps:

1. Select the proper size of die.
2. Clean the pipe surface. Be sure the end is square and free of burrs. Chamfering the pipe end will make it easier to start the die.
3. Mount the threader on the pipe with the die's leading threads facing the pipe.
4. Apply thread cutting oil.
5. Apply pressure to start the die on the pipe.
6. The thread length is correct when the outer surface of the die is even with the end of the pipe (for full-width dies).
7. Remove the die and clean the threads with a brush or rag.
8. Apply an approved joint compound or tape that is to the external threads only.
9. Hand-tighten the fitting, then tighten to the required degree using the correct wrench.

Precautions for Threaded Jointing



Figure 91 Plumber installs (<https://www.pexels.com/photo/plumber-installs-pipe-fittings-6419128/>) (Anıl Karakaya/Pexels) Pexels license (<https://www.pexels.com/license/>)

- Threaded components and threaded ends should be examined before assembly for cleanliness and continuity of threads, and to ensure they conform with applicable standards.
- Compound or lubricant used on threads must be suitable for the service conditions and should not react unfavourably with either the service fluid or the piping material.
- Threaded joints that are to be seal-welded are made up without thread compound or lubricants.
- When a design requires threaded piping to be seal-welded, seal welds must cover all exposed threads.

Compression and Flared Joint Guidelines



Figure 92 Wrenches to tighten a fitting
(https://commons.wikimedia.org/wiki/File:Plumber_uses_two_wrenches_to_tighten_a_fitting.jpg)
(Tomwsulcer/Wikimedia Commons) CC0 1.0
(<https://creativecommons.org/publicdomain/zero/1.0/deed.en>)

For the proper installation and maintenance of compression and flared fittings, use the following guidelines:

- Inspect flare surfaces for imperfections before assembly.
- Where the manufacturer's instructions call for a specified number of turns of the nut, count these from the point at which the nut becomes finger tight.
- Cut ends square using the recommended method as per the type of material.
- Deburr inside and outside for proper entry into fitting and to prevent system contamination and or restricted flow.
- Clean tube ends. Remove all filings, chips, and grit before attachment of fittings.
- Do not force an improperly fitted tube line into the fittings. The fabrication of tube lines (your bend angles and measured lengths) must be accurate. Check to see that the tube end easily enters the fitting in proper alignment.
- The tube end must be bottomed against the shoulder in the fitting body. This is necessary to prevent movement of the tube, while the nut forces the **ferrule** to grip the tube and to seal through any imperfections that may exist on the outside tube surface.
- Use two wrenches. Never permit the fitting body to rotate during tube end makeup. Assemble port connectors to components first and hold this with your first wrench while making up the tube joint. All types of union bodies must be held while each of the tube ends is made up.

Other Types of Pipe and Tube Jointing

Other types of pipe and tube jointing methods include:

- Mechanical joints with external clamping and sealing components, such as elastomeric gaskets and sealing rings.
- Insertion jointing where the pipe is pushed into the fitting, sealed with O-ring-type gaskets with a variety of

profiles to suit the particular manufacturer's fittings and applications. These connections often include components that use compression forces to hold the pipe together and seal the joint.

Many types of piping can be joined with special types of fittings, such as mechanical joint couplings used with cast iron drainage and vent piping, roll and cut grooved pipe couplings and fittings, compression fittings, slip-on fittings, or insert fittings. In some cases, plumbing codes will restrict where and when these types of fittings and jointing methods can be used.

Procedures for these types of fittings may require the pipe ends to be prepared in ways such as the following:

- Measuring
- Cutting the pipe or tubing ends square
- Reaming, de-burring or chamfering the pipe ends
- Cleaning the pipe or fitting end and sockets ends or checking both inside and outside for debris or damage
- Applying lubricants on the pipe or fitting when required
- Ensuring correct arrangement of any clamp components, such as retaining rings, washers sleeve, seals, etc.
- Attaching the clamp and any component parts fully to one end of the pipe or fitting
- Inserting fully the other pipe or fitting end into the clamp
- Aligning the pipe, fittings, and clamps correctly
- Tightening any components, keeping joint alignments as you proceed, following any specified tightening sequences as required to ensure proper seal and joint strength
- Testing all piping system as required by the engineering, manufacturers' and code specifications

Mechanical Joint Method

Mechanical joint or zip couplings use screws or bolts to tighten a stainless-steel collar that compresses a neoprene or rubber sleeve (gasket) around the joint. These couplings can join plain-ended pipe and fittings.



Figure 93 Mechanical joint coupling (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

O-Ring or Gasket Joints (Slip-On Joints)

Hub-and-spigot piping and fittings can be joined with **O-rings** or special **elastomeric gaskets**. O-rings are usually rubber or neoprene ring gaskets that fit over the spigot pipe end and inside the hub of the fitting. The O-rings may be different profiles to match a particular pipe manufacturer.

The O-ring is held in place by the tight fit of the pipe and fitting and seals the pipe joint. In some pipes, a groove is machined into the hub end of the pipe to hold the O-ring in place. This type is often referred to as a **slip-on joint**. This method of joining is commonly used with ductile iron water pipe.

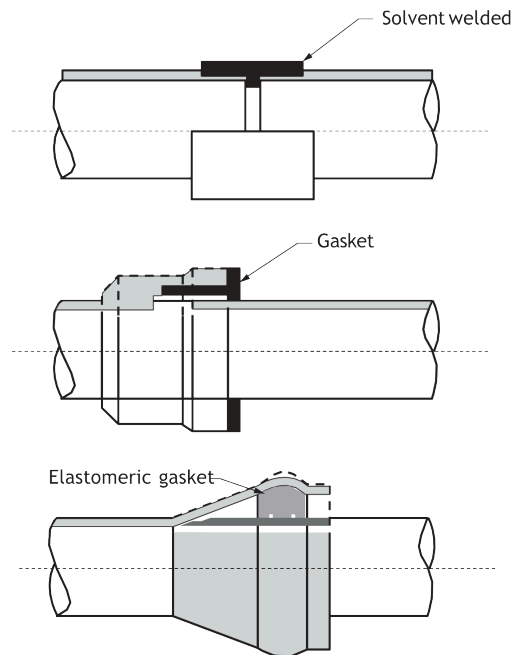


Figure 94 Three types of slip-on joints (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

For calculation of fitting allowances, see the calculations for piping measurements in *Block B: Tools and Equipment* (<https://b-handmeasuringtools-bcplumbingapprl.pressbooks.tru.ca/>).

Flanges

Flanges may be used to join plastic or metal piping. Flanges may be welded or screwed to metal pipe. Plastic flanges may be solvent welded or screwed together.

When measuring for flanged piping, allow for the thickness of the gaskets that will be installed between the flanges (Figure 95).

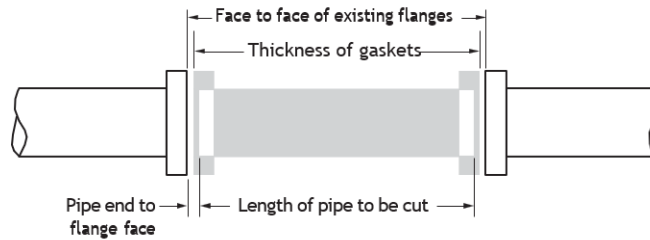


Figure 95 Measuring piping joined by flanges (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

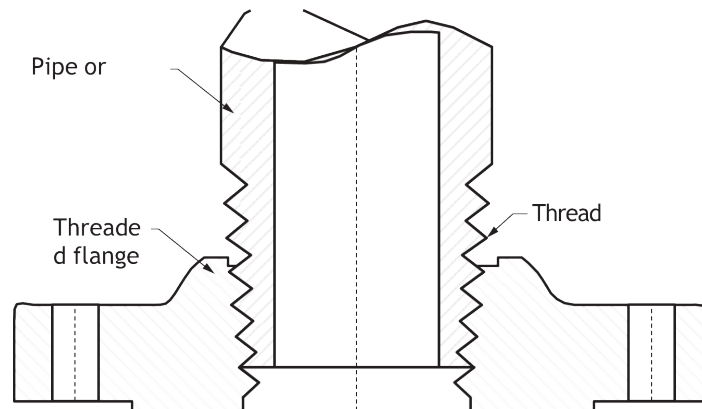


Figure 96 Side view of threaded flange on pipe
1. Threaded flange 2. Thread 3. Pipe or fitting (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

When installing a threaded flange, fully tighten the flange onto the pipe so that the end of the pipe is almost even with the face of the flange. Place the flanges on each piece of pipe together with a sealing gasket between each face. Align the bolt holes in each flange, then insert and tighten bolts to complete the seal.

Making a Flanged Joint

There are four basic steps in making a flanged joint:

1. Clean all surfaces on the parts, remove any grit or grease from the flanges, and make sure the gasket is clean.
2. Support the flanges and align the bolt holes. Support the part that you are installing and align the flanges both face-to-face and hole-to-hole (this is known as **timing flanges**). Bevelled punches are often used to do this.
3. Insert the gasket. For ring gaskets, insert the bottom bolts first, rest the gasket on them and then insert the rest of the bolts. For full-face gaskets, first insert a bottom bolt through one flange, one hole of the gaskets and the other flange. Then roll the gasket into place and insert the other bolts.
4. Tighten the bolts evenly using the **crossover method**. Apply a bit of thread lubricant to each bolt and run up the nuts by hand as far as they will go. Then use a wrench to snug the bolts using the crossover method. The crossover method ensures that bolts are tightened evenly. Start with the top bolt, then tighten the opposite bolt on the bottom, then tighten the bolt on the left side, then the right side, etc. Tighten all the bolts, following the same

numerical sequence shown in Figure 97. Be sure to not over-torque the bolts.

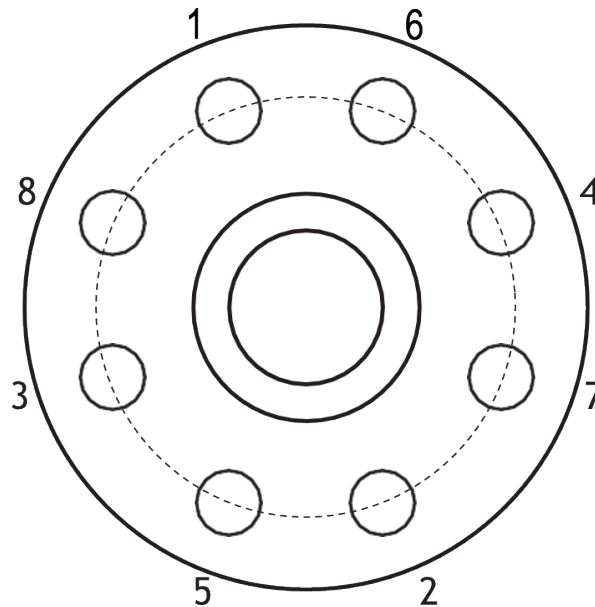


Figure 97 Bolt-tightening order – crossover method (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Note: Sequence and torque method and values vary depending on flange size and ratings, temperature, pressure, etc. Always follow the manufacturer’s recommendations and engineering specifications specific to the installation. For more information on bolt tightening sequence, refer to the section on valves in IPT’s *Pipe Trades Handbook*.

Flange Alignment: Checking Highs and Lows

When installing a flange, it is critical to align the inside diameters so that they are exactly centred. Do this by making sure the OD of the mated flanges are flush with each other (adjust so the highs and lows are flush). If the inside diameters, including the gasket, are not flush, inside turbulence is created, resulting in friction loss and/or noise and erosion.

High and low piping termination describes surface misalignment of the outside diameters of pipes at the point where the two pipes are joined.

Bolt-Tightening Torque

Tighten the bolts in the correct sequence and torque.

- Torque bolts in stages
- Follow the recommended sequence (30%, then 60%, then final value)
 - If this sequence is not followed, the flanges can be misaligned. Then, regardless of the amount of subsequent tightening, they cannot be brought back to parallel. This more of a problem on metallic gaskets than on non-

metallic ones.

On high-pressure, high-temperature applications, the flanges should be retightened after 24 hours at operating pressures and temperatures to compensate for any relaxation or creep that may have occurred.

Common Practices When Completing Flanged Joints

Be sure to:

- Inspect the gasket seating surfaces for damage.
- Make sure the gasket material is suitable for the contents of the system. Look for any defects or damage in the gasket.
- Inspect and clean each stud or bolt, each nut, each washer and the facing on the flanges against which the nuts will rotate.
- Lubricate all thread contact areas and nut facings. When flanges are to be subjected to high temperatures, consider using an anti-seize compound to facilitate subsequent disassembly.
- With raised face and ring gasket installation, loosely install the stud bolts on the lower half of the flange.
- Insert the gasket between the flange faces to allow the bolts to centre the gasket on the assembly. Install the balance of the bolts and nuts and bring all to a hand-tight or snug condition.

Pipe Flange Assembly

Using a Torque Wrench

A **torque wrench** is a tool used to precisely apply a specific torque to a fastener, such as a nut or bolt. It is used where the tightness is critical. The torque wrench is used to measure the torque applied to the fastener so it can be matched to the torque tension specifications required for an installation.

General Torque Wrench Guidelines

Follow these general rules when using a torque wrench:

- Never over-torque a fastener. Over-torquing can cause a fastener to stretch beyond normal limits, causing it to break or come loose.
- Never under-torque a fastener. The fastener could come loose or break.
- Follow torque specifications and sequences for torque application.
- Apply fastener lubricants as required by the manufacturer.
- Read and follow the manufacturer's direction for the torque wrench you are using.
- Do not re-use a fastener if it was installed with an impact wrench.
- Do not use a torque wrench to remove a fastener, especially if it was installed with an impact wrench. You could damage the torque wrench.

Fastener (Bolt) Failure

Fasteners such as bolts could fail under the following circumstances:

- Overloading caused when the torque force exceeds the fastener strength. The fastener may loosen or shear.
- Over-tightening (over-torquing) may cause damage to the threads or deforming of the parts.
- Under-torquing may cause the joint to come loose. It may also allow the joint to flex and thus fail when fatigue occurs.
- *Brinelling* caused by poor-quality washers, leading to a loss of clamp load and failure of the joint.
- Disintegration of a part due to oxidation or other forms of corrosion. This is why fasteners must be lubricated unless stated otherwise by the equipment manufacturer.

Brinelling is a material surface failure caused by contact stress that exceeds the material limit. This failure is caused by just one application of a load great enough to exceed the material limit. The result is a permanent dent or a permanent deformation of the metal surfaces.

Click-Type Torque Wrench Procedures

- Preset the torque value on the torque wrench as specified by the equipment manufacturer
- Torque the fastener using the specified tightening sequence to the point where the desired torque is reached. Listen for a click sound, which indicates that the torque value has been reached.
- Reset the torque value to zero before putting the wrench away.

For more information on torquing, refer to IPT's *Pipe Trades Handbook* (Section 5 Gasketed Joints).

Standard Flange Bolts and Flange Stud Bolts

Bolt up the flanges using stud bolts and the correct bolt-tightening sequence.

The flange stud bolt nuts, located on each side of the mated flanges, must have the same number of threads exposed past the nuts. The 2H or similar identifying mark must be visible.

Stud Bolt Grade Markings

Thread rods and nuts must be marked by the manufacturer with a unique identifier to identify the manufacturer or private label distributor, as appropriate. Figure 98 shows examples of ASTM markings.

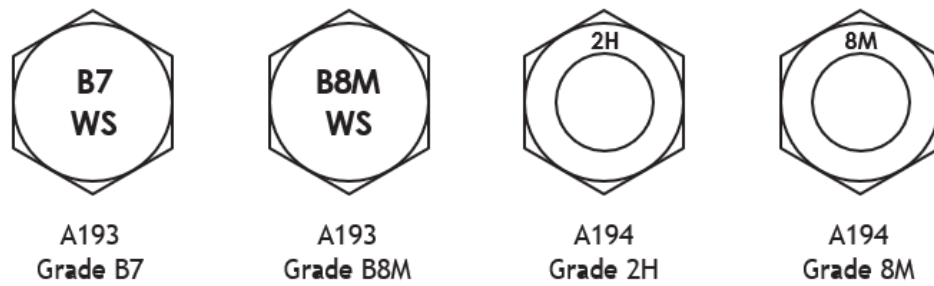


Figure 98 Stud bolt markings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Corrugated Stainless Steel Tubing (CSST)

Specialty piping such as **Corrugated Stainless-Steel Tubing (CSST)** is flexible gas piping suitable for connection to natural gas or propane appliances, and for natural gas and propane piping systems. CSST and its related fittings may have manufacturer-specific methods of installation and jointing that require specialized training. Figures 99–106 show examples of CSST tubing and fittings.

The following information is generic in nature. On the job, you must refer to the specific manufacturer specifications when selecting fittings and installing corrugated stainless-steel tubing (CSST) piping systems.



The installation of CSST flexible gas piping must be performed by a qualified installer who has successfully completed the manufacturer's training program. The installer must also meet all qualifications required by the authority having jurisdiction.



Figure 99 Coil of CSST (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Straight fittings connect the flexible gas tubing to gas supply, distribution manifolds, or gas appliances.

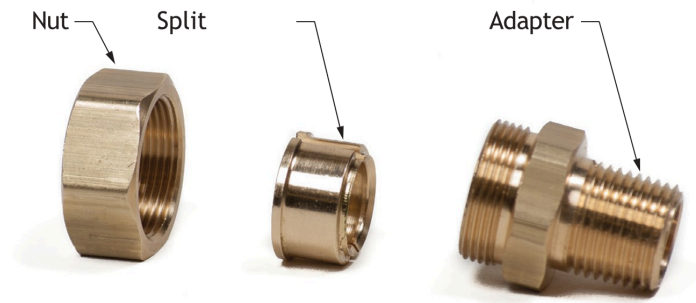


Figure 100 Straight fitting (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Tee fittings create a branch line on tubing runs. Couplings allow for the splicing and additions to the flexible gas tubing.



Figure 101 Tee fitting (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 102 Termination fitting (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 103 Marks on fitting indicate FlashShield (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 104 Appliance stub-outs Gastite (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 105 Striker plates (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 106 Flexible steel conduit for protection (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

General Installation Requirements for CSST

These installation requirements must be used in conjunction with all applicable building standards and codes. In the event that there is a conflict between these guidelines and the local code, the more stringent requirement will take precedence.

- Store all tubing, fittings and hardware in a clean, dry location prior to installation.
- Temporarily plug or tape closed the open ends of tubing prior to installation, to prevent entrance of dirt, dust or other debris.
- The protective plastic jacketing should be kept in place as much as possible to protect the tubing from corrosive threats. Contact with chemicals containing chlorides must be followed by a thorough rinse and wipe dry. This includes fluxes used to solder copper tubing and acid-based cleaners used to wash masonry.
- Keep tubing away from sharp objects.
- Only qualified installers trained in the individual manufacturer's installation instructions can install CSST flexible gas piping.
- Use only the components provided or specified by the manufacturer (including **striker plates** and **armour conduit**).
- Never use CSST flexible gas piping or system components as a ground electrode or as a grounding path for appliances or electrical systems.
- CSST flexible gas piping routed in a location that is concealed, constrained and within 7.5 cm (3 in) of a potential threat must be protected against damage by protection devices listed in the manufacturer's instructions. Contact with sharp objects or harmful substances should be avoided.
- Protect concealed tubing from puncture threats using provided striker plates at all points of penetration through studs, joists, plates or similar structures. The extent of protection is defined in the manufacturer's documentation.
- CSST greater than 25.4 mm (1 in) inside diameter installed within hollow cavity walls made of 2 × 4 construction shall be protected along the entire concealed length in the manner and using the shielding devices specified by the manufacturer.
- The width of the installed striker plate, at the points of penetration through wall studs, floor joists, plates, sills, etc., shall be out at least 1.5 times the outside diameter of the tubing.
- Temporarily plug or tape closed open ends of tubing prior to installation, to prevent entrance of dirt, dust or other debris.
- Keep protective yellow jacketing in place as much as possible to protect the tubing from corrosive threats. Contact with chemicals containing chlorides must be followed by thorough rinse and wipe dry. This includes fluxes used to solder copper tubing and acid-based cleaners used to wash masonry.
- Installation clearance holes for routing CSST are to be approximately 12.7 mm ($\frac{1}{2}$ in) greater than the OD of the CSST. Drilling of any structural member must be in conformance with the local building codes. See manufacturer's guidelines for the recommended drill hole sizing.
- Support CSST tubing with pipe straps (metal pipe straps are preferred), bands or hangers suitable for the size and weight of the tubing, at intervals specified in manufacturer's documentation and codes.
- Do not put stress or strain on the tubing and fittings. Avoid sharp bends, stretching, kinking or twisting of the CSST tubing.
- Sizing of CSST must be performed using the capacity tables found in the manufacturer's guidelines.
- Don't connect CSST flexible gas piping to movable appliances. Connections to movable appliances such as ranges and clothes dryers should be made with a flexible gas appliance connector.
- Regulators are suitable for multi-poise mounting. When using a vent-limiting device, the regulator must be mounted in a horizontal upright position. For outdoor venting, the vent line must be at least the same size as the vent connection and no longer than 914 cm (30 ft) before upsizing. When mounting a regulator outdoors, remove

vent limiting device and position regulator inverted with open port down.

- A manifold assembly shall include a shut-off valve ahead of the regulator and shall be installed in an accessible location so that the regulator can be inspected, maintained and serviced, if necessary.
- CSST shall not be buried directly in the ground or directly embedded in concrete (i.e., patio slabs, foundations and walkways). When it is necessary to bury or embed CSST, the tubing shall be routed inside a non-metallic,

watertight conduit that has an inside diameter at least 1.27 cm ($\frac{1}{2}$ in) greater than the OD of the CSST tubing. For

ends of conduit installed outdoors, the conduit shall be sealed at any exposed end to prevent water from entering. No mechanical joint fittings are permitted within the conduit. Note: CSST must be buried in accordance with all local building codes.

CSST flexible gas piping system must be pressure-tested for leaks during rough construction, in accordance with all local codes. In the absence of local requirements, test in accordance with Part 4 of the NFPA 54, National Fuel Gas Code ANSI Z223.1 and/or CSA B149.1 Installation Code or in accordance with the requirements of the applicable local codes. For a one-part pressure-test, the regulator should be removed from the system. For a two-part test, the regulator should be isolated from downstream test pressures.



Leak-test solutions may cause corrosion in some types of material in the gas piping system. Be sure to water rinse after the test and thoroughly dry all contacted material.

- CSST tubing installed along the outside of a structure (between the ground and a height of 183 cm [6 ft]) in an exposed condition shall be protected from mechanical damage inside a conduit or chase. A conduit or chase is not required if the tubing is installed in a location that will not subject the CSST to mechanical damage.
- Don't use CSST tubing as a means of support for the gas meter. Also check with your local code official or authority having jurisdiction on meter hook-ups. Some restrictions may apply. Local code requirements will always take precedence.
- For a piping system that includes manual gas valves listed as complying with requirements, the instructions shall state that these valves shall not be installed outdoors.
- When using CSST through metal enclosures, the CSST tubing must be protected by grommets, bushings or armour, PVC tape, shrink sleeve material or a minimum of four wraps of minimum 10 mil duct tape. This is to ensure that no physical contact will be made between the metal and the CSST tubing that would cause mechanical wear.
- Physical contact between CSST and a metallic chimney liner and/or vent is prohibited. If this physical separation cannot be specifically identified in the local building code and achieved or, any local building code requirements cannot be met along the entire length, then rerouting of the CSST is required unless such installation is specifically permitted by the local building authority.
- Gas code requirement: CSST systems and copper tubing shall only be connected to an appliance secured in place (not movable). (CSA B149.1 6.11.5)
- Gas code requirement: CSST system piping or copper tubing shall not be used to connect to a meter, unless the

meter assembly is independently supported. (CSA B149.1 6.14.8)

- Gas code requirement: CSST tubing shall be protected against physical damage in accordance with the manufacturer's certified instructions and with the gas code. (CSA B149.1 6.16.12)
- The corrugated stainless steel tubing system has a number of essential hardware and design differences from conventional gas piping using rigid steel pipe and copper tubing. These differences are described as follows:
 - In many applications, the tubing is sized for individual gas appliance loads and is therefore usually small in diameter. The tubing may also be installed in a parallel fashion from a central distribution manifold rather than a series layout commonly used for rigid pipe systems.
 - CSST is pulled through the structure similar in fashion to electrical wiring and therefore requires different handling and installation techniques than rigid pipe.
 - Rigid termination of the tube ends is required.
 - Flexibility and strike plates protect the CSST allowing it to be run in concealed spaces.

Identify CSST tubing, Fittings, and Supports

You should be able to identify and name corrugated CSST tubing, fittings, and supports, and identify the basic joint connection methods. You will also need to know how to describe basic installation requirements for CSST tubing. The following image shows the parts of a CSST joint.



Figure 107 CSST MIP joint components left to right, nut, locking bushings and fitting (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Detailed CSST Assembly Procedures

The following is a manufacturer's installation procedure for completing a CSST joint. Other manufacturers of this CSST tubing system will provide similar procedures. But you will need to apply the installation requirements particular to the manufacture tubing you are using.

Important: Be advised that it is necessary that you comply with any applicable installation codes, such as the Gas Code.

Step 1: Cut to Length

Cut tubing to the desired length, leaving approximately 2.5 cm (1 in) for fitting the attachment. Centre the cut between two corrugations. Use light roller pressure with extra rotations in one direction to leave tubing round and free of burrs.

Note: To ensure a quality flare, make all cuts on a straight section of tubing.



Figure 108 Cut the pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Step 2: Strip Jacket

Using a utility knife, strip the jacket back to the valley of the second corrugation. Do not cut the jacket in such a way that the sealing surface of the tubing is scored. The short piece of jacket can easily be removed by placing the utility knife blade under the jacket to peel the jacket off.

Caution: Tube ends are sharp. Use care when handling.



Figure 109 Strip the jacket (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Step 3: Install Nut and Bushings

Thread fitting body into appliance or manifold. Slide nut over tubing. Separate bushings and position into the valley of

the first corrugation. Leave one corrugation exposed between the end of the bushings and tubing. At this point, the bushings will begin to capture the jacket for a contaminant-resistant seal.



Figure 110 Bushing jacket locking feature (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe dope or sealant must not be used inside the fitting prior to assembly.

Step 4: Position Bushings

Insert bushings into fitting body. A small amount of resistance indicates the bushings are being compressed to further capture the jacket. Note: The piloting feature of the bushings ensures the tubing is aligned properly with the fitting body for a uniform flare and a gas-tight seal.



Figure 111 Align components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Step 5: Tighten the Fitting

Slide nut over bushings and thread onto fitting body. There will be some resistance as the nut begins to compress the tubing and create the double wall flare. Continue to thread the nut until resistance to wrenching increases greatly, and the double wall flare is tightly seated.

Note: During the tightening process, rotate the nut only. Do not rotate the fitting body. Any portions of the exposed stainless-steel tubing shall be wrapped with tape or sleeved to prevent threats by acids or chloride-based cleaning solutions for masonry. Self-bonding silicone tape is recommended here for durability.



Figure 112 Tighten the fitting nut (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Consult the manufacturer's torque values or specifications for tightening instructions.

Describe Basic Installation Requirements for CSST Tubing

CSST can be installed in a variety of ways. Ensure that the manufacturer's instructions are followed and conform to applicable codes, such as the Gas Code.



Figure 113 CSST installation, manifold and support bracket and regulator (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A manifold assembly using a pounds-to-inch regulator should include a shut-off valve ahead of the regulator. It should also be installed in an accessible location so that the regulator can be inspected, maintained and serviced, if necessary.

CSST Tubing Basic Installation Practices and Tubing Protection

Open ends of CSST tubing are to be temporarily plugged or taped closed prior to installation to prevent entrance of dirt, dust or other debris.

CSST must be protected from electrical contact with stray electrical currents, or static buildup. Protection is provided by bonding (grounding) the tubing to a ground rod or source, as required by electrical codes. The ground clamp must be clamped directly (touching) to a metal component of the CSST system, not clamped over the plastic sheath.

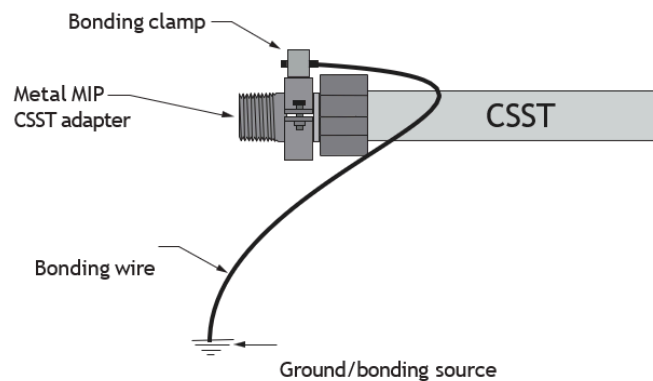


Figure 114 Example of bonding of CSST tubing system (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Never use CSST flexible gas piping or system components as a ground electrode or as a grounding path for appliances or electrical systems. Refer to the manufacturer's instructions. Direct bonding of CSST will be required. When installing CSST tubing, take care to maintain as much separation as reasonably possible from other electrically conductive systems in the building. Any metal piping system, including CSST, that is not adequately bonded may cause any electrical charge to arc from one system to another. Arcing can cause damage to CSST. Ensure the bonding of the CSST is complete to a ground rod or the electrical panel. A qualified electrician may be responsible for this work.

Protection of Concealed CSST

The following are examples of methods used to protect concealed CSST tubing—always refer to manufacturer installation guides and the authority having jurisdiction [AHJ].

- Protect concealed tubing from puncture threats, using the striker plates provided, at all points of penetration through studs, joists, plates, or similar structures.
- For all points of penetration less than 2 in (50.8 mm) from any edge of a stud, joist, plate, etc., a striker plate is required to provide protection at the area of support and within 5 inches (127 mm) of each side (if appropriate) of the support.
- At points of penetration 2 to 3 inches (50.8 to 76.2 mm) from any edge of a stud, joist, plate, etc., a striker plate is required to provide protection throughout the area of support.
- At points of penetration greater than 3 inches (76.2 mm) from any edge of a stud, joist, plate etc., no protection is required.

Protecting CSST from Puncture Damage

CSST tubing can be damaged after it has been installed and when the **wall cladding** is attached to the rough wall framing. As the cladding is attached, screws or nails are driven through wall cladding and can penetrate the CSST tubing. This results in gas leakage.

To prevent this from happening, metal shields called striker plates or steel conduit are installed at locations where a nail or screw will likely be used. CSST tubing routed horizontally through studs should also be protected from puncture threats between the studs with provided shielding devices.

The following diagrams show where the strike plates are used.

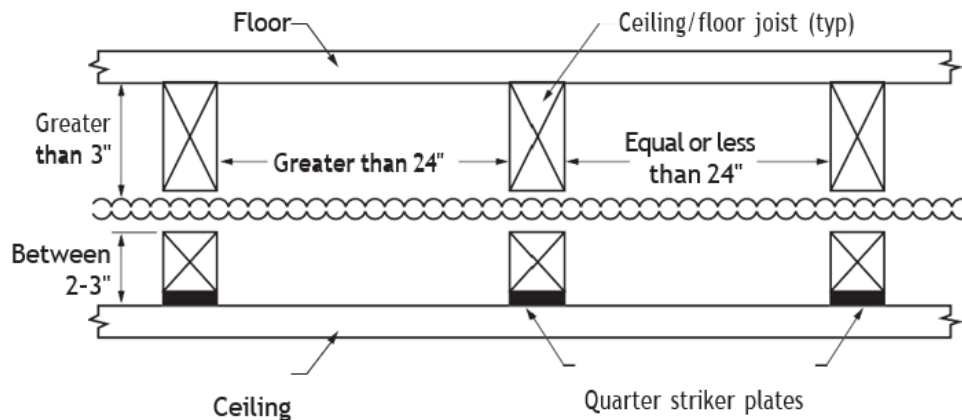


Figure 115 Location of quarter striker plates and steel conduit (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

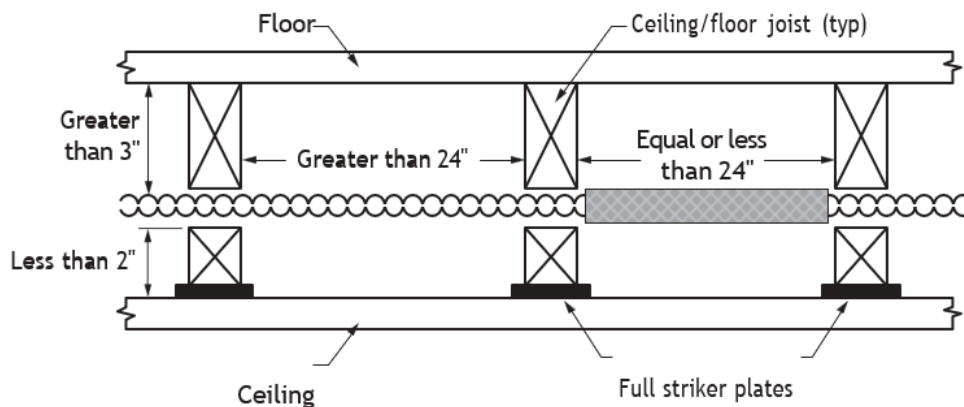


Figure 116 Location of full striker plates and steel protective conduit (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

CSST tubing needs to be supported with pipe straps, bands, or hangers suitable for the size and weight of the tubing. The supports should be placed at intervals not to exceed those shown in the tables outlined in the manufactures installation guide and/or applicable codes.

Avoid undue stress or strain on the CSST tubing and fittings. Also avoid sharp bends, stretching, kinking, or twisting of the CSST tubing.

The following pictures show examples of striker plates and steel conduit used to protect CSST tubing from damage from penetration by nails, screws, or other items used to attach drywall or other wall claddings or attachments.



Figure 117 Floppy steel conduit installation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 118 Striker plate applied at upper wall plates (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The width of the installed striker plate, at the points of penetration through wall studs, floor joists, plates, sills, etc., should be out at least 1.5 times the outside diameter of the tubing.

Flexible gas piping routed in a location that is concealed, constrained, and within three inches of a potential threat should be protected against damage by approved protection devices, as shown below.

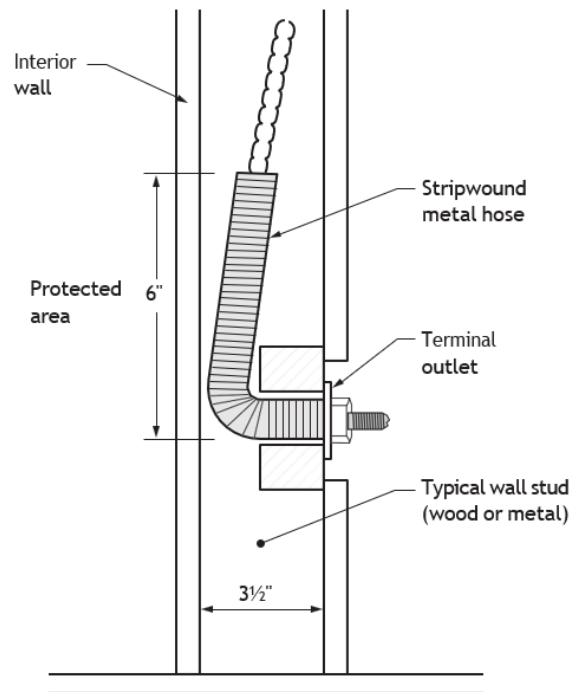


Figure 119 CSST Termination with strip wound metal hose placed over the CSST when the CSST comes too close to the surface of the wall. (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The following is an example of a grommet used when CSST passes through a metal stud.

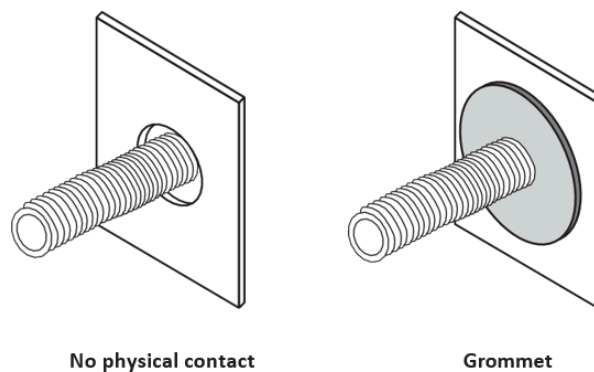


Figure 120 Grommet used with CSST (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A grommet keeps CSST centered in the hole, avoiding contact damages from sharp edges.

For installations buried underground, concrete, asphalt or embedded in concrete, CSST flexible gas piping must be

routed in a non-metallic watertight conduit that has an inside diameter at least ($\frac{1}{2}$ in) inch larger than the outside diameter of the tubing. No mechanical joints are permitted within the conduit.



Self-Test D-1.6: Install Tubing and Pipe

Complete Self-Test 1.6 and check your answers.

If you are using a printed copy, please find Self-Test D-1.6 (#chapter-self-test-d-1-6-section-6) and Answer Key (#chapter-answer-key-self-test-d-1-6-2) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1936#h5p-6> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=1936#h5p-6>)

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- Plumber: Competency D-1 Prepare Pipe

- Steamfitter: Competency D-4 Layout and Install Piping and Tubing
- Sprinkler Fitter: Competency D-1 Prepare Pipe and Tubing

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- **Figure 87** Glueing lengths of pipes ([https://commons.wikimedia.org/wiki/File:David_Caldwell_glueing_lengths_of_pipe_\(12366938823\).jpg](https://commons.wikimedia.org/wiki/File:David_Caldwell_glueing_lengths_of_pipe_(12366938823).jpg)) by USFWS/Southeast from Wikimedia Commons is used under a CC BY 2.0 (<https://creativecommons.org/licenses/by/2.0/deed.en>) license.
- **Figure 88** Plastic Pipes joint (<https://www.pexels.com/photo/plastic-pipes-on-wall-12142829/>) by Bùi Hoàng Long from Pexels, is used under the Pexels license (<https://www.pexels.com/license/>).
- **Figure 89** Outdoor pipes (<https://pixabay.com/photos/tap-water-pipes-closed-water-pipe-5142411/>) by Alexei other from Pixabay is used under the Pixabay Content License (<https://pixabay.com/service/license-summary/>).
- **Figure 91** Plumber installs (<https://www.pexels.com/photo/plumber-installs-pipe-fittings-6419128/>) by Anil Karakaya from Pexels, is used under the Pexels license (<https://www.pexels.com/license/>).
- **Figure 92** Wrenches to tighten a fitting (https://commons.wikimedia.org/wiki/File:Plumber_uses_two_wrenches_to_tighten_a_fitting.jpg) by Tomwsulcer from Wikimedia Commons is used under a CC0 1.0 (<https://creativecommons.org/publicdomain/zero/1.0/deed.en>) license.

Self-Test D-1.1 Describe Piping and Tubing Materials

Complete Self-Test D-1.1 and check your answers.

1. What is piping marked with the word “potable” used for?
 - a. Clear waste
 - b. Footing drain
 - c. Rain water
 - d. Drinking water
2. What is thermoplastic pipe?
 - a. Capable of softening or fusing when heated
 - b. Capable of becoming permanently rigid when heated or cured
 - c. Sensitive to shattering when struck
 - d. Permanently soft and flexible
3. What does the term “nominal pipe size” refer to?
 - a. Actual inside diameter
 - b. Actual outside diameter
 - c. Approximate inside diameter
 - d. Approximate outside diameter
4. What pipe or tubing has the largest outside diameter for the same nominal size of pipe or tubing?
 - a. Copper tubing size
 - b. Iron pipe size
 - c. Air conditioning tube size
 - d. Nominal pipe size
5. What is the thread angle of National Pipe Thread?
 - a. 45 degrees
 - b. 56 degrees
 - c. 60 degrees
 - d. 65 degrees
6. What schedule number is standard weight pipe?
 - a. 20
 - b. 40
 - c. 60
 - d. 80
7. What formula is used to determine the standard dimension ratio (SDR)?
 - a. Minimum wall thickness to the average outside diameter
 - b. Average outside diameter to the minimum wall thickness
 - c. Average inside diameter to the average outside diameter
 - d. Average outside diameter to the average inside diameter
8. What type of tubing material would be identified by a stamping of K, L, M, or DWV?
 - a. Aluminum
 - b. Copper
 - c. Plastic
 - d. Steel

9. What pipe or tubing is typically used in heavy industry such as marine seawater and ship building, pulp and paper manufacturing, medical gas systems, and chemical manufacturing?
 - a. Bronze alloys
 - b. Carbon steel
 - c. Zinc alloy
 - d. Nickel and nickel alloys
10. What piping or tubing is an alloy of copper and zinc?
 - a. Bronze
 - b. Monel
 - c. Brass
 - d. Stainless steel
11. What piping material contains amounts of silicon and cast iron and could be used for acids, solvents, or bleaches?
 - a. Duriron
 - b. Wrought iron
 - c. Black iron
 - d. Stainless steel
12. What piping material that contains chromium is often used where corrosion and oxidation occur?
 - a. Copper nickel
 - b. Stainless steel
 - c. Brass
 - d. Aluminum
13. What piping material is used for potable water distribution, is very strong, fracture-resistant, and centrifugally spun?
 - a. Ductile cast iron
 - b. Cast iron
 - c. Duriron
 - d. Austenitic cast iron
14. What piping material is suitable for fire sprinkler systems?
 - a. PVC CSA B181.1
 - b. PE CSA B137.1
 - c. CPVC standard B137.6.09
 - d. CPVC Type IV Grade 1 cell class 23447

Answer Key: Self-Test D-1.1 (#chapter-answer-key-self-test-d-1-1) is on the next page.

Answer Key: Self-Test D-I.1

1. d. Drinking water
2. a. Capable of softening or fusing when heated
3. c. Approximate inside diameter
4. b. Iron pipe size
5. c. 60 degrees
6. b. 40
7. b. Average outside diameter to the minimum wall thickness
8. b. Copper
9. d. Nickel and nickel alloys
10. c. Brass
11. a. Duriron
12. b. Stainless steel
13. a. Ductile cast iron
14. d. CPVC type IV Grade 1 cell class 23447

Self-Test D-I.2 Describe the Methods of Manufacture of Piping and Tubing

Complete Self-Test D-1.2 and check your answers.

1. What pipe is manufactured by passing strips of high-temperature metal through rollers until shaped and electrically welded at a seam?
 - a. Cast iron
 - b. Ductile iron
 - c. Stainless steel
 - d. Carbon steel
2. What tube or piping is manufactured by forcing a heated billet through a die orifice and over a mandrel?
 - a. Brass
 - b. Copper
 - c. Ductile iron
 - d. Cast iron
3. What copper tube is identified by its outside diameter?
 - a. Type ACR
 - b. Type L
 - c. Type K
 - d. Type DWV
4. What piping is made from a heated raw pellet material, continuously extruded through an annular die, then cooled into a particular size?
 - a. Carbon steel
 - b. Plastic
 - c. Aluminum
 - d. Stainless
5. What piping is manufactured using the (Engel) method?
 - a. PEX
 - b. ABS
 - c. PE
 - d. PB
6. What pipe is manufactured using an extruding head that allows air to be inserted in the middle of the pipe?
 - a. PEX
 - b. ABS
 - c. PE
 - d. PB
7. What is one of several methods used to manufacture steel pipe?

- a. Extrusion
 - b. Mandrel piercing
 - c. Electro-resistant weld
 - d. Pressure weld
8. What method of manufacturing steel pipe starts with a coiled ribbon of steel plate called a skelp?
- a. Seamless weld
 - b. Mandrel piercing
 - c. Electro-resistant weld
 - d. Pressure weld
9. What pipe is manufactured in sizes from 1/8–26" diameter and is typically used in construction, oil refining, chemical, and petro-chemical industries where chemical and oxidation are an issue?
- a. PE
 - b. Copper
 - c. PVC
 - d. Seamless steel
10. What pipe is produced in a cupola furnace and uses either casting molds or a centrifugal casting process?
- a. Cast iron soil pipe
 - b. PVC pipe
 - c. Galvanized iron
 - d. Seamless steel

Answer Key: Self-Test D-1.2 (#chapter-answer-key-self-test-d-1-2) is on the next page.

Answer Key: Self-Test D-I.2

1. d. Carbon steel
2. b. Copper
3. a. Type ACR
4. b. Plastic
5. a. PEX
6. b. ABS
7. c. Electro-resistive weld
8. c. Electro-resistant weld
9. d. Seamless steel
10. a. Cast iron soil pipe

Self-Test D-I.3 Describe the Methods of Pipe and Tubing Support

Complete Self-Test D-1.3 and check your answers.

1. What is the maximum distance between supports for ABS piping?
 - a. 900 mm (3')
 - b. 1219 mm (4')
 - c. 1524 mm (5')
 - d. 3048 mm (10')
2. What description best describes a consideration for seismic restraint for a hot water storage heater tank?
 - a. Install the heater 300–500 mm away from the wall
 - b. Install one perforated iron strap at the bottom of the heater
 - c. Use rigid water supply connections to hold the tank secure to the wall
 - d. Provide wooden blocks to prevent the heater from sliding backwards

For each image (3–13), choose the correct component name from the list below.

- a. Pipe covering protection shield
- b. Single expansion insert
- c. Pre-cast hanger anchor insert
- d. Constant spring support
- e. One-hole strap
- f. Side beam bracket
- g. Wood-form cast-in-place insert
- h. Horizontal rod hanger (hanger-up)
- i. Clevis hanger
- j. U-clamp pipe to sway brace
- k. Adjustable swivel ring hanger

3.



4.



5.



6.



7.



8.



9.



10.



11.



12.



13.



Answer Key: Self-Test D-1.3 (#chapter-answer-key-self-test-d-1-3) is on the next page.

Answer Key: Self-Test D-1.3

1. d. Provide wooden blocks to prevent the heater from sliding backwards
2. b. 1219 mm (4')
3. e. One hole strap
4. k. Adjustable swivel ring hanger
5. f. Side beam bracket
6. d. Constant spring support
7. h. Horizontal rod hanger (hanger-up)
8. i. Clevis hanger
9. j. U-clamp pipe to sway brace
10. g. Wood form cast-in-place insert
11. c. Pre-cast hanger anchor insert
12. a. Pipe covering protection shield
13. b. Single expansion insert

Self-Test D-I.4 Describe the Methods of Protecting Piping

Complete Self-Test D-1.4 and check your answers.

1. What can be done to protect a pipe from internal corrosion?
 - a. Polymer coating
 - b. Polyester fibre coating
 - c. Sandblasting
 - d. Laminar flow
2. What determines the type of external coatings applied to a pipe?
 - a. Velocity of the fluid
 - b. Colour of the piping
 - c. Thickness of the pipe wall
 - d. Expected damage
3. What is used to protect pipes from damage caused by rocky backfill?
 - a. Treated wood
 - b. Rock guards
 - c. Rock screen mesh
 - d. Mastic coating
4. What is the purpose of a transition sleeve?
 - a. To join two pipes of different materials
 - b. To protect underground welded joints
 - c. To join two pipes of different diameters
 - d. To provide internal alignment of pipe joints
5. What does constant circulation prevent?
 - a. Turbulence
 - b. Oxidation
 - c. Freezing
 - d. Corrosion
6. What type of pipe insulation is shown in Figure 1?
 - a. Closed-cell poly
 - b. Rock wool
 - c. Fibreglass
 - d. Mineral wool

7. Which of the following terms is used to describe the application of heat with an electric cable to prevent a pipe from freezing?

- a. Circulation
- b. Insulation
- c. Boxing in
- d. Heat trace



Figure 1 Closed-cell polyethylene foam pipe

8. Which of the following is an example of rigid pipe insulation?

- a. Rock wool
- b. Heat trace
- c. Styrofoam
- d. Mineral wool

9. Which of the following is installed to prevent punctures of piping passing through wood studs?

- a. Rock wool
- b. Steel plates
- c. Plastic grommets
- d. Closed-cell poly

10. Which piping material needs protection against ultraviolet light when in storage?

- a. Copper
- b. PEX
- c. PVC
- d. Fibreglass

11. Under what conditions can condensation form on a pipe?

- a. Pipe warmer than the ambient air temperature
- b. Pipe colder than the ambient air temperature
- c. Heavily insulated pipe
- d. Low-humidity air and a warm pipe

12. What can be done to prevent condensation on piping?

- a. Enclose the pipe in a wall
- b. Apply reflective moisture paint
- c. Reduce moisture content in the air
- d. Increase moisture content in the air

13. What is the purpose of a pipe expansion joint?

- a. Prevent expansion
- b. Keep the pipe cool
- c. Increase expansion range
- d. Control expansion

14. What is the purpose of a pipe guide?

- a. Allow the pipe to buckle
- b. Keep the pipe in line

- c. Support the pipe
 - d. Show where the pipe is located
15. What is the minimum number of elbows in a swing joint?
- a. 1
 - b. 2
 - c. 3
 - d. 4
16. A 40 m (43.7 yards) copper pipe is heated from 8 to 61°C (46 to 142°F). The thermal expansion coefficient is 0.0000166 per degree Celsius (0.0000093 per degree Fahrenheit). What is the total expansion of the pipe, expressed in metres?
- a. 0.352
 - b. 0.035
 - c. 0.532
 - d. 0.875
17. Which of the following terms is used to identify corrosion protection for pipe caused by an electrochemical reaction?
- a. Anodic protection
 - b. Cathodic protection
 - c. Electrolysis
 - d. Galvanic
18. Which metal is the least noble?
- a. Copper
 - b. Stainless steel
 - c. Magnesium
 - d. Brass
19. What is the name given to the fitting in Figure 2?
- a. Galvanized union
 - b. Stainless coupling
 - c. Eccentric reducer coupling
 - d. Dielectric union



Figure 2 Example fitting

Answer Key: Self-Test D-1.4 (#chapter-answer-key-self-test-d-1-4) is on the next page.

Answer Key: Self-Test D-1.4

1. a. Polymer coating
2. d. Expected damage
3. b. Rock guards
4. b. Protect underground welded joints
5. c. Freezing
6. a. Closed cell poly
7. d. Heat trace
8. c. Styroform
9. b. Steel plates
10. b. PEX
11. a. Pipe warmer than the ambient air temperature
12. c. Reduce moisture content in air
13. d. Control expansion
14. b. Keep the pipe in line
15. c. 3
16. b. 0.035
17. a. Anodic protection
18. c. Magnesium
19. d. Dielectric union

Self-Test D-1.5 Describe the Methods of Manufacture of Piping and Tubing

Complete Self-Test D-1.5 and check your answers.

1. What is the result of using defective materials?
 - a. Lower costs
 - b. Time savings
 - c. You will not need to replace the material
 - d. Invalid manufacturer's warranty
2. What would be the correct action to take if the end of a cast-iron pipe is damaged?
 - a. Cut the damaged end off
 - b. Use a clamp to seal over the cracked end
 - c. Seal the crack with a sealing compound
 - d. Discard the entire pipe
3. What would you do to inspect coiled copper tubing when it arrives at the job site?
 - a. Pressure-test the pipe
 - b. Straighten the pipe out to full length
 - c. Solder caps on the ends
 - d. Inspect coils for pinching or flattening
4. What would you do to inspect a steel pipe length when it arrives at the job site?
 - a. Remove the protective shipping coating from the entire pipe length
 - b. Inspect the internal bore for debris
 - c. Thread the pipe end and cap
 - d. Grind off any bevels
5. What type of pipe has the SDR rating printed on it?
 - a. Cast iron
 - b. Copper
 - c. Polyethylene
 - d. PEX
6. What would you do to help detect a crack in a cast iron pipe or fitting before use?
 - a. Test the fitting with air
 - b. Test the fitting with water
 - c. Blow air on the fitting
 - d. Tap the fitting on a hard surface

Answer Key: Self-Test D-1.5 (#chapter-answer-key-self-test-d-1-5) is on the next page.

Answer Key: Self-Test D-1.5

1. d. Invalid manufacturer's warranty
2. a. Cut the damaged end off
3. d. Inspect coils for pinching or flattening
4. b. Inspect the internal bore for debris
5. c. Polyethylene
6. d. Tap the fitting on a hard surface

Self-Test D-1.6 Install Tubing and Pipe

Complete Self-Test D-1.6 and check your answers.

1. Who is responsible for making a pipe joint correctly?
 - a. Owner of the premises
 - b. Engineer who designed the joint
 - c. The manufacturer who made the fitting
 - d. The tradesperson who installed the joint
2. Which of the following best describes the action by which liquid solder is drawn into the annular space between the inside fitting wall and the tubing outside wall?
 - a. Capillary action
 - b. Osmosis
 - c. Attraction
 - d. Adhesion
3. Which pipe joining method uses temperatures below 427°C (800° F)?
 - a. Brazing
 - b. Eutectic
 - c. Soldering
 - d. Fusion
4. Which solder filler metal is not approved for use in potable water systems?
 - a. Antimony
 - b. Lead
 - c. Nickel
 - d. Tin
5. What is the purpose of a soldering and brazing flux?
 - a. Promote oxidation
 - b. Keep the metal surface dry
 - c. Prevent oxidization
 - d. Prevent overheating
6. Which of the following is the first step when preparing a pipe for soldering?
 - a. Cut the pipe
 - b. Deburr the pipe
 - c. Clean the pipe
 - d. Measure the pipe
7. Which method of joining copper tube is used with an extracted tee joint?
 - a. Push-fit
 - b. Brazing
 - c. Press-fit
 - d. Soldering
8. How big should the branch connection of an extracted tee be?
 - a. Same size as the tee mainline
 - b. One size smaller than the tee mainline
 - c. One size larger than the tee mainline

- d. 1-½ times smaller than the tee mainline
- 9. Which method of joining copper tube requires no tools?
 - a. Push-connect
 - b. Pressure fit
 - c. Compression fit
 - d. Roll groove fit
- 10. Which method of joining polyethylene uses a heating iron?
 - a. Solvent cement
 - b. Heat tracing
 - c. Fusion welding
 - d. Soldering
- 11. What is the purpose of bevelling the end of ABS or PVC pipe before assembly?
 - a. Allow solvent cement to cure properly
 - b. Let the pipe and fitting slip together loosely
 - c. Stop the pipe from bottoming out in the fitting
 - d. Minimize wiping solvent cement from the socket
- 12. What colour is ABS DWV solvent cement?
 - a. Yellow
 - b. Clear
 - c. Grey
 - d. Purple
- 13. What is the percentage increase in setting time of solvent cement in damp and humid weather?
 - a. 25%
 - b. 50%
 - c. 70%
 - d. 100%
- 14. Which of the following describes a procedure used when tightening a flange joint?
 - a. Star pattern
 - b. Hexagonal pattern
 - c. Crossover
 - d. Opposed pattern
- 15. Which of the following is never acceptable as a method of testing PVC?
 - a. Air pressure test
 - b. Running water test
 - c. Water pressure test over 345 kPa (50 psi)
 - d. Water pressure test over 689 kPa (100 psi)
- 16. Which drawings show the arrangement of fixtures or equipment in relation to the building?
 - a. Site
 - b. Piping isometric
 - c. Structural
 - d. Architectural
- 17. Which drawings are a useful aid to visualizing piping arrangements and for preparing a materials list?
 - a. Architectural
 - b. Piping isometric
 - c. Structural

- d. As-built
- 18. What do mechanical drawings show?
 - a. Where piping lines travel
 - b. Dimensions of fixtures
 - c. Where electrical wires travel
 - d. Details of wall and floor finishing
- 19. The location of light fixtures and air grilles are shown on which drawing?
 - a. Piping isometrics
 - b. Architectural drawings
 - c. Rough-in sheets
 - d. Reflected ceiling plan
- 20. The size of pipes is likely to be found on which drawings?
 - a. Piping isometrics
 - b. Architectural drawings
 - c. Rough-in sheets
 - d. Mechanical drawings
- 21. More detailed information, including the lengths of piping and the exact placement of fittings, is calculated and indicated on which drawings?
 - a. Piping isometrics
 - b. Piping layouts
 - c. Rough-in sheets
 - d. Architectural drawings
- 22. The detailed dimensions and location of necessary connections for equipment are indicated in which literature?
 - a. Rough-in literature from equipment manufacturers
 - b. Piping layouts from the project engineer or architect
 - c. Rough-in sheets, which should then be drawn in chalk
 - d. Piping isometrics, which should be drawn based on project drawings
- 23. On larger projects, where is information found that specifies the types of hangers that are to be used?
 - a. Plumbing code
 - b. Book of hangers
 - c. Book of specifications
 - d. Structural or site drawing

Answer Key: Self-Test D-1.6 (#chapter-answer-key-self-test-d-1-6-2) is on the next page.

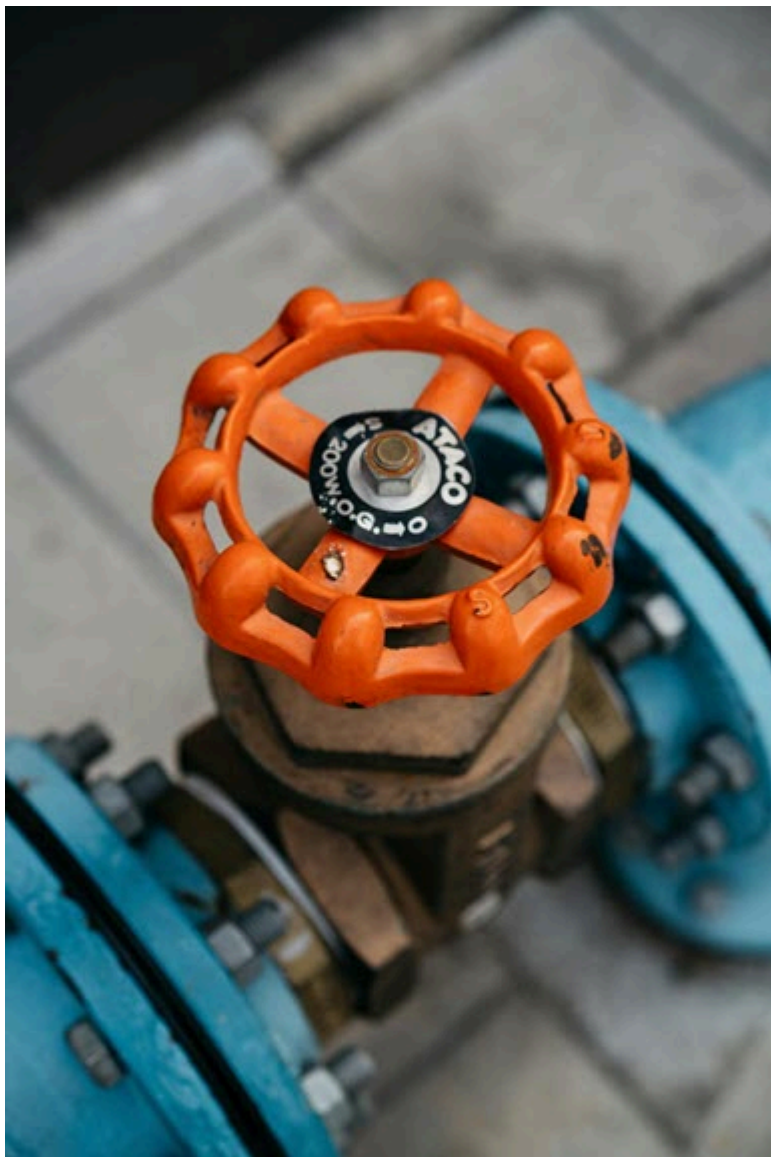
Answer Key: Self-Test D-1.6

1. d. The tradesperson who installed the joint
2. a. Capillary action
3. c. Soldering
4. b. Lead
5. c. Prevent oxidization
6. d. Measure the pipe
7. b. Brazing
8. b. One size smaller than the tee mainline
9. a. Push-connect
10. c. Fusion welding
11. d. Minimizes wiping solvent cement from the socket
12. a. Yellow
13. b. 50%
14. c. Crossover
15. a. Air pressure test
16. d. Architectural
17. b. Piping isometric
18. a. Where piping lines travel
19. d. Reflected ceiling plan
20. d. Mechanical drawings
21. a. Piping isometrics
22. a. Rough-in literature from equipment manufacturers
23. c. Book of specifications

PART II

D-2 INSTALL VALVES

Plumber Apprenticeship Program – Level 1



Close-up of orange valve on a blue pipeline, showcasing industrial equipment details. (<https://www.pexels.com/photo/close-up-of-a-valve-on-a-pipe-12265849/>) (Markus Winkler/Pexels) Pexels license. (<https://www.pexels.com/license/>)

D-2 Install Valves Introduction

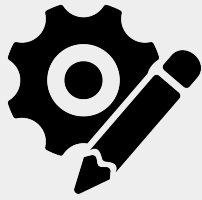
This section introduces the essential knowledge and skills required to install and work with valves in piping systems. You will learn key terminology, materials, and functions of valves, as well as how to select the appropriate valve for specific applications. The section also explores valve service ratings, actuators, and common valve types, along with their parts and functions. In addition, you will develop the ability to identify and understand critical components such as valve seats and stuffing boxes, including their materials, purposes, and installation considerations.

Learning Objectives

After completing this section, you will be able to:

- Define basic valve terminology.
- Identify the materials that valves are made of.
- Describe the purpose of valves.
- Select the correct valve for its intended use.
- Read and interpret valve service ratings and specifications.
- Name the types of valve actuators and visually identify a valve actuator.
- Visually identify, name, and state the purpose of common types of valves.
- Visually identify and name valve parts and describe their function.
- Identify, name, and locate valve seats; describe materials used to make them; and list the factors to consider when selecting a valve seat.
- Identify, name, and locate valve stuffing boxes, name their parts, and identify packing material and basic methods of installing valve packing.
- Read, interpret and apply manufacturer's installation requirements for valves.
- Install valves correctly.
- State the correct stem positions and valve orientation.
- State specific valve installation dimensions from other valves, fittings, and equipment.

Topic areas covered in this publication are in alignment with SkilledTradesBC Harmonized 2018 Program Outlines.



Resources

You may be required to reference publications and videos available online at the WorkSafeBC (<https://www.worksafebc.com/en>) website.

Terminology

The following terms may be used throughout this section. Note that some glossary terms may be in italics throughout the section content but are not included in this list. A complete list of terms can be found in the **Glossary**.

- **backpressure:** The pressure exerted on the downstream side of a valve seat. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **ball valve:** A quarter-turn valve with a ball-shaped closing element held between two seats. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **bellows:** A sealing device that prevents line media from leaking between the stem and the body. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **butterfly valve:** A quarter-turn valve that has a circular disk as its closing element. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **cavitation:** The noise caused when high-velocity turbulent flow and low pressure occur in a valve causing the water to form a gas bubble; the gas bubble rapidly turns back into water when the velocity drops and the pressure increases; cavitation results in deterioration of internal valve parts and premature failure. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **check valve:** A valve designed to allow the fluid to flow in one direction but to stop flow in the reverse direction; the valve closes to prevent backflow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **control valve:** A valve that regulates the flow or pressure of a fluid; control valves normally respond to signals generated by independent devices such as flow meters, temperature gauges, etc.; control valves

are normally fitted with actuators and positioners. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

- **cryogenic valve:** A valve suited for use at temperatures below -40°C (-40°F) (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **galling:** A severe form of metal wear caused when sliding surfaces make contact, tearing areas of the metal surface. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **lantern ring:** A metal ring in a valve that provides for uniform distribution of stem packing pressure over the packing. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **outside screw and yoke (OSY) valve:** A valve with a stem that moves up and down outside the valve body, making it easy to see if the valve is open or closed. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **quarter-turn valve:** A valve in which the handle and stem move from fully closed to fully open in one-quarter of a 360° turn (90°). (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **stuffing box:** An enclosure containing packing to prevent leakage around a moving machine part. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **trunnion:** A valve component such a pin or pivot on which something can be rotated, such in a trunnion ball valve, which has additional mechanical anchoring of the ball at the top and the bottom, suitable for larger and higher pressure valves. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **valve actuator:** A device used to open, close, or control a valve, such as manual handles and electrical, hydraulic, and pneumatic actuators. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))
- **wire drawing:** The visual effect of erosion of a valve seat or disk. Wire drawing occurs when a valve is not closed perfectly tight. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

D-2.1 Describe Basic Valve Types

Valves are essential components in piping systems, used to control, direct, and regulate the flow of fluids. To work safely and effectively in the piping trades, it is important to understand the basic terminology used to describe valves, their parts, and how they operate. The following section introduces key valve terms and concepts that you will encounter on the job and in technical documentation.

Valve Terminology

It is important to be able to define basic valve terminology. You should be familiar with the following terms:

air valve: A valve used to control the flow of air.



Figure 1 High pressure air valve (https://commons.wikimedia.org/wiki/File:High_pressure_air_valve_P8160049.jpg) by (Peter Southwood (<https://commons.wikimedia.org/wiki/User:Pbsouthwood>)/Wikimedia Commons) CC0 1.0 (<https://creativecommons.org/publicdomain/zero/1.0/deed.en>)

backpressure: The pressure exerted on the downstream side of a valve seat.

ball valve: A quarter-turn valve with a ball-shaped closing element held between two seats.



Figure 2 Ball valve
(https://commons.wikimedia.org/wiki/File:Ball_Valve.jpg) by (Bitjungle
(<https://commons.wikimedia.org/wiki/User:Bitjungle>)/Wikimedia Commons) CC
BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/deed.en>)

backwater valve: A check valve designed for use in a sanitary drainage system.

bellows: A sealing device that prevents *line media* from leaking between the stem and the body.

bidirectional valve: A valve that moves or operates in two opposite directions.

butterfly valve: A quarter-turn valve that has a circular disk as its closing element.



Figure 3 Bidirectional tight butterfly valve (https://commons.wikimedia.org/wiki/File:Bidirectional_tight_butterfly_valve-The-Alloy-Valve-Stockist.jpg) (Heather Smith/Wikimedia commons)

bypass valve: A small-bore valve fitted in parallel with a larger main valve.

cavitation: The noise and damage caused when high-velocity turbulent flow and low pressure occur in a valve forming gas bubbles that collapse rapidly; the gas bubble rapidly turns back into water when the velocity drops and the pressure increases. This results in deterioration of internal valve parts and premature failure.

check valve: A valve designed to allow fluid to flow in one direction only and prevent reverse flow. The valve closes to prevent backflow.

control valve: A valve that regulates the flow or pressure of a fluid. Control valves respond to signals generated by independent devices such as flow meters, temperature gauges, etc. Control valves are typically fitted with actuators and positioners.



Figure 4 PI control valve
(https://commons.wikimedia.org/wiki/File:PI_control_valve.jpg) (Rafał Rygielski/
Wikimedia Commons)

cryogenic valve: A valve designed for use at temperatures below -40°C (-40°F).

diaphragm valve: A bidirectional valve operated by applying an external force to a flexible element, or diaphragm (typically an elastomer).

diverter valve: A valve that changes the direction of the flow of medium to two or more outlets/ directions.



Figure 5 Diverter valve with PEX connections
https://commons.wikimedia.org/wiki/File:Shower_project_new_diverter_valve_with_PEX_connections_added.jpg by (Tomwsulcer (<https://commons.wikimedia.org/w/index.php?title=User:Tomwsulcer&action=edit&redlink=1>)/Wikimedia Commons) CC0 1.0 (<https://creativecommons.org/publicdomain/zero/1.0/deed.en>)

double block and bleed: A valve configuration in which positive shut-off is achieved at both the inlet and outlet sides, with a pressure bleed between them.

elastomer: Any material, such as natural or synthetic rubber, that is able to resume its original shape when a deforming force is removed.

galling: A severe form of metal wear caused when sliding surfaces make contact, tearing areas of the metal surface.

lantern ring: A metal ring in a valve that provides for uniform distribution of stem packing pressure over the packing.

positioner: A device used to ensure that the valve is at the correct position of opening as the control signal indicates.

quarter-turn valve: A valve in which the handle and stem move from fully closed to fully open in one-quarter of a 360° turn (90°).



Figure 6 Valve (https://commons.wikimedia.org/wiki/File:Ball_valve_in_household.jpg) (NVgt156/Wikimedia Commons) CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/deed.en>)

resilient seat: A valve disk or seat that is soft-seated rather than a metal-to-metal hard seat. An example is a Teflon seat.

stuffing box: An enclosure containing packing to prevent leakage around a moving machine part, such as a valve stem.

trunnion: A valve component such a pin or pivot on which something can be rotated, such in a trunnion ball valve, which has additional mechanical anchoring of the ball at the top and the bottom, suitable for larger and higher pressure valves.

valve actuator: A device used to open, close, or control a valve, such as manual handles and electrical, hydraulic, and pneumatic actuators.

valve chatter: The noise created when the water flow causes loose valve components to rattle or chatter in rapid succession.

valve packing: A sealing material, usually graphite, used to seal around a *valve stem* to prevent leakage of system fluids.

valve stem: The part of a valve that connects the handle or actuator to the internal closing part (such as a disk or gate) and moves to open or close the valve.

wire drawing: The visual effect of erosion of a valve seat or disk. Wire drawing occurs when a valve is not closed perfectly tight.

Valve Materials

The materials used to construct a valve play an important role in its ability to operate in the working environment to which it will be subjected. It may be unsafe to use materials for services beyond their recommended maximum limits.

Valve materials are selected by the following considerations:

- Pressure limitations
- Temperature limitations
- Structural limitations

Valve materials commonly used in industry include the following:

- Bronze
- Iron
- Malleable iron
- Ductile iron
- Steel
- Stainless steel
- Titanium
- Plastics
- Composites

Valve Purpose

The main purpose of a valve is often to turn on (start) or shut off (stop) the flow in a piping system. However, valves can serve many purposes, such as:

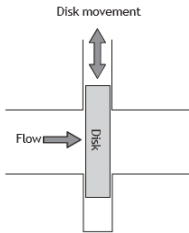
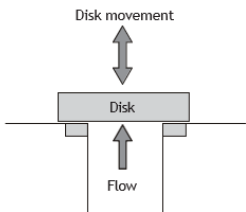
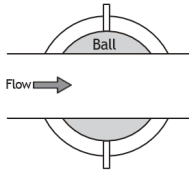
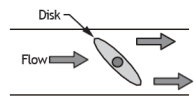
- Limiting pressure
- Regulating pressure
- Controlling flow rate
- Turning flow off and on
- Mixing water of different temperatures
- Limiting maximum temperature
- Preventing reverse direction flow
- Balancing flow across different circuits

Valve Classification

Valves can be classified into two general categories based on the motion of the *valve stem*/operator:

- **Linear movement valves:** The stem moves in a straight line. These include gate valves, globe valves, diaphragm valves and pinch valves.
- **Rotary movement valves:** The stem rotates around an axis at right angles to the direction of flow. These include ball valves and butterfly valves.

Table 1: Identifying the Valve Type by the Motion of the Actuator

Valve Movement	Linear Motion		Rotary Motion	
Operating motion of the closing device	In a straight line		Rotating about an axis at right angles to the direction of flow	
Direction of flow in the seating area	At right angles to the operating motion	Longitudinal to the operating motion	Through the disk	Around the disk
Basic types	Gate valve	Globe valve	Ball valve	Butterfly valve
Schematic				

Valve Selection

When selecting a valve for a specific job, you will need to match the valve specifications to the job specifications. This is important to ensure dependable, long-term performance.

Before selecting a valve, consider the following factors:

- Operation cycle (number of times the valve will have to open and close)
- Specific purpose of the valve (to stop, regulate, divert, or relieve pressure)
- Pressure loss through the valve (pressure loss must be within system requirements)
- Expected flow volume of the system (must allow sufficient flow for system)
- Working and maximum pressures of the system (the valve characteristics should not be lower than those of the system)
- Working and maximum temperatures of the system (the valve characteristics should be the same or higher)
- Characteristics of the fluid being handled (for example, viscosity, volatility, corrosiveness)
- Presence of debris in the fluid (the valve's capability to handle solids)
- Maintenance schedule (need for frequent maintenance may be a concern)
- Installation costs, maintenance costs and initial cost
- Exposure to the surrounding environmental conditions (for example, heat, freezing, physical damage and corrosive)

atmospheric conditions)

- Clearances for operation and maintenance
- Other specific job-related specifications and conditions, including any code requirements

Valve Specifications

Valves should be clearly marked with the manufacturer's name and the size of the valve. Valves may also be marked with other information, such as the temperature and pressure ratings. Often letter codes are used to indicate the valve's appropriate uses. Detailed service ratings are usually found in the manufacturer's published specifications.

- G: gas service
- L: liquid service
- O: oil service
- S: steam service
- W: water service

The ability to read and interpret valve markings and specifications is key to installing the correct valve. Each manufacturer may have a different system of valve markings, which is explained in that manufacturer's product literature. Following are examples of valve markings found on Crane valves.



Figure 7a Example letter code on a crane valve (Audrey Curran/TRU Open Press) CC BY-NC-SA (<https://creativecommons.org/licenses/by-nc-sa/4.0/deed.en>)



Figure 7b Example letter code on a crane valve (Audrey Curran/TRU Open Press) CC BY-NC-SA (<https://creativecommons.org/licenses/by-nc-sa/4.0/deed.en>)

Table 2: First Example of Letter Codes

2	pipe size in inches
Crane	manufacturer
125	basic steam working pressure
6	pipe size in inches
Crane	manufacturer
Steel	carbon cast steel valve
150	basic steam working pressure

Forged steel valves typically include the marking “Forged Steel.”

Table 3: Second Example of Letter Codes

6	pipe size in inches
Crane	manufacturer
Forged Steel	carbon cast steel valve
150	basic steam working pressure
6	pipe size in inches
Forged Steel	carbon cast steel valve
150 WOG	working pressure water, oil or gas

Tags may also be attached to the valve body or handle to indicate any approval ratings, such as an ASSE (American Society of Stationary Engineers) rating, etc.

Examples of Valve Specifications

On most jobs, you will install valves that have already been selected by the design engineer. On some jobs, however, you will need to select the correct valve yourself, using the manufacturer’s written specifications. You therefore must be able to read and interpret specifications such as those shown in the following tables. Note that these example tables are general in nature and are for the purpose of illustration. Always refer to the manufacturer’s specifications.

Table 4: Valve Test Pressure Specification

Test Pressures		
Body	1.5 MPa (15 kg/cm ²) (217.6 psi)	2.4 MPa (24 kg/cm ²) (348 psi)
Seat & back seat	1.0 MPa (10 kg/cm ²) (145 psi)	1.6 MPa (16 kg/cm ²) (232 psi)

Table 5: Valve Materials

Part No.	Name of Part	Material
1.	Body	Bronze
2.	Wedge	Bronze
3.	Stem	High tensile brass
4.	Bonnet	Bronze
5.	Stuffing box	Bronze
6.	Gland packing	Asbestos/Teflon
7.	Gland	Bronze
8.	Gland nut	Bronze
9.	Handwheel	Cast iron
10.	Washer	Mild steel
11.	Screw	Mild steel

Table 6: Valve Dimensions

Nominal Size		Length (mm)	Height (mm)	Width (mm)	Flange Diameter (mm)	Flange Thickness (mm)
Inches	mm					
0.5"	15	72	102	58	95	6
$\frac{3}{4}$ "	20	76	115	58	105	6
1"	25	90	129	67	115	8
1.25	32	100	140	73	140	8
1.5"	40	110	162	85	150	9
2"	50	120	188	110	165	11
2.5"	65	140	220	110	185	13
3"	80	150	249	133	200	13
4"	100	190	292	173	220	16

Valve Actuator

A *valve actuator* is a device used to open, close or control a valve.

The types of valve actuators include the following:

- **Handwheel:** used to open or close a valve by turning it by hand (manually). No power is required.
- **Pneumatic (air-operated) diaphragm:** uses compressed air to move the valve open or closed. Air pressure pushes on a flexible diaphragm.
- **Electric motor:** uses electricity to turn the valve open or closed. It is often used when the valve needs to be controlled from a distance (remote control).
- **Electric solenoid:** uses electricity to create a magnetic force that moves the valve (electromagnetic force). It is usually used for quick on-off control.
- **Hydraulic (piston-operated):** uses pressurized oil or fluid to push a piston that moves the valve. It is used when a lot of force is needed.



Figure 8 Handwheel/gear-actuated butterfly valve (BC Industry Training Authority, 2019).
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Figure 9 Electric solenoid-actuated valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pneumatically actuated globe valves are widely used for control purposes in many industries, although quarter-turn types such as (modified) ball and butterfly valves may also be used.

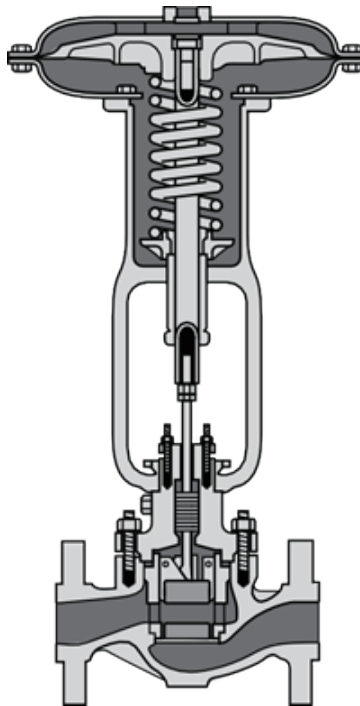


Figure 10 Pneumatically actuated globe valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 11 Hydraulically operated ball valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Principal Valve Types

Gate Valves

Gate valves are commonly used in industrial piping. This type of valve should only be used to fully stop or fully open the flow. The valve gets its name from the gate-like disk, which operates at a right angle to the path of flow. It is a **linear movement valve**.

The gate valve has the following characteristics:

- It is suited for wide-open (fully open) service.
- There is little resistance to flow when the disk is fully open.
- When the valve is closed tight, there is no wear or undue strain on the disk or seats.
- A partially open disk may cause turbulent flow, vibration, and chatter.
- A gate valve usually requires more turns to open and close fully.

Unlike many globe valves, the volume of flow through the valve is not in direct relation to the number of turns of the handwheel. Gate valves with wedge disks and matching tapered seats may be difficult to re-face or repair.

Advantages of using gate valves include the following:

- They have good shutoff features.
- They are bidirectional and therefore can be used in two directions.
- Pressure loss through the valve is minimal.

The major drawbacks of using gate valves are as follows:

- They cannot be quickly opened or closed.

- They are not suitable for regulating or throttling flow.
- Vibration and chattering can occur when a gate valve is left in a slightly open position with high-velocity turbulent flow. This can lead to wire drawing and erosion of seating surfaces.
- Repeated movement of the disk near the point of closure under a high-pressure flow may gall or score the seating surfaces on the downstream side. Galling can be minimized by decreasing contact stresses or by using protective surface layers.

Gate Valve Parts

A gate valve consists of four main components:

- Body
- Bonnet (or cover)
- Disk/gate
- Stem

Other parts include:

- Handle (or wheel)
- Yoke
- Packing gland
- Packing
- Stuffing box
- Body seat rings

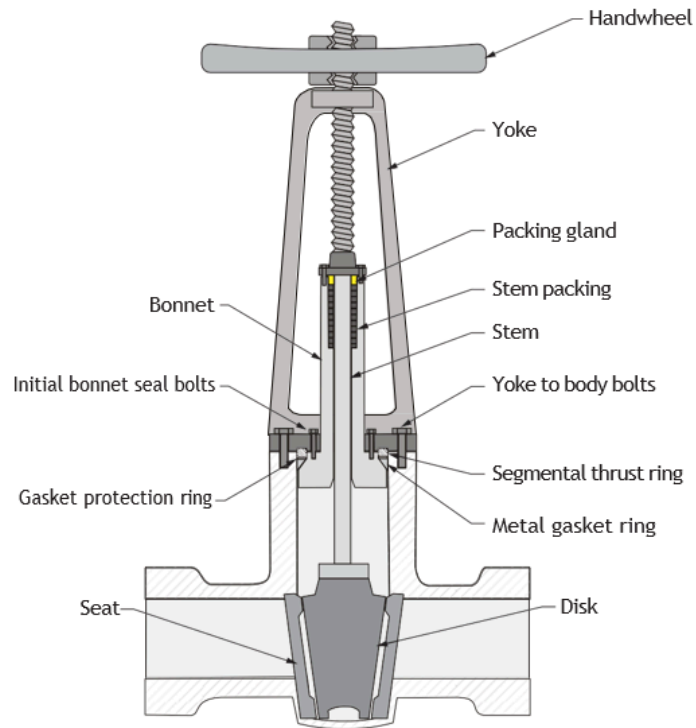


Figure 12 Gate valve parts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

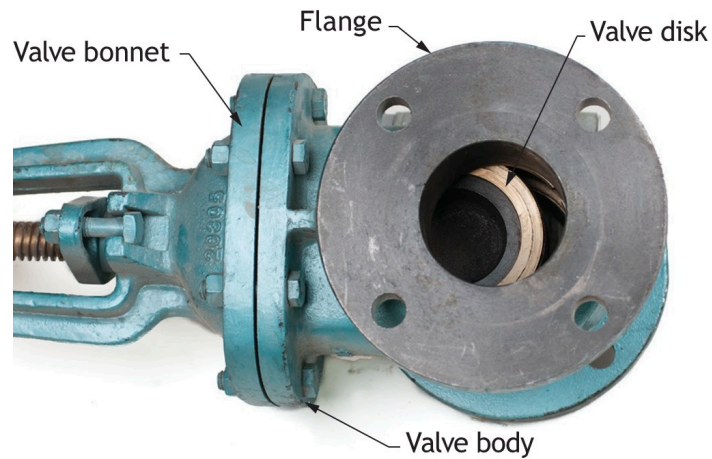


Figure 13 Cast iron flanged gate valve, bolted bonnet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Gate Valve Seating and Disk Design

Gate valves are usually classified by the type of disk used.

The types of disks are:

- Solid wedge
- Flexible wedge
- Split wedge
- Parallel disk

Solid Wedge Disk

The solid wedge disk gate is wedge shaped, and it seats on corresponding faces in the valve body. The mechanical advantage of the valve stem threads together with the wedge angle provides the force for positive closure without excessive handwheel effort. The seat can sometimes be coated with Teflon Polytetrafluoroethylene (PTFE) to assist in a positive shutoff.



Figure 14 Example of a solid wedge gate valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

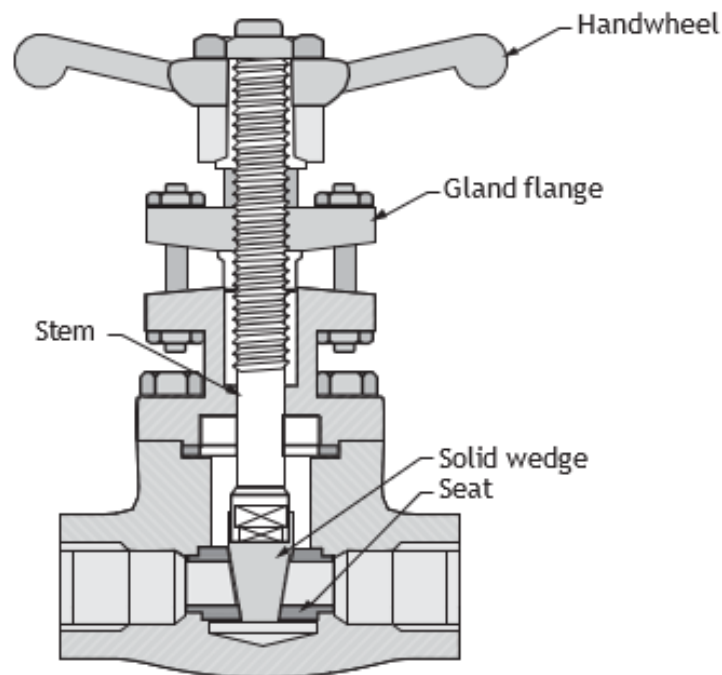


Figure 15 Solid wedge gate valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The solid wedge characteristics are that it:

- Consists of a strong and simply designed single part
- Can be installed in any position without danger of jamming due to misalignment of parts
- Ideal for service with steam, water, air, oil, gas and many other fluids

- Suitable for turbulent flow because there is nothing inside that can vibrate and chatter
- The disk may be subject to sticking under extreme temperature changes. For such conditions the flexible wedge disk is recommended.

Flexible Wedge Disk

The flexible wedge disk was developed especially to overcome sticking in high-temperature service with extreme temperature changes.

The flexible wedge disk characteristics are:

- Flexibility that allows the disk to be tight on both faces over a wide range of pressures
- No sticking during temperature changes
- Two disk faces that can move independently of each other, up to two full degrees.
- One-piece construction, so no loose parts to cause harmful vibration.

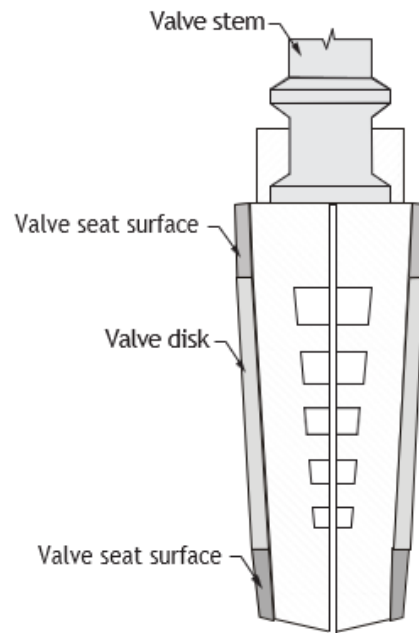


Figure 16 Flexible wedge disk (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A problem associated with flexible wedge gates used on a steam system is that water tends to collect in the body neck. Under certain conditions, the admission of steam may cause the

valve body neck to rupture, the bonnet to lift off, or the seat ring to collapse. Following correct warming procedures will prevent these problems.

Gate valves used in steam systems have flexible wedges. The reason for using a flexible gate is to prevent binding of the gate within the valve when the valve is in the closed position. When steam lines are heated, they expand and cause some distortion of valve bodies. If a solid gate fits snugly between the seat of a valve in a cold steam system, when the

system is heated and pipes elongate, the seats will compress against the gate and clamp the valve shut. This problem is overcome by using a flexible gate, whose design allows the gate to flex as the valve seat compresses it.

Split Wedge Disk

The split wedge disk is a two-piece wedge disk that sits between matching tapered seats in the valve body.

The split wedge characteristics as follows:

- A spreader device is simple and integral with disk halves.
- When closing, the last turn of the handwheel forces the disk against the seats.
- When opening, the first turn releases the disk from the seats.
- The split wedge gate is suitable for handling non-condensing gases and liquids at normal temperatures, particularly corrosive liquids.
- Freedom of movement of the disk in the carrier prevents binding even though the valve may have been closed when hot and later contracted due to cooling.
- The split wedge disk valve should be installed with the stem in the vertical upright position.

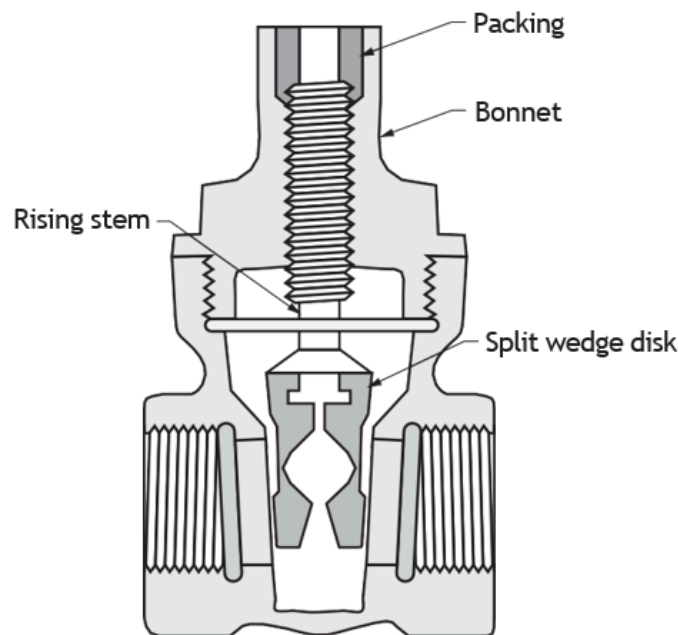


Figure 17 Split wedge gate valve (BC Industry Training Authority, 2019).
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Parallel/Double Wedge Disk

The parallel or double wedge disk makes closure by moving between matching seats in the valve body. As the valve is being closed, upper and lower spreaders contact a stop. The disks are forced outward tightly against the seats. This type is widely used for water service, in waterworks and sewage disposal plants, and also in cross-country oil and gas

pipelines. The parallel disk gate valve is designed to prevent valve binding due to thermal heating and cooling of the piping systems.

This design is used in both low- and high-pressure applications. Parallel disks are used in valves having parallel seats.

The parallel wedge disk characteristics are as follows:

- The first opening movement releases the disk from the seat.
- Exposure of a closed valve to a rise in external temperature may cause a dangerous increase in internal pressure, if non-compressible liquid is trapped between the disks.
- Repairing or re-facing is easier than it is on a tapered wedge disk.
- It is generally not suitable for steam. Rapid expansion and the high velocity of steam flow tend to vibrate loose internal parts in the disk assembly.
- It should be installed with the stem above horizontal for best results. Spreader mechanisms are subject to jamming when installed with the stem below the horizontal line.

In some parallel disk gates, the two halves do not move apart with a wedge action. Instead, the upstream pressure holds the downstream disk against the seat. A carrier ring lifts the disks, and a spring or springs hold the disks apart and seated when there is no upstream pressure.

Another parallel gate disk design provides for sealing only one port. In these designs, the high- pressure side pushes the disks open and forces the disk closed on the low-pressure side. With such designs, the amount of seat leakage tends to decrease as differential pressure across the seat increases. These valves usually have a marking that indicates the high-pressure side. Care should be taken to ensure that these valves are not installed backwards in the system.

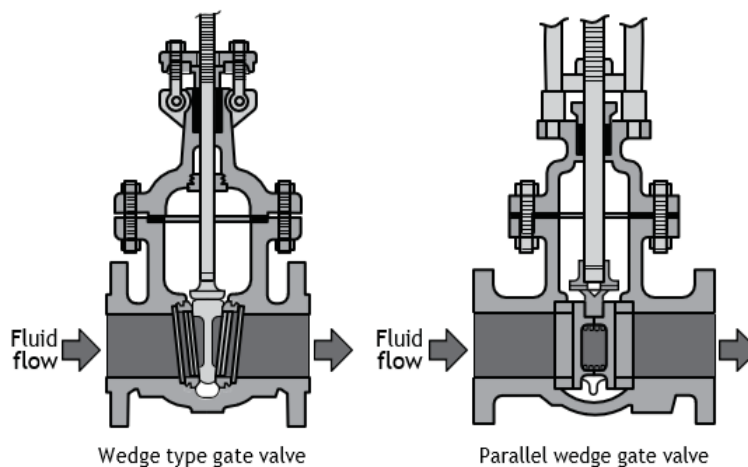


Figure 18 Wedge gate valve types (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Gate Valve Stem Operations

A *valve stem* connects the handle to the valve disk and transfers motion to open or close the valve. When selecting a valve, the type of stem can be important for:

- The need to indicate if a valve is in the open or closed position; for example, a rising stem
- Clearance requirements, such as restricted clearance above the valve; for example, a non-rising stem

Rising Stem Valve with Outside Screw

A **rising stem outside screw valve** has stem threads on the outside of the valve body. The stem is then not subjected to damage caused by corrosion, erosion, sediment, or line fluids. Being outside, the stem threads can be lubricated easily when necessary. The position of the rising stem valve indicates whether the valve is open or closed. Turning the handle to open the valve causes the stem to rise up through the handle. The handle stays attached to the yoke. The **outside screw and yoke valve (OSY)** shown in Figure 19 is an indicating valve. When the valve stem is fully exposed above the handle, this indicates that the valve is fully open.

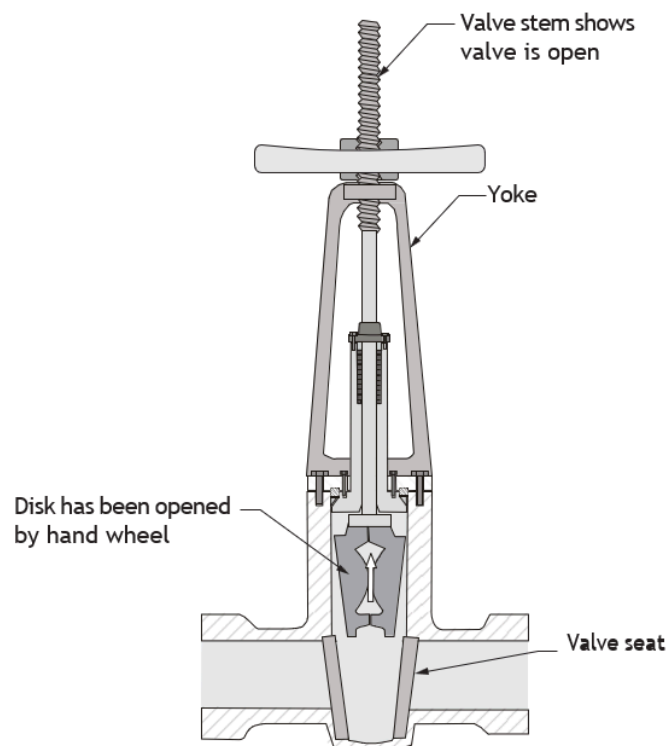


Figure 19 Rising stem gate valve, outside stem and yoke (OSY) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Rising Stem with Inside Screw

The **rising stem inside screw valve** is the simplest and most common stem construction for gate, globe, and angle valves in the smaller sizes. In these valves, the stem turns and rises on threads inside the valve. A close look at the position of the handwheel indicates whether the disk is open or closed (Figure 20).

The position of the valve is not as easily identified as the OSY valve.

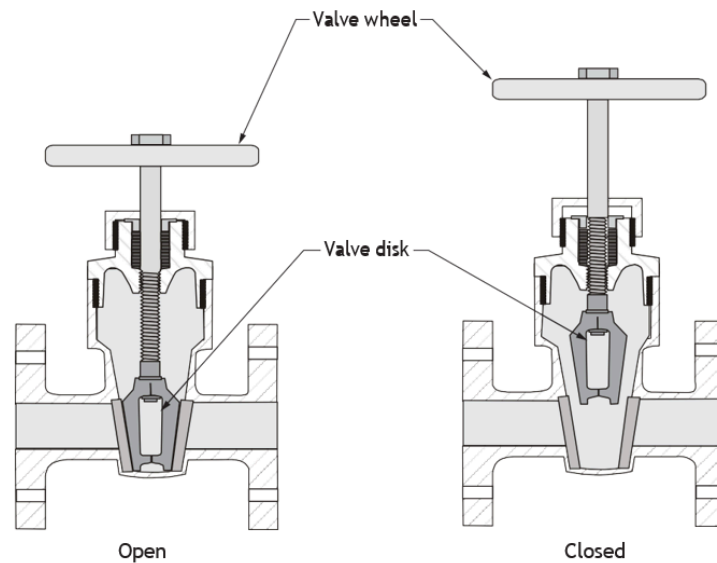


Figure 20 Rising stem inside screw valve (BC Industry Training Authority, 2019).
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Non-rising Stem with Inside Screw

Generally used on gate valves only, this stem does not rise, but merely turns with the handwheel. The non-rising stem disk travels up and down on the threaded stem inside the valve body when the handwheel is turned. Since only the valve stem rotates, there is less packing wear. This valve is ideal for locations where headroom is limited.

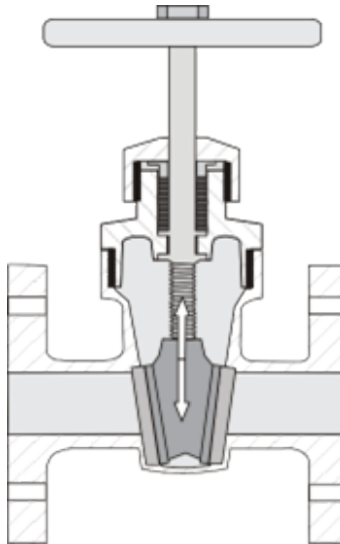


Figure 21 Non-rising stem gate valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 22 Flanged gate valve, non-rising stem (Courtesy of NIBCO INC). Used with permission.

Globe and Angle Valves

The **globe valve** is named after its globular body. The flow through a globe valve passes up under the seat, changing the direction of flow and thereby causing increased resistance and higher pressure loss than gate valves. Globe valves are best suited for throttling and flow control because of the seating arrangements.

The features of a globe valve are:

- Globe valve seating is parallel to the line of flow, unlike the right-angle seating in gate valves.
- All contact between the seat and disk ends when flow begins.
- The globe valve is efficient for throttling of flow.
- There is minimal wire drawing and seat erosion.
- The size of the seat opening is directly proportional to the number of turns of the hand wheel.
- The operator can gauge the rate of flow by the number of turns of the hand wheel.
- Plug-type globe valves permit close flow regulation.
- A shorter disk travel with fewer turns is required to operate globe valves.
- Globe valves save time and work.
- There is less wear on valve parts.
- Globe valves have fewer maintenance problems than gate valves.
- The seat and disk in most globe valves can be repaired without removing the valve from the pipeline.

Note: Globe valves are generally ideal for throttling, and are preferable for frequent operation.

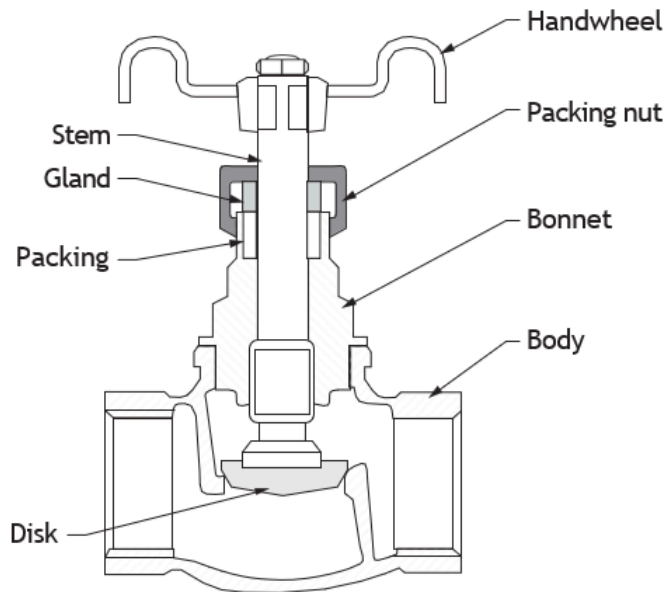


Figure 23 Parts of a globe valve (BC Industry Training Authority, 2019).
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Globe Valve Body Designs

The three primary body design patterns for globe valves are:

- Z-body
- Y-body
- Angle body

The **Z-body globe valve** is the simplest globe valve design and is often used for water applications. The Z-body provides a symmetrical form that simplifies manufacture, installation and repair.

The **Y-body globe valve** reduces the pressure drop found in the Z-body and angle globe valves. The seat and stem are angled at approximately 45 degrees. A Y-body globe valve is suited for high- pressure and other severe services.

The **angle body globe valve** design allows the fluid to flow through with only one change of direction. A standard globe has two changes of fluid direction. An advantage of the angle valve is that it can function as both a valve and a piping elbow.

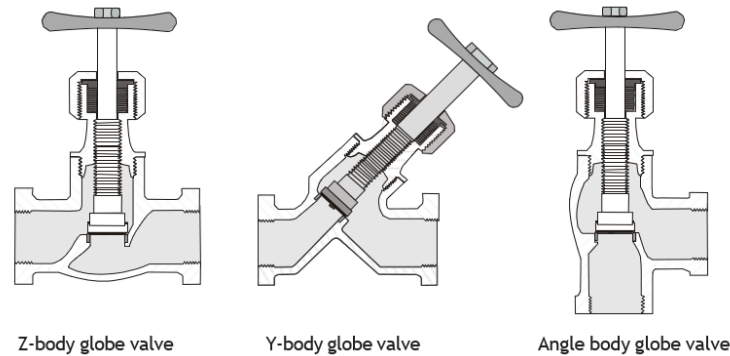
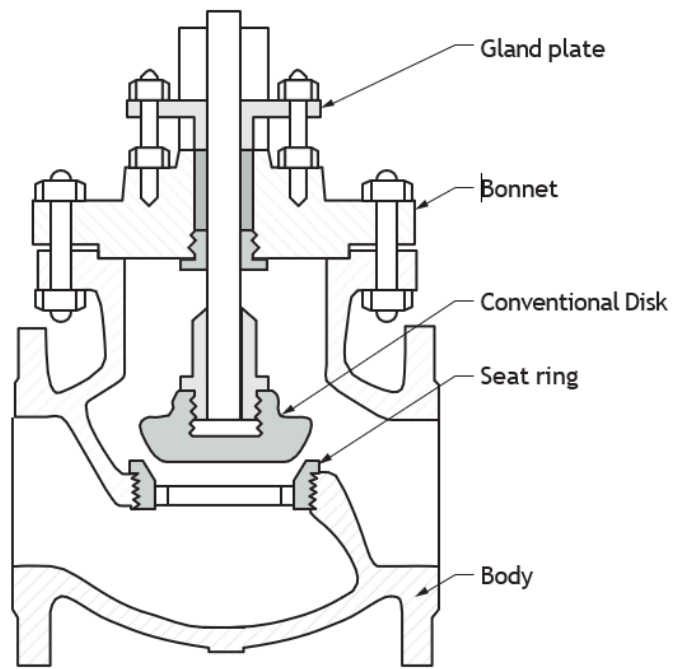


Figure 24 Types of globe valve body designs (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

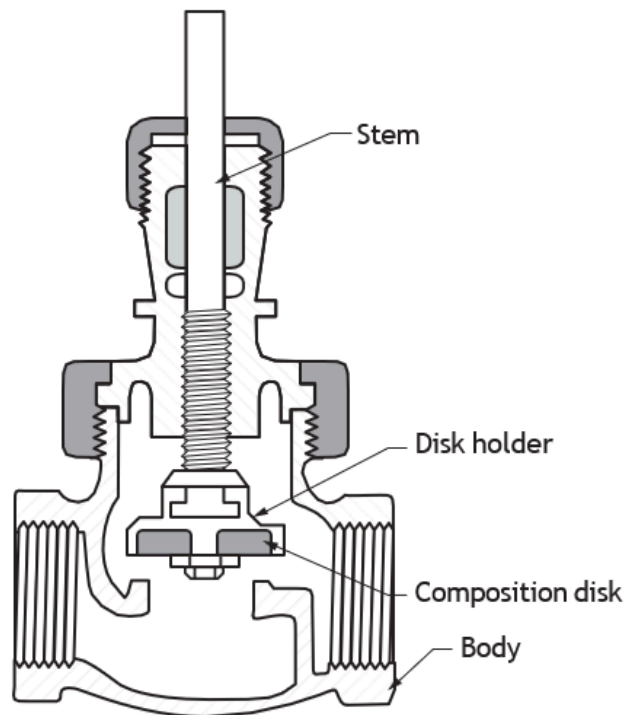
Globe Valve Disks

Globe valves are available with different shapes of disks or plugs:

- Conventional disks, which are often replaceable.
- Composition disks made of composite rubber type material; often replaceable.
- Plug disks, which are broad disks that provide more control under severe operating conditions.
- Needle disks, used where fine throttling control is needed.



Conventional globe valve



Composition globe valve

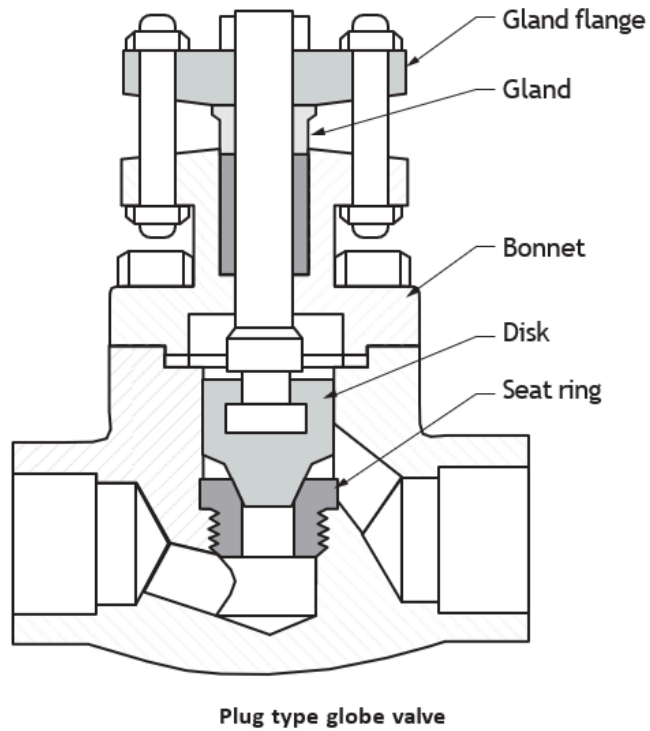


Figure 25 Types of globe valve disks (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

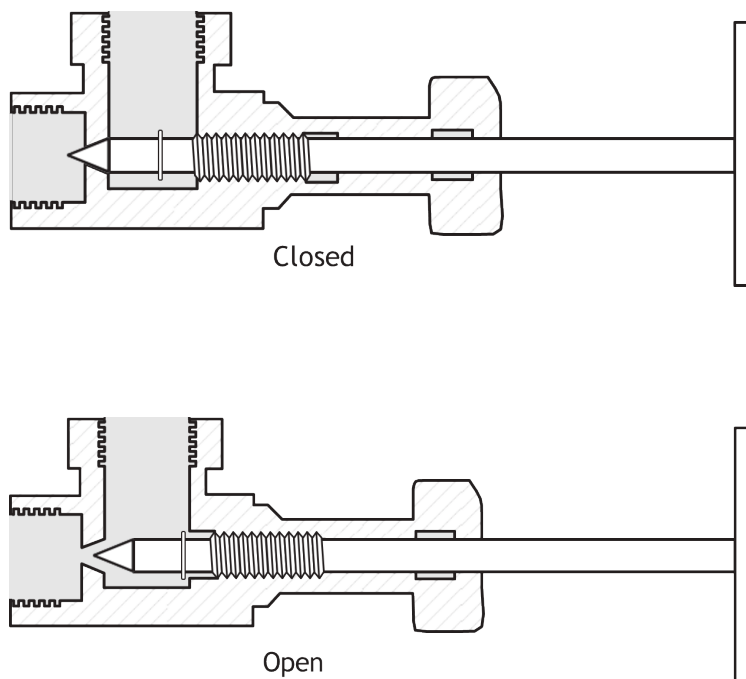


Figure 26 Needle valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Plug Pattern Valve/Plug Cock

A **plug valve** is a quarter-turn rotational motion valve with a tapered or cylindrical plug that stops and starts flow. The plug has an angular hole in it that matches the diameter of the inlet and outlet of the valve. In the open position, the plug-passage is in line with the inlet and outlet ports of the valve body. If the plug is rotated 90° from the open position, the solid part of the plug blocks the port and stops the flow.

Advantages of using plug valves:

- Quick quarter turn on-off operation
- Minimal resistance to flow
- Smaller in size than most other valves

Disadvantages of plug valves:

- Requires a large force to actuate, due to high friction
- NPS 4 and larger valves requires the use of an actuator
- Reduced port, due to tapered plug

Plug valves come in a non-lubricated or lubricated design and with several styles of port openings. The port in the tapered plug is generally rectangular, but you can also get round ports and diamond ports.

Typical Plug Valve Uses

A plug valve can be used in many different fluid services, including:

- Air, gaseous and vapour services
- Natural gas piping systems
- Oil piping systems
- Vacuum to high-pressure applications
- Water service connections

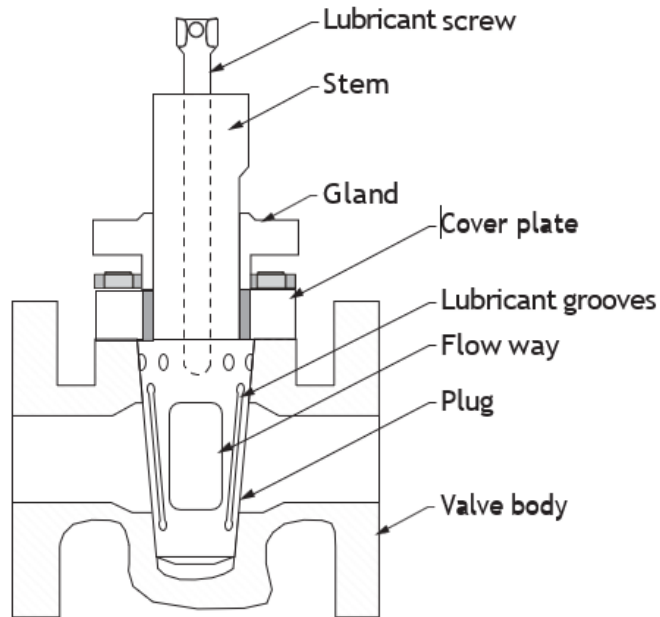


Figure 27 Parts of a plug valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Typical types of plug valves include:

- **Corporation valve**
- **Curb stop**
- **Lubricated gas cock**

Plug valves are predecessors of today's ball valves but can still be found in use as corporation fittings. The term "corporation" is used to describe valves and fittings of heavy brass or bronze construction that are manufactured to be capable of direct earth burial or exposed to the elements—in other words, heavy brass or bronze fittings that can be installed in harsh environments and that should last indefinitely. Corporation water valve locations can be on the city main under the street (street connection), at the property line (known as a curb stop) or on water meters. They are also used as shutoffs just upstream of a gas meter. Piping connections to corporation valves and fittings can be threaded, flared, or compression types.



Figure 28 Plug valves (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Ball Valves

The **ball valve** gets its name from the ball-shaped disk located within the body. A hole through the centre of the ball allows the flow to go straight through, which is a characteristic of ball valves. Ball valves are used to control the flow of a wide variety of fluids in industrial, chemical, petrochemical, refinery, pulp and paper, gas transmission, water works and sewage, and power plants.



Figure 29 Ball valve with soldered connections (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Ball valve features:

- Can be opened or closed with a quarter-turn of the operating handle
- Positive closure
- Handle position indicates the valve position as partially or fully open or closed
- Straight-through flow, minimum turbulence, low torque, tight closure and compactness
- Reliable operation, easy maintenance and long-life economy

Advantages of using ball valves:

- Quick, quarter-turn on-off operation
- Tight-sealing with low torque
- Smaller in size than most other valves

Disadvantages of ball valves:

- Poor throttling properties



Figure 30 Ball valve with partially open ball port showing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

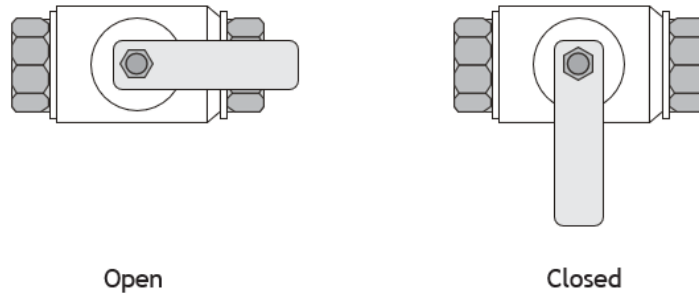


Figure 31 Handle positions, open and closed (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Ball Valve Function

Ball valves are best used for fast-acting stop/start applications. They are considered quick-acting because they only require a 90° turn of the handle to operate the valve. The quarter-turn minimizes valve operation time and decreases the possibility of leakage due to wear.

Ball Valve Types

Ball valve types include:

- Full port ball valve
- Standard and reduced port ball valves
- V-port ball valve
- Three port ball valve

A **full port ball valve** has an oversized ball, with the hole in the ball the same diameter as the inside of the pipe. This results in unrestricted flow and less friction loss. However, the valve is larger and more expensive, so this is only used where free flow is required.

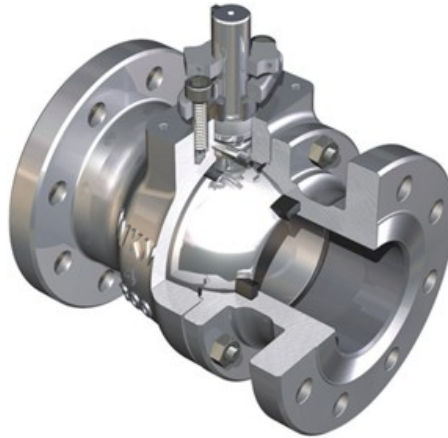


Figure 32 Full port ball valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In **standard port** and **reduced port ball valves**, the ball opening is smaller than the pipe's inner diameter, and so flow through the valve is reduced.

A **V-port ball valve** has either a V-shaped ball or a V-shaped seat. This allows the orifice to be opened and closed in a more controlled manner. When this valve is opened, the small end of the V-shaped ball opens first, allowing stable flow control during opening.



Figure 33 Three-port ball valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Butterfly Valve

The **butterfly valve** gets its name from the wing-like action of the disk, which operates at right angles to the flow. In the standard design, the valve stem runs through the disk, giving it a symmetrical appearance. In later designs, the stem is offset, so that the disk “**cams**” into the valve seat.

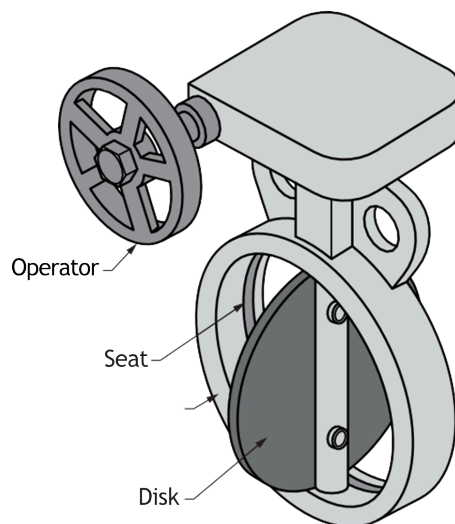


Figure 34 Butterfly valve components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Butterfly valves are widely used in water distribution and waste water processing. Butterfly valves come in two body

types, lugged and wafer. Wafer-style valves are common. Butterfly valves are an indicating-type valve. The position of the handle indicates the valve position as open or closed.

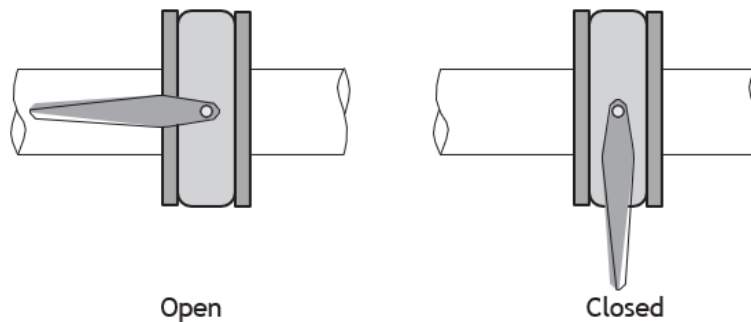


Figure 35 Handle position, open and closed (BC Industry Training Authority, 2019).
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The butterfly valve is extremely durable, efficient, and reliable. The disk holds against a resilient liner to provide bubble tightness with low operating torque. The valve opens or closes with a quarter-turn of the operating handle, providing positive closure. The handle position indicates the valve position as partially or fully open or closed.

Advantages of butterfly valves:

- Compact design requires considerably less space than other valves.
- Light weight.
- Quick operation requires less time to open or close.
- They come in very large sizes.
- They have low-pressure drop and high pressure recovery.

Disadvantages of butterfly valves :

- Throttling service is limited to low differential pressure.
- Cavitation and choked flow are two potential concerns.
- Disk movement is unguided and is affected by flow turbulence.

Wafer-Type Butterfly Valve

The **wafer-type butterfly valve** is designed for quick installation between pipe flanges. No gasket is needed because the moulded-in seat is lapped over into a recess in both faces of the valve body ends.



Figure 36 Wafer-type butterfly valve (Courtesy of NIBCO INC.) Used with permission.

Wafer Lug Type Butterfly Valve

Wafer lug type valves have the same design as wafer-type valves, but include lugs in the body. These lugs can be threaded or non-threaded. The threaded lugs in a wafer lug type butterfly valve allow the upstream piping to be left intact while downstream piping is dismantled for cleaning or revamping.



Figure 37 Wafer lug type butterfly valve. No gaskets required; manual operation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 38 Wafer lug type butterfly valve. No gaskets required; manual gear operated; indicator for fire service (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Butterfly valves can be supplied as manual gear operated, or with electric pneumatic or hydraulic operated actuators.



Figure 39 Wafer butterfly valve with no actuator (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 40 Pneumatic (air) actuated wafer lug butterfly valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Double Flange Type Butterfly Valve

The **double flange type butterfly valve** differs from the wafer-type only in its body and seat design. A gasket may or may not be required as a seal between the pipe flanges and body flanges. Check the manufacturer's specification.



Figure 41 Double flange type butterfly valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Check Valves

Check valves, also called *non-return valves*, automatically prevent the flow in a piping system from reversing direction. Sudden closure can produce water hammer, which will damage check-valve components. Small swing-checks generally have screwed caps, although some have bolted caps. The larger sizes have bolted caps or pressure-seal bonnets. Composition disks are common in small valves and in larger valves on water service. Seats in larger valves are often separate, although hard facing on integral seat and disk is also found.

The ideal check valve should have the following features:

- Open when upstream pressure appears
- Pass all flow in the normal direction without resistance
- Close at the instant of zero flow velocity
- Remain closed during minor forward pressure surges
- Resist backpressure without leakage

The two basic types of check valve are the swing-check and the lift-check. Other types include tilting disk check, wafer check and silent check.

Swing-Check Valve

The **swing-check valve** with a single hanging disk is widely used. Swing-checks work automatically to prevent reverse flow. Valve bodies are either globe-like or a Y-form (also known as “wye”). The flow through swing-checks goes in a straight line, with low resistance to flow at the seat, similar to a gate valve. This similarity in effect on flow is the reason for generally using swing-checks in lines in combination with gate valves. Swing-checks are used for service at lower flow velocities and where pressure loss needs to be avoided.



Figure 42 Flanged T pattern iron body swing-check (Image courtesy of Watts) Used with permission.



Figure 43 Bronze wye pattern swing-check (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Double-Disk Wafer-Type Check Valve

The **double-disk wafer-type check valve**, also called *split disk* or *dual plate check valve*, is a wafer pattern check valve designed to fit between two pipeline flanges. The split disk check valve requires less space for installation than standard swing-check valves. The split disk check valve is suitable for the prevention of reverse flow in pipelines carrying most types of liquids and gases, including fire sprinkler systems, steam and condensate lines.

The split disk wafer check valve employs two spring-loaded plates hinged on a central hinge pin. When the flow decreases, the plates close by the action of a torsion spring before flow reversal takes place, eliminating water hammer. It is a type of silent check valve.

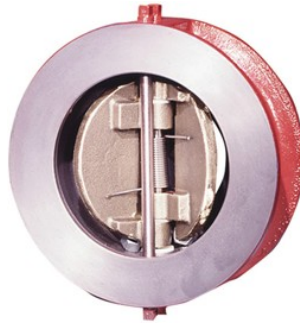
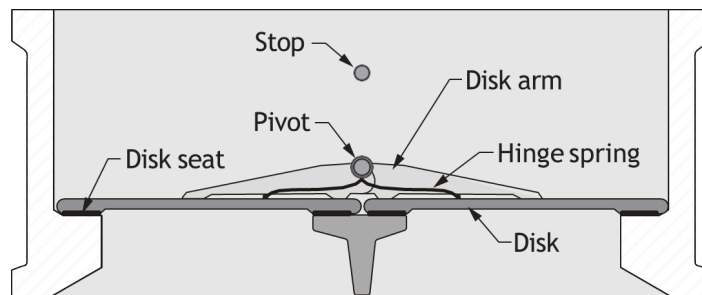


Figure 44 Split disk wafer check valve (Image courtesy of Watts) Used with permission.



Closed

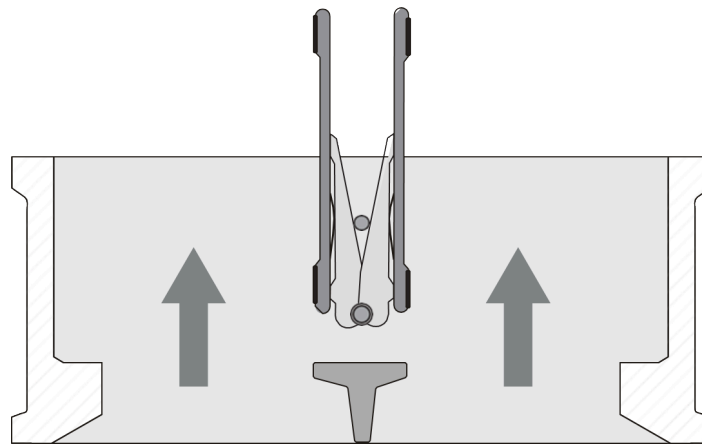


Figure 45 Open and closed positions of split disk wafer check valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Sealing methods for these valves were originally developed for low-temperature water and petroleum-industry liquids, but metal-to-metal seals now allow the valve type to take up to 650°C at 13 410 kPa (1200°F at 1945 psi).

Tilting-disk Swing-Check Valve

The **tilting-disk swing-check valve** is another variant of the basic swing-check valve. These valves have a disk that swings partly through the seat. The geometry for sealing and avoiding jamming is more complicated than for other swing-checks. The pivot shaft is generally large-diameter in tilting-disk valves, so attaching **dashpots**, indicators, and limit switches is easy. Access to the internals of some tilting-disk check valves, when they are mounted in the line, is through conventional bonnets or removable plates. The internals of other models are inaccessible, because the valve body is of the wafer or short-spool type.

Tilting-disk swing-check valves are generally made of plastic or stainless steel, the latter being the most widely used in chemical and petrochemical applications.



Figure 46 Tilting-disk swing-check valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Lift-Check Valve

Lift-check valves operate automatically to prevent reverse flow. Lift-checks include the flat disk type, the plug-like disk type and ball-checks. The flow pattern through a lift-check is similar to that of the globe valve. Pressure losses in the lift-check are generally similar to those of a globe valve of the same size. The lift-check adapts well to pulsating service, even though not all lift-checks are recommended for this. The lift-check generally forces at least two right-angle turns on fluid flowing through it, so the pressure loss through it is higher than for a swing-check. Some in-line lift-checks have an improved flow path, with resistance nearly as low as the double-disk swing-checks. Traditionally, lift-checks are recommended for lines containing globe valves, which are high-resistance valves, or for lines carrying pulsating gases and vapours. A plug configuration disk is found in some lift-checks.

Bodies of lift-checks can resemble those of globe valves with either straight or Y bonnets. Bonnets can be screw cap, union cap, or pressure seal. The wafer form is common in silent lift-checks, but globular bodies and split, flanged bodies also appear.

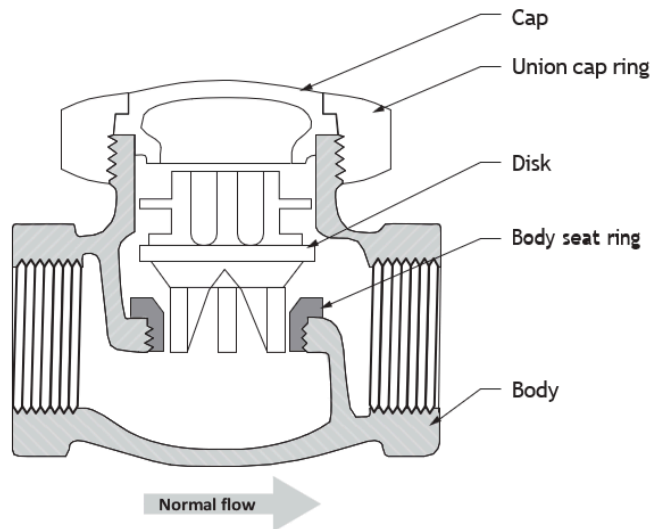


Figure 47 Parts of a globe-type lift-check valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Silent Flow Lift-Check Valves

Silent flow check valves are used in commercial and industrial HVAC applications to prevent water hammer and reverse fluid flow in water lines with a maximum pressure of 2758 kPa (400 psi). Silent check valves have a low-pressure drop and can be installed in a horizontal or vertical position. The silent lift-check valve is often spring loaded. The spring prevents the check valve from slamming shut by closing the check valve either slightly before or at the instant of flow stoppage, thereby preventing water hammer. In systems where a pump is used, the silent check will not hammer when the pump stops.



Figure 48 Flanged silent check valve (Image courtesy of Watts) Used with permission.



Figure 49 Silent flow bronze maxi-flo check valve, used in conjunction with well pumps (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

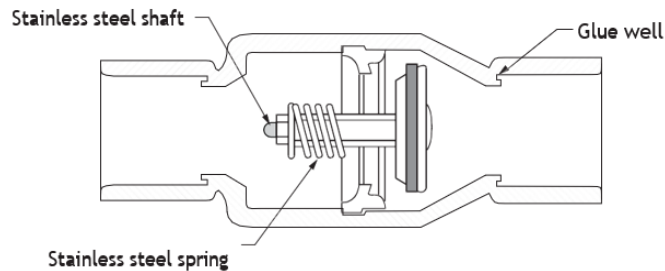


Figure 50 Silent check valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Special-Purpose Service Check Valve (SVC)

Service check valves are used in heating applications. They are installed between the boiler piping and system component. The service check facilitates the servicing of components under pressure, such as thermal expansion tanks and float vents, without draining the piping. As the component is threaded into the service check valve, the spring-loaded valve opens to system pressure. As the component is removed, the valve closes, maintaining system integrity while the component is being inspected. The service check is not to be used on safety relief valves or other safety or flow-sensitive components.

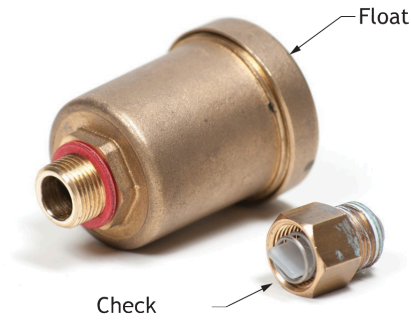


Figure 51 Service check valve (SCV) for a float vent (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Installation of Service Check Valves

Install the service check on the system component, whether it is an expansion tank, float vent, pressure gauge, etc. Check to be certain the spring-loaded check valve opens, and then install the component with the service check into the system piping.



Figure 52 Location of service check valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Removing System Components

System pressure must be reduced to atmospheric pressure, and the contained liquid must be allowed to reach the ambient temperature before removing any component attached to this valve. Failure to follow this procedure can result in the sudden release of hot or pressurized fluid, which may cause serious injury (such as burns), damage to equipment, or loss of system control.

Backwater Valve

Backwater valves are check valves that prevent backflow in a sanitary drainage system or storm water system. Backwater valves prevent flood damage to lower floors in a building.

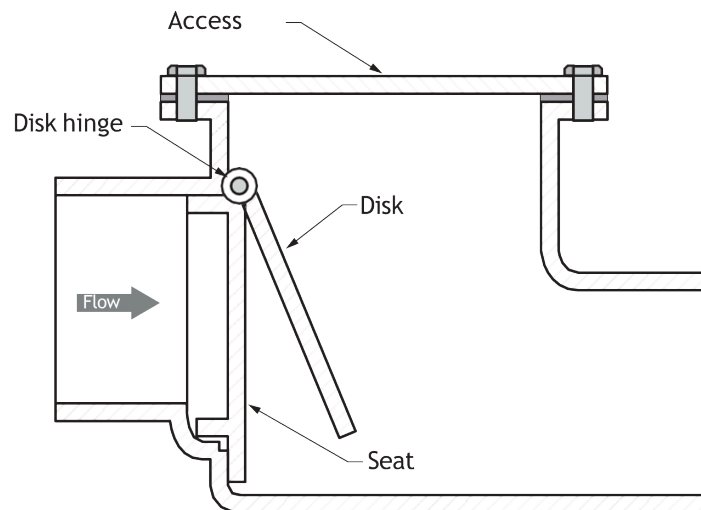


Figure 53 Backwater valve cutaway (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 54 Cast iron backwater valve (Image courtesy of Watts). Used with permission.

Special-Purpose Valves

Knife Valves

Knife valves are gate valves specially designed for tough applications. They are used in the food, cement, and pulp and paper industries, and in power-plant, chemical and slurries applications. The gates can be made of stainless steel and other alloys. They can slice through the handled fluid types to provide a positive shut-off.

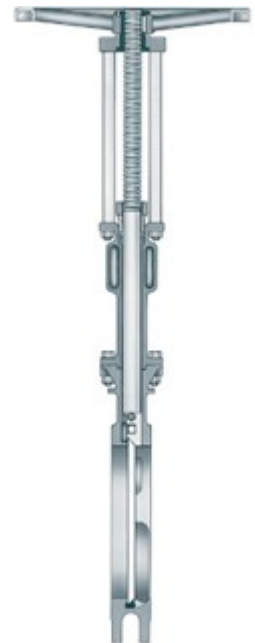


Figure 55 Knife valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Combination Valves

Combination ball valve and relief valves are used for applications that require a means to shut off the water supply to the water heater, and for providing protection from excess water pressure caused by thermal expansion. **Combination valves** may appear in commercial and residential applications on water heater installations.



Figure 56 Combination ball and relief valves (Image courtesy of Watts) Used with permission.

Bypass Valves

Bypass valves are usually identified as valves placed on a piping arrangement called a bypass.

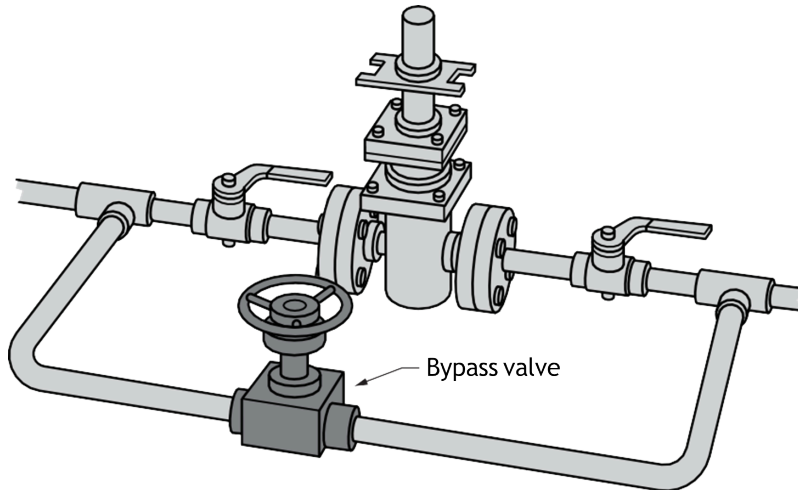


Figure 57 Bypass valve arrangement with bypass valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A bypass valve can control the fluid flow when the main valve is shut down for maintenance. The bypass valve may be used around equipment or pressure-reducing valves. The bypass can act as a quick fill in some cases or to divert flow, such as in a water treatment system. The type of valve used in the bypass depends on whether it will be used to open, close or adjust the flow. A globe valve bypass valve would provide some flow control. A gate valve or ball valve bypass valve would serve to stop flow rather than regulate the flow.

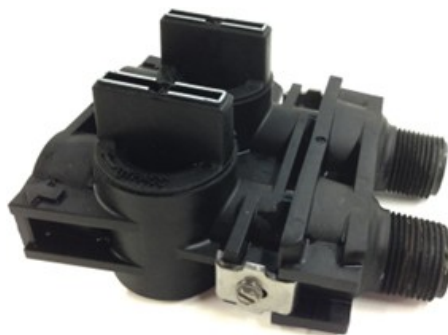


Figure 58 Water treatment bypass valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Stop and Waste Valves and Drain Valves

Stop and waste valves are specialty valves that serve as on and off shutoffs. They have a drain cap on the upstream side

of the shut-off. *Stop and drain valves* allow the system to be drained for winterizing or repairs. Both types of valve are available with several different connection types (Figure 59).



Globe pattern stop and waste valve with threaded connections



Ball valve pattern stop and waste valve with compression connections (*Image courtesy of Watts*)



Ball valve stop and drain for cross-link polyethylene tubing (PEX)



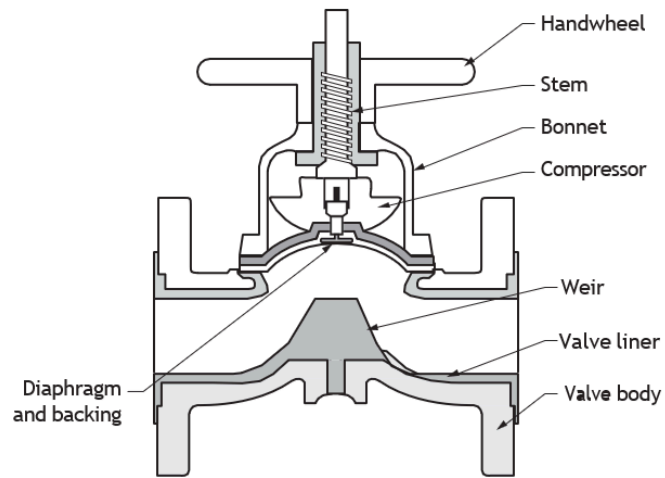
Globe pattern stop and drain valve with soldered connections

Figure 59 Stop and drain valves; Stop and waste valves (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

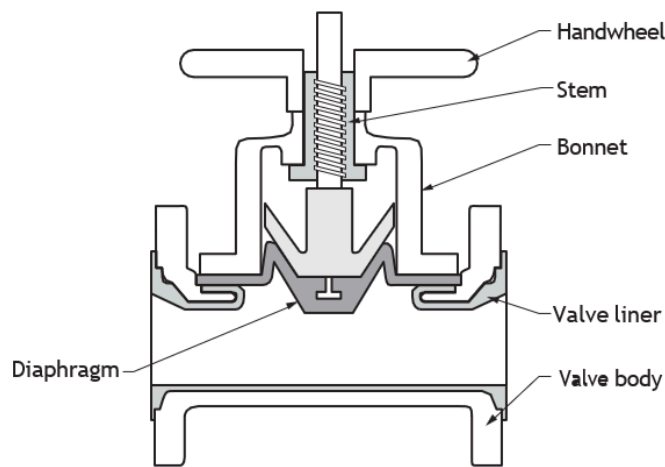
Diaphragm Valve

Diaphragm valves are used for corrosive and abrasive applications with 100% leak-tight operation. The valve stem and components are separated from the fluid by the diaphragm.

Diaphragm valves may be used for slurries (where other valve designs might clog) and in hygienic applications.



Weir-type Diaphragm



Straightway-type Diaphragm

Figure 60 Diaphragm valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pinch Valve

Pinch valves are suited for applications in which slurries or liquids contain large amounts of suspended solids. Pinch valves seal by pinching a flexible element such as a rubber tube.

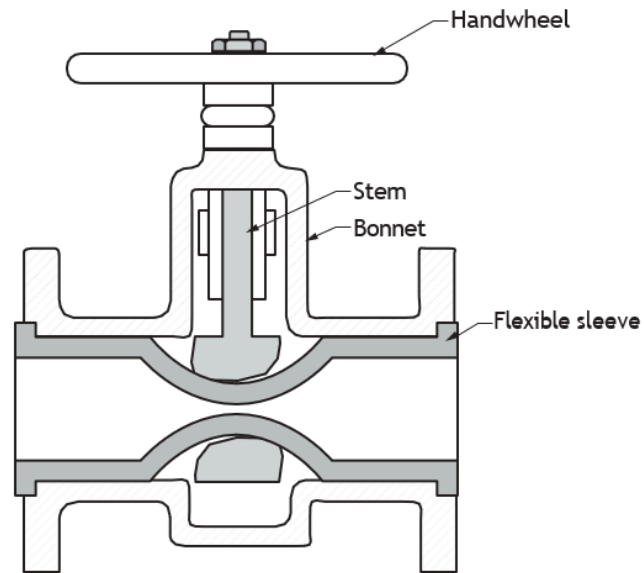


Figure 61 Manual control pinch valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Multiport Valves

Three-Port Mixing and Diverting Valves

Three-port valves can be used for either mixing or diverting service, depending upon the piping arrangement. Valves similar to these types of valves are used on hydronic heating systems and domestic hot water systems.

Mixing valves and diverting valves can be easily distinguished visually by inspecting the piping arrangement:

- The **mixing valve** has two inlets and one outlet.
- The **diverting valve** has one inlet and two outlets

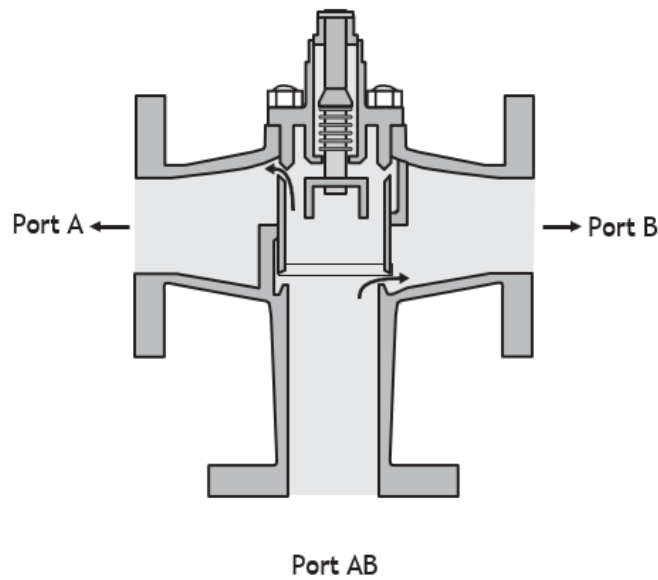


Figure 62 Piston type diverting valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

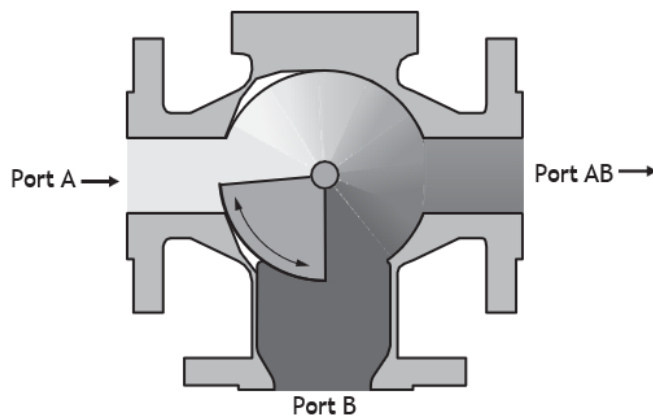


Figure 63 Rotating shoe on a mixing application (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

There are three basic types of three-port valve:

- Piston valve type
- Globe, plug type
- **Rotating shoe type**

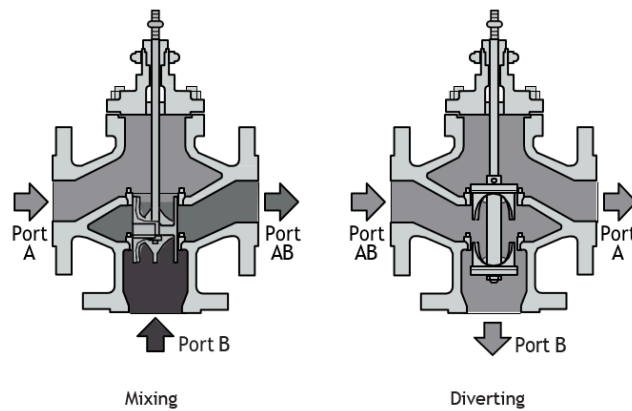


Figure 64 Globe-type three-port valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Hot Water Temperature Control Valves

Thermostatic mixing valves maintain and limit mixed hot water to a desired, selectable temperature. Hot water temperature control valves are used in commercial, residential, and institutional applications to reduce the temperature of the hot water supply, thereby minimizing the risk of thermal shock and scalding to those using the water.



Figure 65 Hot water control valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Double Block and Bleed Valves

Double block and bleed valves have evolved to replace the process of bolting together individual valves to provide dual isolation. The block and bleed valve manifold is used to isolate or block the flow of fluid in the system. A block and bleed

valve would be used to stop the flow of fluids to some component. Fluid would be vented from that component's side of the manifold to allow maintenance.

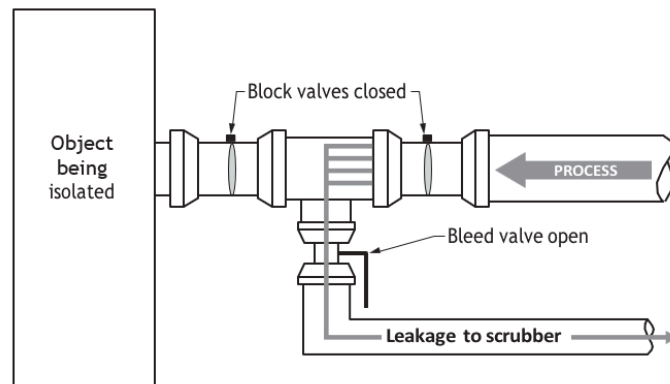


Figure 66 Double block and bleed valve arrangement (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

This configuration is often required to isolate high-pressure sections of a system to facilitate safe maintenance, etc.



Figure 67 Double block and bleed valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Post Indicator Valves

A **post indicator valve** is little more than a gate valve, usually installed underground, that has an indicating post attached to the valve riser above ground to show whether the valve is open or closed. The valve is often used for underground fire protection lines.

Pressure Relief Valves

The **pressure relief valve (PRV)** is a type of safety valve used to control or limit the pressure in a piping system or components. The PRV opens when the pressure in the system reaches the relief valve pressure set point. The pressure relief set point is usually set below the maximum design limits of the piping system components or pressure vessel. PRVs can be preset by the factory for a specific purpose or they can be adjustable. Adjustable PRVs should be set at least 25% higher than system pressure but below the maximum pressure limit of the system components.

Regulations require PRVs on specific piping systems and pressure vessels. PRVs are typically required on domestic and commercial hot water storage heaters, heat exchangers, hydronic heating systems, compressed air systems, and other pressure vessels where safety pressure relief is required.



Figure 68 Boiler pressure relief valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Spring Relief Valve

The most common type of relief valve is the **spring relief valve**, also called a *pop safety valve*, because it opens and closes suddenly. Spring relief valves use the tension of a spring to withstand internal pressure in a pipe. A sudden increase in pressure will force the spring open, and pressure will vent. As the pressure level drops, the spring forces the valve closed.



Figure 69 Pop safety valve for steam boiler application (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Thermal Expansion Relief Valve

Thermal expansion relief valves are used to relieve excessive pressure caused by thermal expansion of water. Thermal

expansion relief valves are used when hot water storage heaters are installed, especially when the water service has a check valve or backflow preventer installed.



Figure 70 Thermal expansion relief valves (Image courtesy of Watts) Used with permission.

Temperature and Pressure Relief Valves (TPRV/T&P)

Combined **temperature and pressure relief valves (TPRV/T&P)** provide fully automatic protection against both excessive temperature and pressure in an emergency condition. They are required on all hot water storage type heaters and are set to relieve at 1034 kPa (150 psi) and 99°C (210°F).

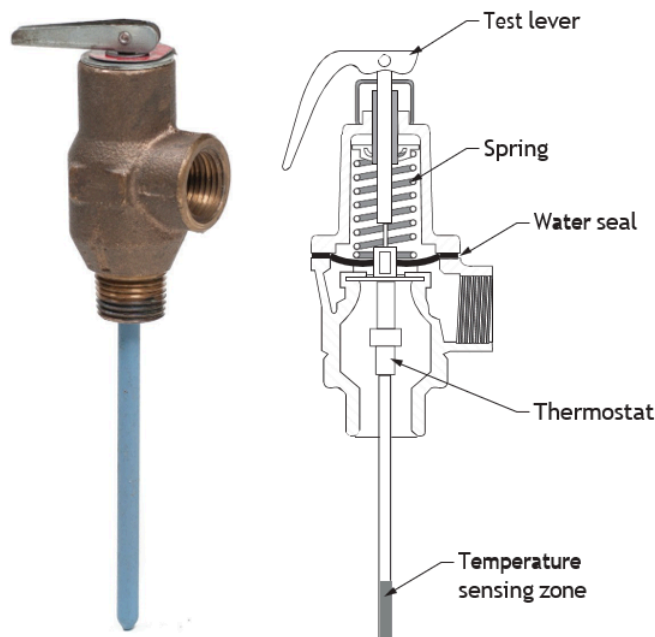


Figure 71 Parts of a temperature and pressure relief valve used for a domestic hot water heater (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Vacuum Relief Valves

Vacuum relief valves allow air to enter the system to prevent negative pressure (lower than atmospheric) from developing in the tank. Vacuum conditions could siphon the water from the system, causing the tank or water heater to collapse or equipment to burn out.

Vacuum relief valves are found on the cold water inlet lines of domestic hot water supply tanks and heaters.

Applications of vacuum relief valves:

- Domestic water heaters and supply tanks
- Tabletop heaters
- Jacketed steam kettles
- Unit heaters
- Low-pressure steam systems
- Steam coil heaters

Note: A vacuum relief valve is not a backflow preventer.

A vacuum relief valve should be installed on the following:

- Domestic hot water heaters
- Supply tanks
- Unit heaters
- Steam kettles
- Other equipment where a vacuum could cause damage



Figure 72 Vacuum relief valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pressure Reducing Valves/Regulators

Water pressure reducing valves are used in commercial, industrial and residential applications to reduce incoming water pressure for protection of plumbing system components and to reduce water consumption. Water supply utilities use pumps and pumping stations to increase pressure in water mains to sufficient levels to supply water for firefighting, to overcome loss of pressure in the upper floors of high-rise buildings and to supply water towers and supply tanks. Pressure in water supply mains can exceed 1380 kPa (200 psi).

Most plumbing codes require water pressure reducing valves on domestic systems where the municipal water main's pressure exceeds 551 kPa (80 psi). Higher pressures could rupture pipes, damage fixtures, and cause personal injury. Pressure-reducing valves can greatly reduce the effects of water hammer. They are available within specified pressure ranges and are adjustable within the specified ranges.

Two types of water pressure reducing valves are:

- Direct acting
- Pilot operated

Direct acting and **pilot operated** pressure reducing valves both use globe or angle-pattern bodies. Valves used on smaller piping diameter units are usually cast from brass; larger piping diameter units are made from ductile iron.



Figure 73 Pilot-operated water pressure regulator (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 74 Direct acting water pressure regulator with strainer (Image courtesy of Watts) Used with permission.



Figure 75 Steam pressure regulator (Image courtesy of Watts) Used with permission.

Direct acting pressure relief valves consist of globe-type bodies with a spring-loaded, heat-resistant diaphragm connected to the outlet of the valve that acts upon a spring. This spring holds a preset tension on the valve seat installed with a pressure equalizing mechanism for precise water-pressure control.

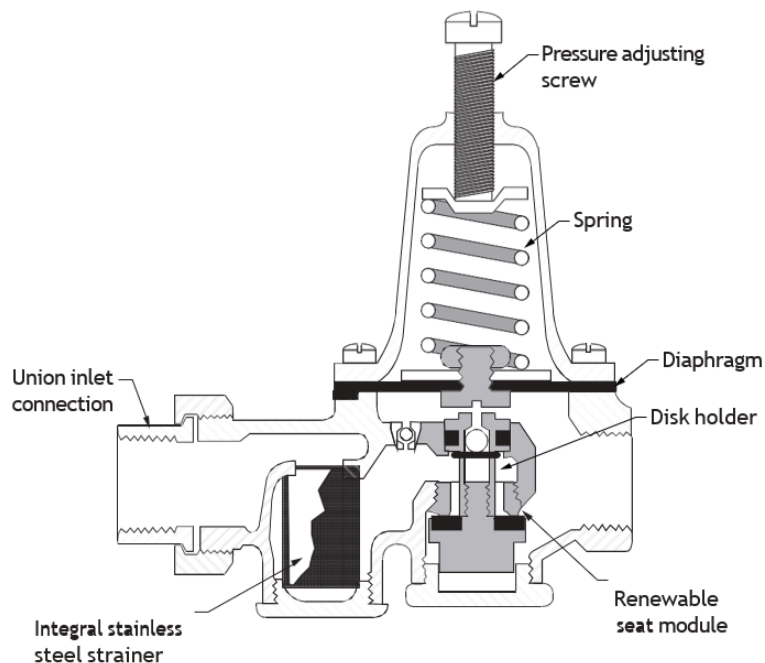


Figure 76 Pressure-reducing valve cutaway (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Float-Control Valves

Float-control valves are designed to automatically maintain a constant liquid level in a tank or reservoir. Mechanical float valves are used in commercial, industrial and agricultural applications to control high-capacity water flow. Mechanical float valves can be mounted on the tank wall.

Float-control valves can be controlled by ball floats or by remotely mounted sensing devices. A decrease in reservoir level causes the valve to move toward an open position, allowing the reservoir level to increase. An increase in reservoir level causes the valve to move toward a closed position, allowing the reservoir level to decrease.

The two float-control valves you are likely to encounter are the float-control valve in a water closet tank and the float-control valve in a water storage tank of a rural water supply system.



Figure 77 Float valve, float arm and ball float (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 78 Float valve, float arm and ball float (Image courtesy of Watts) Used with permission.

Toilet fill valves and thermal expansion relief valves are triple-function devices that consist of a toilet tank fill valve, an anti-siphon backflow preventer, and a thermal expansion pressure relief valve. This assembly is adjustable to fit all standard toilet tanks and performs the following functions:

- Limits the domestic water system's pre-set static pressure
- Protects the temperature and pressure relief valve on the water heater
- Reduces the requirement for a thermal expansion tank or an auxiliary relief valve
- Prevents backflow from water closets.



Figure 79 Toilet fill valve and thermal expansion relief valve (Image courtesy of Watts) Used with permission.

Sliding-Stem Valves

The **sliding-stem valve**'s body actuates with a linear motion using a manual lever or actuator rather than a handwheel, and there are no stem threads. Sliding-stem valves are available in both gate and globe valve designs. The sliding-stem valve is useful where quick opening and closing are needed.

Most sliding-stem control valves are direct acting, which means the valve opens up wider as the stem is drawn out of the body and closes when the stem is pushed into the body.



Figure 80 Sliding-stem globe valve with actuator (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

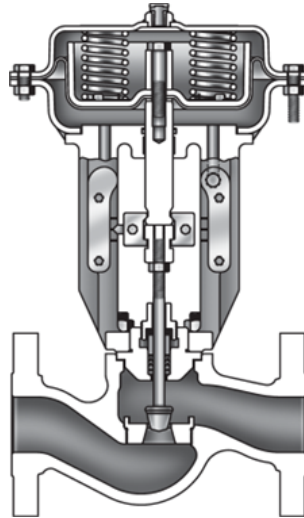


Figure 81 Cutaway of sliding-stem globe valve with actuator (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Backflow Preventers

Cross-connection means the contamination of a potable drinking water piping system by a non-potable substance. Preventing contamination of the potable drinking water distribution system is achieved through cross-connection control. A **backflow preventer** is a valve specially designed, tested and approved to prevent or eliminate cross connections.

A backflow preventer may consist of any or all of the following: shutoff valves, test valves, relief valves, or **air inlet valves**. A backflow preventer may come as an assembly that has been tested and approved as a single unit. It should not be altered or replaced with field-constructed valves.

Types of backflow preventers include the following:

- Reduced pressure backflow assembly
- Double check valve assembly
- Pressure vacuum breaker assembly



Figure 82 Reduced pressure backflow assembly (Image courtesy of Watts) Used with permission.



Figure 83 Double check valve assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



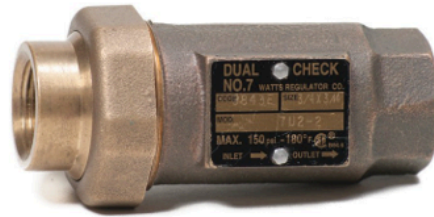
Figure 84 Pressure vacuum breaker (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Backflow Prevention Devices

Backflow prevention devices also prevent or eliminate cross connections of a lower risk level.



Atmospheric vacuum breaker



Dual check valve backflow preventer



Dual check with atmospheric relief port



Hose connection vacuum breaker



Stainless steel dual check with atmospheric relief port

Figure 85 Backflow prevention devices (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Valve Components and Materials

Valve Seat Ring

A **seat ring** is a part of the valve body assembly that provides a seating surface for the closure member. The seat ring provides a stable, uniform and replaceable shutoff surface. The seat rings may be threaded, pressed or machined into the valve body. Seat rings are typically bevelled at the seating surface. This allows the valve disk to be guided during the final stages of closing the valve. Some valve seats can be resurfaced in place with seat resurfacing tools when practical or economically suitable.

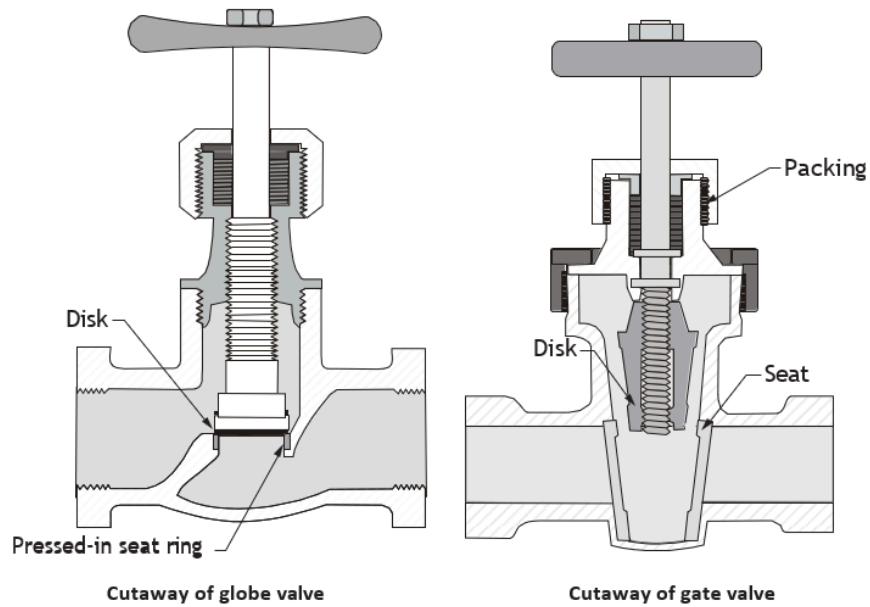


Figure 86 Disk and seat locations (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Types of Seating Materials

The material selected for valve seats and disks depends on the temperature, pressure and type of the fluid being controlled.

Factors to consider when selecting valve seating material include:

- Capability for replacement or resurfacing
- Hardness and resistance to wear, corrosion, erosion, galling, seizing and temperature

Valve seats can be made for relatively low pressure and temperatures and for ordinary fluids. They can be made of the following materials:

- Bronze or bronze-faced seating for bronze valves
- Iron surfaces may have iron or bronze seats
- Non-metallic composition disks such as Teflon



Figure 87 Bronze seat rings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Teflon Polytetrafluoroethylene (PTFE)

PTFE is almost totally insoluble and chemically inert. It has high temperature resistance. Teflon PTFE ball seats require no lubrication because of natural lubricity. Teflon PTFE diaphragms and flange gaskets are used in the most severe chemical resistance applications.



Figure 88 Teflon seat rings from a ball valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Ethylene Propylene Diene Monomer (EPDM)

EPDM is a synthetic rubber used as the standard seal material for some valves. It has excellent chemical resistance on the great majority of applications, including acids, alkalis and salts at temperatures up to 90°C (194°F). EPDM is weak on organic compounds and cannot be used on oils and fats.

Fluorocarbon Rubber (FKM or FPM) (Viton)

FKM/FPM is more expensive than EPDM, and so is used as an alternate when required. It has excellent resistance to

mineral acids, oils and many aliphatic and aromatic hydrocarbons. FKM/ FPM is weak on sodium hydroxide. FKM-C is a special formulation with higher resistance to chlorine services. FKM-F offers better chemical resistance on inorganic acids than standard FKM.

Chlorinated Polyethylene (CPE)

CPE is superior for sodium hypochlorite handling than other elastomers. It resists hypochlorite up to a full strength of 13%.

Nitrile (Acrylonitrile-Butadiene Copolymer, NBR)

Nitrile is also known as *Buna-N*. It has high chemical resistance to oil and petroleum but is weak on oxidizing media (i.e., acids). Nitrile has excellent abrasion resistance and is less expensive than FKM/FPM.

Basic Stuffing Box Designs

A **stuffing box** must provide an enclosure—a tight seal around the stem to retain pressure inside the piping system. The packing is placed in the stuffing box around the stem and held in place by a packing gland and/or nuts. The seal must be tight without binding the stem. Packing is subject to wear and must be periodically compressed and eventually replaced.

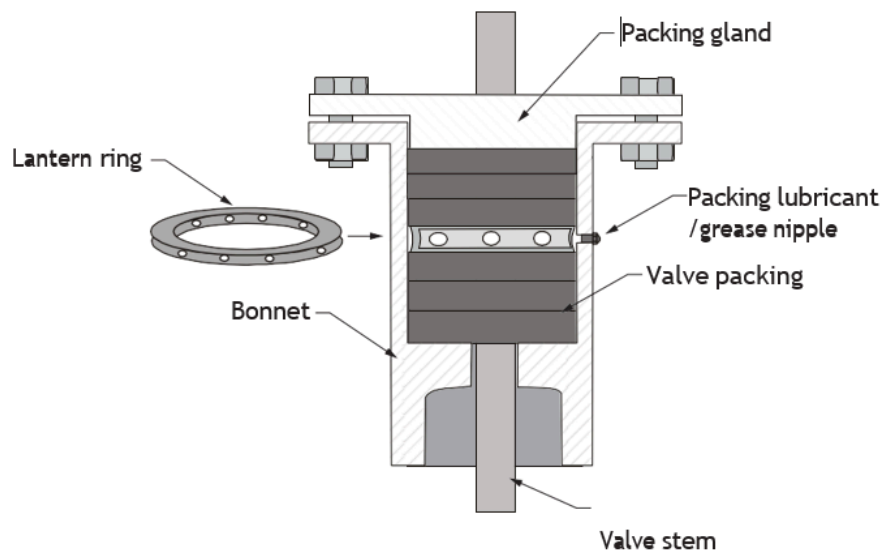


Figure 89 Partial cross-section of a valve showing stuffing box (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Packing that is too tight can cause the operation of the valve to be stiff. If tightening down on the packing gland nuts does not stop the leakage or causes the valve operation to be stiff, the packing should be replaced.

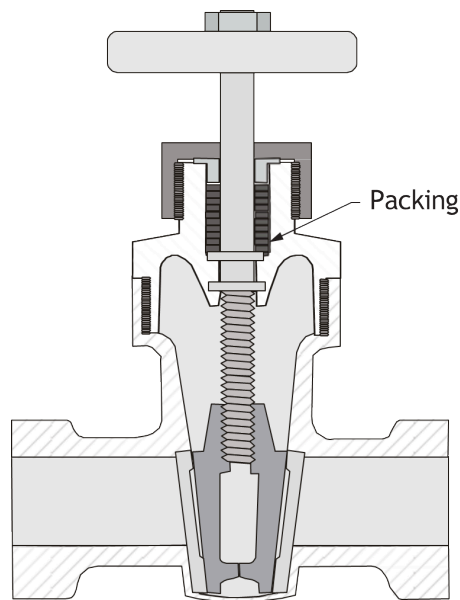


Figure 90 Stuffing box showing packing inside (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In some larger valves, a lantern ring is inserted between the turns of packing and is placed opposite to a lubrication point where grease can be injected to ease the valve operation.

Valve Stem Packing

Valve packing provides a seal between the system fluids and the valve stem. The selection and installation of valve packing material provides positive and long life. Excessive tightening of a packing nut can apply excessive pressure against a valve stem, making the valve difficult to operate and reducing packing life. Check the manufacturer's directions for torque values and procedures. If no specific instructions are available, the proper amount of packing torque to apply is that which results in a tight seal with the least amount of friction against the valve stem.

Packing Materials

Packing is made of different types of material depending on the manufacturer's specification for the valve and the intended service conditions. Examples of packing materials include:

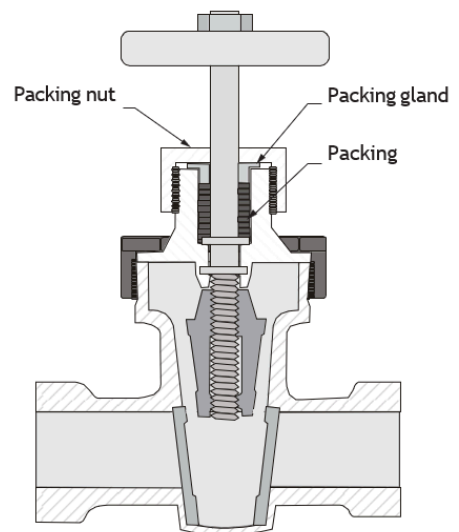


Figure 91 Cutaway of valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

- Graphite l
- Teflon (PTFE)
- Spun synthetic fibre
- Glass fibre optic glaze (GFO fibre)
- Compression-braided packing (see below)
- Combinations of the above



Figure 92
Compression-braided
packing (BC Industry
Training Authority,
2019). CC BY-NC-SA 4.0
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Generic Packing Replacement Procedure

When packing needs to be replaced, avoid adding new packing to old. Remove all old packing and replace with new packing material. Following is the general procedure:

1. Examine the valve.
2. Loosen the packing gland to release any trapped pressure.
3. Remove all old packing and thoroughly clean the shaft/stem and stuffing box area.
4. Examine the shaft/stem for corrosion, nicks, scoring and excessive wear.
5. Examine other components for burrs, cracks and wear that could reduce packing life.
6. Check the stuffing box for excessive clearances and the shaft for straightness.
7. Replace any components found defective.
8. Inspect the old packing as part of failure analysis for clues as to the cause of premature packing failure.

Prepare and Install Braided Packing

Always refer to the packing manufacturer's instructions. Ensure the equipment and packing are clean before proceeding.

1. Select the specified packing.
2. Examine the packing to be sure it is free from defects.
3. Wind the packing around a properly sized mandrel, or use a calibrated packing ring cutter.
4. Cut the packing ends cleanly, square or diagonal, according to the packing manufacturer's instructions.
5. Cut one ring at a time, assuring that rings are sized precisely to the shaft or stem.
6. Carefully install the packing rings one at a time. Ensure the cut ends are staggered so no easy pathway may be found.
7. Install the packing nut or packing gland and nuts if used.
8. Torque the packing nuts to the manufacturer's specifications. If no specifications are available, do not overtighten the nuts.
9. Tighten the nuts evenly to provide easy operation of the valve stem and a tight seal.
10. Test the valve under operating conditions.

Bonnet Characteristics of Gate, Globe and Angle Valves

The bonnet is the portion of the valve that contains the packing box and stems seal, and can guide the stem. It provides the principal opening to the body cavity for assembly of internal parts, or it can be an integral part of the valve body.

It can also provide for the attachment of the actuator to the valve body. Typical bonnets are bolted, threaded, welded, pressure-sealed or integral with the body.

There are many types of valve bonnet. The three most common types are:

- Screwed-in bonnet
- Screwed union ring bonnet
- Bolted bonnet

Screwed-in Bonnet

The **screwed-in bonnet** is used on bronze gate, globe and angle valves, where frequent dismantling is not needed. The bonnet screws into the valve body, rather than over the matching threads of a valve body. The screwed-in bonnet makes a durable, pressure-tight seal, suited for many services.

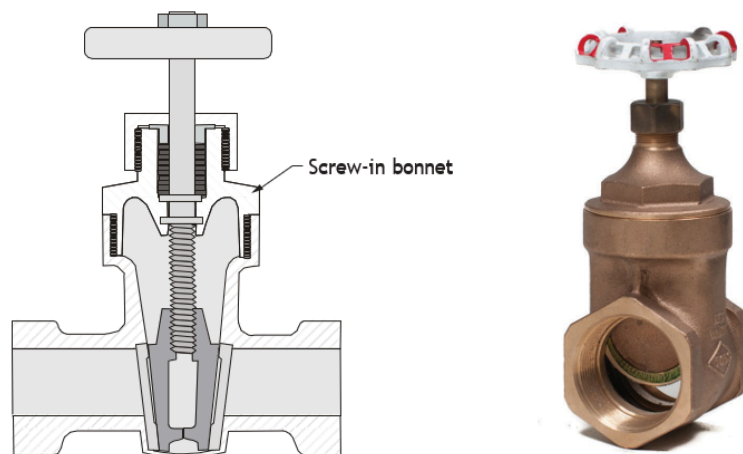


Figure 93 Gate valve with screwed-in bonnet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Screwed Union Ring Bonnet

The **union bonnet** is ideal for smaller size valves. The union bonnet provides relatively easy access to the valve parts for inspection or maintenance. The union bonnet ring is easily screwed or removed from the valve body, providing a tight seal.



Figure 94 Screwed Union Ring Bonnet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Bolted Bonnet

The **bolted bonnet** is used for larger valves or for higher pressure applications. The bonnet is adaptable to all types of gaskets. Multiple bolting permits equal sealing pressure without using excessive torque.



Figure 95 Gate valve with bolted bonnet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Lip-Seal Bonnet

The **lip-seal bonnet** and the valve body are screwed together until a firm metal-to-metal contact is made between the machined surfaces of the bonnet and the top of the body. One type of this bonnet is screwed and fillet welded to the valve body. Dismantling is accomplished by grinding off the fillet weld and unscrewing the bonnet. This valve is designed for high pressure and temperature services.

Bellows Seal Bonnet

A **bellows seal bonnet** is a bonnet that uses a bellows for sealing against leakage around the valve stem.

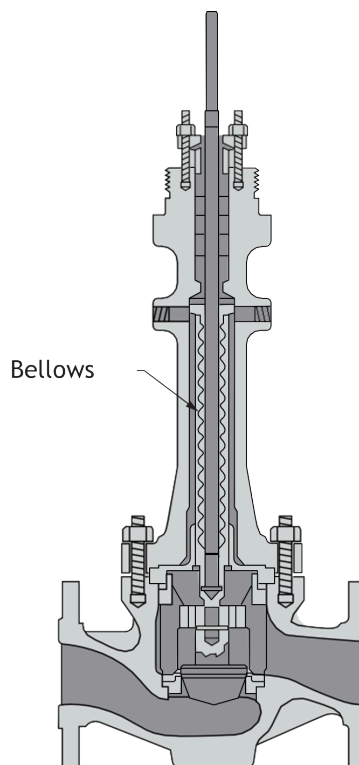


Figure 96 Bellows seal bonnet (BC Industry Training Authority, 2019).
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Pressure-Seal Bonnet

The **pressure-seal bonnet** is a newer style that is effective for sealing high pressures and temperatures. A pressure-seal bonnet utilizes line fluid pressure to seal the joint. As the line pressure increases, the bonnet seal gets tighter. The actual seal is at the contacting area of a wedge-shaped metal ring, making a pressure-tight metal-to-metal joint.

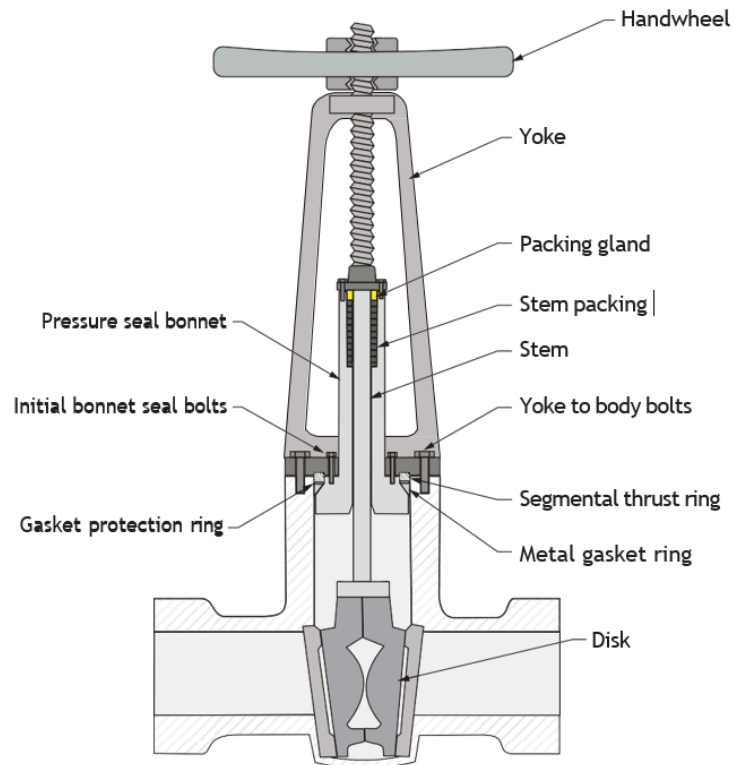


Figure 97 Cutaway of gate valve with pressure seal bonnet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Self-Test D-2.1: Describe Basic Valve Types

Complete Self-Test 2.1 and check your answers.

If you are using a printed copy, please find Self-Test D-2.1 (#chapter-self-test-d-2-1-describe-basic-valve-types) and Answer Key (#chapter-answer-key-self-test-d-2-1) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2013#h5p-7> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2013#h5p-7>)

References

BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S

- Plumber: Competency D-4 Install Valves
- Steamfitter: Competency D-1 Install Valves
- Sprinkler Fitter: Competency D-4 Install Valves

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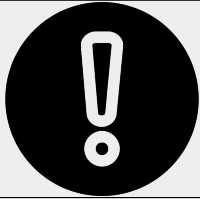
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- **Figure 3** Bidirectional tight butterfly valve (https://commons.wikimedia.org/wiki/File:Bidirectional_tight_butterfly_valve-The-Alloy-Valve-Stockist.jpg) (Heather Smith/Wikimedia commons)
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 - **Figures 42** Flanged T pattern iron body swing-check
 - **Figure 44** Split disk wafer check valve
 - **Figure 48** Flanged silent check valve
 - **Figure 54** Cast iron backwater valve
 - **Figure 56** Combination ball and relief valves
 - **Figure 70** Thermal expansion relief valves
 - **Figure 74** Direct acting water pressure regulator with strainer
 - **Figure 75** Steam pressure regulator
 - **Figure 78** Float valve, float arm and ball float
 - **Figure 79** Toilet fill valve and thermal expansion relief valve
 - **Figure 82** Reduced pressure backflow assembly

D-2.2 Install Valves

Now that you understand the types and purpose of valves, the next step is learning how to install them correctly. Proper valve installation is important for safe operation. The location and position of a valve in a piping system can affect how it works.



ALWAYS follow the manufacturer's installation instructions when installing a valve.

General Valve Installation Guidelines

Accessibility

Valves need to be easily accessible for regular maintenance, replacement, or inspection. Some valves have gauges or indicators that must be visible and accessible, as they are used to adjust valve operation. There should always be enough headroom to dismantle the **valve stem** or **spindle** and to repack or replace the *packing* in the *stuffing box*. Easy access is important to enable consistent lubrication of moving parts and, in some valves, the replacement of seats, seals, bonnets, or disks.

Installation

Valves may be joined to piping by screwed, welded, sweated, or flanged joints. Always follow these precautions during installation:

- **Screw-joint valves:** Place your wrench on the valve end into which a pipe is inserted. This prevents excessive strain and potential damage on the valve body.
- **Globe-type valves with sweated or welded joints:** Make sure the valve stem is backed off or removed so that the disk will not be damaged.
- **Unions or flanges** are often installed between valves and equipment to make repairs easier. Make sure that valves are aligned correctly with the flanges or unions. Misalignment can place undue strain on the valve.

Code Requirements for Valve Installation

Be sure to check codes and municipal bylaws for regulations that are pertinent to your location and application.

Globe Valve Installation

In piping systems that must be drained in freezing weather, *globe valves* should be positioned with the stem or spindle vertically up or horizontal to ensure that water does not remain inside the valve. Avoid installing a valve with the valve stem facing down, especially if it will be exposed to freezing conditions.

The position of globe and angle valves depends on operating conditions. Flow should be from underneath the disk when continuous flow is critical to safe operation (Figure 1a). If water flow is directed onto the top of the disk and the disk becomes separated from the stem, flow may stop completely (Figure 1d). When handling high-temperature fluids, cooling of the valve stem can cause contraction away from the valve seat when it cools down (Figure 1c). Fluid will find its way past the seat and continue to leak even if the valve was closed tight when the valve was hot. Figure 1b shows the valve correctly installed to keep the valve stem warm and closed.

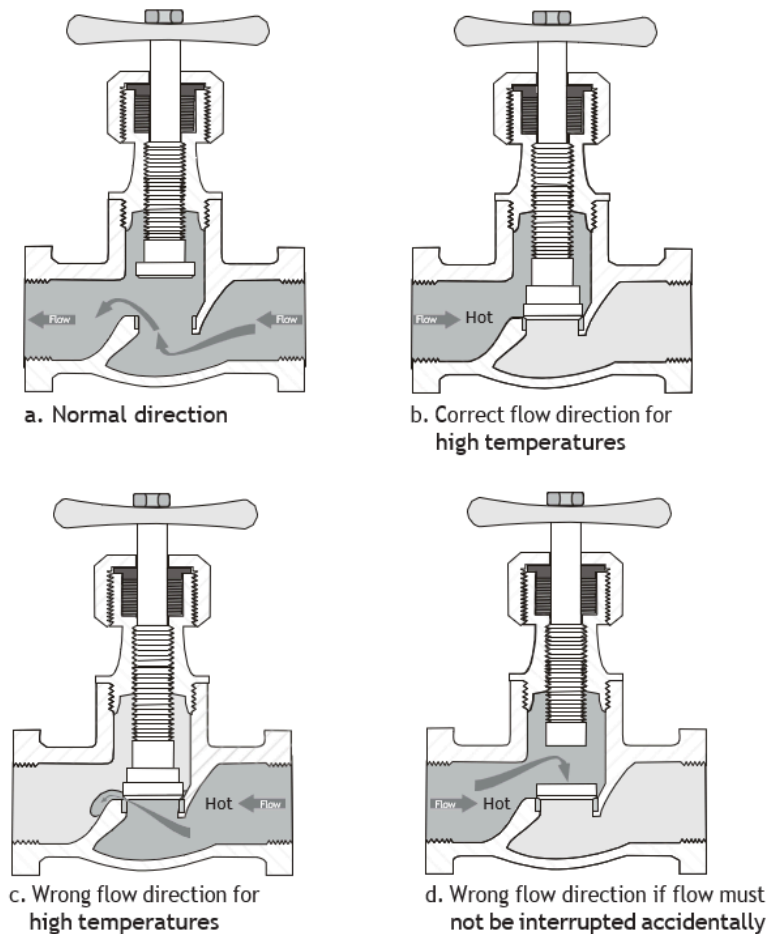


Figure 1 Correct and incorrect flow directions (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Stop and Waste Valve Installation

Stop and waste valves allow water on the downstream side of the valve seat to drain when the valve is shut. These valves are sometimes referred to as *stop and drain valves*.

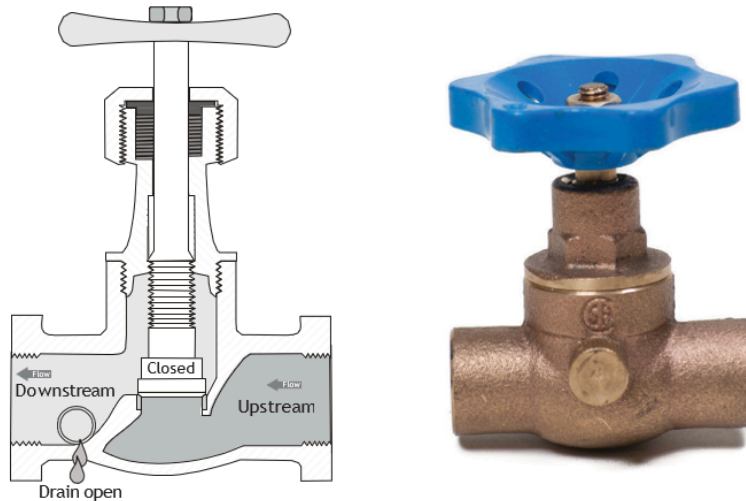


Figure 2 Stop and waste/drain valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Stop and waste valves must be installed so that the drain is on the downstream side of the valve seat. They are typically installed directly inside the building on the water service connection to the rest of the building. They are often used when a water pipe supplies an outside hose valve. The stop and drain is installed in other locations where freezing conditions require the system to be shut down and drained for winterization.

Gate Valve Installation

Gate valves must be installed with the stem vertical or at an angle (Figure 3), but not less than horizontal, as debris can collect in the bonnet (Figure 4). The exception is **solid wedge gate valves**, which can be installed in any position if there is no alternative.

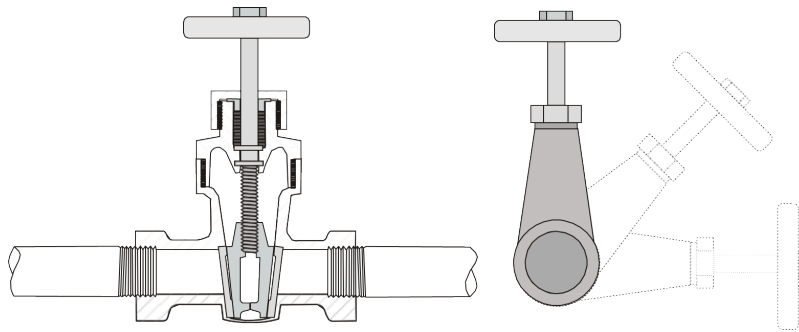


Figure 3 Acceptable gate valve positions.
Solid wedge gates can be installed in any position. (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

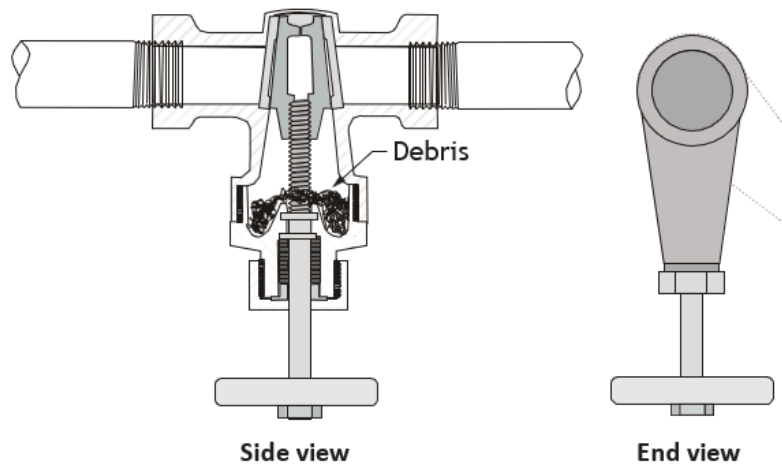


Figure 4 Unacceptable gate valve positions (BC Industry Training Authority, 2019).
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Do not install parallel disk gate valves with the stem facing down.

When installing threaded valves, place your wrench on the end of the valve that you are screwing onto the pipe (Figure 5). Never tighten with the wrench on the opposite end of the valve. Tightening this way would subject the valve body to force that could deform it and prevent the valve from operating correctly.

Use a flat-jawed wrench to tighten the valve when the ends are shaped for flat-jawed wrenches.

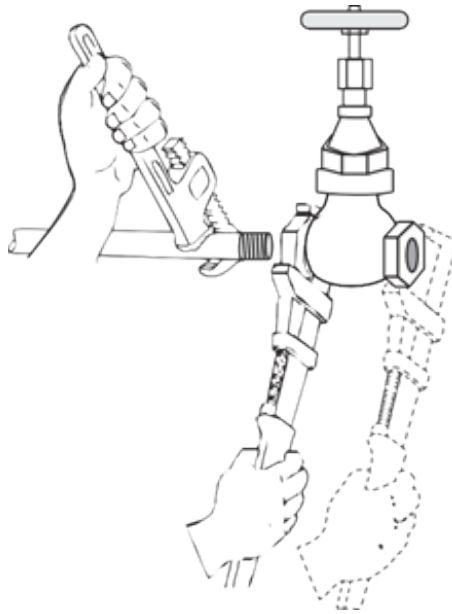


Figure 5 Proper tightening technique (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Check Valve Installation

Check valves should be installed away from other valves and fittings to avoid excessive turbulence caused by the other valve or fitting. Consult the manufacturer's specifications. They must be:

- Properly sized to pressure, temperature, and flow requirements.
- Installed in the correct orientation according to manufacturer instructions.

Swing-Check Installation Instructions

Swing-check valves can be installed in horizontal or vertical upward flow, but must be installed with pressure under the disk in the direction of flow or they will not function properly. The **hinge pin** should be horizontal.

- Avoid high flow velocities, rapid pressure fluctuations, and sudden flow stoppages. The resulting water hammer can damage the check-valve. High-velocity flow may cause vibration and rattling of the disk, increasing wear and reducing the service life of the valve.
- Ensure that the temperature, pressure and flow specifications are correct for the system.
- Ensure that the correct distances are maintained between upstream and downstream fittings. Refer to the specific manufacturer's specifications.

Butterfly Valve Installation

Gaskets

The seat in a resilient seated *butterfly valve* usually extends around to both faces of the valve. As these seats serve the function of a *gasket*, no gaskets are required. The seat material that extends past the face is compressed during installation and flows toward the centre of the valve seat. Any change in this configuration due to improper installation directly affects the pressure rating and seating/unseating torques.

Shipment and Storage

- Position disks at 10% open so that they are unseated.
- Cover the faces of each valve to prevent damage to the seat face, disk edge, or valve interior.
- Store indoors, preferably with ambient temperatures between 5°C and 30°C (40°F to 86°F).
- Open and close the valves every three months.
- Ship and store valves so that no heavy loads are applied to the bodies.

Valve Location

Butterfly valves should be installed, if possible, at a minimum of six pipe diameters from other line elements, such as elbows, pumps, valves, etc. Sometimes this is not feasible, but it is important to achieve as much distance as possible.

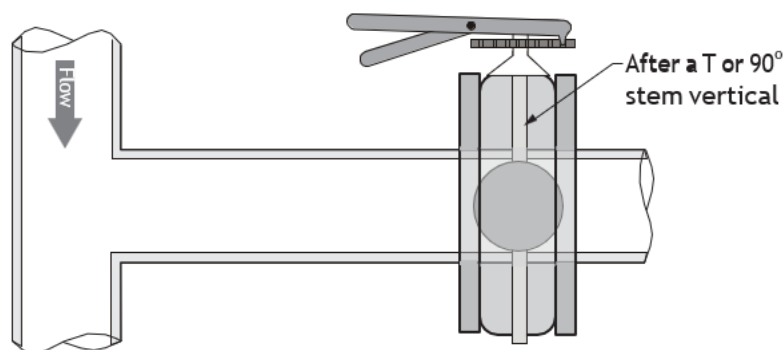


Figure 6 Butterfly valve located downstream of a bend or a tee (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

- Where the butterfly valve is connected to a check valve or pump, keep enough space between them to ensure that the disk does not interfere with the adjacent equipment.

Valve Orientation

Butterfly valves are typically installed with the stem vertical and with the **actuator** mounted vertically directly above it. There are some applications where the stem should be horizontal.

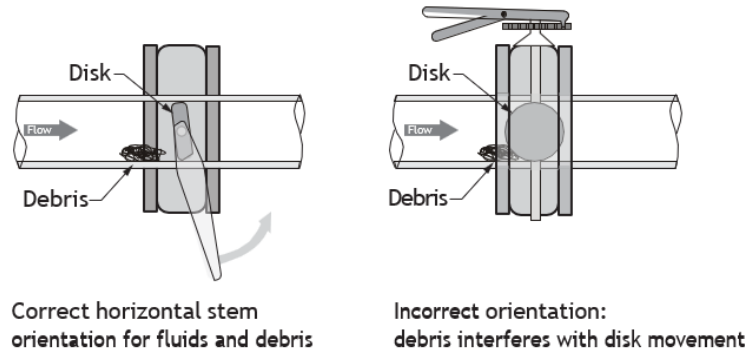


Figure 7 Butterfly valve installation orientation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

For media with sediment or particles, such as slurries, sludge, mine tailings, pulp, and dry cement, install the valve with the stem horizontal, and the lower disk edge opening toward the downstream direction.

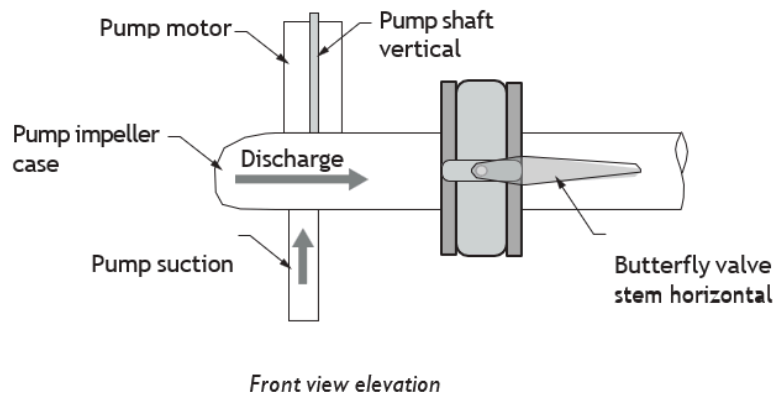


Figure 8 Butterfly valve located downstream of a pump (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

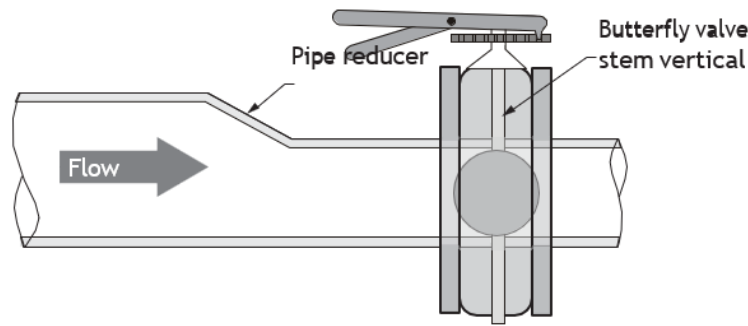


Figure 9 Butterfly valve located in a pipe reducer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

When combinations of butterfly valves are installed close together, there is a possibility of noise, vibration, and erosion due to fluid turbulence. Noise, vibration, and erosion are less likely when the stem of the centre control valve is at a right angle to those of the adjacent valves.

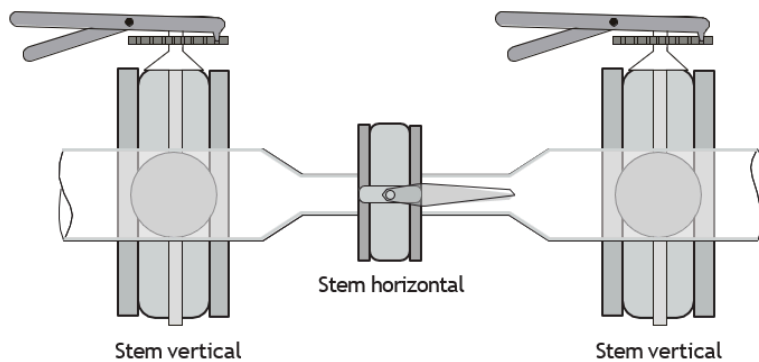


Figure 10 Butterfly valves in combination for control/isolation applications (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Butterfly Valve Flanged Installation Procedures

1. Make sure the pipeline and flange faces are clean. Any foreign material such as metal filings, pipe scale, welding slag, welding rods, etc., can limit disk movement or damage the disk or seat.
2. Gaskets are often not required on resilient seated valves because they extend to both faces of the valve. Check the manufacturer's specifications.
3. Align the pipe-work, and spread the flanges enough to allow the valve body to be easily inserted between the flanges without contacting the pipe flanges.
4. Check that the valve disk has been set to about 10% open so it does not become jammed in the fully seated position.

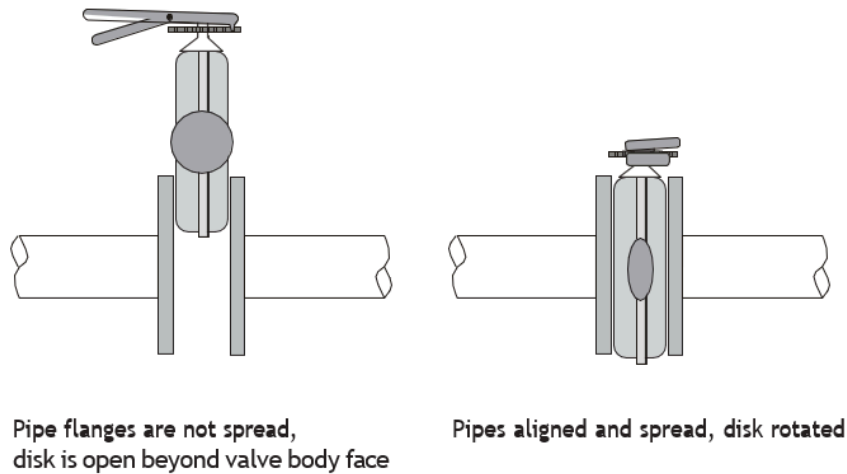


Figure 11 Butterfly valve flanged installation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

5. Insert the valve between the flanges as shown, taking care not to damage the seat faces. Always lift the valve by the locating holes or by using a nylon sling on the neck or the body. Never lift the valve by the actuator or operator mounted on the valve.
6. Centre the valve between the flanges, insert the bolts and hand-tighten them. Carefully open the disk, making sure the disk does not contact the inside of the adjacent pipes.
7. Very slowly close the valve disk to ensure disk edge clears the adjacent pipe flange.
8. Fully open the disk and tighten all flange bolts in the order shown in Figure 12.
9. Repeat a full close to full open rotation of the disk to ensure proper clearances.

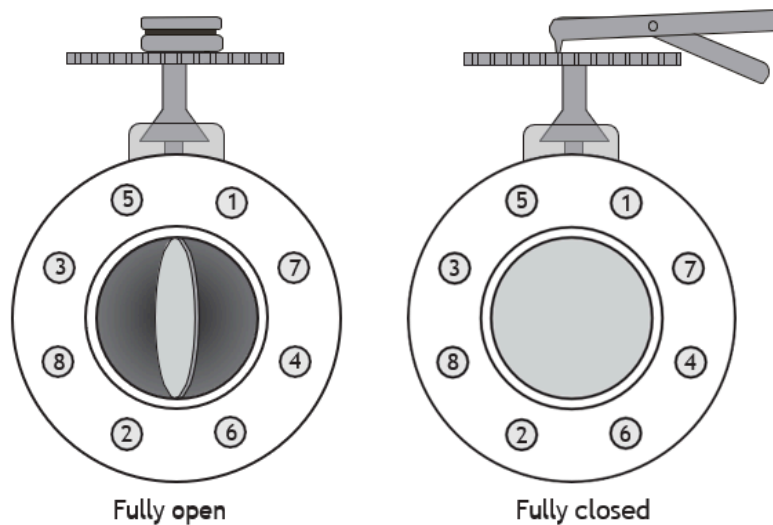


Figure 12 Butterfly valve in open/closed positions (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Butterfly Valve Installation with Welded Flanges

When butterfly valves are to be installed between welding-type flanges, take the following measures to ensure the seat is not damaged:

1. Place the valve between the flanges with the flanges and valve body aligned. The disk should be 10% open.
2. Bolt the flanges to the valve body. Ensure that the valve and flanges are aligned with the pipe.
3. Tack-weld the flanges to the pipe.
4. Remove the bolts and the valve from the pipe flanges and finish welding the flanges.
5. Wait for the pipe and flanges to cool before installing the valve.



Never complete the welding (after tacking) with the valve between flanges because heat transfer will cause severe seat damage.

Temperature and Pressure Relief Valve Installation

The temperature-sensing element placed in a hot water storage tank so the element is positioned in the water within the top 150 mm (6 in) of the tank. The standard temperature relief setting is 99°C (210°F). Standard pressure setting of a hot water storage heater is 1034 kPa (150 psi).

Pressure relief valve settings for other equipment can vary. It is essential that a discharge line be piped from the valve in order to carry the overflow to a safe place of disposal. The discharge line must be the same size as the valve outlet and must pitch downward from the valve and terminate at least 152 mm (6 in) above the floor drain where any discharge will be clearly visible.

Check with the local regulatory authority for drain installation.

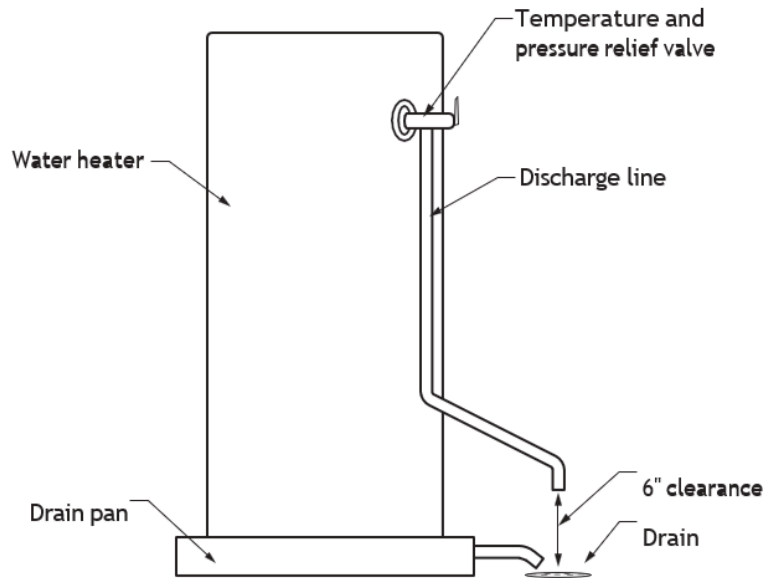


Figure 13 Temperature and pressure valve installation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Relief Valve Installation

Always check the manufacturer's specification for recommendations regarding positioning relief valves. For example, although relief valves are usually installed in the upright position, with the stem vertical, there are exceptions. For air or gas service, relief valves are positioned upside down so that moisture will collect and seal the seating surfaces inside the valve.

Vacuum Relief Installation

A *vacuum relief valve* must be installed on a hot water storage heater so that it is approximately 150 mm (6 in) above the storage heater tank. The vacuum relief is located on the cold water supply line downstream of any shut-off valves used to isolate the equipment it is protecting. Check with the local regulatory authority for drain installation.

Valve Locations

Any sharp change in pipe direction, such as at an elbow or tee, will cause turbulence and pressure loss. To minimize overall turbulence and pressure loss, valves should be installed at a reasonable distance from any sharp bend or turn in piping.

Figure 14 shows a general guide for locating valves away from other fittings. For example, if the pipe has a diameter of 2 inches, then the valve should be located at least 510 mm (20 in) downstream or 152 mm (6 in) upstream from the nearest elbow or tee.

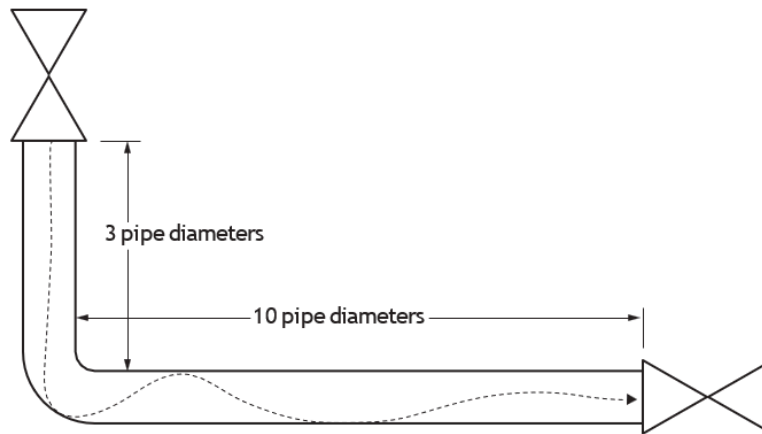


Figure 14 Valve spacing at sharp turns (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Self-Test D-2.2: Install Valve

Complete Self-Test 2.2 and check your answers.

If you are using a printed copy, please find Self-Test D-2.2 (#chapter-self-test-d-2-2) and Answer Key (#chapter-answer-key-self-test-d-2-2) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.





An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2016#h5p-8> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2016#h5p-8>)

References

BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S

- Plumber: Competency D-4 Install Valves
- Steamfitter: Competency D-1 Install Valves
- Sprinkler Fitter: Competency D-4 Install Valves

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Self-Test D-2.1 Describe Basic Valve Types

Complete Self-Test D-2.1 and check your answers.

1. What valve is described as a quarter-turn valve with characteristics that include quick opening and positive shut-off?
 - a. Ball
 - b. Gate
 - c. Globe
 - d. Needle
2. What valve is described as a valve designed to stop reverse flow in a sanitary drainage system?
 - a. Backflow valve
 - b. Butterfly valve
 - c. Backwater valve
 - d. Backflow preventer
3. What valve is described as a quarter-turn valve that has a fat circular disk as its closing element?
 - a. Gate valve
 - b. Butterfly valve
 - c. Backwater valve
 - d. Diaphragm valve
4. What valve is described as a small-bore valve fitted in parallel to a larger main valve?
 - a. Globe valve
 - b. Needle valve
 - c. Bypass valve
 - d. Pressure relief valve
5. What valve material provides high strength and excellent resistance to wear, seizure, galling, erosion and oxidation?
 - a. Cast iron
 - b. Ferro steel
 - c. Stainless steel
 - d. Malleable iron
6. What does the numbers 150 stand for on a valve identification stamp?
 - a. Metric size in mm
 - b. Basic water working pressure
 - c. Basic steam working pressure
 - d. Basic steam working temperature
7. What type of valve actuator is shown in Figure 1?
 - a. Pneumatic
 - b. Solenoid
 - c. Hydraulic
 - d. Motor
8. What type of valve is shown in Figure 2?



Figure 1 Illustration for Question 7

- a. Manually operated wafer butterfly valve
- b. Manually operated wafer lug butterfly valve
- c. Gear-operated wafer lug butterfly valve
- d. Pneumatic operated wafer butterfly valve

9. What is the correct name of the valve shown in Figure 3?

- a. Flat disk check
- b. Split wing check
- c. Wafer disk check
- d. Split swing check



Figure 2 Illustration for Question 8

10. What is the name of Part 2 shown in Figure 4?

- a. Body
- b. Yoke
- c. Frame
- d. Support

11. What is the name of Part 8 in Figure 4?

- a. Seat
- b. Slider
- c. Lantern
- d. Disk



Figure 3 Illustration for Question 9 (Image courtesy of Watts)

12. What is the name of Part 6 in Figure 4?

- a. Stem
- b. Bonnet
- c. Guide
- d. Support

13. What is the name of Part 4 in Figure 4?

- a. Stem
- b. Bonnet
- c. Packing
- d. Yoke

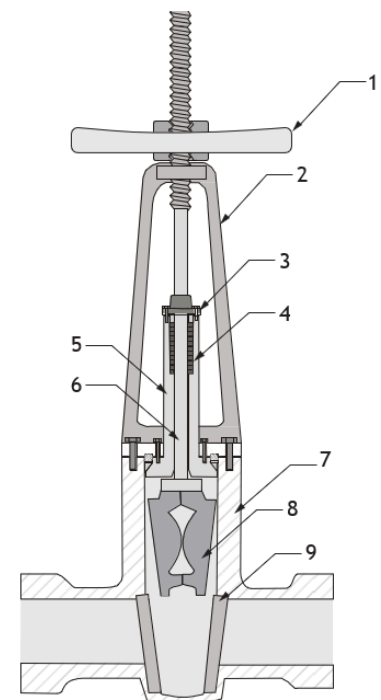


Figure 4 Illustration for Questions 10 to 13

Answer Key: Self-Test D-2.1 (#chapter-answer-key-self-test-d-2-1) is on the next page.

Answer Key: Self-Test D-2.1

1. a. Ball
2. c. Backwater valve
3. b. Butterfly valve
4. c. Pressure relief valve
5. c. Stainless steel
6. c. Basic steam working pressure
7. a. Pneumatic
8. b. Manually operated wafer lug butterfly valve
9. c. Wafer disk check
10. b. Yoke
11. d. Disk
12. a. Stem
13. c. Packing

Self-Test D-2.2 Install Valve

Complete Self-Test D-2.2 and check your answers.

1. In what position would a swing-check be installed?
 - a. Vertical flow down or up
 - b. Horizontal hinge pin vertical
 - c. Horizontal position, flow above disk only
 - d. Horizontal or vertical flow up position
2. What operation condition is suitable for a swing-check valve?
 - a. Low velocity
 - b. High velocity
 - c. Rapid pressure fluctuation
 - d. Sudden stoppages in flow
3. In what position should a swing-check hinge pin be?
 - a. Vertical
 - b. Horizontal
 - c. 45 degrees from vertical
 - d. 60 degrees from vertical
4. What is the minimum distance from another fitting that a butterfly valve should be installed?
 - a. 2 diameters
 - b. 6 diameters
 - c. 8 diameters
 - d. 10 diameters
5. What position is recommended for a butterfly stem with an actuator installed?
 - a. Horizontal
 - b. At an angle of 45 degrees
 - c. Vertical directly above the actuator
 - d. Vertical directly below the actuator
6. What type of valve is used on a water service just inside the building and at a location where draining is required to prevent freezing?
 - a. Gate valve
 - b. Ball valve
 - c. Straight stop
 - d. Stop and waste valve
7. In what position should the hinge pin of a swing-check valve be installed?
 - a. Vertical
 - b. Horizontal
 - c. 45 degrees to the vertical
 - d. 45 degrees from the horizontal
8. In what position must the temperature-sensing element of a relief valve be placed on a hot water storage heater tank?
 - a. Upstream of the tank shut-off valve
 - b. Downstream of the tank shut-off valve

- c. Within the top 150 mm (6 in.) of the tank
 - d. Within the bottom 150 mm (6 in.) of the tank
9. How far away do you need to install a valve from another fitting? (minimum distance)?
- a. 3 pipe diameters upstream
 - b. 3 pipe diameters downstream
 - c. 8 pipe diameters upstream
 - d. 10 pipe diameters upstream

Answer Key: Self-Test D-2.2 (#chapter-answer-key-self-test-d-2-2) is on the next page.

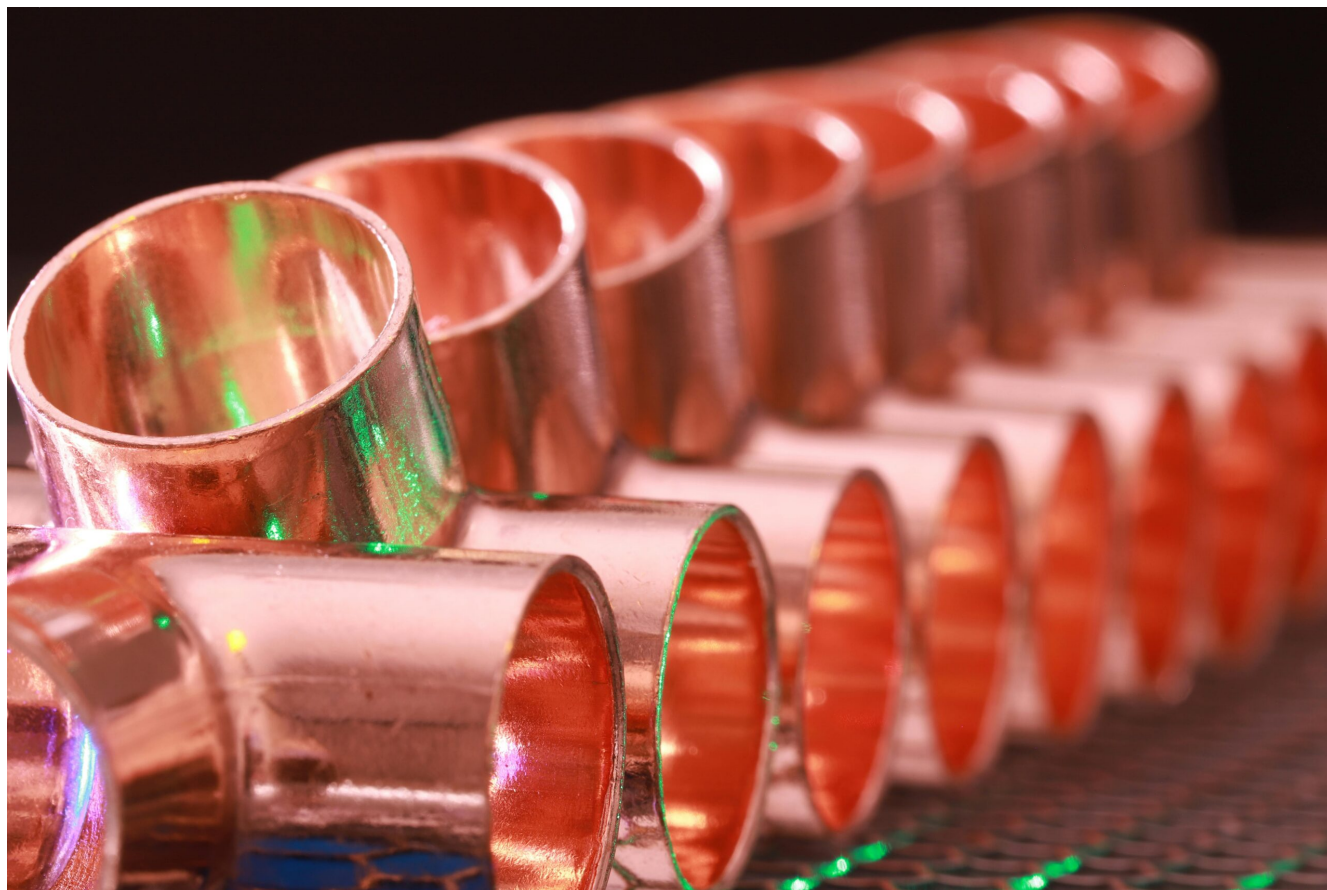
Answer Key: Self-Test D-2.2

1. d. Horizontal or vertical flow up position
2. a. Low velocity
3. b. Horizontal
4. b. 6 diameters
5. c. Vertical directly below the actuator
6. d. Stop and waste valve
7. b. Horizontal
8. c. Within the top 150 mm (6 in.) of the tank
9. a. 3 pipe diameters upstream

PART III

D-3 INSTALL FITTINGS

Plumber Apprenticeship Program – Level 1



Copper plumbing fittings arranged in a row, showcasing metallic texture and industrial detail. (<https://www.pexels.com/photo/copper-plumbing-fitting-28169591/>) (Nic Wood/Pexels) Pexels license (<https://www.pexels.com/license/>)

D-3 Install Fittings Introduction

Pipe fittings are essential components used to connect, direct, and control the flow of piping systems in the trades. In this section, you will learn how to visually identify common fittings, understand their purpose, and interpret the abbreviations used to describe them. You will also explore different connection methods and develop the skills needed to select appropriate fittings for various applications. Building a strong understanding of fittings terminology and use is a key step toward working safely and effectively in the pipe trades.

Learning Objectives

After completing this section, you will be able to:

- Visually identify and name common types of pipe fittings
- Interpret and write common abbreviations used in the pipe trades
- Describe fittings used in the pipe trades.
- Describe connection methods of fittings.
- Select fittings.
- Compile a basic, *readable, logically ordered* materials list using the basic procedures outlined in this section.

Topic areas covered in this publication are in alignment with SkilledTradesBC Harmonized 2018 Program Outlines.



Resources

You may be required to reference publications and videos available online at the WorkSafeBC (<https://www.worksafebc.com/en>) website.

The following terms may be used throughout this section. Note that some glossary terms may be in *italics* throughout the section content but are not included in this list. A complete list of terms can be found in the **Glossary**.

- **adapter fitting:** A fitting used to connect pipes with different connection types. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **branch:** The pipe that connects off the main run of a fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **bushing:** A fitting used to reduce the size of a pipe opening, usually with threaded ends. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **cap:** A fitting used to close the end of a pipe with internal threads. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **cleanout:** An access point in a pipe system used to remove blockages. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **coupling:** A short fitting used to join two pipes in a straight line. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **dwv fittings:** Fittings used to carry drainage, waste, and vent fluids by gravity. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **elastomeric:** A material that is flexible and rubber-like, able to stretch and return to its original shape. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **elbow:** A fitting used to change the direction of a pipe. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **full-face gasket:** A gasket that covers the entire face of a flange, including the bolt holes, to provide a complete seal between two flanged surfaces. (Section D-3.2 (#chapter-d-3-2-section-2))
- **gasket:** (Sometimes referred to as a *compression type fitting* or *connection*); A flat sealing material placed between two surfaces to prevent leaks when they are joined together. (Section D-3.2 (#chapter-d-3-2-section-2))
- **hub end:** The end of a fitting that receives another pipe or fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **materials list:** A list of materials needed to complete a job, used to communicate with suppliers or plan work on site. (Section D-3.3 (#chapter-d-3-3-select-fittings))
- **materials takeoff (materials takeoff list):** A detailed list of materials and quantities required for a job, often used for estimating costs and planning. (Section D-3.3 (#chapter-d-3-3-select-fittings))
- **packing:** A sealing material made of flexible (pliable) materials that provides a dynamic seal between a moving part and a stationary part, such as around a valve stem to prevent leaks. Common types include graphite packing. (Section D-3.2 (#chapter-d-3-2-section-2))
- **plug:** A fitting with external threads used to seal the end of a pipe. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **plumber's putty:** A soft, moldable sealing compound used to create watertight seals around fixtures such as sinks and drains. (Section D-3.2 (#chapter-d-3-2-section-2))
- **pressure fittings:** Fittings designed to carry fluids under pressure. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

- **reducing fitting:** A fitting used to connect pipes of different sizes. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **run:** The straight-through portion of a fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **sanitary tee (san tee):** A fitting used in drainage systems to connect pipes at a 90-degree angle with a curved path for smooth flow. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **sealant:** A material used to fill gaps and create a watertight or airtight seal between surfaces. (Section D-3.2 (#chapter-d-3-2-section-2))
- **side inlet fitting:** A fitting with an additional connection on the side. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **silicone caulking:** A flexible sealant and adhesive compound used to fill gaps and create a watertight seal around fixtures, joints, and surfaces, often containing mildew-resistant chemicals. (Section D-3.2 (#chapter-d-3-2-section-2))
- **solvent cement:** A chemical adhesive used to join plastic pipes by softening and fusing the surfaces together to form a permanent bond. (Section D-3.2 (#chapter-d-3-2-section-2))
- **spigot end:** The end of a pipe or fitting that fits into a hub end. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **street elbow:** An elbow with male threads on one end and female threads on the other. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **tee:** A fitting that connects three pipes. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **teflon thread compound:** A type of thread sealant that contains PTFE (Teflon) to help seal threaded connections, reduce friction, and prevent leaks. (Section D-3.2 (#chapter-d-3-2-section-2))
- **thread compound (pipe dope):** A paste applied to threaded pipe connections to seal gaps, prevent leaks, and make assembly easier. (Section D-3.2 (#chapter-d-3-2-section-2))
- **union:** A fitting that allows pipes to be easily connected and disconnected. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))
- **wye:** A fitting that connects pipes at an angle (usually 45°) for smoother flow. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

D-3.1 Describe Fittings Used in the Pipe Trades

Fittings Terminology

The terminology used to identify fittings may include all or some of the following information:

- Fitting size
- Material the fitting is made from (e.g. cast iron, copper, ABS, etc.)
- Intended use for the fitting (pressure or drainage, etc.)
- Basic shape of the fitting (tee, elbow, wye, etc.)
- Joint type (soldered, threaded, solvent cement, etc.)

As you proceed through this section, you will learn to use all of these characteristics to identify and name fittings.

Abbreviations Used to Identify Fittings

Abbreviations are used throughout the industry to reduce the amount of writing needed to identify fittings. Pipe tradespersons use abbreviations when compiling **material takeoff lists**. Abbreviations may vary depending on the manufacturer and local practices. These differences can cause errors when interpreting a material list. If you do not know the correct abbreviation, write out the full word.

Incorrect use of an abbreviation may result in a wrong fitting being priced and shipped to the job site. Abbreviations should be clearly written, and both the writer and the reader should be able to interpret the abbreviation correctly.

Table 1 lists some common abbreviations used in the pipe trades. You must memorize these common abbreviations, and be able to interpret and write them. Be aware that the table does not show all possible abbreviations.

Table 1: Common Pipe Fitting Abbreviations

Abbreviation	Meaning
Adpt	Adapter
Blk CI	Black cast iron (threaded pipe fittings)
Blk mal	Black malleable (threaded pipe and fittings not galvanized)
C×C	Copper by copper (pipe and fittings)
C×FIPT	Copper by female iron pipe thread
c/o	Clean out
CB	Cast brass; also catch basin
CI	Cast iron (pipe and fittings)
CSA	Canadian Standards Association. Note: All fittings and pipe used in the plumbing system must be CSA approved for the application for which they are used.
Dbl	Double (e.g. double wye)
90 degree ell	90 degree elbow
DWV	Drainage waste and vent fittings and pipe
Fit.C×FIPT	Fitting copper by female iron pipe thread
Galv	Galvanized (pipe and fittings with a zinc coating for corrosion resistance)
IPS	Iron pipe size
IPT	Internal pipe thread, or iron pipe thread
F or M	Female or male
FPT	Female pipe thread
FIPT	Female iron pipe thread
JIC	Joint Industry Conference
Mal	Malleable (pipe and fittings)
MJ	Mechanical joint clamp (pipe and fittings)
MIP, MPT, or MIPT	Male iron pipe, male pipe thread or male iron pipe thread

OPT	Outside pipe thread
RH or LH	RH = right hand; LH = left hand (used when identifying the location of the side outlet on a DWV fitting)
S	Solvent cement ABS and PVC socket fitting joint
SAE	Society of Automotive Engineers
San	Sanitary (drainage fittings)
Sch	Schedule (used to describe a steel pipe wall thickness)
SO	Side outlet (used to describe a tee with a side outlet connection)
SP	Spigot end
Tapt	tapped (refers to fitting openings that are threaded to accept MIP threads)
w/o	without (e.g. an ABS P trap w/o cleanout)
WB	Wingback
WC	Water closet
WOG	Water, oil, gas
SWOG	Steam, water, oil, gas
Wrot	Wrought
Wye	Y fitting

Abbreviations Exercise

Complete Table 2 from memory if possible. Then refer to Table 1 and other sources to check your answers and find any missing abbreviations.

Table 2: Abbreviations Exercise

Abbreviation	Meaning
ell	
	Adapter
	Black cast iron (threaded pipe fittings)
	Black malleable (threaded pipe and fittings, not galvanized)
C×C	
C×FIPT	
c/o	
	Cast iron (pipe and fittings)
CSA	
Dbl	Double (e.g. double wye)
DWV	
FIPT	
Galv	
IPS	
IPT	
FPT or FIPT	
	Malleable (pipe and fittings)
	Mechanical joint clamp (pipe and fittings)
OPT and MPT	

RH or LH	
MIPT	
SAE	
	Sanitary (drainage fittings)
	Schedule (used to describe a steel pipe wall thickness)
	Side outlet (used to describe a tee with a side outlet connection)
	Spigot end
Tap	
	without (e.g. an ABS P-trap w/o cleanout)
WC	
WB	
WOG	
	Wrought
	Y fitting

Types of Fitting Applications

Fittings are commonly separated into two basic application types:

- **Pressure fittings** (used to carry fluids under pressure)
- **DWV fittings** (used to carry fluids by gravity; drainage, waste, and venting)

Differences Between DWV and Pressure Fittings

Plumbing fittings are often identified by application and shape. There are four main differences between **DWV fittings** and **pressure fittings**. You should be able to note these differences and identify, from a selection of fittings, which fittings are for pressure applications and which fittings are for DWV applications.

The four main differences between pressure and DWV fittings are:

1. Pressure fittings have an abrupt turn **radius** at the **throat** of the fitting, while the DWV fitting has a gradual change in direction.
2. The socket end of pressure fittings are usually much deeper, providing greater joint strength than DWV fitting joints.
3. DWV fittings have a recessed interior surface. When the inside surfaces are aligned, flow is smoother and blockages are reduced. All DWV fittings have this recess.
4. Copper pressure fittings may have thicker walls than DWV fittings.

Test Yourself

You must be able to identify fittings correctly when making a *material takeoff list*. As you go through this module, cover the fitting descriptions and write out the correct identification of each fitting. Remember, one of your objectives is to be able to visually name and identify pipe fittings.

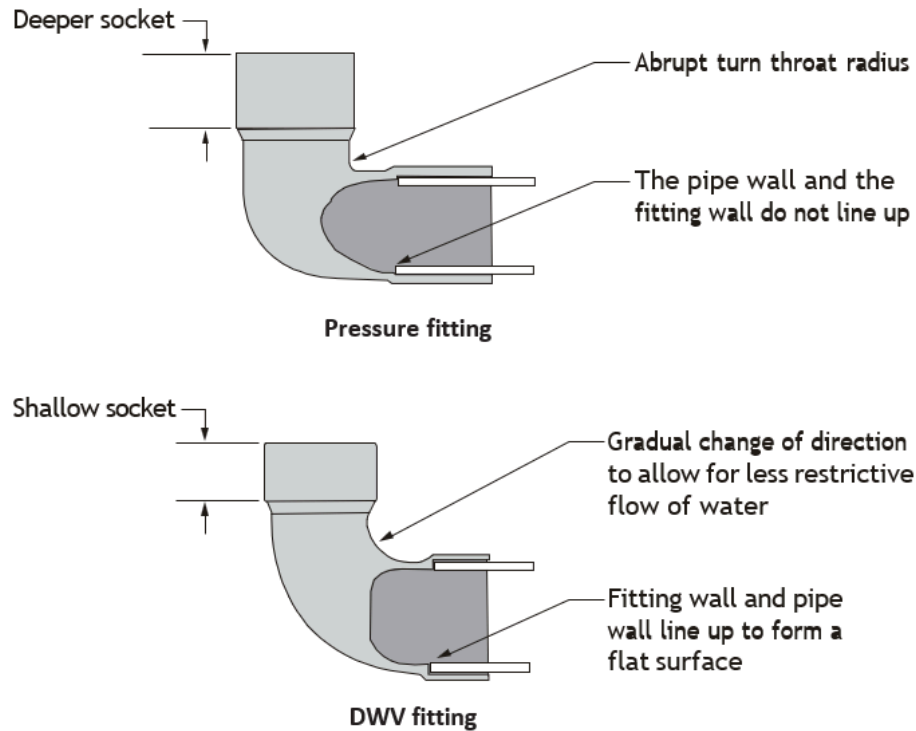


Figure 1 Differences between pressure fittings and DWV fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Fittings used for pressure applications should not be interchanged with those for drainage, waste, and vent purposes (DWV systems). Although the basic shapes and sizes may be the same, the specific design of each is different. An important feature to remember when you are trying to identify fittings is that DWV fittings have more gradual bends to direct the flow (Figure 2).

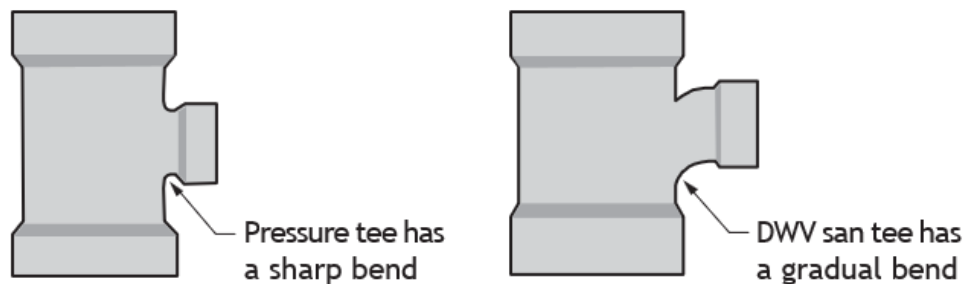


Figure 2 Pressure and DWV tees (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Basic Parts of Fittings

Pipe tradespersons must be able to identify the basic parts of fittings to measure and install them correctly. For example,

plumbing codes require that 4" diameter (10 cm) or less than 90 degree elbows have a **centreline** radius of not less than their diameter. To interpret the code, the pipe tradesperson must be able to identify where the radius and the centreline are located. Similarly, when installing pipe, tube, and fittings, a tradesperson must be able to identify the parts of fittings in order to accurately measure them.

The basic parts of a fitting include:

- Throat
- Radius
- **Hub end** (also referred to as the *socket* or *bell end*)
- **Spigot end** (the end of a fitting or pipe that has no hub: fits into the hub end of another fitting or pipe)
- Centreline (an imaginary line along the centre of pipes and fittings)
- **Face** (also referred to as front; generally used to refer to a flange face)
- Back (the back of the fitting)

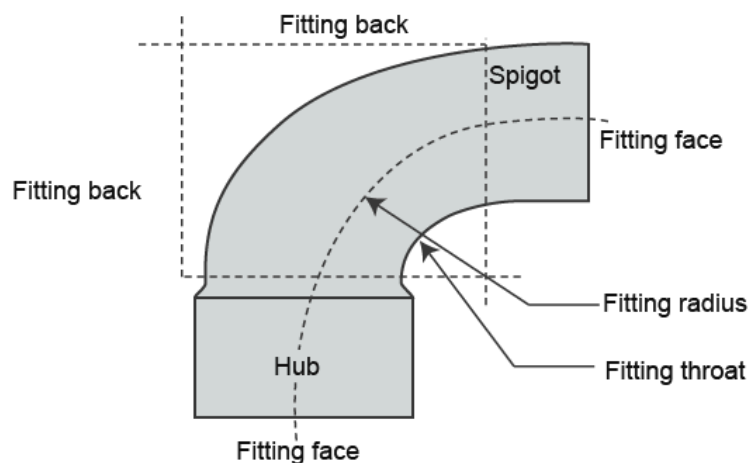


Figure 3 Parts of a 1 1/2" ABS hub x spigot 90 deg elbow (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Considerations When Selecting Fittings

Pressure Ratings

System pressure is an important factor when selecting fittings. Piping system pressures can vary from atmospheric pressure to several thousand kilopascals (kPa), or pounds per square inch (psi). Fittings must be designed and made from materials that can withstand these pressures. You will learn later how pressure ratings are also used when describing fittings.

Wrought (Wrot) Copper Compared to Cast Brass

Fittings for copper piping can be made of **wrought copper** or **cast brass**. Wrought copper fittings, sometimes referred to as *streamline fittings*, have the same colour, smooth texture and **malleability** as copper pipe. Cast brass fittings have a rougher texture and a brass-coloured appearance, and are not as malleable as copper. These differences may be a concern when selecting a fitting: cast brass fittings manufactured for use in DWV and potable water systems may not be suitable for high temperature **brazing**. Industrial-grade cast brass fittings can be used for high-temperature brazing.

Figure 4 shows wrought copper and cast brass fittings for various applications. Figure 5 show examples of copper and brass fittings.



Wrought copper DWV sanitary reducing tee
(Courtesy of NIBCO INC)



Cast brass DWV tapt sanitary reducing tee
(Courtesy of NIBCO INC)



**Copper pressure fitting has a deeper socket
for greater strength of the joint**
(Courtesy of NIBCO INC)



DWV fitting has a shallow socket
(Courtesy of NIBCO INC)

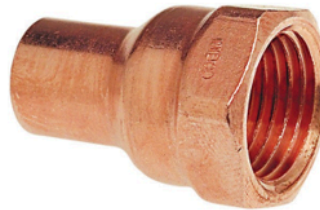


Cast brass DWV double tee C x C x C x C (Courtesy of NIBCO INC)

Figure 4 Various wrought copper and cast brass fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Flush brass bushing FIP, 3/4" up to 1 1/2" (Courtesy of NIBCO INC)



Wrought copper fitting adapter Ftg x FIP Wrot (Courtesy of NIBCO INC)



Copper 180 deg return bend (Courtesy of NIBCO INC)



Cast 90° Elbow Close Rough C x C (Courtesy of NIBCO INC)

Figure 5 Various copper and brass fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A **wrought copper solder pressure female adapter** is used in residential and commercial systems such as potable water, air conditioning and refrigeration. Options also include cleaned and bagged for medical gas applications.

Malleable Iron vs Cast Iron Threaded Fittings

Table 3: Malleable Iron Compared to Cast Iron Threaded Fittings

Cast Iron	Malleable Iron
Cast iron fittings have a larger bead than <i>malleable iron fittings</i> . Recall that the term bead is used to describe thickening on a threaded fitting, to provide strength at the point of the thread connection. The thick bead is required for strength.	Malleable fittings resist cracking due to their malleability.
Cast iron fittings will crack if subjected to excessive stress, such as over-tightening.	Malleable iron fittings are stronger and will stretch rather than crack under normal installation. The size of the bead is therefore smaller than a cast iron fitting bead.
Cast iron fittings have a greater chance of containing sand holes produced at the time of manufacture.	Malleable iron fittings are typically used in gas piping systems.
Cast iron fittings can crack and are unsuitable for gas piping.	
Cast iron pattern threaded fittings may be used in hot water (hydronic) space heating systems.	



Mal iron 90 deg elbow



Cast iron 90 deg elbow

Figure 6 Malleable iron to cast iron bead comparison (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Both types of fittings are used in piping systems. Always check the job specifications and local codes to determine the correct application.

Threaded fittings are also available in brass for use in potable water systems, and forged steel for use in high-pressure fluid systems such as steam and hydraulic systems.

Types of Fittings

Figures 7 show examples of fittings in the three basic categories: elbows, tees, and specialty fittings. Notice that the size designations have not been included. Sizing identification will be included later in this section.

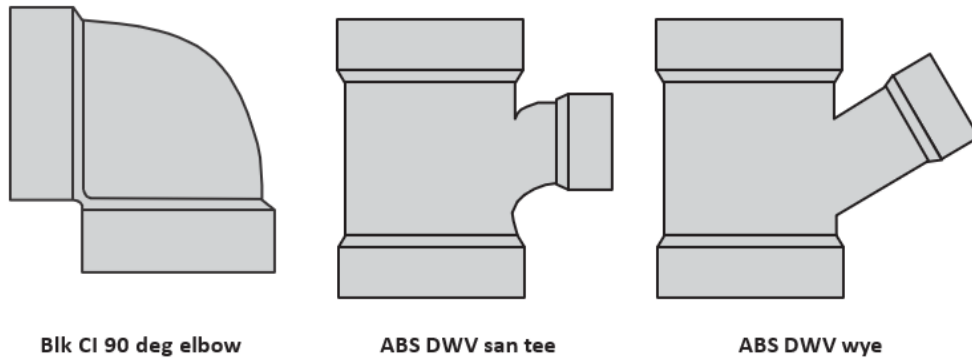


Figure 7 Three common fitting configurations (elbow, tee and wye) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

- Elbows (bends)
- Tees, double tees (crosses), wyes, double wyes
- Specialty fittings (fittings that do not fit into the first two groups), including:
 - ▶ Couplings and unions
 - ▶ Adapters
 - ▶ Bushings and reducers
 - ▶ Caps, plugs and cleanouts
 - ▶ Traps and continuous waste fittings



Cast iron fittings



Malleable iron fittings

Figure 8 Various threaded fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Elbows

Pipe tradespersons use the term **elbow** to describe fittings that change the direction of a pipeline.

Common angles include:

- $22\frac{1}{2}^\circ$
- 45°
- 60°
- 90°

Other angles can be obtained from the manufacturer, or in some cases the elbow may be fabricated on the job site. Fabrication of fittings is more closely related to the job of a steamfitter. Plumbers would normally purchase elbows with the standard changes of direction. Experienced pipe tradespersons can correctly identify the angle of a fitting just by looking at it.

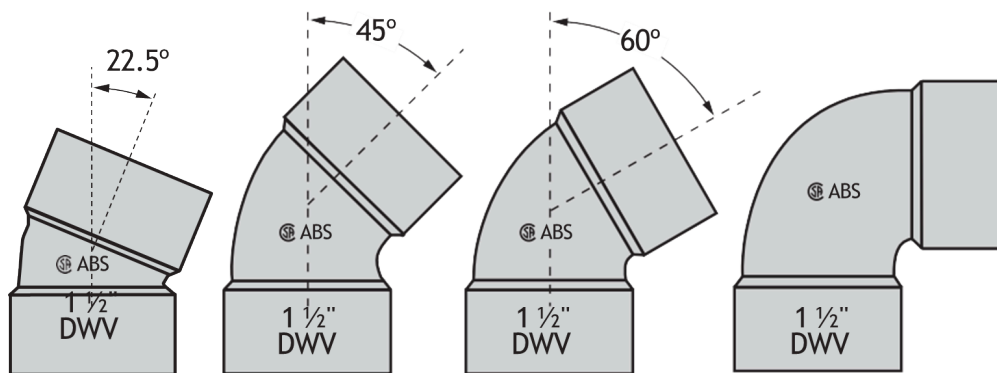


Figure 9 Elbows (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Standard radius elbows and long radius elbows are also manufactured. **Long radius** can also be referred to as *long sweep*.

Manufacturers sometimes use the terms **short radius**, **long radius** and **standard turn** to describe the different radii of their elbows. Some elbows are available with a 180 degrees change of direction. These are called **return bends**.

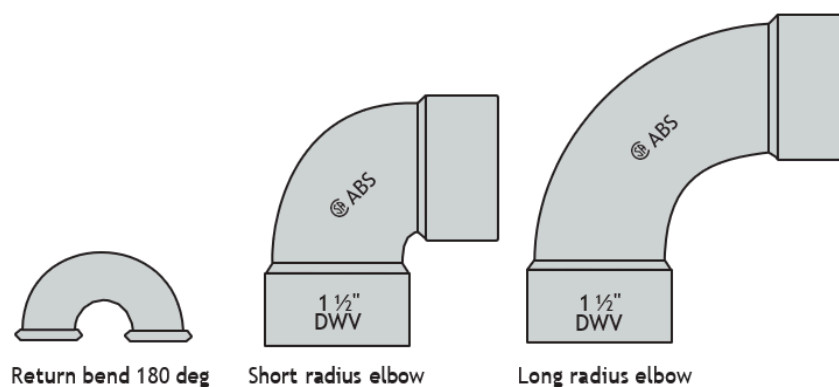


Figure 10 Bend and elbows (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Fittings often include printing that indicates the size, use, and type of material from which the fittings are made. Also notice the Canadian Standards Association (CSA) stamp of approval.

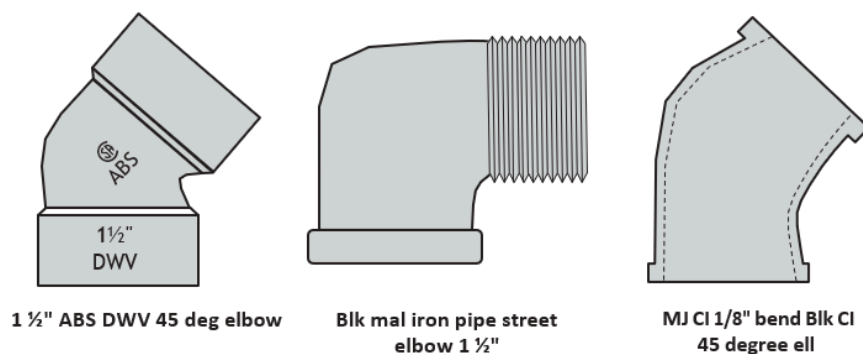


Figure 11 Various fittings for identification (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Street Elbows

A **street elbow** is an elbow with outside threads on one end (**MIP**) and inside threads on the other (**FIP**). The name *street elbow* derives from its use on water mains and services located on the street.

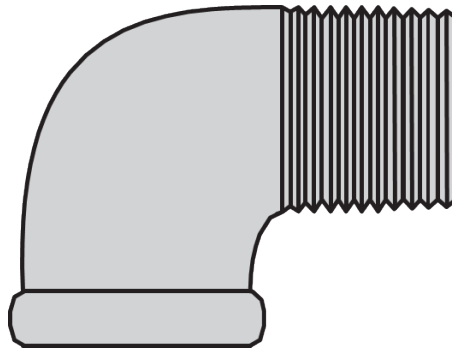


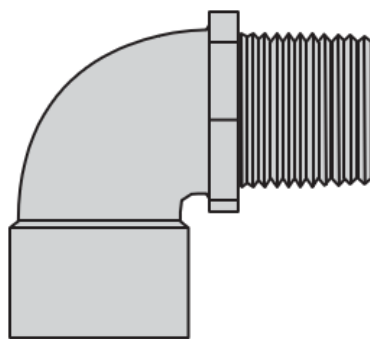
Figure 12 Blk mal IP street elbow (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Exercise

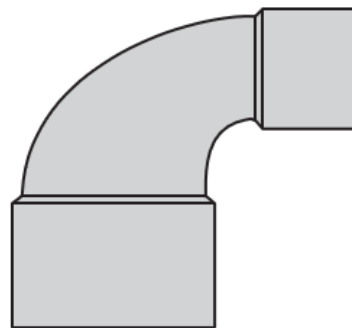
Recall the use of abbreviations while reading the descriptions of fittings shown in these illustrations.

Reducing Elbow

Elbows can be used to reduce the size of piping and at the same time change direction. These elbows are called **reducing elbows**. An elbow can also be used as an adapter, as shown here:



C x MIP adapter 90 deg elbow



C x C reducing elbow

Figure 13 Reducing elbows (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Bends

The term **bend** may also be used to describe an elbow. For example, cast iron DWV fittings are traditionally referred to as *bends* instead of elbows. A plumber would therefore refer to a 90 degree cast iron DWV elbow as a 1/4 bend. The 1/4 refers to 1/4 of a 360-degree circle. Cast iron DWV elbows are available in 1/4, 1/6, 1/8 and 1/16 bends.

Following are the equivalent degrees of cast iron DWV bends:

- A 1/16 bend is equal to a $22\frac{1}{2}$ degree elbow.
- A 1/8 bend is equal to a 45 degree elbow.
- A 1/6 bend is equal to a 60 degree elbow.
- A 1/4 bend is equal to a 90 degree elbow.

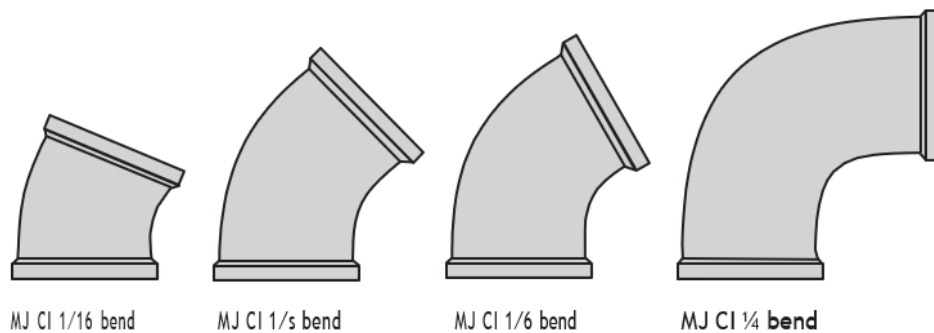


Figure 14 Bends (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 15 MJ cast iron 3" 1/4 bend (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Specialty Elbows

Some elbows are manufactured to serve a specific purpose in addition to allowing a change of direction. One such elbow is called a **wingback elbow**. A wingback elbow may be used to provide support for the piping in the wall behind showerheads and fixture water supply piping. The wingback elbow has two lugs that allow it to be fastened to backing. The wingback elbow is known by several other names, including:

- Lug ear elbow
- Drop-ear elbow
- Drop elbow



Figure 16 Specialty support elbows (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A variation of the copper by copper wingback 90 degrees is the copper by female iron pipe wingback 90 deg, which is often used to secure the stub-out for a showerhead.

Tees, Wyes, and Double Sanitary Tees (Crosses)

Pipe tradespersons refer to fittings that allow three pipes to be joined together as tees and wyes. Tees are shaped similar to the letter “T,” and wyes are shaped similar to the letter “Y.”

Straight Tees, Sanitary (San) Tees and Wyes

Straight tees and **san tees** are used to connect two pipes together at an angle of 90 degrees.

A standard wye designed for DWV use connects one pipe to another at a standard angle of 45 degrees.

Plumbers will purchase DWV wyes with the standard 45-degree angle. A steamfitter, however, may be required to fabricate a wye at a different angle.

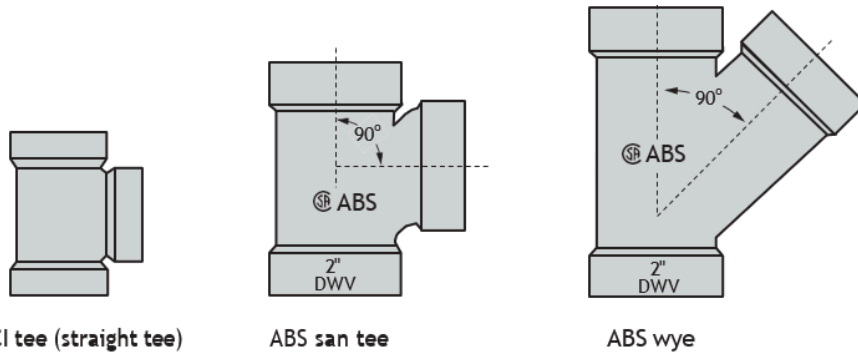


Figure 17 Tee and wye bend angles (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Double Sanitary Tee and Double Wyes

Sanitary cross (double sanitary tee) and **double wye** are the names given to fittings that allow four pipes to be joined together. The name cross comes from its shape. Plumbers use the terms *san cross* and *double san tee* interchangeably.



Figure 18 Double sanitary fittings (Courtesy of NIBCO INC) Used with permission.

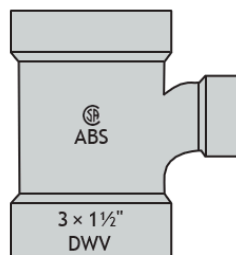
A **tee wye** is a sanitary tee with a longer radius throat. On the job today the sanitary tee has become the fitting of common use and the true tee wye is used less and less.



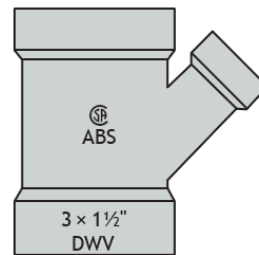
Figure 19 ABS tee wye combination, long radius (Courtesy of NIBCO INC) Used with permission.

Reducing Tees and Wyes

Tees, wyes and crosses can also be used to connect pipelines of different sizes. These fittings are called **reducing fittings** (Figure 20).



ABS DWV reducing san tee



ABS DWV reducing wye

Figure 20 ABS reducing fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Note: When naming a fitting such as these reducing fittings, the term *reducing* might not be used in the description. The fitting would instead be called a $2'' \times 1 \frac{1}{2}''$ ABS DWV san tee. Stating the fitting opening sizes with the largest opening first indicates that the tee is a reducing tee.

Specialty Tees and Wyes

Manufacturers have produced variations of tees, crosses, and wyes for use in specific plumbing installations.

Side Inlet and Tapped Fittings

A **side inlet tee** is a standard sanitary tee with an additional opening located on the right-hand or left-hand side. Side inlet fittings can have more than one opening on the side. The side inlet is usually located at 90 degrees to the branch opening but may also be 45 degrees to the branch opening.



Sanitary tee with 90 deg left inlet hub, ABS
DWV (Courtesy of NIBCO INC)



Sanitary tee with 90 deg right inlet hub, ABS
DWV (Courtesy of NIBCO INC)

Figure 21 ABS DWV left and right side inlet hubs (Courtesy of NIBCO INC) Used with permission.

Tapped (Tapt) Internal Pipe Thread Fitting Openings

Cast iron DWV fittings are often tapped to allow for adaptation to other pipe materials such as copper or ABS. The opening is referred to as a **tapt opening**, and so the fitting is described as a **tapt side outlet**.

Note: Fitting side outlets are not always tapped.

Other types of specialized wyes and tees include **Boston** (a wye and 1/8 bend combination in one fitting), **upright wye**, and **apartment tees**.



Figure 22 3 × 2" MJ tapped tee (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 23 3" MJ cast double Boston (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Specialty Fittings

Couplings

Couplings are loosely defined as short fittings that are used to join piping in a straight line without changing its direction. Couplings generally have socket-type ends and may be screwed, soldered or solvent-cemented onto piping. Malleable iron or steel couplings are usually available with internal iron pipe threads; plastic couplings may have slip-type or FIPT ends.

Standard and Reducing Threaded Couplings

Standard couplings are used to join pipes that are the same size. Reducing couplings can be used to connect different sizes of piping. Figures 24 and 25 show couplings used to connect threaded pipes. Couplings are also available to connect other piping, including ABS and PVC.

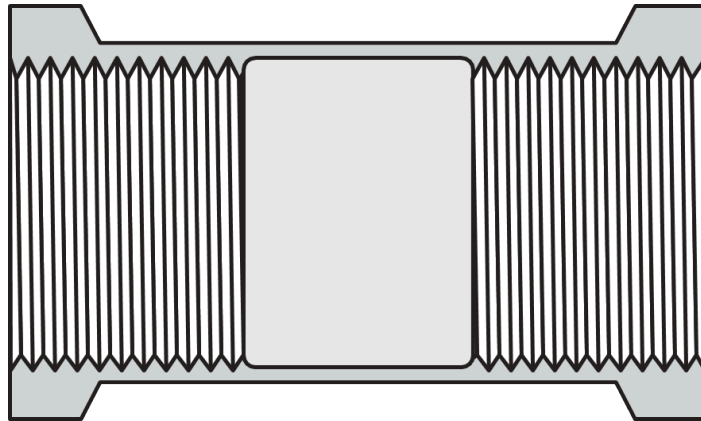
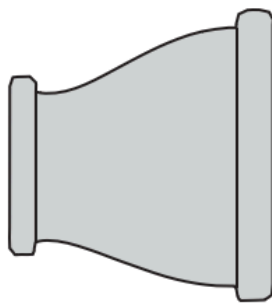
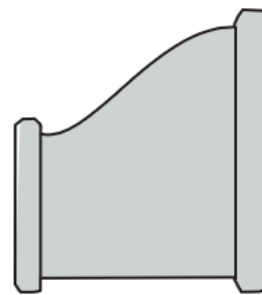


Figure 24 Black malleable coupling, cross section (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Blk mal concentric reducing coupling



Blk mal eccentric reducing coupling

Figure 25 Threaded reducing couplings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Merchant Couplings

Merchant couplings are often used to protect pipe threads during transportation. They are not generally used for pressure piping. Couplings $\frac{1}{8}$ to 2 in. are straight threads, and 2 $\frac{1}{2}$ in. and larger diameter are NPT (tapered).



Figure 26 Merchant steel coupling (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Couplings for Copper Tube

Copper tube couplings are available with or without internal stops. The internal stops are located at the centre of the fitting. The stop prevents the tubing from being pushed into the coupling past the centrepoint of the coupling. This ensures that each pipe is soldered at the correct depth in the socket.

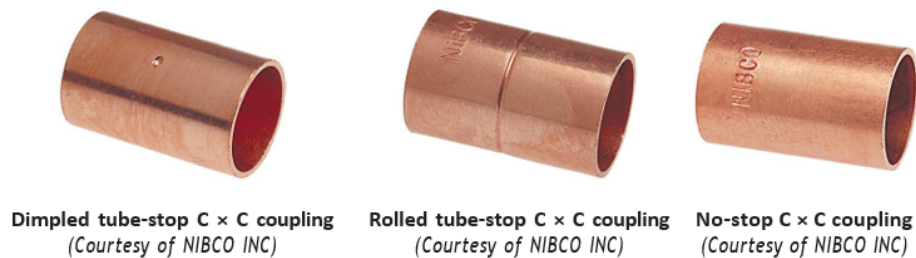


Figure 27 Copper tube couplings (Courtesy of NIBCO INC) Used with permission.



A coupling with no stop will allow the pipe to slide right through the coupling. Be cautious when using this type of coupling. Each pipe must be pushed into the coupling to an equal depth, with the ends of each pipe positioned at the centrepoint of the coupling. Failure to centre the coupling will result in a weak joint

Practical Use for No-Stop Coupling

Perhaps a less familiar fitting, let's take a look at its installation.

A **no-stop coupling** can be used to advantage when repairing or altering a pipeline. As described in the steps below, pipe ends that cannot be pulled apart far enough to allow a fitting to be installed, could be spread sideways and a no-stop coupling slid all the way over the end of one pipe.

The pipe can then be realigned and the coupling slid back from one pipe over the other until the coupling is centred on both pipes. Mark the pipe with a line to help determine where to position the coupling.

Note: Proper cleaning and **fluxing** of the joint surfaces before assembly and soldering is required.

Step 1. Pull one pipe end to one side.



Figure 28 Pull one pipe end to one side (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Step 2. Slide the no-stop coupling over one end of the pipe.



Figure 29 Slide the no-stop coupling over one end of the pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Step 3. Mark the pipe.



Figure 30 Mark the pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Step 4. Realign the two pipes.



Figure 31 Realign the two pipes (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Step 5. Slide the no-stop coupling back to the mark on the pipe.



Figure 32 Slide the no-stop coupling back to the mark on the pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Unions

Unions allow piping to be assembled and equipment to be installed so the piping or equipment can be easily removed and reconnected if necessary.

Standard pipe threads are normally right-hand thread; therefore, connections must be turned in a clockwise direction to tighten. A union allows piping to be tightened into a stationary fixture such as a boiler.



Wrought copper union, soldered connections (Courtesy of NIBCO INC)



Malleable iron threaded union

Figure 33 Various types of unions (Courtesy of NIBCO INC) Used with permission.

A union has three parts, two of which are screwed or solvent-welded to a pipe. The third piece is a threaded hexagonal nut, collar, or ring to hold the union together.

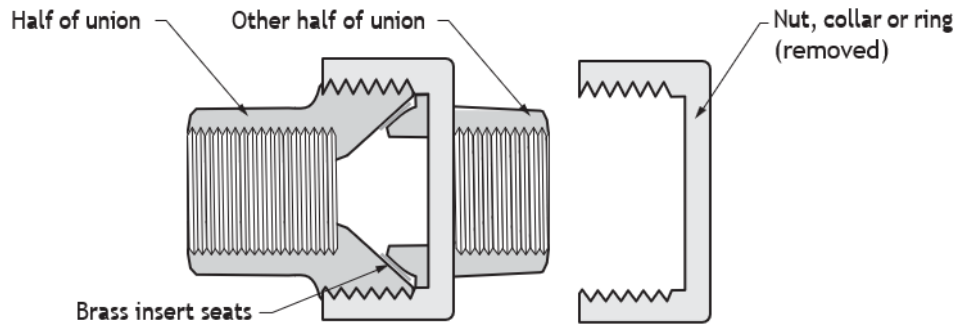


Figure 34 Parts of a union (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

There are two types of threaded unions:

Ground unions may have iron-to-iron or brass insert seats with a tapered design. The tapered seat union forms a watertight seal without a gasket.

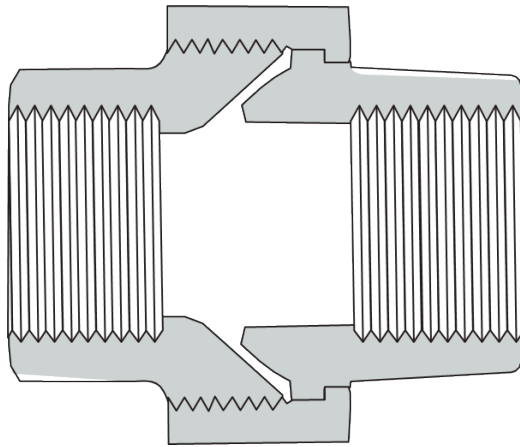


Figure 35 Ground joint union (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Gasket unions require a washer between the two fitting pieces to seal the joint. The two fitting pieces have flat seats that provide a watertight seal when used with the washer.

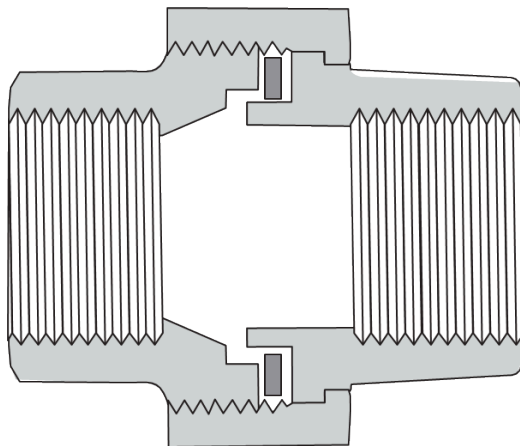


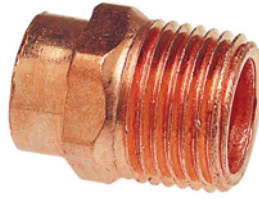
Figure 36 Gasket union (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Adapter Fittings

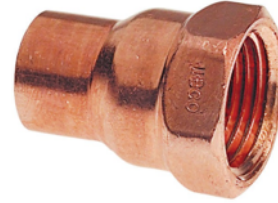
Adapters are fittings used to connect sections of piping that have different jointing designs. Adapters may be used to connect copper pipe to iron pipe threads. Adapters are sometimes called *transition fittings*. Some manufacturers identify any fitting that joins threaded pipe to soldered or welded pipe as an adapter.



C x MIP cast brass adapter
(Courtesy of NIBCO INC)



C x MIP wrought copper
(Courtesy of NIBCO INC)



C x FIP wrought copper
(Courtesy of NIBCO INC)

Figure 37 Adapter fittings (Courtesy of NIBCO INC) Used with permission.

Bushings and Reducers

Bushings and **reducers** are used to connect different sizes of piping or fittings in a straight line. Bushings generally have inside- and outside-threaded ends and are used to connect smaller piping to larger fittings or fixtures. An MJ cast iron fitting that changes a pipe size is called a **reducer or increaser**.

Figures 38 show examples of bushings and reducers.



Blk mal iron outside hex bushing



Blk mal iron inside hex bushing



Face bushing



Blk mal reducing coupling



Concentric reducer



Eccentric reducer



Flush socket reducer bushing, Spg × S, PVC Schedule 80

Figure 38 Various bushings and reducers (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Caps and Plugs

Caps and plugs are used to seal the ends of pipes. **Caps** are fittings with internal threads that screw onto the end of a pipe. Caps are also available for other piping materials such as ABS and copper. A **plug** is a fitting with external threads and a square head or square socket head. Plugs can be easily installed and removed with a wrench.

Figures 39 show various types of caps and plugs.



Threaded square head plug



Blk mal threaded pipe cap



Square head plug, cored



Copper tube permanent pressure cap
(Courtesy of NIBCO INC)



DWV temporary test cap
(Courtesy of NIBCO INC)



ABS cap (Courtesy of NIBCO INC)



BlazeMaster CPVC cap (Courtesy of NIBCO INC)

Figure 39 Various types of plugs and caps (Courtesy of NIBCO INC) Used with permission.

Cleanouts

Cleanout openings are provided to allow access to DWV pipelines to clear blockages.



ABS DWV test tee H x H x cleanout with plug
(Courtesy of NIBCO INC)



Cleanout adapter (Courtesy of NIBCO INC)



MJ CI iron body c/o (or fitting c/o)



On-grade adjustable cleanout, cast iron MIP thread
(Image courtesy of Watts)

Figure 40 Various types of cleanouts (Courtesy of NIBCO INC and Watts) Used with permission.

Factors Used in Describing Fittings

Manufacturers identify fittings by some or all of the following seven factors:

1. Size
2. Material (e.g. cast iron, copper, ABS, pipe schedule, etc.)
3. Intended use (pressure, drainage, etc.)
4. Basic shape (tee, elbow, wye, etc.)
5. Type of joint (soldered, threaded, solvent cement, compression, flared, slip joint, etc.)
6. Other components/information (e.g. hub end, spigot end, drop ear, with cleanout, without cleanout)
7. **Class designation:** manufacturers often designate their fittings as classes to indicate the maximum pressure and temperature ratings the fitting can withstand; for example, cast iron threaded fittings include classes 125 and 250. This indicates a maximum of 125 psi (862 kPa) saturated steam and 250 psi (1724 kPa) saturated steam, respectively. Other rating classes include 150- and 300-pound malleable class fittings.

Identifying Run and Branch

When identifying the size of fitting openings, you must start by first determining the **run** size. You must therefore be able to identify which openings make up the run and which opening is the **branch** (also called the *lateral*). Figure 41 illustrates how to correctly identify the run and the branch.

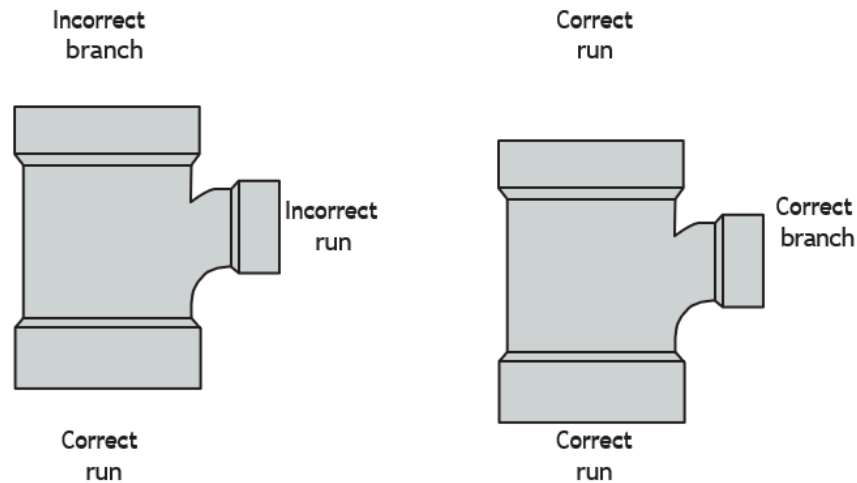


Figure 41 Run and branch identified incorrectly (left) and correctly (right) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

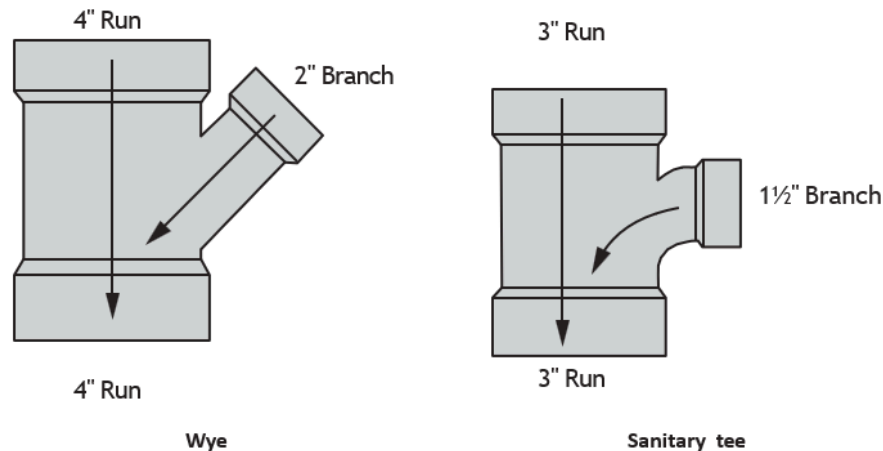


Figure 42 Branch direction of flow (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Side Inlet Connections

A tee with an additional opening on its side is identified as a **side inlet fitting**. A tee with a side inlet can be identified as

right hand or left hand by looking at the tee with the branch facing you (Figure 43), and checking which side the inlet is on. If it is on your right, it is a right-hand side inlet fitting. If the outlet is on the left, it is a left-hand side inlet fitting.

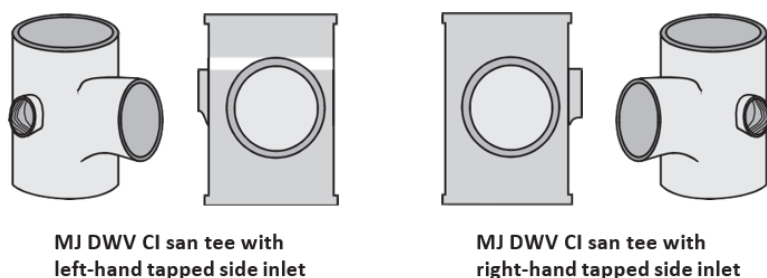


Figure 43 Side outlet connections (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Note: The side inlet is called a **tapped side inlet**. **Tapped** indicates that the side inlet is threaded internally. The tapped inlet allows the installation of an adapter to connect to another type of piping material such as copper or ABS.

Rules for Describing a Fitting

Descriptions of fittings are written in a set order and following specific rules. The order of the information is as follows (Figure 44):

1. Size
2. Material type
3. Use
4. Shape
5. Joint method
6. Additional information, if required

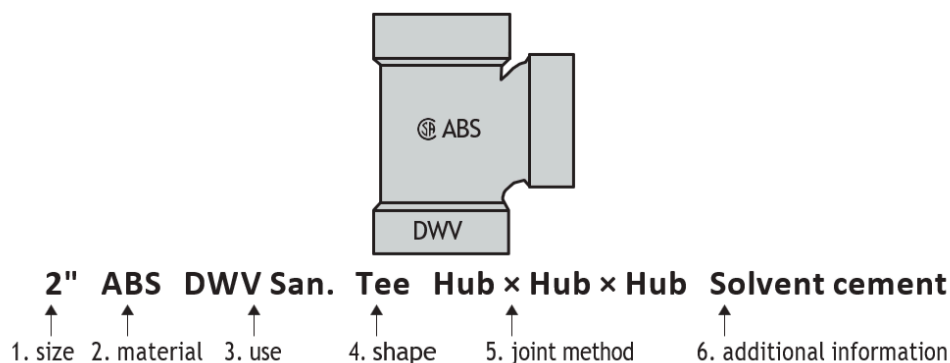


Figure 44 Order of information in a description (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In Figure 44, since all the openings are the same size, only one opening size need be stated. (Refer to the fitting description guidelines below.) Also, fitting description numbers 5 and 6 are both optional because the material

description (ABS) indicates that solvent cement and hub-type ends are typical (for ABS fittings). If the fitting was anything other than a standard ABS fitting, you may have to include the additional descriptions. Some ABS fittings, for example, may have spigot ends or threaded ends; those ends would have to be identified. You will identify these types of fittings later in this section.

Basic Rules for Fitting Descriptions

When writing a fitting description, observe the following rules:

- Start the size description with the largest size run first, then the smallest size run, followed by the branch size last.
- Only one size description is needed when all the openings of the fitting are the same size.
- The jointing method may be obvious from the material type description. Therefore the jointing method may not have to be stated. For example, the material description ABS DWV would normally indicate a solvent cement joint, so there would be no need to mention solvent cement in your fitting description.
- Start with the opening that will be the furthest downstream.
- Specialty fittings with odd connections may require a more detailed description, or you may have to change the order of your description. Remember, be accurate and concise in your description.

Describing a Reducing Fitting

Correctly describing the sizes of the openings is of prime importance when you are identifying a fitting. Figure 45 illustrates the correct way to identify the openings of a reducing wye and a reducing tee.

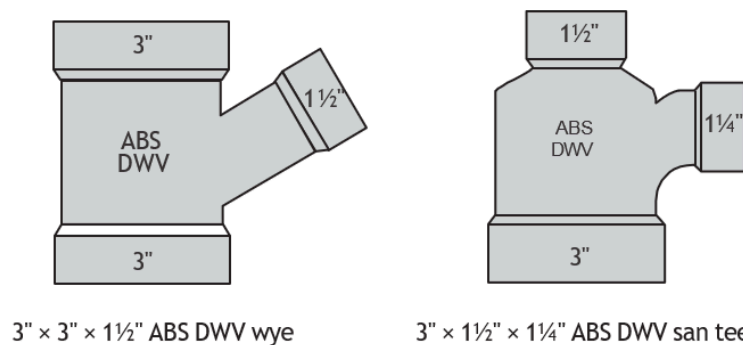


Figure 45 Correctly identifying openings in reducing tees (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Describing a Sanitary Cross or Double Sanitary Tee and Wye

Figure 46 illustrates how to describe a **DWV cross** (also called *double sanitary tee*) and an **ABS double wye**. Note that only two sizes are stated in each fitting even though there are four openings. There is no need to repeat the sizes when the

run stays the same size or the branches are the same size. Furthermore, fittings that have several openings that are all the same size can be described by one dimension.

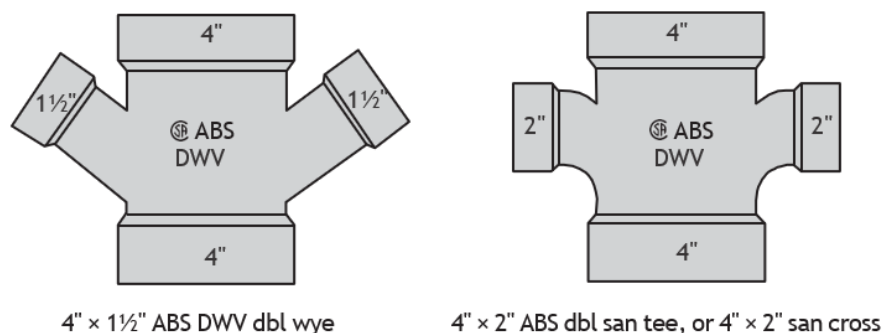


Figure 46 Describing a sanitary cross and double wye (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Describing a Bullhead Tee

Although most fitting descriptions list the largest size opening first, this is not always the case. In the case of a **bullhead tee** configuration, the openings on the run of the tee are smaller than the branch opening, so the largest opening is listed last.

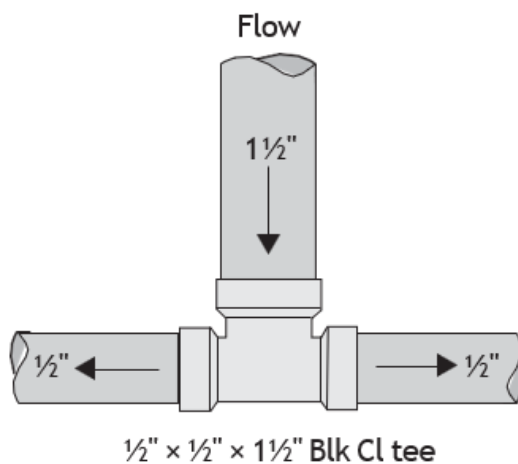


Figure 47 Describing a bullhead tee (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In Figure 47, notice that the flow is supplied through the branch. When you describe the fitting, however, you must follow the rules and start with the run first, regardless of the flow direction. **Do not start your fitting description with the largest opening when describing a bullhead tee.**



Figure 48 Malleable cast iron bullhead tee (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Describing a Plumbing Trap

A **plumbing trap** (abbreviated as P-trap) is a type of specialty fitting used to connect plumbing fixtures to the plumbing drainage system. P-traps are available in several design types and can be made from different materials. Figure 49 illustrates how to describe traps.

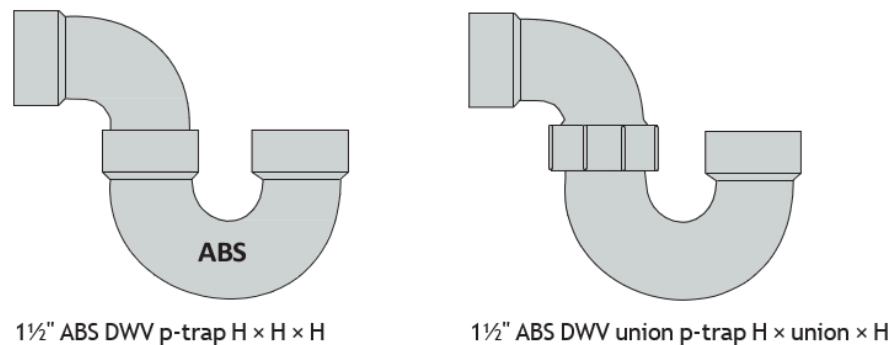


Figure 49 Describing plumbing traps (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

You can see from the plumbing trap descriptions in Figure 49 that you need to include additional information. The size, material, and use do not provide enough information to give a full description.

Examples of ABS Trap Types

Figure 50 show various types of ABS traps.



Figure 50 ABS traps (Courtesy of NIBCO INC) Used with permission.

Describing Pipe Nipples

A **pipe nipple** is a short piece of threaded piping up to 300 mm (12 in.) long. Pipe nipples are available in standard IPS diameters and may be made from any threadable piping such as black iron, galvanized steel, brass, or PVC. Nipples are used to assemble piping projects where fittings are close together or in tight spaces. Pipe tradespersons would normally purchase a variety of nipples rather than thread their own nipples on the job. In most cases, it is more economical to purchase pipe nipples. Plumbing companies with threading equipment may find it more economical to thread all their pipe nipples on the job.

Pipe tradespersons purchasing nipples commonly purchase threaded pipe nipples up to 2 in. diameter and 150 mm (6 in) long; longer pipe nipples are threaded on the job. Pipe nipples over 2" diameter are usually purchased.

There are three common types of nipples:

- Close nipple
- Shoulder nipple
- Long nipple

A **close nipple** is a short piece of pipe, threaded from each end so that it appears as though the entire outer surface is threaded.



Figure 51 1/2" Sch 40
blk IPT close nipple
(BC Industry Training
Authority, 2019). CC
BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A **shoulder (short) nipple** has a short space between the threads at either end.



Figure 52 1/2" Sch 40 blk IPT short nipple (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A **long nipple** has the same number of threads as a shoulder nipple, but is available in a range of lengths from 5–60 cm (2–12 in).



Figure 53 1/2" × 6" Sch 40 galv IPT nipple (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 54 3/4" × 3" brass IPT nipple (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Methods of Joining Pipe and Fittings

There are several methods of joining piping and fittings, and new methods are continually being developed. Pipe tradespersons must be familiar with many methods of joining pipe and fittings.

When describing a fitting, you must indicate what joint method is to be used. A $\frac{1}{2}$ inch elbow, for example, could be soldered, threaded, flared, or crimped, so you would need to include the joint type in the fitting description.

Some of the common joining methods are as follows:

- Soldered fittings (also referred to as *sweat fittings*), used for joining copper tube

- Threaded fittings, used for joining steel pipe, including stainless steels and brass pipe
- Flanged fittings, used for joining steel pipe and many other pipe material types
- Welded fittings, used for joining steel pipe, including stainless steel
- MJ clamp fittings, used for joining cast iron DWV pipe and several other pipe materials
- Flared fittings, used for joining copper tube and other pipe materials
- Compression fittings, used for joining copper tube and several other pipe materials
- Fusion welded fittings, used for joining plastics such as polyethylene gas pipe
- Solvent cement fittings, used for joining ABS and PVC pipe
- Crimped fittings, used for joining polyethylene and polybutylene pipe
- Grooved fittings, used to join steel pipe, copper and ductile iron
- Brazed fittings, used to join copper or brass
- Push-on fittings, used for water main piping

Note: Variations of these joining methods are used throughout the pipe trades.

Soldered Fittings (Sweat)

Soldered fittings (sweat) and **brazed fittings** are often used to install potable (safe for human consumption) water systems, drainage systems and other systems where soldered or brazed joints are acceptable. Soldered and brazed fittings are often made of wrought copper or brass, depending on their intended application.

Figure 55 show various types of soldered fittings.



Figure 55 Soldered fittings (Courtesy of NIBCO INC) Used with permission.

You may have noticed that **pressure fitting** has not been stated in the descriptions in Figure 55. This is because the smallest DWV fitting is $1 \frac{1}{4}$ inch, so the fitting could be assumed to be pressure. Of course, this must be clear to the person who is going to supply the material to you.

Threaded Fittings

Threaded fittings are used for joining steel pipe, including stainless steels and brass pipe. Typically, threaded joints are

used in gas piping, hot water and steam heating systems, for compressed air, fire protection or in any system where threaded piping is acceptable.

Figure 56 illustrates typical threaded fittings with their descriptions.



Figure 56 Threaded fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Threaded Fitting Classifications

Cast iron threaded fittings are available in classes 125 and 250. Malleable threaded fittings are available in classes 150 and 300, with black or galvanized finishes.



Figure 57 Class 150 threaded fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Cast Iron Drainage Fittings

Cast iron threaded drainage fittings (also known as *Durham fittings*) have an interior shoulder to create a smooth, continuous interior surface. Figure 58 illustrates cast iron drainage fittings. Cast iron drainage fittings are no longer used on new installations.



Figure 58 Cast iron threaded drainage fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Flanged Fittings

Flanged fittings are another pipe joint method used where ease of assembly and disassembly of piping or system components is required. Flanged joints are assembled using flange gaskets and bolts. Flanges are made from various materials, including steel, cast iron, and brass.

Flange Fitting Classifications

Flanges are designated in several classes according to the material from which they are made. It is best to consult the job specification and/or manufacturer's information to obtain the correct classification of the flange you require.

Flange Styles

Flanges are available in different styles, some of which are:

- Weld-neck flange
- Slip-on flange
- Lap joint flange
- Threaded flange
- Socket flange
- Blind flange

Figures 59 to 63 illustrate these flange styles.



Figure 59 300 psi weld-neck flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

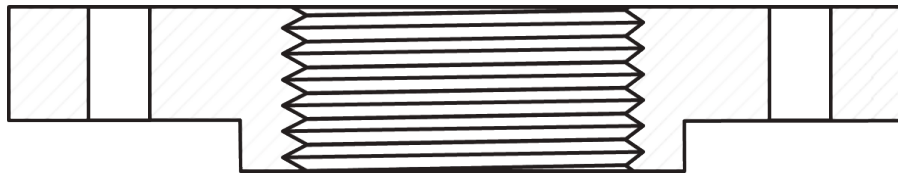


Figure 60 Threaded flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

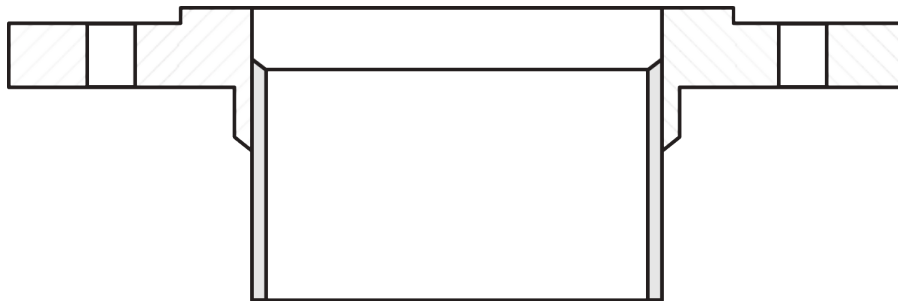


Figure 61 150 psi slip-on flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 62 300 psi lap joint flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 63 Blind flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Flange Faces

Flanges are manufactured with a variety of face types, some of which are:

- Flat face
- Raised face
- Ring joint face
- Lap joint face

Figures 64 to 67 illustrate these flange face types.

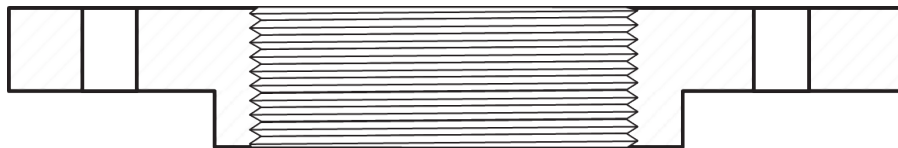


Figure 64 Flat face flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 65 Raised face flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

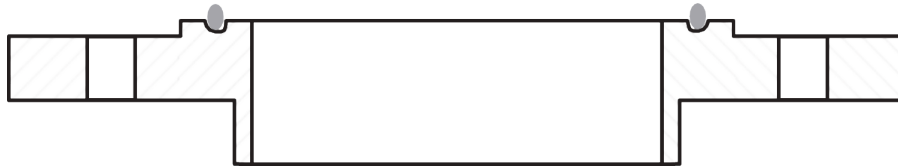


Figure 66 Ring joint face flange with O-ring (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 67 Lap joint face flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Flange faces may have smooth or serrated finishes (Figures 68 and 70).



Figure 68 150 class smooth face steel slip-on flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 69 125 class CI serrated face flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 70 Example of assembled flanges (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Identify Flange Types

A **companion flange** is a pipe flange designed to receive a pipe length, and drilled so it may be bolted to another similar flange—or any flange that fits together in companion to another flange. The term is often referred to as a flange that is not part of a valve or piece of equipment.

The following are several examples of different types of manufacturers' companion flanges.



150 class soldered/brazed companion flange
(Courtesy of NIBCO INC)



150 class threaded companion flange
(Courtesy of NIBCO INC)



125 class cast iron black threaded companion flange



**Socket flange S, PVC Schedule 80,
two-piece van stone** (Courtesy of NIBCO INC)



Assembled set of flanges

Figure 71 Flange types (Courtesy of NIBCO INC) Used with permission.

Slip-on Pipe Flanges

Slip-on pipe flanges actually slip over the pipe. These pipe flanges are typically machined with an inside diameter slightly larger than the outside diameter of the pipe. Slip-on pipe flanges are secured to the pipe with fillet welds at the top and bottom of the slip-on pipe flange.

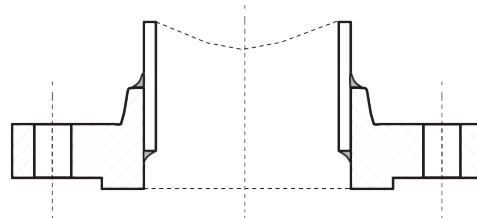


Figure 72 Slip-on pipe flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Weld-neck Pipe Flanges

Weld-neck pipe flanges attach by welding the neck of the flange to the pipe. This reduces the high concentration of stress at the base of the flange hub and transfers the stress from the flange to the pipe. This makes weld-neck pipe flanges suitable for high-pressure applications.

Weld-neck pipe flanges are machined so that their inside diameter matches the inside diameter of the pipe. Weld-neck pipe flanges have raised, flat or RTJ facing. Weld-neck pipe flanges under 400 pounds have a standard raised face height of $\frac{1}{16}$ in. For flanges of 400 pounds or more the standard is $\frac{1}{4}$ in.

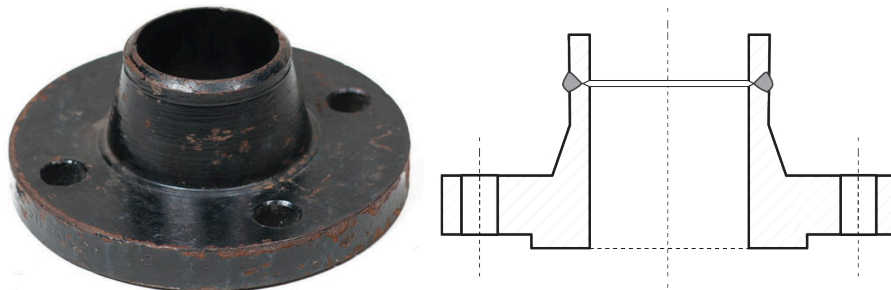


Figure 73 Weld-neck (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Blind Pipe Flanges

Blind pipe flanges are pipe flanges used to seal the end of a piping system or pressure vessel openings to prevent flow. Blind pipe flanges are commonly used for pressure testing the flow of liquid or gas through a pipe or vessel. Blind pipe flanges also allow easy access to the pipe in the event that work must be done inside the line.



Figure 74 Blind flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Lap Joint Pipe Flanges

Lap joint pipe flanges are usually used together with a matching stub end that fits inside the flange. The stub end is welded to the pipe, and the flange is left free to rotate around the stub end. The same arrangement is made on the pipe section that is to be joined together. The ability of the flanges to rotate means that the bolt holes on each flange can be easily aligned when bolting the pipe sections together. Lap joint pipe flanges are often used in systems where frequent dismantling is required.



Figure 75 Lap joint (Van Stone) flange with stub end (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Threaded Pipe Flanges

Threaded pipe flanges resemble slip-on pipe flanges except that the bore of the threaded pipe flange has tapered threads that enable the flange to be attached to a pipe that has external threads. This eliminates the need for welding. Threaded pipe flanges are generally used with small-diameter piping that operates under high pressure.



Figure 76 Threaded flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Socket Weld Flanges

Socket weld pipe flanges have a recess on their inside surface that creates a smooth bore when the correct size of piping is inserted. This enables a smooth flow of fluid through the joint. The flange is attached to the pipe by a fillet weld around the top edge of the flange. Typical applications are in high-pressure, small-diameter piping systems.

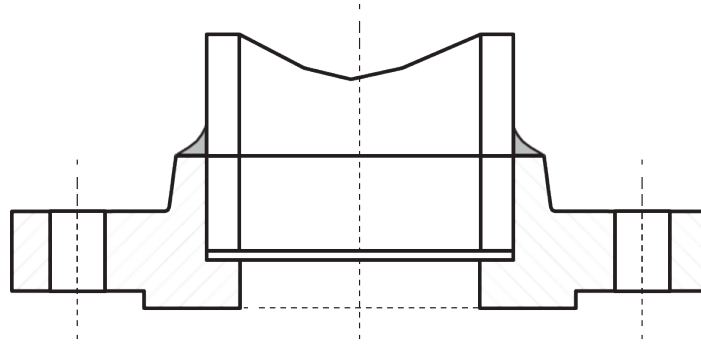


Figure 77 Socket weld flange (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Welded Fittings

Welded fittings are used for joining steel pipe, and are available in elbows, tees, flanges, increasing and reducing types.

Figure 78 show various welded fittings. Refer to Level 1 B-5 Use Soldering and Brazing and Oxy-Fuel Cutting Equipment (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/part/b-5-use-soldering-and-brazing-equipment-and-oxy-fuel-cutting-equipment/>) and D-1 Describe Piping and Tubing Materials (#chapter-d-1-1-describe-piping-and-tubing-materials) for more information on pipe welding, fitting, and fabrication.



Figure 78 Welded fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Socket Welded Fittings

Socket welded fittings are typically used to connect smaller pipe diameters such as 2 inch and under. The socket weld connection is made by slipping the pipe into the socket of the fitting, then fillet welded.



Socket Weld outlet



1 1/2" 316 stainless 150 pound cast
socket 90 deg elbow

Figure 79 Socket welded fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Compression Fittings

Compression-type fittings similar to the one shown in Figure 80 can be used to join copper tubing, steel piping, PVC, polyethylene, and polybutylene.

Compression fittings consist of the following parts:

- Compression fitting body
- Compression ferrule
- Compression nut

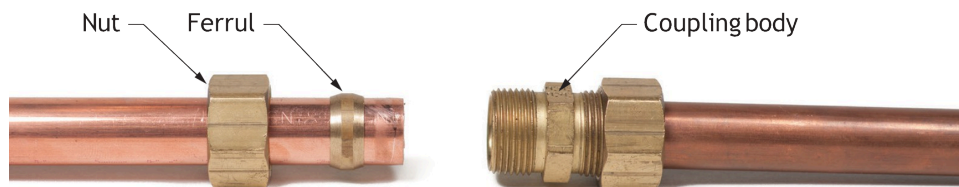


Figure 80 Parts of a compression fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The design of compression fittings can vary, but they all rely on the same principle: As a coupling nut is tightened onto the fitting, the **ferrule** is compressed against the tubing into a tapered seat.

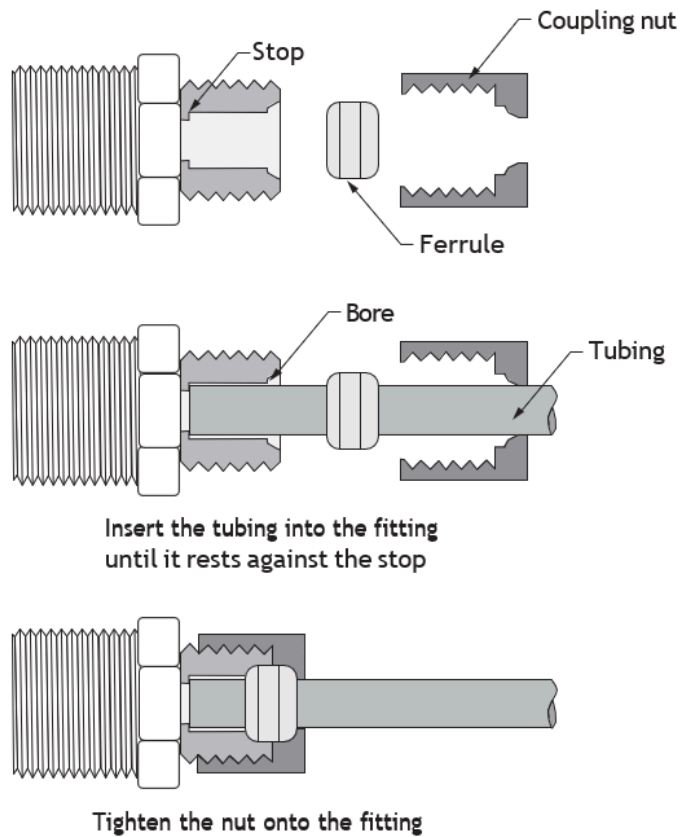


Figure 81 3/8" MIP × 1/4" OD comp adapter for copper tube (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 82 shows examples of compression fittings.

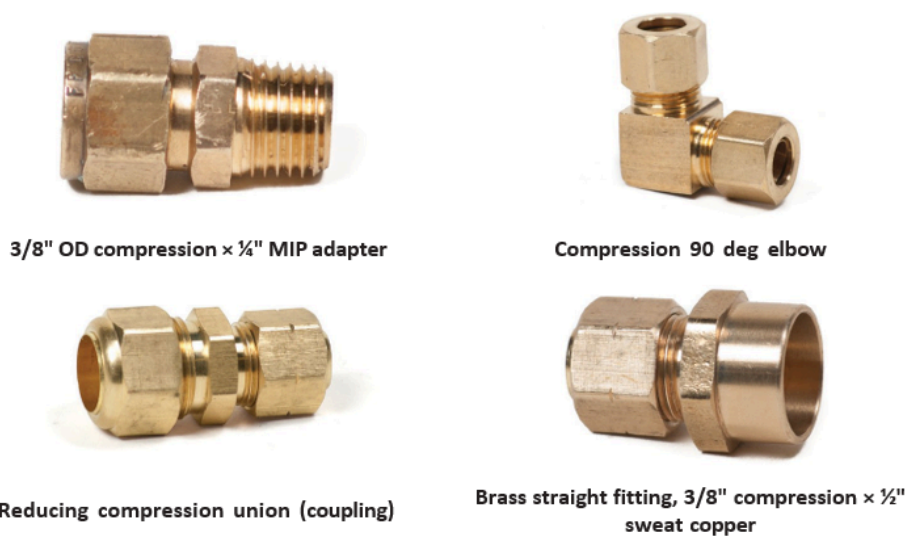


Figure 82 Compression fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Insert Sleeves

A plastic or metal insert sleeve is used with some types of plastic tubing compression fittings. The **insert sleeve** provides additional support to the walls of the tubing. Many manufacturers have designed compression fittings for use with specific types of tubing or pipe. When identifying compression fittings, it is important to include in your description the specific tubing type to which the fitting will be joined (e.g. PE, PB, PEX, etc.).



Figure 83 Insert sleeve or stiffener.

Always check the manufacturer's information for specific requirements as to where and how the fitting is to be used. You must order the correct fitting to match the tubing or pipe, otherwise the warranty will not be valid. It is not a good idea to mix and match fittings and use them for applications for which they were not specifically designed.

The fitting shown in Figure 84 is a generic example of a plastic tubing compression coupling using an insert sleeve.

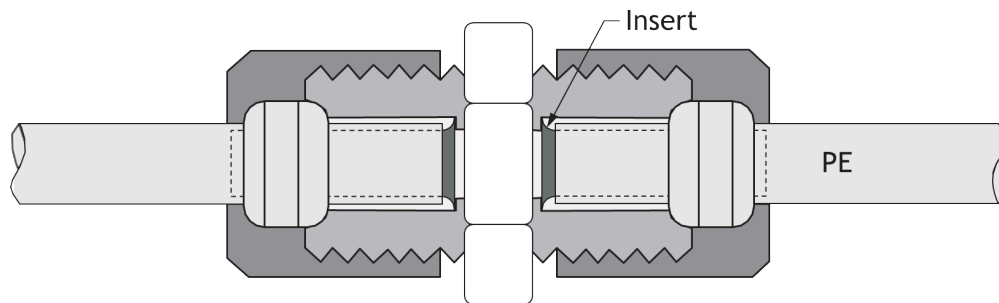


Figure 84 3/4" compression coupling for PE plastic tubing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Flare Fittings

Flare fittings are a type of compression fitting generally used to join copper tubing, although they can also be used with other types of tube and piping systems. Flare nuts can be machined from brass stock or forged (cast brass).

Three types of flare fittings are available:

- SAE flare
- Inverted flare (discussed below)
- JIC flare

The **SAE flare** is the flare that is most commonly used by the plumbing trade for gas copper tubing systems. The angle of the SAE flare is 45 degrees.



Figure 85 Flare-to-flare union without flare nuts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The **JIC flare** is suitable for hydraulic fittings and steel tubing. The angle of the JIC flare is 37 degrees.

Figures 86 and 87 show examples of SAE flare fittings.

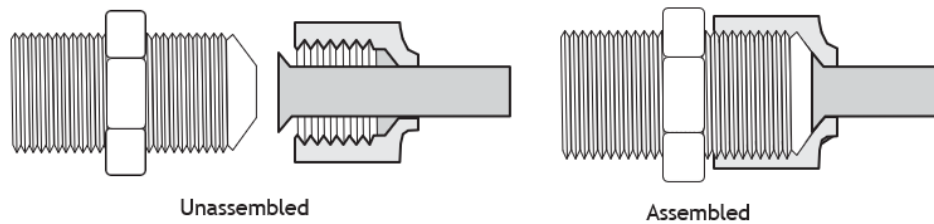


Figure 86 Saddle fusion components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

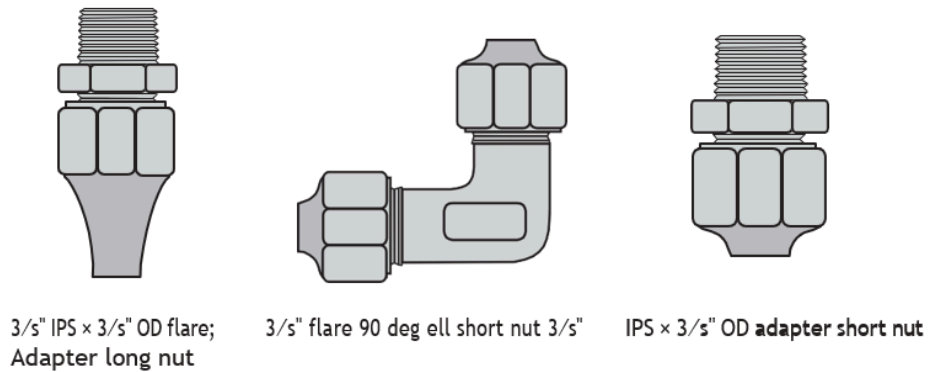


Figure 87 Flare fitting assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Flare Nuts

Machined brass long and short **flare nuts** are not to be used on gas systems, they must be forged as seen in Figure 88.

The following images show a series of flare nuts.



Figure 88 Flare nuts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Inverted Flare

A flare nut fits over the flared end of a brake or fuel pipe at a union, used to clamp the tubing flare against another fitting. The **inverted flare** is usually used in the automotive industry for fuel lines and brake lines.

Figures 89 to 91 show various inverted flare fittings.

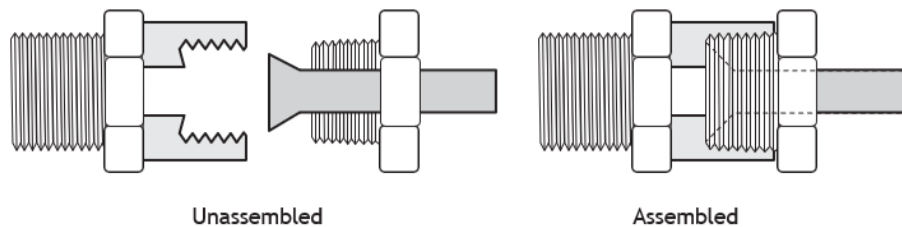


Figure 89 Inverted flare assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 90 Male inverted flare used in hydraulic systems such as automobile brake lines (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 91 Female inverted flare connection (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

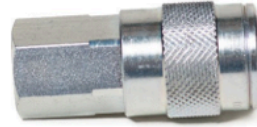
Quick-Connect Fittings

Quick-connect fittings, as the name suggests, are used to make quick connections, usually for pneumatic, hydraulic, and water hoses, and piping and equipment. They are made out of steel, stainless steel, brass, or plastic.

Figure 92 shows examples of quick connect fittings.



Steel 1/4" MIP x 1/4" coupler, straight through



Steel 1/4" FIP x 3/8" coupler, straight through



Brass 3/8" nipple x 1/4" FIP, straight through



3/8" nipple x 1/4" MIP, straight through



Brass water hose quick connect coupling x female water hose thread



Brass water hose coupling nipple x male water hose thread



CSA LPG/nat gas coupler; 1/4" coupler x 1/4" FIP

Figure 92 Various types of quick connect fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Insert Fittings for Polyethylene

Insert fittings are another type of fitting used to join polyethylene tubing. Insert fittings may be made of brass, copper, galvanized iron, or plastic. Insert fittings have barbed ends that help to hold the fitting in place and seal the joint inside the tubing. A stainless steel **gear clamp** is used to squeeze the pipe onto the fitting.

An extra gear clamp is sometimes applied on the elbow when a little more insurance against leakage or pulling apart is desired. The gear clamps are installed in alternating directions to each other for a better seal (Figure 93).



Figure 93 3/4" plastic insert, 90 deg for series 100 PE (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

There are different pressure designations of polyethylene tubing. It is important to identify exactly what type of tubing you are working with when ordering these fittings. Insert fittings used with gear clamps are designed to work with polyethylene of series 75, 100, 125, etc. They are not designed for series 160 golden-flow PE or PEX tube. **Note:** Insert fittings using gear clamps are not approved by the plumbing code for use in potable water systems.



Figure 94 Polyethylene fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

PEX Fittings

PEX fittings are available in a variety of types to suit various types of installations. They can be made from metal or poly, and can use the push connection method.

Polybutylene (PB) plastic pipe is a grey-coloured, flexible pipe that was introduced in the 1980s and was installed in many residential buildings. The pipe has since been discontinued and PEX piping has taken its place. Polybutylene pipe is included here because you may have to repair existing systems.



The BC Plumbing Code (Part 7 of the BC Building Code) (<https://nrc-publications.canada.ca/eng/view/object/?id=6e7cabf5-d83e-4efd-9a1c-6515fc7cdc71>) (Canadian Commission on Building and Fire Codes, 2022) only permits the use of series 160 PE (Polyethylene) for a water service pipe underground outside the building and underground inside the building. Series 160 PE is not to be used above ground inside the building. Series 160 PE uses compression fittings for joining.

PEX can be used for both hot- and cold-water piping. PEX can be installed outside below ground and inside the building above and below ground. However, crimp joints and expanding ring joint methods are not permitted underground. One word of caution: some manufacturers require that no PEX piping be used to connect to a hot water storage heater within 458 mm (18 in.) of storage heater piping connections.

PEX/aluminum/PEX is a composite pipe used in the hydronic heating industry. It is also approved for potable water. This pipe has been discontinued.

PEX Crimp Fittings

Crimp fittings are designed to join cross-linked polyethylene used in domestic water systems. The fittings were originally made of plastic (no longer approved), but they are now made from wrought copper or brass. Crimp fittings insert into the tubing. **Note:** Crimp fittings used for PEX are not to be used with gear clamps or polybutylene fittings. Look closely at the barbs on the insert fittings and compare them to the barbs on the crimp fittings—note the difference.

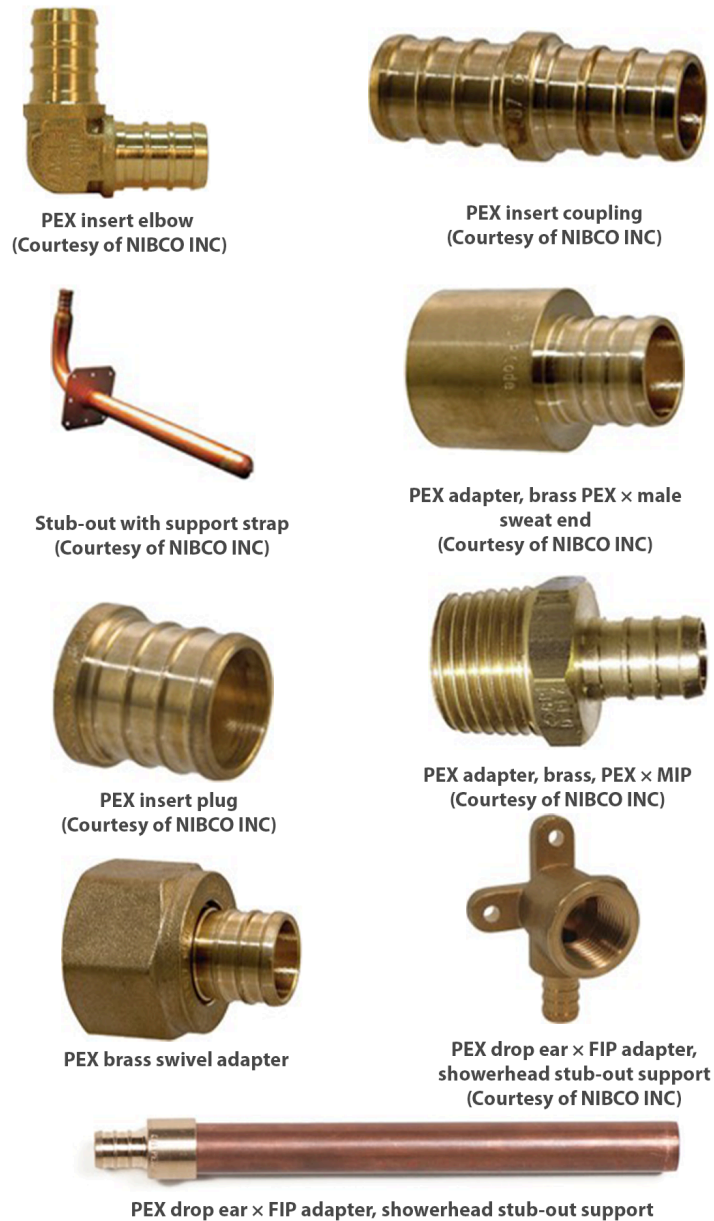


Figure 95 PEX crimp fittings (Courtesy of NIBCO INC) Used with permission.

Crimp Rings

Crimp rings (Figure 96) slide over the tubing and positioned over the fitting. A special crimping tool (Figure 97) is used to squeeze the crimp ring onto the tube and fitting, creating a leak-tight joint. Figure 98 shows the correct placement of crimp rings before crimping.



PEX crimp ring, black
(Courtesy of NIBCO INC)



Polybutylene crimp ring, copper colour
(Courtesy of NIBCO INC)

Figure 96 Crimp rings (Courtesy of NIBCO INC) Used with permission.



Figure 97 Crimping tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

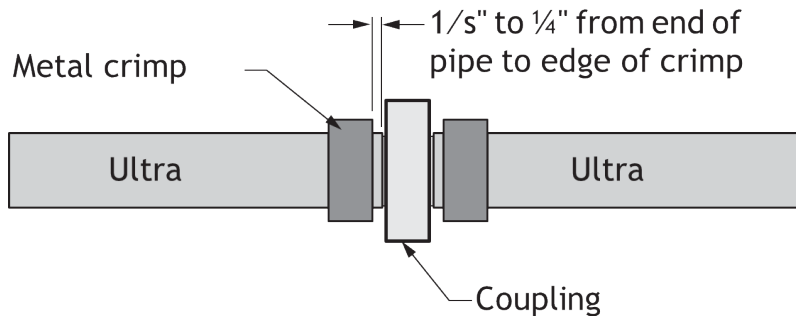


Figure 98 Placement of crimp ring before crimping (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Crimp Gauges

After installing a crimp fitting and crimp rings, use a **Go/No-go gauge** (Figure 99) to check the crimp for correct compression.

First, slide the Go side of the gauge over the crimped ring. If the crimp was made correctly, the gauge will pass over the ring with no problems.

Then turn the gauge over and try to pass the No-Go side of the gauge over the crimp ring. The crimp ring should be unable to enter the gauge at any point on the No-Go side of the gauge.

If the crimp ring fails either test, cut the PEX fitting out and replace it with a new crimp ring and fitting.



Figure 99 Go/no-go gauge (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

SDR Fittings

SDR stands for *standard dimension ratio*. It is an identification system that is used on plastic tubing. For example, you may read the number SDR 9 stamped on a PEX plastic tube. The number 9 is found by dividing the average outside diameter by the minimum wall thickness. Comparing two similar tubes from the same manufacturer, one with an SDR 11 rating and one with an SDR 9, typically the SDR 9 rating would have a higher pressure rating than the SDR 11 rating. The thicker the pipe wall, the lower the SDR number will be.

Transition from PEX to Polybutylene Piping

When transitioning from PEX tubing to polybutylene piping, you must use the correct transition coupling and crimp rings for each type of pipe.

Figure 100 shows a coupling used to connect PEX piping to PB piping. The left side is used for PB and the right side is for PEX. Notice that the PEX side has three rings and the PB side has four rings.



Figure 100 PB to PEX transition coupling (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Oxygen Barrier

An **oxygen barrier** is a plastic layer on the outside of PEX tubing in hot water heating systems. The oxygen barrier prevents oxygen from permeating through the tube into the water. Water containing oxygen can damage the heating system by corroding or oxidizing the metal components of the system.

ProPEX (Wirsbo) PEX Fittings

ProPEX (formally called *quick and easy*) rings are manufactured from **PEX-A** material, and are required to make a proper ProPEX connection.

- **Wirsbo** = brand (older name people still use) – now part of Uponor (<https://www.uponor.com/en-ca>)
- **ProPEX** = connection method (expansion system)

ProPEX rings and pipe come in red, blue and white. This colour-coding helps identify the piping system as conveying hot or cold, and reduces the chance of unintentionally cross-connecting the hot and cold water supplies.

Figure 101 shows examples of expansion ring fittings.



Figure 101 ProPEX rings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

ProPEX® fittings are made from brass or engineered plastic (EP).



Figure 102 PEX expansion fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

These rings are not crimped using a crimping tool. After the ring has been positioned on the pipe, an expanding tool (Figure 103) is used to expand the pipe end and the ring at the same time.



Figure 103 PEX expansion tool with expansion heads (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The expanded pipe and ring are then quickly slid over the fitting up to the stop lugs on the fitting (Figure 104). After a very short time the pipe and ring contract and compress onto the fitting. When the procedure is completed according to the manufacturer's directions, the joint is tight and leak- proof.

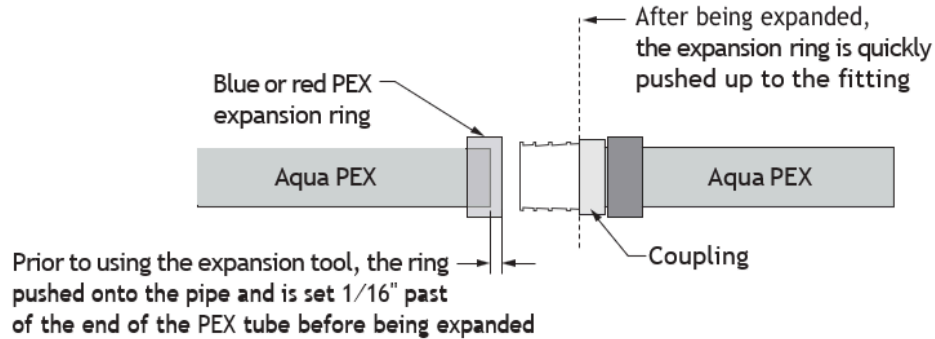


Figure 104 Applying an expansion ring (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Compression Fittings and PE or PEX Connections

A stainless steel, plastic or brass stiffener/sleeve must be used inside the end of the PE or PEX tubing to prevent the plastic pipe from collapsing inward when the compression nut is tightened. If the stiffener is not used, the connection may fail. Check the manufacturer's directions for accurate assembly of these compression fittings and tubing.



Figure 105 Stiffener slid inside PE tubing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

PEX/AL/PEX Fittings

PEX/AL/PEX [Cross-link Polyethylene (PEX)/Aluminum (AL)/Cross-link Polyethylene (PEX)] has been discontinued, but you may find this tube and fittings on the job.

Fittings used to join PEX/AL/PEX tubing are manufactured specifically for this tubing. The fittings are a type of compression fitting that has a built-in insert complete with two O-rings that slip inside the tube. A nut is first slipped onto the tubing and a split brass ferrule is then slipped over the end of the tube. The fitting and tube are then pushed together until the tube bottoms out in the socket of the fitting. When the nut is tightened with a wrench, the ferrule is compressed against the tube, completing a tight joint.

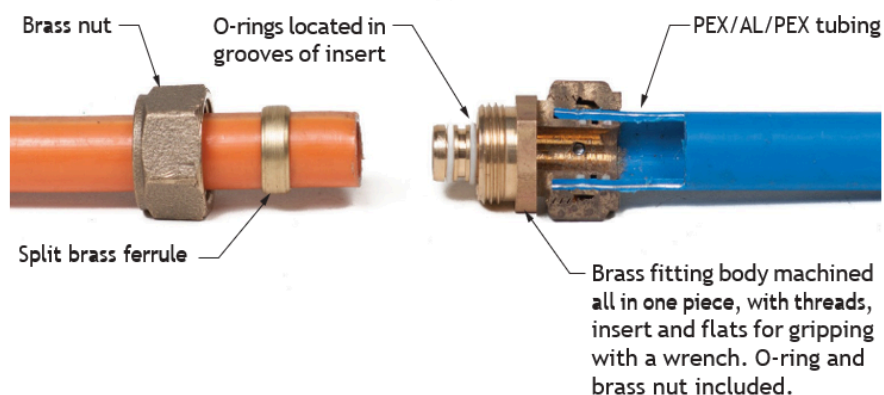


Figure 106 Parts of a fitting for PEX/AL/PEX tubing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 107 PEX compression coupling, nuts and brass ferrule (Courtesy of NIBCO INC). Used with permission.

Push Fittings

The **push-fitting system** is completed without any soldering, crimping or joining materials. These fittings can be used to join PEX, copper, CPVC, or CTS pipe. Refer to the manufacturer's instructions.

Push fittings are available in a variety of types, including adapters, caps, couplings, elbows, and tees.

Figure 108 shows examples of push fittings.



Push-fitting coupling, push x push
(Courtesy of NIBCO INC)



Push x MIP adapter (Courtesy of NIBCO INC)



Tee, push x push x push
(Courtesy of NIBCO INC)



Push fitting removal and deburring tools

Figure 108 Push fittings (Courtesy of NIBCO INC) Used with permission.

The **press-fit joint** fitting is a quick seal that is reliable, permanent and watertight. The press system joins seamless copper water tube or PEX in residential and commercial potable, hot, chilled and process water applications for plumbing and HVAC systems.

The term “press-fit” refers to a generic connection method. A number of companies manufacture tools and fittings for

these types of systems. All press-fit fittings can be used with standard pipe or tubing that they were made for, but check with manufacturers' literature to be sure that the pressing tools can be used with intended fittings before making any connections.



Figure 109 Copper x PEX press-fit adapter (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Press fittings are available in a broad range, including adapters, caps, couplings, elbows, flanges, manifolds, tees, and unions. Figure 110 shows examples of press fittings.



45 deg grooved elbow



Grooved tee



Grooved elbow



Outlet coupling, Style 72



**Plain end Roust-A-Bout coupling,
Style 99**



**Snap-joint coupling, a
type of quick-connect
grooved fitting**

Figure 110 Examples of press fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Vic-Press

Vic-Press is a patented system manufactured by the Victaulic Co. (<https://www.victaulic.com/>) that uses stainless press fittings and pipe for sprinkler systems. Figure 111 shows various types of Vic-Press fittings.



Figure 111 Vic-Press fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Vic-Press couplings have internal rubber O-rings to create a seal as seen in Figure 112.



Figure 112 Cutaway of a Vic-Press coupling showing O-rings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The Vic-Press® tool compresses the fitting to create a rigid mechanical connection as seen in Figure 113.



Figure 113 Vic-Press tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

CPVC Fire Protection

Injection-moulded CPVC thermoplastic fittings are designed for use in residential and commercial fire protection and fire sprinkler systems. Fittings include adapters, bushings, caps, couplings, crosses, elbows, flanges, tees, and unions.

Figure 114 shows examples of CPVC thermoplastic fittings.



Figure 114 CPVC Fire protection fittings (Courtesy of NIBCO INC). Used with permission. (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

PVC Schedule 80 Fittings

Polyvinyl chloride (PVC) Schedule 80 fittings are designed for use with chemical processing, industrial plating, chilled water distribution, deionized water lines, chemical drainage and waste water treatment systems.

Figure 115 shows various types of PVC Schedule 80 fittings.



Figure 115 PVC Schedule 80 fittings (Courtesy of NIBCO INC) Used with permission.

PVC Schedule 40 Fittings

PVC Schedule 40 fittings are similar to Schedule 80 fittings; however, they are not designed to withstand higher pressures.

Mechanical Joint Fittings

The term **mechanical joint fittings** refers to a variety of fittings that use specially designed clamps and elastomeric gaskets to connect the pipe and fittings. Many of these fittings are described by the manufacturer's name, such as Victaulic or Gruvlok. A mechanical joint clamp used for joining cast iron no-hub DWV pipe and fittings is simply referred to as an **MJ clamp**.

Elastomeric refers to a flexible synthetic rubber-like compound (neoprene) designed for specific uses. Some elastomeric compounds, for example, must be able to resist different chemicals, temperatures and pressures. Manufacturers supply elastomeric gaskets for many different applications.

Grooved Fittings

Victaulic and Gruvlok fittings are used to join steel pipe and tubing, copper tubing, or piping materials that are suitable for grooving. The term **grooving** refers to a process of rolling or cutting a groove into the end of the pipe. The groove provides a channel into which the clamp body fits, as shown in the joint cross-section in Figure 116. The clamp is held together with bolts and the elastomeric gasket.

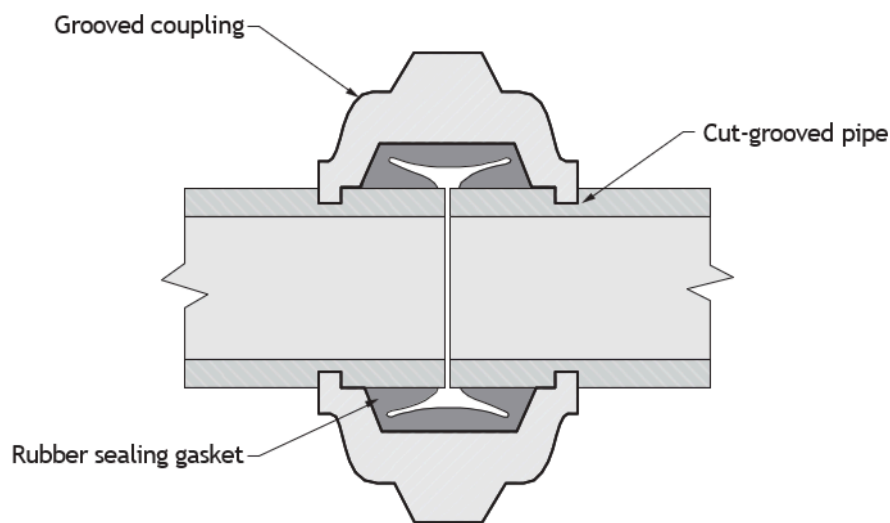


Figure 116 Grooved mechanical joint cross-section (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

When describing these types of fittings, you are often required to include the name of the manufacturer and specify the gasket required to suit the pressures, temperatures and fluid that will be transported.

Victaulic's Zero-Flex coupling (<https://www.victaulic.com/products/style-07-zero-flex-rigid-coupling/>) (Figure 117) adjusts so that it can be clamped to a pipe with standard pipe tolerances, providing resistance to flexing and twisting.



Figure 117 Zero-Flex coupling with gasket for grooved pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 118 shows various types of grooved fittings. The plain end Roust-A-Bout coupling, also from Victaulic, features gripping teeth that help form a strong joint between plain and bevelled ends (including Schedule 80 carbon steel pipe). However, it cannot be used on plastic pipe, pipe with brittle linings, cast or ductile iron pipe, or any pipe with a surface hardness greater than 150 Brinell.



45 deg grooved elbow



Grooved tee



Grooved elbow



Outlet coupling, Style 72



Plain end Roust-A-Bout coupling,
Style 99



Snap-joint coupling, a
type of quick-connect
grooved fitting

Figure 118 Various types of grooved fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Mechanical Joint Couplings for Cast Iron Drainage

A **mechanical joint (MJ) coupling** is used to join no-hub cast iron DWV piping and fittings. The coupling is a neoprene sleeve inside a stainless steel sleeve with attached gear clamps. Mechanical joints have replaced the **bell and spigot (lead and oakum) joint**.



Figure 119 An assembled MJ coupling (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

MJ clamps can be made entirely of elastomeric compounds with individual gear clamps and no stainless steel sleeve. These clamps are used as transition couplings (adapters) from one type of piping material to another, and can be purchased as straight or reducing couplings. They are popular for renovations.

Bushings can be purchased that will allow a standard size clamp to be used to join pipes of the same size but with different OD. The bushing fits inside the clamp to adapt to the OD of the smaller pipe (Figure 120).



Figure 120 4" MJ clay coupling with 4" clay x ABS bushing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

MJ couplings are quite flexible—they make leak-proof seals on virtually any pipe material: plastic, cast iron, asbestos cement, clay, concrete, steel, copper, and ductile iron. All couplings are clearly marked with part number, size, and pipe materials that the coupling will connect.

Some examples of trade names for these clamps are Zip, Fernco, Mission Clay, and Rollee. When you describe these clamps, you should include the trade name in the description.



Figure 121 Examples of flexible coupling fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Push-on Fittings

A **push-on joint** is a type of fitting that resembles a bell and spigot joint. These joints are used extensively for water mains, sanitary and storm sewers, and municipal services.

Push-on fittings are available in a variety of materials for different piping materials, including PVC and ductile cast iron. This method of joining pipe uses a type of ring gasket, which is placed in a groove in the hub of the fitting. The gaskets may be designed for use with only the fittings of a specific manufacturer. You must specify the manufacturer of the fittings to ensure you receive the right gaskets.

Push-on fittings must be restrained when they are pressurized in use. Fitting restraint is accomplished by a system of rodding, thrust blocks, and clamping devices.

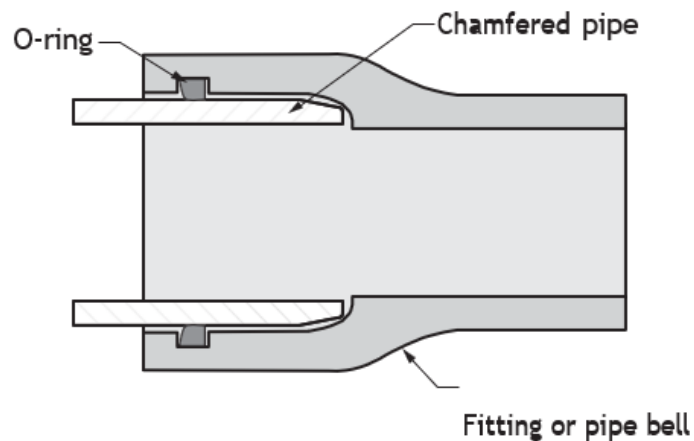
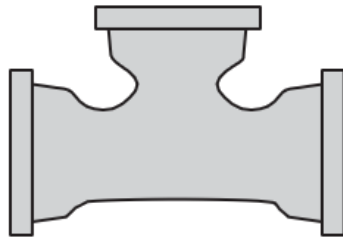
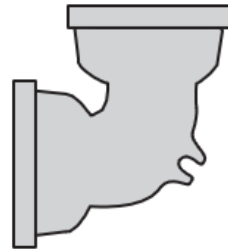


Figure 122 Cutaway of push-on fitting connection (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Ductile CI tee



Ductile CI 90 deg

Figure 123 Common ductile iron push-on fittings for water mains (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 124 Ductile iron push-on joint pipe fitting (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Self-Test D-3.1 Describe Fittings Used in the Pipe Trades

Complete Self-Test 3.1 and check your answers.

If you are using a printed copy, please find Self-Test D-3.1 (#chapter-self-test-d-3-1-describe-fittings-used-in-the-pipe-trades) and Answer Key (#chapter-answer-key-self-test-d-3-1) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2055#h5p-9> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2055#h5p-9>)

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- Plumber: Competency D-5 Install Fittings
 - Steamfitter: Competency D-2 Install Fittings
 - Sprinkler Fitter: Competency D-5 Install Fittings
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- The following images are courtesy of NIBCO INC (<https://www.nibco.com/nibco-products/fittings/>), and are used with permission:
 - **Figure 18** Double sanitary fittings
 - **Figure 19** ABS tee wye combination, long radius
 - **Figure 21** ABS DWV left and right side inlet hubs
 - **Figure 27** Copper tube couplings
 - **Figure 33** Various types of union
 - **Figure 37** Adapter fittings
 - **Figure 39** Various types of plugs and caps
 - **Figure 40** Various types of cleanouts
 - **Figure 50** ABS traps
 - **Figure 55** Soldered fittings
 - **Figure 71** Flange types
 - **Figure 95** PEX crimp fittings
 - **Figure 96** Crimp rings
 - **Figure 107** PEX compression coupling, nuts and brass ferrule
 - **Figure 108** Push fittings
 - **Figure 114** CPVC Fire protection fittings
 - **Figure 115** PVC Schedule 80 fittings
- **Figure 40** [Various types of cleanouts] Ongrade adjustable cleanout is courtesy of Watts and is used with permission.

D-3.2 Describe Connection Methods of Fittings

Sealants

Most piping joints are designed to be leak-proof. **Sealants**, such as thread compounds, gaskets made of elastomeric or fibrous substances or some type of packing can be used to prevent leaks. Sealants may be used in combination with gaskets to ensure that liquids or gases do not leak out and that dirt and contaminants are prevented from entering the piping system.

An effective sealant should have some or all of these characteristics:

- Spread evenly over piping surface or threads
- Seal tightly
- Be non-hardening (should act as lubricant)
- Withstand system temperatures and pressures
- Withstand corrosive effects of pipe contents resist rust and corrosion
- Not leach into piping contents

Piping installation codes may prohibit the use of certain types of compounds, especially on potable water systems.

These common types of sealants are:

- Thread compounds
- Gaskets
- Packing
- Plumber's putty
- Silicone caulking

Thread Compounds

Thread compounds (often referred to as *pipe dope*) are used to ensure a tight seal between threaded piping and fittings. Thread compounds also act as lubricants as joints are tightened. When a wrench is used to run up the threads, the amount of torque required to tighten the joint and the heat caused by friction will be minimized.

Thread compounds are available to suit each application. They may be in paste, stick, liquid, powder, or spray form. Pastes are usually squeezed from a tube. Sticks are paper-wrapped solids that are scraped off and deposited as the stick is rubbed across threads. Liquid compounds are generally applied with a brush applicator which is often attached to the lid of the compound container. Some types of compounds, such as graphite, are available in powder, liquid, or paste forms.



Many thread compounds should only be used in well ventilated conditions. Some are flammable or mildly toxic if swallowed or left on skin. Make sure you check the labels on any products you use and obtain Safety Data Sheets from supplier.

Thread compounds have been formulated to be used in a wide range of operating temperatures and pressures. A common line of pipe sealants known as Permatex® (<https://www.permatex.com/>) has a pipe joint compound that can be applied over grease or oil and is suited to temperature ranges from -54 °C to 204 °C (-65 °F to 400°F). Other popular compounds are available under the line known by the “Unyte” trade name by J. C. Whitlam (<https://www.jcwhitlam.com/>), a long-running family-owned plumbing chemical manufacturer based in Wadsworth, Ohio. “Tyte-Unyte®” is a type of thread compound safe for potable water systems that has a temperature range from -26 °C to 204 °C (-15 °F to 400 °F) and a pressure range up to 13 790 kPa (2000 psi).

Teflon Thread Compounds

Teflon thread compound is available in tape or liquid form. It can be used when joining iron, stainless steel, aluminum, **Monel steel**, and plastics. The tape form is widely used because it is simple to use, clean, strong, durable and extremely effective (Figure 1). Teflon® tape can be used in potable water systems.

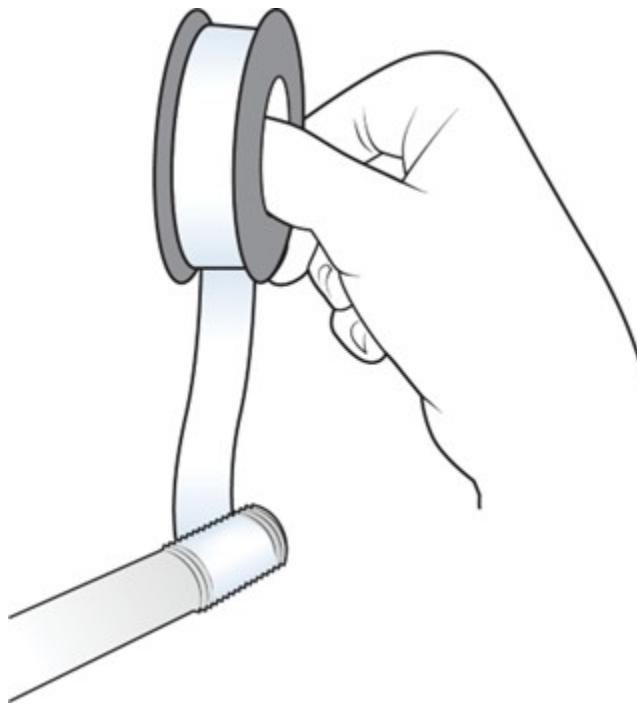


Figure 1 Teflon pipe tape (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Teflon is widely used because of its superior chemical, thermal, electrical, and mechanical properties. It is non-flammable and does not react with most chemicals. It can be used for a wide range of operating temperatures and pressures. Teflon can withstand pressures up to 13 790 kPa (2000 psi). It is used in systems that carry water, steam, chemicals, hydraulic fluids, natural gas, compressed natural gas (CNG), and liquefied petroleum (LP) gas, freon, and food products.

Graphite Thread Compounds

Graphite is finely-flaked carbon that can be used in powder form or mixed with oils and greases for easier application. It can be used to seal and lubricate all threaded, flanged, and gasketed joints on pipe systems carrying alkalis, brine, acids, steam, air, fuel gas, hot or cold water, and aqueous solvents. It will not harden over time so joints should not seize, and disassembly for maintenance is relatively easy.



Graphite mixed with oil or grease must never be used on medical gas piping.

Liquid Thread Compound

Liquid thread compounds can be easily brushed on pipe threads (Figure 2).

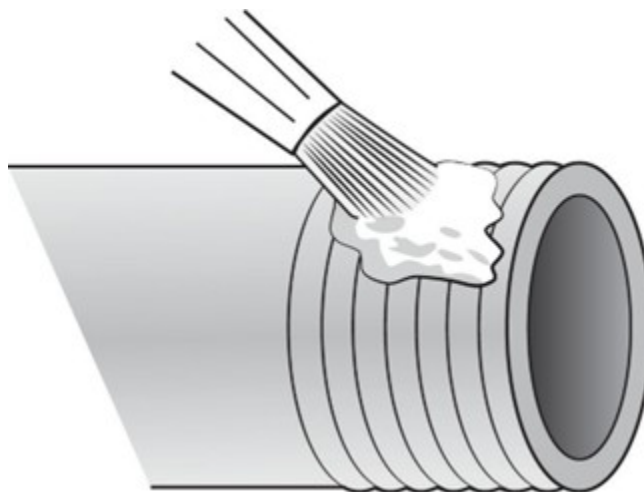


Figure 2 Liquid thread compounds are easy to apply (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Lead-based compounds are not suitable for portable water service piping. Lead is toxic if ingested. Dispose of in accordance with provincial regulations. Refer to the compound product Safety Data Sheet (SDS) for detailed information.

Applying Thread Compounds

Before applying any thread compound, check that pipe joint surfaces are clean, free of oil, dirt, scratches, burrs or imperfections. The following basic steps should be followed before applying any type of thread compound:

1. Clean external and internal threads.
2. Inspect threads for damage. The mating threads should be perfect (sharp at the top and bottom of the thread). Run a tap (for internal threads) or a die (for external threads) to repair any damage.
3. Apply thread compound only to external threads. Start from the second thread and apply it to the remaining perfect threads (Figure 3). This will prevent the compound from squeezing into the pipe.

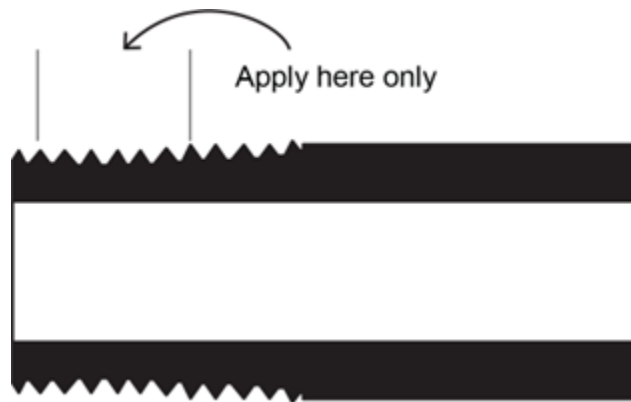


Figure 3 Applying thread compounds (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

4. Engage the threads by hand first and run up the threads as far as possible. Complete the job with a wrench. Be careful not to over-torque the pipe.

Applying Teflon Tape

1. Clean and repair the threads as necessary.
2. Lay the tape on the externally threaded pipe. Start from the second thread and wrap in the direction of the thread (clockwise for right-hand threads). This will prevent the tape from unravelling when the joint is tightened. Wrap the tape in a spiral fashion, overlapping half the width of the tape as you go up the pipe. This will provide two layers of tape where the threads are engaged.
3. Engage the threads by hand first and run up the threads as far as possible. Be careful not to over-torque the pipe when using a wrench for final tightening. Teflon is a very effective lubricant and it is easy to overtighten joints. If joints are overtightened, fittings will stretch and may leak over time.

Gaskets

Gaskets are placed between pipe connections and squeezed together to seal a joint. Sometimes referred to as

compression type fittings or connections, gaskets will only form an effective seal if they are smooth and properly aligned. Gaskets will seal joints, prevent leaks and reduce vibration and noise in piping systems.

The shape of a gasket and the type of material it is made from will depend on the piping size, the type of connection (such as flanged, compression or grooved), and the requirements of particular applications. Before selecting a gasket, you must consider the following characteristics:

- Pipe and fitting sizes
- Type of join connection
- Pipe material
- Temperature range
- Pressure range
- Corrosive nature of pipe content

You must also consider whether ready-made gaskets can be purchased or whether they should be fabricated on the job.

Full-face gaskets (Figure 4) are ready-made gaskets that fit flat flanges and have matching bolt holes for easy installation.

Raised face flanges use ring gaskets without bolt holes.

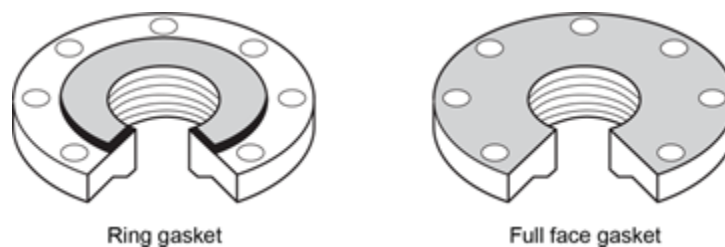


Figure 4 Gaskets for flanges (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Gaskets made from elastomeric compounds (Figure 5) are found in many types of pipe fittings or joints. **Ring gaskets** are made of neoprene or other elastomeric compounds that fit inside the hub of piping such as iron soil pipe and form a tight, sealed joint. **Sleeve type gaskets** are used to seal hub-and-spigot type piping or plain end piping (such as an MJ coupling). Special types of ring gaskets are used inside the housing of Victaulic couplings.

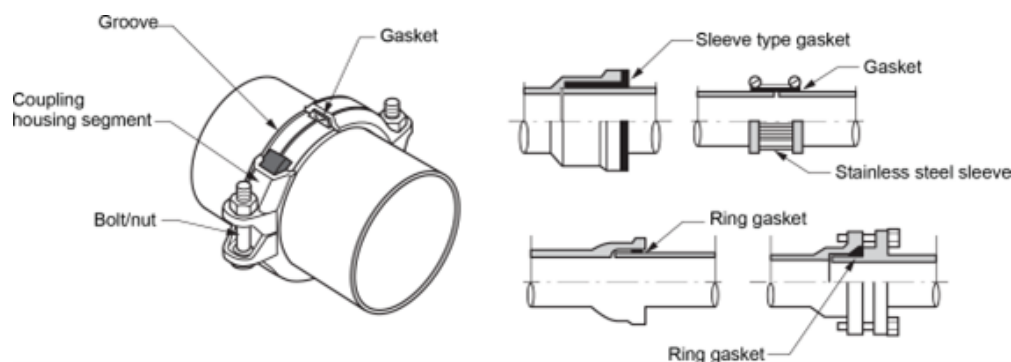


Figure 5 Various types of gasketed joints (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Gasket Materials

Different materials are used to construct different styles of gasket. These include:

- Metal gaskets
- Vegetable fibre gaskets
- Wax gaskets
- Elastomeric gaskets
- Teflon gaskets

Metal Gaskets

Gaskets may be made from tin, aluminum, Monel steel, stainless steel, copper, silver, nickel, brass, iron, low carbon steel and chrome steel. **Metal gaskets** can be used for high temperatures up to 835 °C (1,600 °F) or for high pressures up to 70,000 kPa (10,000 psi). These gaskets are available in a wide variety of shapes and can be used where rubber or fabric type gaskets are unsuitable.

Vegetable Fibre Gaskets

Natural fibres such as cotton, flax, or cork may be saturated with a glue-glycerin solution and used as gaskets in hydraulic applications, such as pumps. The **glue-glycerin solution** ensures that they are permanently oil-proof and natural **vegetable fibre gaskets** can be used for hot oil or steam and hot water applications. They are recommended for temperatures up to 121 °C (250 °F).

Wax Gaskets

Thick, soft **wax gaskets** are used to seal toilets to floor flanges.

Elastomeric Gaskets

Elastomeric substances such as natural rubber, synthetic rubber and PCV are used to make gaskets for a wide range of applications. They may be found in hot and cold water piping, steam piping and drainage piping. Synthetic rubbers, such as neoprene, silicone, nitrile and Viton A, are recommended for oil and corrosive chemical applications. Newer types of gaskets for sealing floor-mounted or wall-hung toilets may be plastic or special types of foam or neoprene.

Rubber gaskets can be reinforced with high tensile cloth or bronze wire mesh for added strength. Natural rubber gaskets are used for pressures up to 1,050 kPa (150 psi) and over a wide range of temperatures from -54 °C to 150 °C (-65 °F to 330 °F). Synthetic rubbers can be used from -90 °C to 288 °C (-130 °F to 550 °F) and with a wider range of pressures.

Teflon Gaskets

A type of plastic, known as Teflon, is very versatile and durable and can be used with almost any substance. **Teflon gaskets** can be used in systems that carry acids, alkalis, oil, water or corrosive solvents. These gaskets are suitable for a wide range of temperatures from -268 °C to 288 °C (-450 °F to 550 °F) and high pressures.

Selecting and Applying Gaskets

Before applying gaskets, you must consider a number of factors to ensure that the proper material and shape of gasket is used and that a tight, durable seal will result.

1. Determine the fluid contents, operating pressures and temperatures. The gasket may have to withstand very high temperatures and pressures. Materials such as Teflon or metal may be more suitable. Temperatures and pressures may not be the important factor. Some systems carry very corrosive liquids at lower pressures and temperatures. Rubber gaskets may be more suitable than others.
2. Consider the type of joint. Is it a flange-type connection or will the gasket be used for pressure type connections between hub-and-spigot piping or fittings? Flange types must be compatible with system pressures. Raised face flanges have smaller surface areas so greater pressure is exerted by the connecting bolts. Full-face gaskets are made to fit flat flanges. If flanges are slightly misaligned, you may choose thicker gaskets to ensure a proper seal.
3. Make sure that gaskets are sized so that they will not protrude past the opening of the pipe when the flange or fitting is tightened. An improperly sized gasket will interfere with the flow of liquid or gases through the pipe. When ordering gaskets, specify:
 - Normal pipe size (i.e., 6" pipe)
 - Service pressures
 - Services temperatures
 - Type of fitting
 - Pipe contents (intended used)
4. With the gasket type selected, check for imperfections in joining surfaces. Clean the end of pipe or flange surfaces. Check for imperfections in mating surfaces such as scratches, warps, or gouges. Make sure all surfaces are clean and dry.
5. Check the gasket manufacturer's specifications for the appropriate lubricant or sealant. Some lubricants may damage the gasket material. Plastic piping may require silicone or petroleum jelly. Teflon is widely used. For ring gaskets or **Tyton® joints** (used to join ductile iron pipe), apply lubricant to the inside of the gasket and to about 75 mm (length of mating surface) of the spigot end of the pipe.
6. For hub and spigot type connections, insert the spigot end until it is seated against the gasket and apply pressure until the pipe is firmly seated and sealed. Flange-type connections should be tightened carefully. Align flanges as accurately as possible, insert bolts and tighten.

Packing

Packing is made of various kinds of pliable materials that will provide a dynamic seal between a moving part and a stationary part. For example, gate valves require packing to prevent leaks from around the centre stem.

A common type of packing is graphite, held in place by a gland and adjustable nut mechanism (Figure 6). In the gate valve stem shown, the graphite will seal the valve and provide lubrication to the stem as it travels up and down. The rubber O-ring packing shown in Figure 7 is usually lubricated by grease.

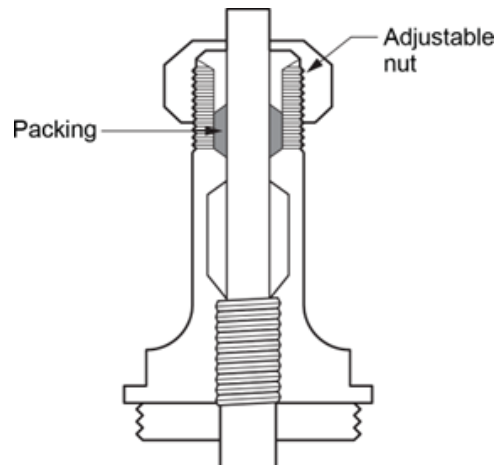


Figure 6 Gland nut mechanism (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

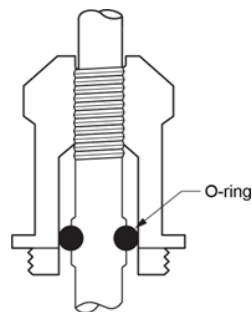


Figure 7 Rubber O-ring packing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Packing is also available in a circular braided ring made of Teflon with a temperature range of -240°C to 315°C (-400°F to 600°F). It can withstand pressures up to 68,950 kPa (10,000 psi).

Other Common Sealants

Plumbers will often use silicone caulking or **plumber's putty** to seal fixtures and some fittings. Plumber's putty is a malleable paste that is rolled into narrow tubes or strips and placed under lavatory or shower drain fixtures, under the rim of counter-top basins and wherever watertight seals are required in fixture trim. This type of compound becomes

softer as it is kneaded or handled. Plumber's putty will harden and set but it can always be worked to become pliable again.

Silicone caulking for plumbing applications is an adhesive compound that has mildew-resistant chemicals added. It is available in tubes of various sizes and will remain in a paste-like form as long as it is not exposed to air.

Silicone is applied along joints between bathtubs and acrylic enclosures or tiles, along sink ledges or rims and along all seams of shower enclosures. Silicone sets fairly quickly but must be allowed to cure, usually for 24 to 36 hours, before being exposed to water.



Silicone caulking is toxic and should not be swallowed or left on skin. Use only in well-ventilated conditions. Consult SDS or manufacturers' directions for safe storage and use.

Solvent Cements

Solvent cements are special types of glue that chemically weld plastic piping together, forming a tight, permanent seal. Some types of cements come in different weights:

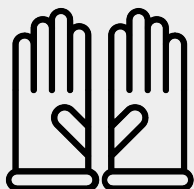
- Light
- Medium
- Heavy
- Extra-heavy

Light cements are free flowing while heavier weights become progressively thicker and can be used on larger diameter, thicker walled plastic piping.

Some solvent cements are formulated to seal effectively in wet installation conditions such as irrigation systems, pools and spas. Acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polyethylene (PE) and polypropylene (PP) may require different types of solvent cements.



Solvent cements are flammable and should not be used near heat, sparks or flames. They must be stored in tightly sealed containers at moderate temperatures. Refer to manufacturer's directions for safe storage and handling.



Solvent cements are toxic. Avoid contact with skin or eyes. Use in well ventilated condition or wear a respirator. Check the Safety Data Sheet (SDS) available for each product.

Solvent cements are spread on the surface of plastic piping with brushes, rollers or daubers. **Daubers** are similar to a cotton ball on a stick but are made from nylon or cotton fibres. Cements are sold in different sizes of cans or glue-pots and the brush, roller or dauber is usually attached to the inside of the container's lid.

Solvent cements will generally set within 2 to 5 minutes and cure in 15 to 20 minutes for common plumbing installations. However, setting and curing times will vary with the temperature and the pipe size. Consult manufacturer's detailed information before applying solvent cement (Tables 1 and 2).

Table 1: Initial Set Times for Weld-on PVC Solvent Cements* (Courtesy of IPS Corporation)

Temperature Range	Pipe Sizes ½" to 1¼"	Pipe Sizes 1½" to 2"	Pipe Sizes 2½" to 6"	Pipe Sizes 10" to 15"	Pipe Sizes 15"+
60°–100°F 16°–38°C	2 minutes	3 minutes	30 minutes	2 hours	4 hours
40°–60°F 4°–16°C	5 minutes	8 minutes	2 hours	8 hours	16 hours
0°–40°F –18°–4°C	10 minutes	15 minutes	12 hours	24 hours	48 hours

Note. Initial set schedule is the necessary time to allow before the joint can be carefully handled.

Table 2: Joint Cure Schedule for Weld-on PVC Solvent Cements* (Courtesy of IPS Corporation)

Relative Humidity 60% or Less**	Cure Time Pipe Sizes ½" to 1¼"		Cure Time Pipe Sizes 1½" to 2"		Cure Time Pipe Sizes 2½" to 8"		Cure Time Pipe Sizes 10" to 15"	Cure Time Pipe Sizes 15"+
Temperature Range During Assembly and Cure Periods	Up to 160 psi	Above 160 to 370 psi	Up to 160 psi	Above 160 to 315 psi	Up to 160 psi	Above 160 to 315 psi	Up to 100 psi	Up to 100 psi
60°–100°F 16°–38°C	15 minutes	6 hours	25 minutes	12 hours	1½ hours	24 hours	48 hours	72 hours
40°–60°F 4°–16°C	20 minutes	12 hours	30 minutes	24 hours	4 hours	48 hours	96 hours	6 days
0°–40°F –18°–4°C	30 minutes	48 hours	45 minutes	96 hours	72 hours	8 days	8 days	14 days

Note. Joint cure schedule is the necessary time to allow before pressurizing system.

*These figures are estimates based on our laboratory tests. Due to many variables in the field, these figures should be used as a general guide,

only.

**In damp or humid weather, allow 50% more cure time.



Self-Test D-3.2: Describe Connection Methods of Fittings

Complete Self-Test 3.2 and check your answers.

If you are using a printed copy, please find Self-Test D-3.2 (#chapter-self-test-d-3-2-section-2) and Answer Key (#chapter-answer-key-self-test-d-3-2) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2100#h5p-10> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2100#h5p-10>)

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BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S

- Plumber: Competency D-5 Install Fittings
- Steamfitter: Competency D-2 Install Fittings

- Sprinkler Fitter: Competency D-5 Install Fittings

IPS Corporation. (n.d.). *Weld-On cements, primers, and cleaners*. <https://ipsplumbingproducts.com/brands/weld-on/>

J.C. Whitlam Manufacturing Company. (n.d.). <https://www.jcwhitlam.com/>

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D-3.3 Select Fittings

In the pipe trades, the ability to create a clear and accurate materials list is essential for planning and completing any plumbing installation. In this section, you will learn how to compile a basic materials list that effectively communicates the required fittings and materials for a job. You will explore common practices used in the field, including organizing materials logically, using clear descriptions, and ensuring readability. By the end of this section, you should be able to compile a basic, readable, and logically ordered materials list using standard procedures. Developing these skills will help you work more efficiently, reduce errors, and communicate effectively with suppliers and other tradespeople.

Basic Materials List

A **materials list** is a list of materials that a pipe tradesperson will need to complete the installation of a plumbing system. The pipe tradesperson compiles a materials list to communicate with the plumbing wholesale supplier or other pipe tradespersons.

A **materials takeoff** is similar to a basic *materials list*, but is more detailed. The materials takeoff is sometimes referred to as a *quantity survey* or *quantity cost sheet*. These terms are generally associated with estimating job costs. Estimating job costs is beyond the scope of this section.

Many pipe tradespeople have their own procedures for making a materials list. The procedure outlined in this section is simplified to provide you with a system to compile a basic materials list when on the job.

Compiling a Basic Materials List

The four basic rules to follow when compiling a materials list are:

1. **Use a suitable material list form.**

Materials list forms are not standardized. They can be simple or very detailed, depending on the intended use. A materials list form, or just a simple sheet of paper, may be used on the job. Many pipe tradespeople use lined pads provided by the wholesaler. A pipe tradesperson on the job would use a simple materials list to order fittings or to prepare work for the day. The materials list form example provided here (Table 1) is for illustration only, and may not be exactly what you use on the job.

Table 1: Sample materials list form

Job #	Address		
Description	Quantity	Unit Price	Cost
Drainage ABS			
3" ABS 90O ell	5	\$ 3.00	\$ 15.00
2" ABS 90Oell	3		
1.5" ABS 90O ell	6		
Potable water			
0.5" C × C 90O ell	20		
0.5" C × C × C tee	8		
		Net cost	

2. Write clearly.

Your list must be legible. Unclear handwriting could be interpreted incorrectly.

3. Describe each fitting fully.

Describe each fitting in as much detailed as required to ensure that the materials list is complete.

4. List fittings in a logical order.

Listing in a logical order means to list fittings of the same type one after the other. Listing the fittings in this way allows the use of ditto marks ("").

5. Use headings to group fittings into common uses.

For example, list all the drainage fittings under one heading and all the potable water systems fittings under a different heading. Heading choice is up to you.

Examples of Materials Lists

Table 2 is an example of a materials list that is written in a logical order. Compare it to Table 3, which is not written in a logical order.

Table 2: Materials List in Logical Order

Job #	Address		
Description	Quantity	Unit Price	Cost
Drainage ABS			
3" ABS 90O ell	5	\$3.00	\$15.00
2" " "	3		
1.5" " "	6		
3" ABS 45O ell	3		
2" " "	12		
1.5" " "	6		
Potable water			
0.5" C × C 90O ell	20		
0.5" C × C × C tee	8		
		Net cost	

Table 3: Materials List That is Not in Logical Order

Job #	Address		
Description	Quantity	Unit Price	Cost
3" ABS 90O ell	5	\$ 3.00	\$15.00
0.5" C × C × C tee			
1.5" ABS 90O ell			
3" ABS 45O ell			
3" ABS wye			
1.5" ABS 45O ell			
2" ABS 90O ell		Net cost	

The materials list in Table 3 has no headings and the fittings are in a random order. A materials list such as the one in Table 3 is not in a logical order, and it would therefore take longer to write, longer to fill out, and longer to price.



Self-Test D-3.3: Select Fittings

Complete Self-Test 3.3 and check your answers.

If you are using a printed copy, please find Self-Test D-3.3 (#chapter-self-test-d-3-3-select-fittings) and Answer Key (#chapter-answer-key-self-test-d-3-3) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2104#h5p-13> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2104#h5p-13>)

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BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S

- Plumber: Competency D-5 Install Fittings
- Steamfitter: Competency D-2 Install Fittings
- Sprinkler Fitter: Competency D-5 Install Fittings

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Self-Test D-3.1 Describe Fittings Used in the Pipe Trades

Complete Self-Test D-3.1 and check your answers.

1. The abbreviation “SO,” when used for plumbing fitting descriptions, stands for
 - a. Soldered outlet
 - b. Side outlet
 - c. Steam outlet
 - d. Slip-on
2. The abbreviation “Galv,” when used for plumbing fitting descriptions, stands for
 - a. Grey aluminum valve
 - b. Galvanic
 - c. Gallon volume
 - d. Galvanized
3. The abbreviation “San,” when used for plumbing fitting descriptions, stands for
 - a. Sanitary
 - b. Steam and nitrogen
 - c. Sand cast
 - d. Sand finish
4. The abbreviation “CSA,” when used for plumbing fitting descriptions, stands for
 - a. Canadian Standards Association
 - b. Copper Systems Alliance
 - c. Copper Standard Adapter
 - d. Canadian Safety Association
5. The abbreviation “w/o,” when used for plumbing fitting descriptions, stands for
 - a. Wide/offset
 - b. White/orange
 - c. With/out
 - d. Water/oil
6. The abbreviation “IPS,” when used for plumbing fitting descriptions, stands for
 - a. Internal pipe size
 - b. International plumbing system
 - c. Inside pipe size
 - d. Iron pipe size
7. The abbreviation “DWV,” when used for plumbing fitting descriptions, stands for
 - a. Drain water valve
 - b. Double waste vent
 - c. Drainage waste and vent
 - d. Downstream water valve
8. The abbreviation “MIPT,” when used for plumbing fitting descriptions, stands for
 - a. Male iron pipe thread
 - b. Malleable iron pipe thread

- c. Maximum inside plastic tapping
 - d. Medium iron pipe tap
9. When comparing a DWV fitting to a pressure fitting, which one of the following statements is true?
 - a. The pressure socket is shallower.
 - b. The pressure fitting has a gradual bend throat.
 - c. The DWV fitting has a gradual bend throat.
 - d. The DWV socket is deeper.
 10. The end of a fitting that fits into the socket end of another fitting is called the
 - a. Bell
 - b. Hub
 - c. Spigot
 - d. Face
 11. A malleable iron fitting differs from a cast iron threaded fitting in which of the following ways?
 - a. Cast iron fittings will not crack; malleable fittings will crack.
 - b. Cast iron fittings have a thicker bead; malleable fittings have a thinner bead.
 - c. Cast iron fittings will stretch; malleable fittings will not stretch.
 - d. Cast iron fittings have a short radius; malleable fittings have a long radius.
 12. Which category of fitting is primarily used to change direction of piping?
 - a. Elbow
 - b. Tee
 - c. Coupling
 - d. Adapter
 13. Which category of fittings is used to join three pipes together?
 - a. Elbow and bushings
 - b. Tees and wyes
 - c. Union and couplings
 - d. Branch and runs
 14. Which type of fitting will change the direction and reduce the size of a pipe at the same time?
 - a. Sanitary double tee
 - b. Copper by MIP adapter
 - c. Reducing elbow
 - d. Reducing coupling
 15. Another name for an elbow is a
 - a. Wye
 - b. Union
 - c. Bend
 - d. Round turn
 16. Which fitting is used change direction and to secure piping to backing for support?
 - a. Street elbow
 - b. Wingback elbow
 - c. Pipe clamp
 - d. Pipe cap
 17. Which elbow has MIP threads on one end and FIP threads on the other end?
 - a. Wingback elbow
 - b. Reducing elbow

- c. Spigot elbow
 - d. Street elbow
18. Which fitting allows four pipes to be joined together?
- a. Sanitary tee
 - b. Double wye
 - c. Reducing tee
 - d. Cleanout
19. Which fitting allows two straight lengths of pipe to be joined together without changing direction of the pipe?
- a. Tee
 - b. Wye
 - c. Elbow
 - d. Coupling
20. This fitting allows connection of piping to equipment and provides for easy removal, if necessary.
- a. Street elbow
 - b. Union
 - c. Coupling
 - d. Bushing
21. Which fitting is used to provide easy access to a pipeline for maintenance?
- a. ABS permanent cap
 - b. ABS test cap
 - c. Cleanout
 - d. Reducer
22. Which of the following choices is not a factor used to identify a fitting?
- a. Size
 - b. Use
 - c. Shape
 - d. Weight
23. When describing the opening sizes of a wye, which one of the following rules applies?
- a. State the largest size of the run first.
 - b. State the smallest size of the branch first.
 - c. State the smallest size of the run first.
 - d. State the largest size of the branch first.
24. The first item written when describing a single fitting is the fitting
- a. Shape
 - b. Size
 - c. Use
 - d. Joint method
25. Which one of the following rules applies when describing the sizes of a sanitary double tee?
- a. State each size starting with the branch when all sizes are the same.
 - b. State the largest size on the branch first and then each size on the run.
 - c. Only one size needs to be described when all sizes are the same.
 - d. No sizes need to be stated when all sizes are the same.
26. In which type of tee is the branch connection larger than the run?
- a. Sanitary
 - b. Straight

- c. Double sanitary
 - d. Bullhead
27. A short piece of threaded pipe that appears to be threaded over its entire length is a
- a. Short nipple
 - b. Close nipple
 - c. Long nipple
 - d. Shoulder nipple
28. Which of the following is a pipe flange style?
- a. Goose neck
 - b. Slip-on
 - c. Strap-on
 - d. Gear
29. Which of the following is a flange face type?
- a. Flat
 - b. Round
 - c. Square
 - d. Rough
30. Which fitting joint includes a coupling nut and ferrule?
- a. Flange
 - b. Soldered
 - c. Compression
 - d. Slip-on
31. An insert sleeve is used with which one of the following joint types?
- a. Compression
 - b. Flanged
 - c. Soldered
 - d. Socket-weld
32. The SAE flare fitting angle is
- a. 37 deg
 - b. 45 deg
 - c. 60 deg
 - d. 30 deg
33. Which fitting requires a gear clamp to join polyethylene tube?
- a. Insert
 - b. Crimp
 - c. PEX
 - d. Compression
34. Which joint method is used to join no-hub cast iron?
- a. Victaulic clamp
 - b. MJ clamp
 - c. Flange

- d. ABS coupling
35. Which joint method uses a ring gasket and joint restraint to hold the pipe together?
- Welded
 - Solvent cement
 - Push-on
 - MJ clamp
36. The fitting shown in Figure 1 is a C × C
- Adapter
 - Streamline elbow
 - 45 deg DWV elbow
 - Coupling
37. The fitting shown in Figure 2 is a
- 45 deg elbow
 - three-way elbow
 - 45 deg wye
 - DWV tee
38. The fitting shown in Figure 3 is a
- Wye
 - Sanitary tee
 - Offset tee
 - Short turn tee
39. Figure 4 shows a copper
- Bushing
 - Rolled tube-stop coupling
 - Adapter
 - MJ coupling
40. Figure 5 shows a
- Compression fitting
 - 3-piece coupling
 - Gasket union
 - Flare fitting



Figure 1 Image for question 36 (Courtesy of NIBCO INC)



Figure 2 Image for question 37 (Courtesy of NIBCO INC)



Figure 3 Image for question 38 (Courtesy of NIBCO INC)



Figure 4 Image for question 39 (Courtesy of NIBCO INC)

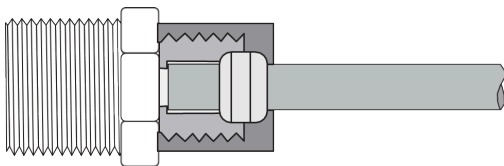


Figure 5 Image for question 40

Fill in the blanks in the Table below with the correct abbreviation or description.

Table 1: Abbreviation Exercise Table

Abbreviation	Meaning
ell	
	Adapter
	Black cast iron (threaded pipe fittings)
	Black malleable (threaded pipe and fittings, not galvanized)
C×C	
C×FIPT	
c/o	
	Cast iron (pipe and fittings)
CSA	
Dbl	Double (e.g. double wye)
DWV	
FIPT	
Galv	
IPS	
IPT	
FPT or FIPT	
	Malleable (pipe and fittings)
	Mechanical joint clamp (pipe and fittings)
OPT and MPT	
RH or LH	
MIPT	
SAE	
	Sanitary (drainage fittings)
	Schedule (used to describe a steel pipe wall thickness)

	Side outlet (used to describe a tee with a side outlet connection)
	Spigot end
Tapt	
	without (e.g. an ABS P-trap w/o cleanout)
WC	
WB	
WOG	
	Wrought
	Y fitting

Answer Key: Self-Test D-3.1 (#chapter-answer-key-self-test-d-3-1) is on the next page.

Answer Key: Self-Test D-3.1

1. b. Side outlet
2. d. Galvanized
3. a. Sanitary
4. a. Canadian Standards Association
5. c. Without
6. d. Iron pipe size
7. c. Drainage waste and vent
8. a. Male iron pipe thread
9. c. The DWV fitting has a gradual bend throat.
10. c. Spigot
11. b. Cast iron fittings have a thicker bead; malleable fittings have a thinner bead.
12. a. Elbow
13. b. Tees and wyes
14. c. Reducing elbow
15. c. Bend
16. b. Wingback elbow
17. d. Street elbow
18. b. Double wye
19. d. Coupling
20. b. Union
21. c. Cleanout
22. d. Weight
23. a. State the largest size of the run first.
24. b. Size
25. c. Only one size need be described when all sizes are the same.
26. d. Bullhead
27. b. Close nipple
28. b. Slip-on
29. a. Flat
30. c. Compression
31. a. Compression
32. b. 45 deg
33. a. Insert
34. b. MJ clamp
35. c. Push-on
36. b. Streamline elbow
37. c. 45 deg wye
38. b. Sanitary tee
39. b. Roll-stop coupling
40. d. Compression fitting

Fill in the blanks in the Table below with the correct abbreviation or description.

Table 1: Abbreviation Exercise

Abbreviation	Meaning
ell	elbow
Adpt	Adapter
Blk CI	Black cast iron (threaded pipe fittings)
Blk mal	Black malleable (threaded pipe and fittings, not galvanized)
C×C	Copper by copper (pipe and fittings)
C×FIPT	Copper by female iron pipe thread
c/o	Clean out
CI	Cast iron (pipe and fittings)
CSA	Canadian Standards Association. Note: All fittings and pipe used in the plumbing system must be CSA approved for the application for which they are used.
Dbl	Double (e.g. double wye)
DWV	Drainage waste and vent fittings and pipe
Fit.C×FIPT	Fitting copper by female iron pipe thread
Galv	Galvanized (pipe and fittings with a zinc coating for corrosion resistance)
IPS	Iron pipe size
IPT	Internal pipe thread, or iron pipe thread
FPT or FIPT	Female pipe thread or Female iron pipe thread
Mal	Malleable (pipe and fittings)
MJ	Mechanical joint clamp (pipe and fittings)
OPT and MPT	Outside pipe thread and male pipe thread
RH or LH	RH = right hand; LH = left hand (used when identifying the location of the side outlet on a DWV fitting)
MIPT	Male iron pipe
SAE	Society of Automotive Engineers
San	Sanitary (drainage fittings)
Sch	Schedule (used to describe a steel pipe wall thickness)

SO	Side outlet (used to describe a tee with a side outlet connection)
SP	Spigot end
Tapt	tapped (refers to fitting openings that are threaded to accept MIP threads)
w/o	without (e.g. an ABS P-trap w/o cleanout)
WC	Wingback
WB	Water closet
WOG	Water, oil, gas
Wrot	Wrought
Wye	Y fitting

Self-Test D-3.2 Describe Connection Methods of Fittings

Complete Self-Test D-3.2 and check your answers.

1. To lubricate and seal threaded piping, you should use
 - a. Teflon thread
 - b. Pipe dope
 - c. Silicone
 - d. Plumber's putty
2. Two common forms of Teflon thread sealants are liquid and
 - a. Gelatin
 - b. Spray
 - c. Stick
 - d. Tape
3. O-ring and shaped gaskets are used to form seals between
 - a. Bell-and-spigot piping
 - b. Flanged piping
 - c. Groove piping
 - d. Threaded piping
4. The most common types of sealing gaskets used in domestic plumbing installations are made from
 - a. Wax
 - b. Lead
 - c. Silicone
 - d. Elastomeric substances
5. The sealants that may be toxic and should only be used in well-ventilated conditions include
 - a. Plumber's putty, silicone caulking, wax
 - b. Silicone caulking, pipe dope, solvent cement
 - c. Solvent cement, vegetable fibre gaskets, wax
 - d. Pipe dope, graphite packing, plumber's putty
6. Ready-made gaskets that fit flat flanges and have matching bolt holes for easy installation are
 - a. Donuts
 - b. Ring gaskets
 - c. O-rings
 - d. Self-sealing gaskets
7. A self-sealing gasket is found in a
 - a. Victaulic fitting
 - b. Bell-and-spigot joint
 - c. Full face flange
 - d. Mechanical joint coupling
8. Thread compounds act to lubricate, seal and protect threaded pipe joints from
 - a. Overtightening
 - b. Damage from rapid temperature changes

- c. Rust and corrosion
 - d. Staining
9. Metal gaskets are usually found in
- a. Fixture drains
 - b. Industrial applications
 - c. Medical fixtures and fittings
 - d. Hot water piping
10. The sealant used to form watertight seals under faucets, drains and strainers
- a. Plumber's putty
 - b. Silicone caulking
 - c. Solvent cement
 - d. Teflon

For questions 11 to 15, use the set times and cure schedule for PVC solvent cements shown in Table 1.

Initial Set Times for Weld-on PVC Solvent Cements*								
Temperature Range	Pipe Sizes ½" to 1¼"		Pipe Sizes 1½" to 2"		Pipe Sizes 2½" to 6"		Pipe Sizes 10" to 15"	Pipe Sizes 15" +
60°–100° F	2 minutes		3 minutes		30 minutes		2 hours	4 hours
40°–60° F	5 minutes		8 minutes		2 hours		8 hours	16 hours
0°–40° F	10 minutes		15 minutes		12 hours		24 hours	48 hours
Note: Initial set schedule is the necessary time to allow before the joint can be carefully handled.								
Joint Cure Schedule for Weld-on PVC Solvent Cements*								
Relative Humidity 60% or Less**	Cure Time Pipe Sizes ½" to ¾"		Cure Time Pipe Sizes 1½" to 2"		Cure Time Pipe Sizes 2½" to 8"		Cure Time Pipe Sizes 10" to 15"	Cure Time Pipe Sizes 15" +
Temperature Range During Assembly and Cure Periods	Up to 160 psi	Above 160 to 370 psi	Up to 160 psi	Above 160 to 315 psi	Up to 160 psi	Above 160 to 315 psi	Up to 100 psi	Up to 100 psi
60°–100° F	15 min.	6 hrs	25 min.	12 hrs	1½ hrs	24 hrs	48 hrs	72 hrs
40°–60° F	20 min.	12 hrs	30 min.	24 hrs	4 hrs	48 hrs	96 hrs	6 days
0°–40° F	30 min.	48 hrs	45 min.	96 hrs.	72 hrs.	8 days	8 days	14 days
* These figures are estimates based on our laboratory tests. Due to many variables in the field, these figures should be used as a general guide only.								
** In damp or humid weather all 50% more cure time.								
Note: Joint cure schedule is the necessary time to allow before pressurizing system.								

Table 1 Set times and cure schedule for PVC solvent cement (courtesy of IPS Corporation)

11. If you were sealing 1/2 PVC piping inside a house, in the summer, how much time should you allow for the cement to set?
- 1. 2 minutes
 - 2. 2 minutes
 - 3. 2 minutes
 - 4. 2 minutes
12. How long would you allow the 1/2 PVC piping to cure completely?
- 1. 15 minutes
 - 2. 20 minutes

3. 30 minutes
 4. 6 hours
13. If you were sealing 6 PVC piping in an irrigation system on a mild, dry day in the middle of winter, how long would you allow for the cement to set?
1. 10 minutes
 2. 15 minutes
 3. 30 minutes
 4. 2 hours
14. Assuming that the irrigation system was at pressures above 160 psi, how long would you allow the joints to cure?
1. 12 hours
 2. 24 hours
 3. 48 hours
 4. 8 days
15. If you had to solvent weld 2 PVC piping at freezing temperatures, how long would you allow the joint to set?
1. 3 minutes
 2. 5 minutes
 3. 8 minutes
 4. 13 minutes

Answer Key: Self-Test D-3.2 (#chapter-answer-key-self-test-d-3-2) is on the next page.

Answer Key: Self-Test D-3.2

1. b. Pipe dope
2. d. Tape
3. a. Bell-and-spigot
4. d. Elastomeric substances
5. b. Silicone caulking, pipe dope, solvent cement
6. b. Ring gaskets
7. a. Victaulic fitting
8. c. Rust and corrosion
9. b. Industrial applications
10. a. Plumber's putty
11. a. 2 minutes
12. b. 15 minutes
13. d. 2 hours
14. c. 48 hours
15. d. 15 minutes

Self-Test D-3.3 Select Fittings

Complete Self-Test D-3.3 and check your answers.

1. Complete the materials list sheet provided for the fittings shown in Figure 1 and then check your answers. Recall that your goal is to be able to identify and name fittings correctly, and to be able to compile a basic material list.

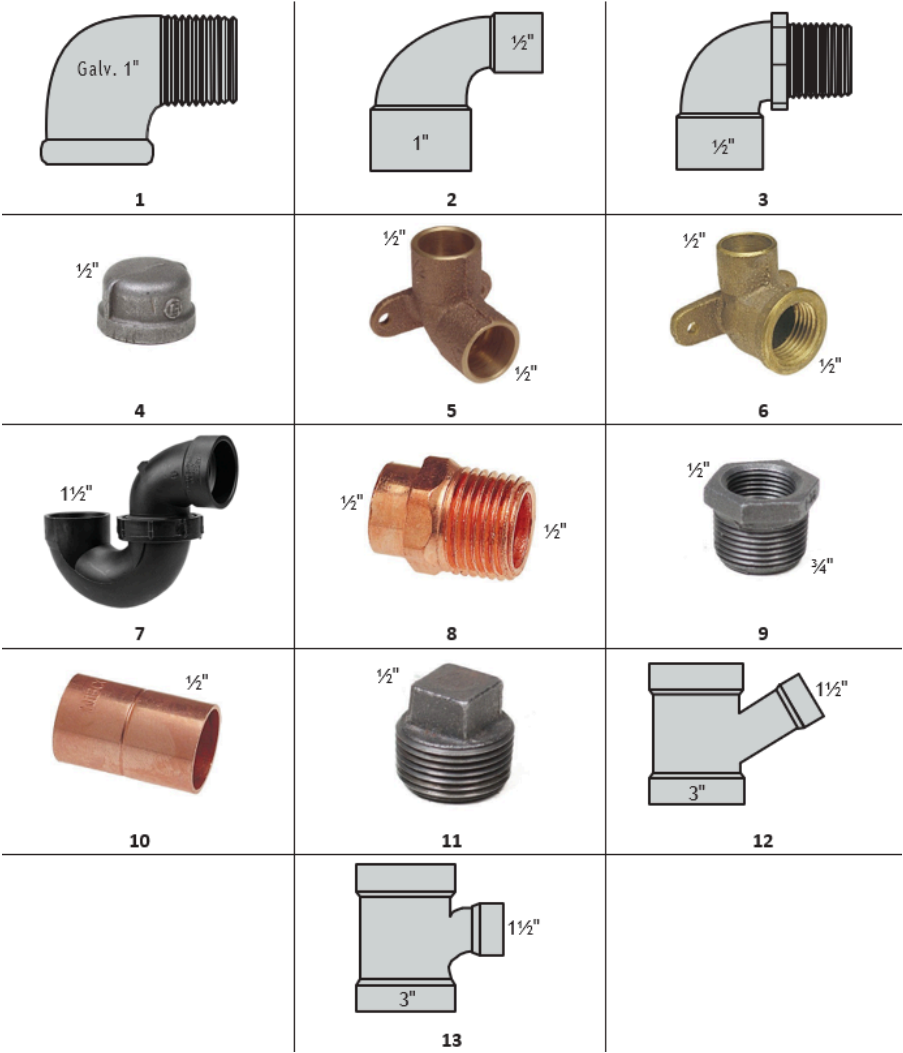


Figure 1 Images for Question 1

The fittings in Figure 1 are identified as numbers 1 to 13. Write these numbers in the appropriate space in the “No.” column, then fill in the rest of the table.

Table 1: Material List for Figure 1

Job #	No.	Quantity	Fitting Description
ABS DWV			
Sweat Copper			
Iron Pipe			

2. Identify the fittings in Figure 2 and complete the materials list.

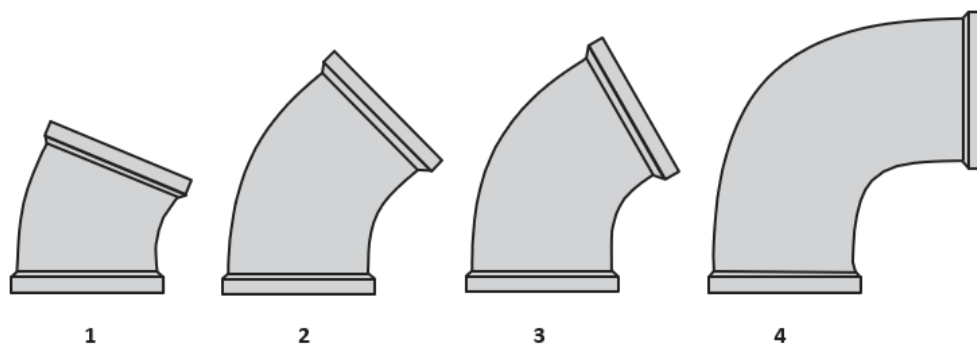


Figure 2 Images for Question 2

The fittings in Figure 2 are 3 in. cast iron drainage.

Table 2: Material List for Figure 2

Job #	No.	Quantity	Fitting Description
Drainage	1		
	2		
	3		
	4		

3. Identify the fittings in Figure 3 and complete the materials list.

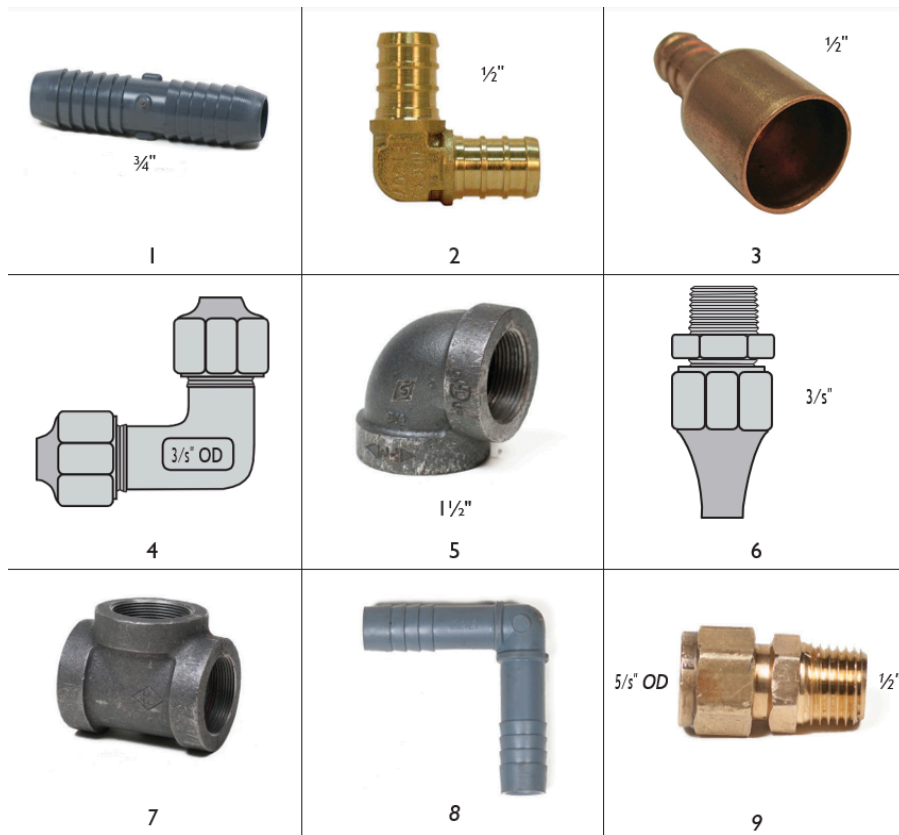


Figure 3 images for Question 3

The fittings in Figure 3 are identified as numbers 1 to 9. Write these numbers in the spaces in the No. column, then fill in the rest of the table.

Table 3: Material List for Figure 3

Job #	No.	Quantity	Fitting Description

4. Identify the fittings in Figure 4 and complete the materials list.

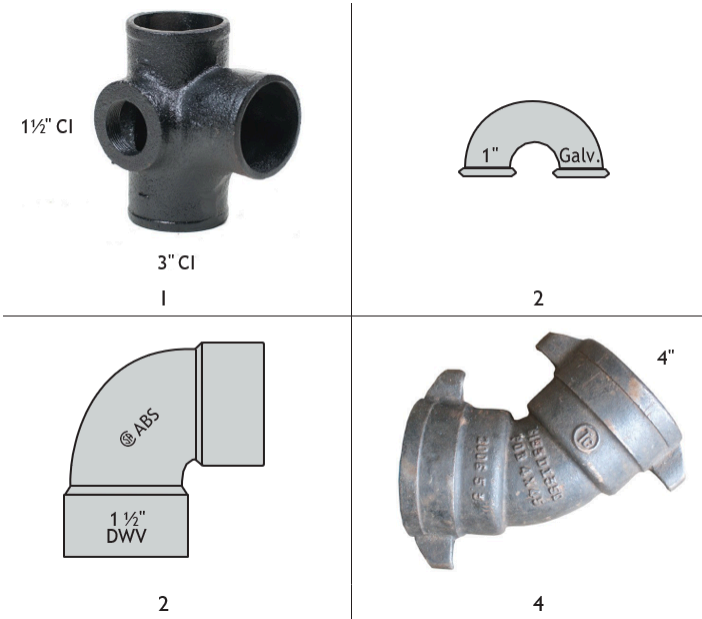


Figure 4 Images for Question 4

The fittings in Figure 4 are identified as numbers 1 to 4. Write these numbers in the spaces in the No. column, then fill in the rest of the table.

Table 4: Material List for Figure 4

Job #	No.	Quantity	Fitting Description

5. Identify the fittings in Figure 5 and complete the materials list.

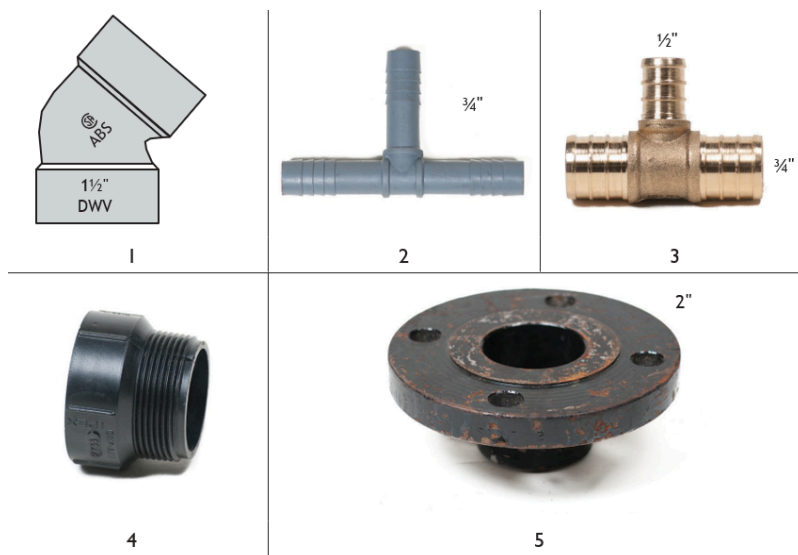


Figure 5 Images for Question 5

The fittings in Figure 5 are identified as numbers 1 to 5. Write these numbers in the spaces in the No. column, then fill in the rest of the table.

Table 5: Material List for Figure 5

Job #	No.	Quantity	Fitting Description

Answer Key: Self-Test D-3.3 (#chapter-answer-key-self-test-d-3-3) is on the next page.

Answer Key: Self-Test D-3.3

The fitting descriptions used on these answer sheets are generic. They may not exactly match your answers or a given manufacturer's descriptions. On the job, you may wish to consult the manufacturers' catalogues for exact fitting descriptions.

1.

Table 1: First Answer Material List

Job #	No.	Quantity	Fitting Description
ABS DWV	7	1	1.5" ABS DWV hub × union P trap
	12	1	3" × 1.5" ABS DWV wye
	13	1	3" × 1.5" ABS DWV san tee
Sweat Copper	2	1	1" × 0.5" C × C red. 90° ell
	3	1	0.5" C × 0.5" MIP 90° ell
	5	1	0.5" C WB 90° ell
	6	1	0.5" C × FIP WB 90° ell
	8	1	0.5" C × 0.5" MIP adapt
	10	1	0.5" C roll tube coupling
Iron Pipe	1	1	1" galv IP street 90° ell
	4	1	0.5" blk mal IP cap
	9	1	$\frac{3}{4}$ " × 0.5" IP blk mal bushing
	11	2	0.5" blk IP plugs

2.

Table 2: Second Answer Material List

Job #	No.	Quantity	Fitting Description
Drainage	1	1	3" MJ CI 1 16 bend
	2	1	3" MJ CI 1/8 bend
	3	1	3" MJ CI 1/6 bend
	4	1	3" MJ CI 1/4 bend

3.

Table 3: Third Answer Material List

Job #	No.	Quantity	Fitting Description
PE Insert	1	1	$\frac{3}{4}$ " plastic insert coupling for series 100 PE
	8	1	0.5" plastic insert 90° ell for series 100 PE
PB Crimp	2	1	0.5" crimp 90° ell
	3	1	0.5" crimp × 0.5" sweat female adapt
Flare	4	1	$\frac{3}{8}$ " OD SAE flare 90° ell short nut
	6	1	$\frac{3}{8}$ " OD flare × $\frac{3}{8}$ " IP adapt
Threaded	5	1	1.5" blk CI IP 90° ell (designate class 125 or 250)
	7	1	1.5" blk CI IP tee (designate class 125 or 250)
Compression	9	1	$\frac{5}{8}$ " OD compression × 0.5" IP adapt

4.

Table 4: Fourth Answer Material List

Job #	No.	Quantity	Fitting Description
Misc. Fits.	1	1	3" MJ san tee w/1.5" LH tapt SO
	2	1	1" galv IP 180° return bend
	3	1	1.5" ABS DWV 90° ell
	4	1	4" ductile Ring-Tite 45° ell

5.

Table 5: Fifth Answer Material List

Job #	No.	Quantity	Fitting Description
ABS DWV	1	1	1.5" ABS DWV 45° ell
ABS DWV	2	1	1.5" ABS DWV hub × MIP adapt
Misc. Fits	3	1	$\frac{3}{4}$ " plastic insert tee for PE series 100
	4	1	$\frac{3}{4}$ " × $\frac{1}{2}$ " crimp tee
	5	1	2" 150 psi weld neck raised face flange

PART IV

D-4 PENETRATE STRUCTURES

Plumber Apprenticeship Program – Level 1



Installation of pipe sleeves is from installation of pipe sleeves #work #plumbing #aboutconstruction [video] by About Contstruction (<https://www.youtube.com/@louiemendoza4616>) (@louiemendoza4616) (2025).

D-4 Penetrate Structures Introduction

When installing piping systems, it is often necessary to pass through walls, floors, and other structural components of a building. These penetrations must be done carefully to avoid weakening the structure or compromising safety features such as fire separations. In this section, you will learn how to identify building structural components, understand the factors that affect structural penetrations, and apply safe methods for cutting, drilling, and installing piping through different types of construction. You will also become familiar with common terminology and components such as sleeves, block-outs, and supports. By the end of this section, you should be able to install piping through structural elements without compromising the integrity of the building.

Note: The information in this section is general in nature. Always refer to manufacturer specifications, job-site requirements, and applicable codes when performing structural penetrations.

Learning Objectives

After completing this section, you will be able to:

- Describe factors affecting penetrations in structures.
- Describe methods of structure penetration.
- Identify and describe building structural components and their structural integrities
- Define structural penetration terminology
- Visually identify the building structural components that are affected by penetration for piping, including fire separations, firewalls, structural supports and components
- Install piping without jeopardizing the structural integrities of the building structure
- Identify and install pipe sleeves, canning and block-outs
- Identify and apply procedures (cutting, drilling, and notching) used to penetrate various building structures for piping without jeopardizing the integrity of structural components, including wood-frame, steel and concrete construction; walls; floors and roof structures
- Apply various methods of firestopping for pipe penetrations, and read and interpret the related manufacturer's specifications, code regulations and job specifications
- Define firestopping terminology
- Identify and install firestops
- Install piping through vapour and air barriers and rain-screen exterior walls without affecting their structural integrity

Topic areas covered in this publication are in alignment with SkilledTradesBC Harmonized 2018 Program Outlines.

Terminology

The following terms may be used throughout this section. Note that some glossary terms may be in *italics* throughout the section content but are not included in this list. A complete list of terms can be found in the **Glossary**.

- **ablative:** resisting heat transfer by using the heat of the exposing fire to erode the material. The material, by sacrificing itself, protects the unexposed side from rapid temperature rise until it is spent. A typical example is a silicon-based firestop material. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))
- **annular space:** The gap between a pipe and the sleeve or opening it passes through. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **block-out:** An opening intentionally formed in concrete or other structural components during construction to allow space for pipes, ducts, or other services to be installed later. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **bond beam:** A reinforced horizontal element in a masonry wall that strengthens and ties the wall together. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **caddy clip:** A fastening device used to secure pipe sleeves to formwork or structural surfaces. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **canning:** The process of installing pipe sleeves in formwork before concrete is poured. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **caulking gun:** A tool used to apply sealants into joints or openings. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))
- **closure (fire-rated):** A device such as a door or shutter used to close an opening in a fire separation. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))
- **concrete formwork:** Temporary structures used to shape and support concrete until it hardens. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **core drilling (coring):** A method of drilling circular holes in concrete using a specialized drill. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **draft stop:** A material intended to stop air movement and fire spread. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))
- **exothermic:** A reaction that releases heat energy. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))
- **fire-block:** A material installed to prevent the spread of fire through concealed spaces. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **fire load:** The amount of combustible material present in a space. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))
- **fire-rated assembly:** A construction system designed to resist fire for a specified period of time. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **fire separation:** A construction assembly designed to resist the spread of fire. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **firestop:** A sealing system used to prevent fire and smoke from passing through penetrations. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **firewall:** A fire-resistant wall that separates buildings or sections of a building. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **flashing:** A material installed to prevent water penetration at roof or wall openings. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

- **fusible link:** A heat-sensitive component that melts to activate a fire damper. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))
- **glued-laminated beam:** (Also called *glulam* and *paralam*); an engineered wood beam made by bonding together layers of lumber with adhesive to create a strong, stable structural member. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **I-joist:** (Also called *I-beam*); a lightweight engineered wood beam shaped like the letter “I,” commonly used in floors and roofs. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **load-bearing structural member:** A structural element designed to hold up the load above it, such as a second storey or roof. Cutting, drilling, or removing this support will weaken the structure. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **moment critical zone:** A section of a structural beam where stress is highest and drilling is restricted. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **non-load-bearing structural member:** A support that is installed as a partition to divide space in a structure and does not support the weight above it. Cutting, drilling or removing this support will not weaken the structure. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **party wall:** A shared wall between two adjoining buildings or units that acts as a fire separation and may also provide sound insulation. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **pipe chase:** A framed or enclosed space within a building used to conceal and protect pipes as they run vertically or horizontally through the structure. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **pipe sleeve:** A protective tube that allows a pipe to pass through a structure safely. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **post-tension slab:** A concrete slab reinforced with tensioned steel cables to increase strength and reduce cracking. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **rebar (reinforcing bar):** Steel bars embedded in concrete to provide strength and support. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **sleeve seal:** A sealing device used to close the gap between a pipe and a pipe sleeve. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **structural integrity:** The ability of a building or structure to remain strong, stable, and safe under loads without failure or damage. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **teleposts (telescopic):** Adjustable steel support posts used to temporarily support structures such as formwork or beams during construction, allowing height to be changed as needed. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **tendon (post-tension):** A steel cable used in post-tension concrete to apply compressive force. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **vibration isolator:** A device used to reduce the transfer of vibration and noise between components. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))
- **waterstop:** A material used to prevent water from passing through joints in concrete. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

D-4.1 Describe Factors Affecting Penetrations in Structures

As a pipe trades worker, it is your job to install, maintain, and repair piping systems and components. Much of the pipe you install will be within structures and will penetrate through foundations, walls, floors, ceilings, and roofs. When installing piping systems, you must maintain the integrity of the structure. You should be able to correctly make pipe penetrations through building structural components.

On the job, you should be aware of the function of the various building structural components. You cannot simply remove, cut, notch, drill, or otherwise alter a building's structural components without considering the effect you are having on that structural component's purpose.

Structural Integrity

Structural integrity is the ability of the **structural component** to perform its designed purpose.

When penetrating structural components with piping, you must consider, identify, and maintain the following:

- Structural support integrity of beams, columns, walls, floors, roofs, and ceilings
- Fire safety integrity of fire-rated assemblies, including firestops, firewalls, and separations
- Humidity, moisture, and water penetration integrity of the structure, roofs, walls and foundations, including protection against rain and groundwater penetration
- Energy efficiency, including heat loss and gain, insulation, and **air barrier** integrity
- Air quality, ventilation, air conditioning, and heat recovery system integrity
- Occupant health and safety integrity
- Appearance and environmental integrity
- Non-interference with adjoining properties
- Sound penetration integrity
- Other engineered structural concerns and requirements

You must have a clear understanding of the design purpose of the structural components within a structure. Every pipe system component installed must not compromise the structural integrity of the building. The following information identifies the related structural components of the building and the acceptable methods for penetrating piping components.

Wood-Frame Construction Components

The following definitions are important in understanding the restrictions around cutting floor, roof, and ceiling framing members:

- **Load-bearing structural member:** A structural element designed to support the load above it, such as a second

storey or roof. Cutting, drilling, or removing this support *will* weaken the structure.

- **Non-load-bearing structural member:** A structural element that is installed as a partition to divide space and does not support the weight above it. Cutting, drilling or removing this support *will not* weaken the structure.

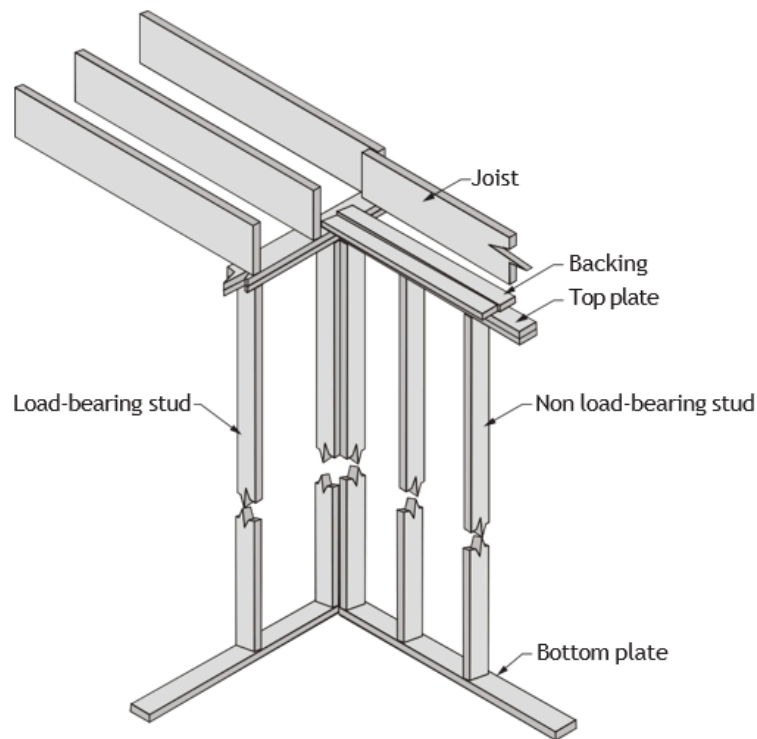


Figure 1—Typical wood framing components

Figure 1 Typical wood framing components (BC Industry Training Authority, 2019).
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Fire Separation

A **fire separation** is a construction assembly that resists the spread of fire. A fire separation is constructed of components that make up a **fire-rated assembly** or system. The **fire rating** of each component in the assembly contributes to the final fire rating for the fire-separation assembly.

Figure 2 shows a typical application of vertical and horizontal wood-frame fire separations and their locations.

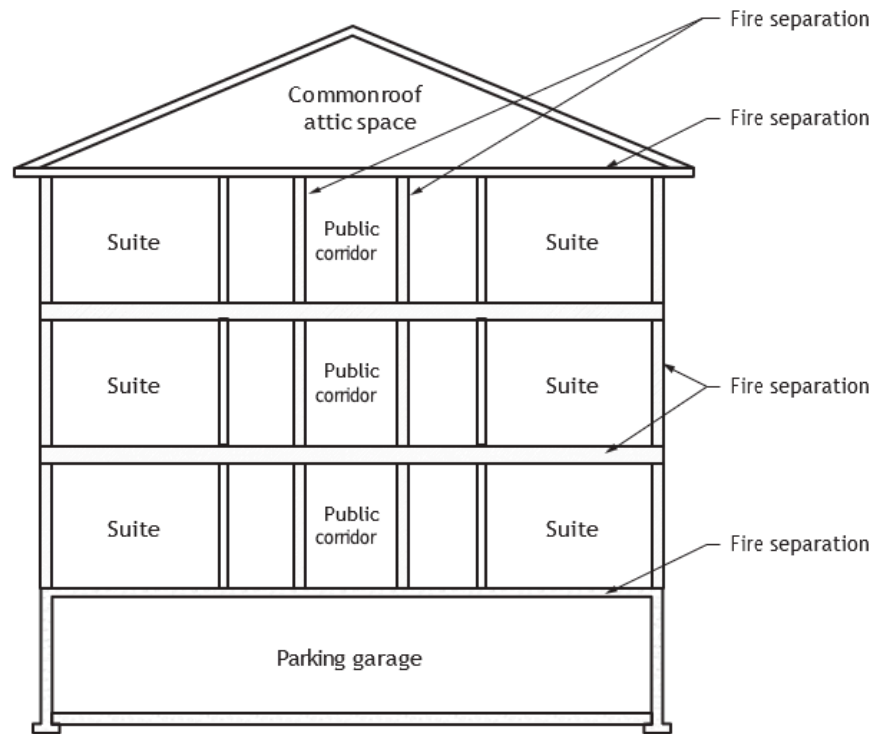


Figure 2 Fire separation locations (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Firewalls

A **firewall** is defined by a building code as a type of fire separation made of non-combustible construction that subdivides a building, or separates adjoining buildings, to resist the spread of fire and remain structurally intact for the required period of time. Typically, a firewall is constructed of concrete or concrete block. A firewall has a higher overall fire rating than a fire separation.

An example of a firewall in a multi-storey wood-frame building is a concrete block wall that extends from the ground floor right up through the roof (Figure 3).

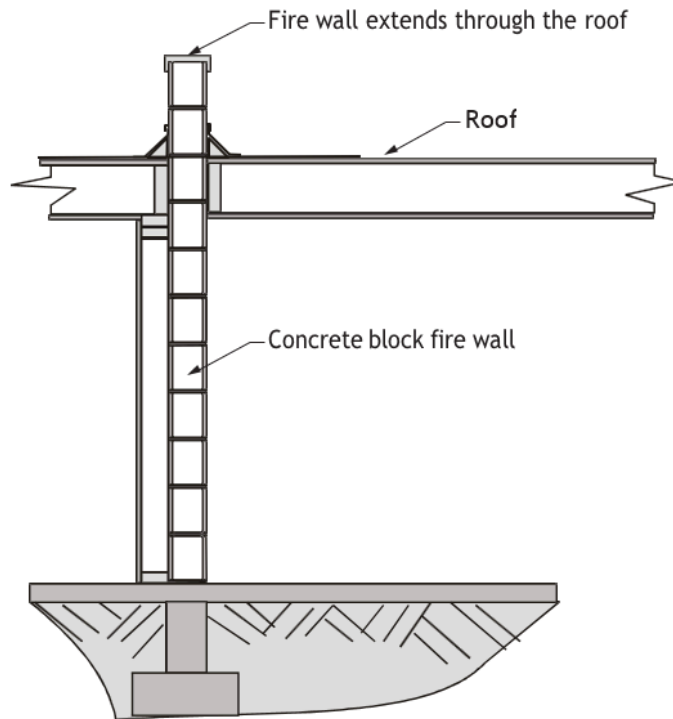


Figure 3 Concrete block fire wall (BC Industry Training Authority, 2019).
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Party Walls

A **party wall** is a fire-separation wall jointly owned and used by two parties under an easement agreement or by right in law, and erected at or upon a line separating two parcels of land, each of which is capable of being a separate real estate property.

An example of a fire separation in a multi-storey wood-frame residential building would be the party wall that is required between the suites and the wall between the suite and the community hallway. Both of these walls must meet a fire rating that is specified in the building code.

The party wall shown in Figure 4 separates two suites and acts as a fire separation and a sound barrier. The wall consists of a double wall with an air space between. One wall is sheeted on the inside, and each floor has a sheet metal firestop.

Note: Plumbing pipes should not be placed inside a party wall. Check with the authority having jurisdiction.

It is critical that piping systems do not compromise the integrity of fire separations, walls, and firestops.

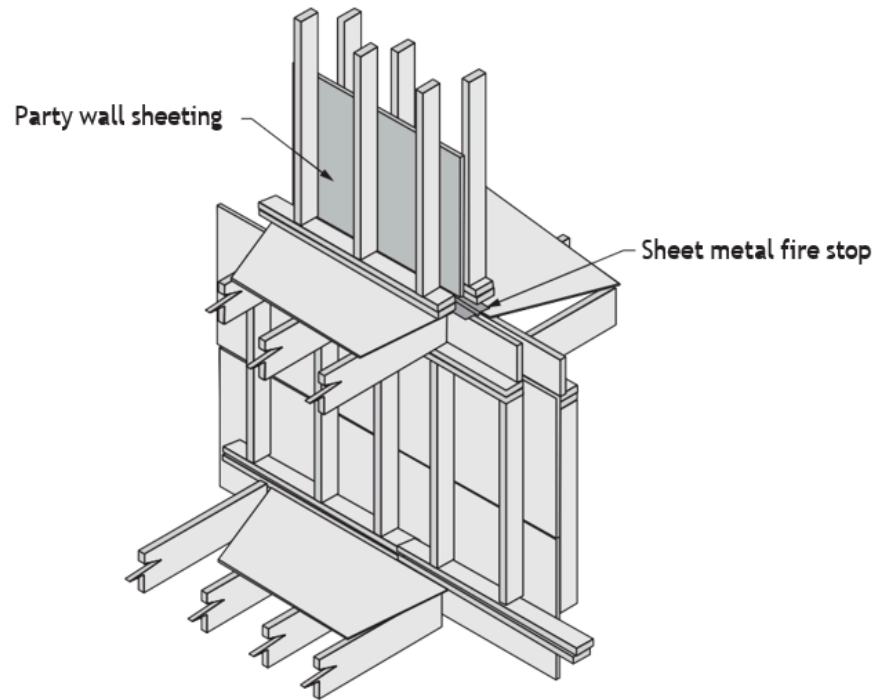


Figure 4 Party wall (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Glued, Laminated Beams

Glued-laminated beams are commonly referred to by a variety of names, such as *glulam* and *paralam*. A glued-laminated beam consists of multiple layers of thin strips of wood glued together to create a beam of standard dimensions.

In general, avoid drilling or notching glued-laminated beams. However, the Engineered Wood Association (APA) says that you can field-drill small-diameter holes for wiring and conduit. The location, size and number of these holes are restricted. You must consult with the manufacturer and confirm with the inspection regulatory authority. Avoid cutting, notching or drilling laminated beams unless the manufacturer, engineer and building officials specifically approve. **Always consult the manufacturer's specifications and regulatory authority before making any modifications.**



Figure 5 Laminated Veneer Lumber (LVL) beam (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Fire-Blocks

A **fire-block** is a firestop material installed during construction. A fire-block should not be confused with a *firestop*. Firestops are required when a higher degree of fire protection is required, particularly when there are penetrations through fire-rated separations. Firestops are covered in D-4.2 Describe Acceptable Methods of Structure Penetration (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration). Fire-blocking involves field-installing building materials to prevent undetected flames and gases from moving through concealed spaces to other areas.



Do not remove or damage fire-blocks, as this will compromise fire safety.

During a fire, flame and heated products of combustion can spread via paths of least resistance. Certain structures, particularly wood-frame structures, have concealed voids or cavities within walls, ceilings, attics, and crawl spaces. These concealed spaces not only affect the spread of fire, but also make suppression more difficult. Frequently, and inevitably, pipes, vents, ducts, and similar items will penetrate fire-blocks. You must be able to recognize a fire-block when you see one so that you do not remove it or otherwise jeopardize its ability to restrict the spread of flames and gases.

Fire-blocks are required in the following locations:

- Between floors
- Between a top-storey and a roof or attic space
- In furred spaces or the cavities between studs in wall assemblies
- At connections between horizontal and vertical spaces created in floor joists or trusses, soffits, drop or cove ceilings, combustible exterior wall finishes and architectural elements
- Openings for pipes, vents, ducts, chimneys and fireplaces

Fire-blocks can be constructed of various materials, including:

- 2 inch nominal lumber
- Structural wood panels
- Gypsum board (drywall)
- Cement fibreboard for larger fire-blocks
- For smaller fire-blocks, batts or blankets of mineral wool or glass fibre, loose fill insulation and caulks, sealants, and putties

Check with the local authority having jurisdiction for appropriate fire-block material.

Figure 6 shows a fire-block in an attic space.

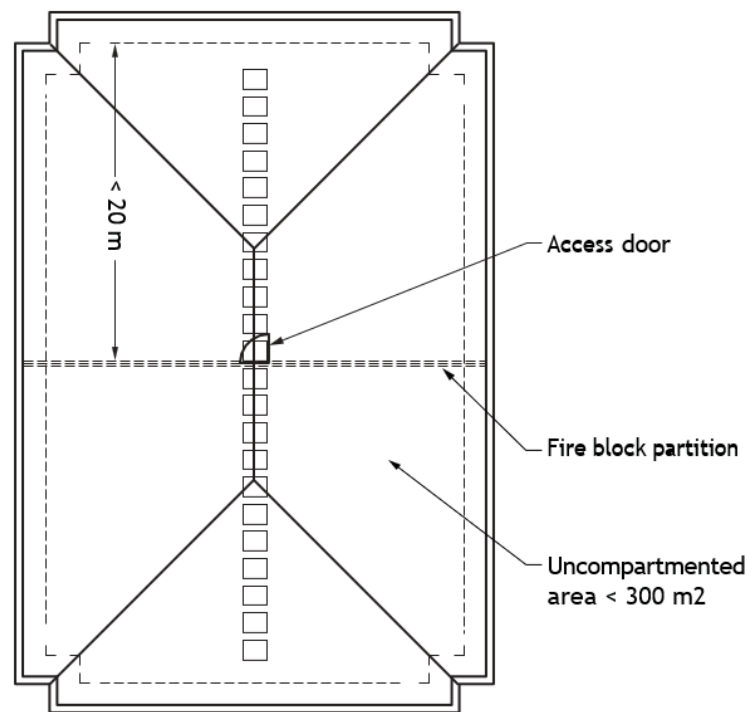


Figure 6 Fire-block in a shared concealed attic space above two occupancies (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 7 shows an example of an attic firestop under construction. Any items penetrating this firestop will need to be fire blocked to prevent rapid fire spread.



Figure 7 Attic fire block (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Wood-Frame Construction Penetrations

One important consideration when installing piping in wood-frame buildings is the placement of piping to avoid interfering with the integrity of the building's structural supports. Normally, drilling and notching structural support members is not permitted. There may be exceptions to this rule; however, consultation with and approval by engineers and building officials will be required.

The following information is generic in nature and is not specific to a particular code wording or manufacturer's specifications. The information is based on references to the BC Building Code (<https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/bc-codes/2024-bc-codes#2024>) and manufacturer's information. On the job you will need to reference the building code and specific manufacturer's specifications for drilling and cutting of building framing.

Cutting Holes in I-Joists

Today, wood-based lightweight **I-beams** (also called I-joists) (Figure 8) are widely used in the construction industry. An important feature of these beams is that holes may be cut in the web, but not in the flange.



Figure 8 Wood I-beam type joist components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Hole-cutting specifications for wood I-joists:

- Round holes do not have to be centred on the joist centre but must not be closer than 1.25 cm ($\frac{1}{2} \text{ in.}$) from the joist flange.
- Do not cut or damage the joist flange.
- A maximum of three holes is permitted per joist.
- Cut all holes carefully.
- When more than one circular hole is cut, the distance of uncut web between the holes (Figure 9) must be twice the diameter of the largest diameter hole. For square holes, the minimum distance of uncut web between the holes must be two to four times the length of the largest adjacent hole.
- A maximum size of 3.75 cm ($1 \frac{1}{2} \text{ in.}$) holes may be cut anywhere in the web, provided the centre-to-centre measurement is 30 cm (1 foot) on centre.

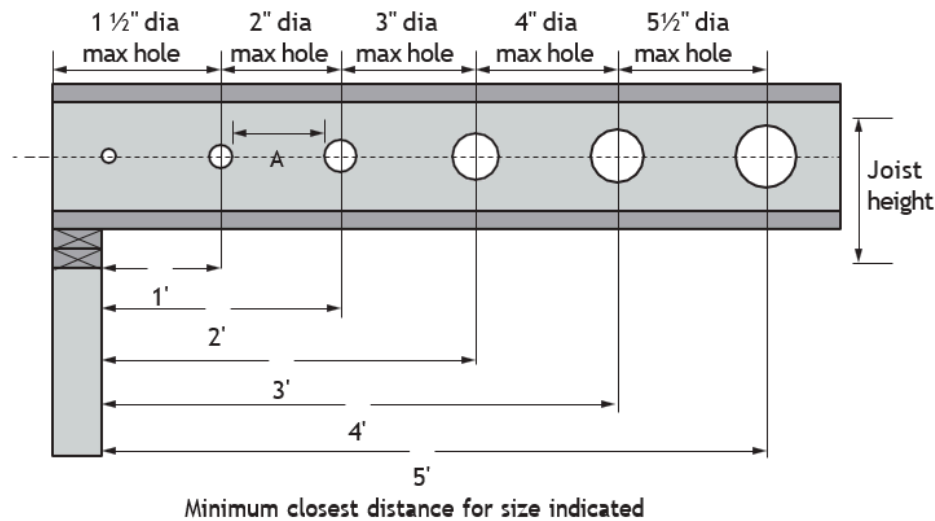


Figure 9 Spacing of holes in wood I-joists (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 9 shows the typical maximum dimensions for round hole diameters and the minimum distance from the bearing support for joist depths of 237.5, 298 and 350 mm (9.5 in., 11 $\frac{7}{8}$ in. and 14 in.). Consult the manufacturer's specifications before cutting any holes.

- Square cut holes must be centered on the web.
- Some manufacturers require square or rectangular holes to be located in the middle third of the span.
- Some manufacturers will not allow any holes in a joist within 120 cm (48 in.) of the supporting member (Figure 10).

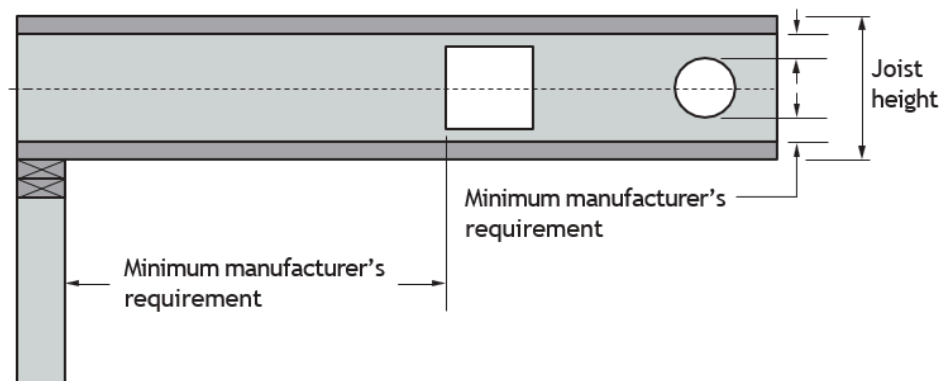


Figure 10 Spacing of square and rectangular holes in a laminated I-joist (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Observe the following rules when cutting a laminated I-joist:

- Do not cut, drill, notch or chisel the flange.
- Do not over-size the holes in the web.
- Do not break out holes with a hammer.
- Do not cut holes too close to the bearing supports.

Do not assume that it is OK to cut or drill a hole in a beam for a small pipe. Always consult with the manufacturer's specifications, regulatory codes, inspection authority and design engineer before attempting to drill or cut a structural support. The job site supervisor (general contractor) would be a good source of information.

Specifications for Holes in Glued, Laminated Beams

Examples of access holes include those used for the passage of wires, electrical conduit, small-diameter sprinkler pipes, fibre-optic cables, and other small, lightweight materials. These field-drilled horizontal holes should meet the following guidelines.

- The hole diameter should not exceed 38 mm (1.5 in.) or $\frac{1}{10}$ the beam depth, whichever is smaller.
- The minimum distance from the edge of the hole to the bottom or top edge of the beam is four hole diameters.
- The minimum distance from the edge of the hole to the end of the beam is eight hole diameters.
- Holes 25 mm (1 in.) diameter or smaller should not be drilled in the area above and below the center rectangle (Figure 11) unless approved by the design engineer and regulative authority. This area is called the **moment critical zone**. The dimension of the zone will be provided by the manufacturer.
- The horizontal hole should not be drilled in areas other than as defined in Figure 11 unless approved by an engineer or architect qualified in engineered timber design.
- Field-drilled horizontal holes should be used for access only and should not be used as attachment points for brackets or other load-bearing hardware unless specifically designed by the engineer or designer.

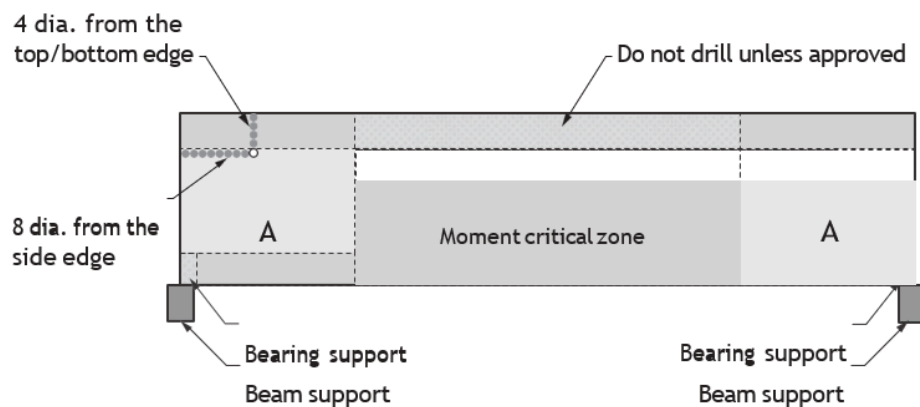


Figure 11 A = Zones where small-diameter horizontal holes are permitted for passage of wires, conduit, etc. (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Notching and Drilling of Joists

The BC Building Code advises that holes in roof, floor, or ceiling framing members shall not be larger than one-quarter the depth of the member and must be located at least 50 mm (2 in.) from the edge, unless the depth of the member is increased by the size of the hole (Figure 12).

Note: Round holes are preferred over square holes or notches.

Nominal vs. Actual Joist Dimensions

The actual dimension of a 2" x 10" joist is $1 \frac{1}{2}$ " x $9 \frac{1}{2}$ " .

The actual size of a 2" x 12" joist is $1 \frac{1}{2}$ " x $11 \frac{1}{2}$ " .

Maximum hole sizes are calculated based on actual dimensions rather than nominal dimensions, as follows:

- The maximum diameter hole in a 2" x 10" joist is $\frac{23}{8}$ " .
- The maximum diameter hole in a 2" x 12" joist is $\frac{27}{8}$ " .

Note: To obtain the metric dimensions use the conversion factor 1 in. = 25.4 mm. Actual metric dimensions of some common nominal sizes are:

- 2" x 10" nominal joist = actual size 38 mm x 241 mm
- 2" x 12" nominal joist = actual size 38 mm x 292 mm

A nominal 3 in. diameter pipe has an outside diameter of approximately $3 \frac{1}{2}$ " inches. The pipe therefore cannot be

installed in a nominal 2" x 10" joist or 2" x 12" joist. A 3 in. pipe would require at least a $3 \frac{5}{8}$ " in. hole to allow for clearance. This would mean a minimum 16 in. joist is needed.

Note: Never notch the bottom of a joist or cut sections out of a joist.

The BC Building Code advises to avoid notching if possible, but notching floor, roof and ceiling framing members is permissible under the following restrictions (Figure 12):

- The notch must be located on the top of the member within half the joist depth from the edge of the bearing.
- The notch must be not deeper than one-third the joist depth, unless the depth of the member is increased by the size of the notch.

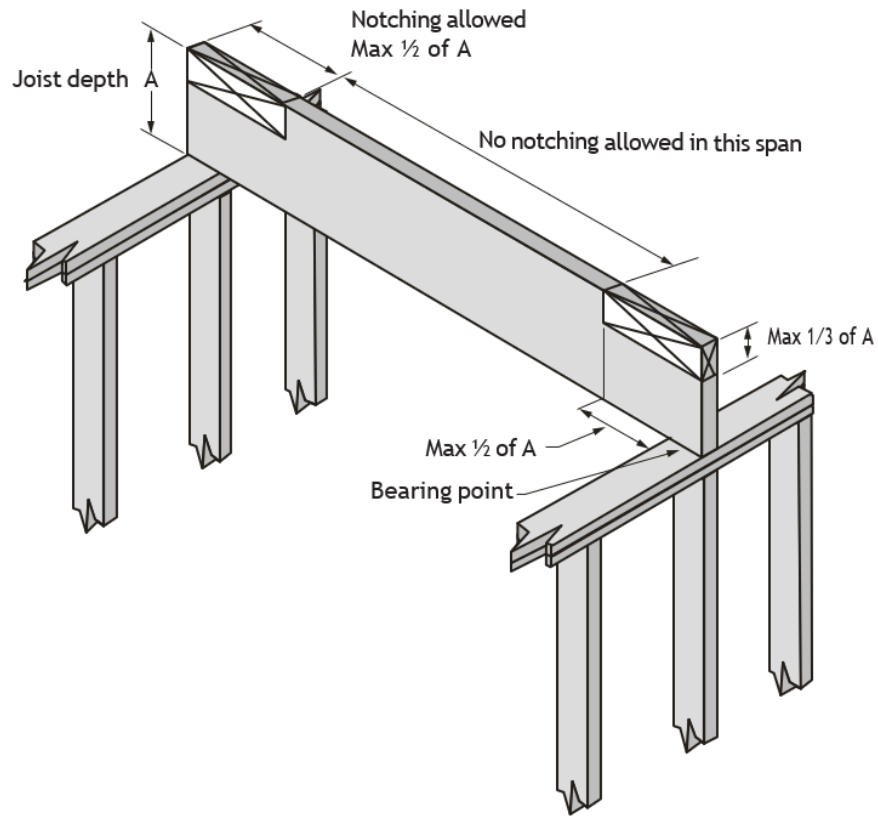


Figure 12 Permissible notching of floor, roof and ceiling framing members (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Notching or Drilling Studs or Plates

Notching and drilling studs and plates is acceptable as long as the following BC *Building Code* requirements are followed.

Wall studs must not be notched, drilled, or otherwise damaged so that the undamaged portion of the stud is less than two-thirds the depth of the stud if the stud is load-bearing, or less than 40 mm (1.6 in.) if the stud is non-load-bearing, unless the weakened studs are suitably reinforced.

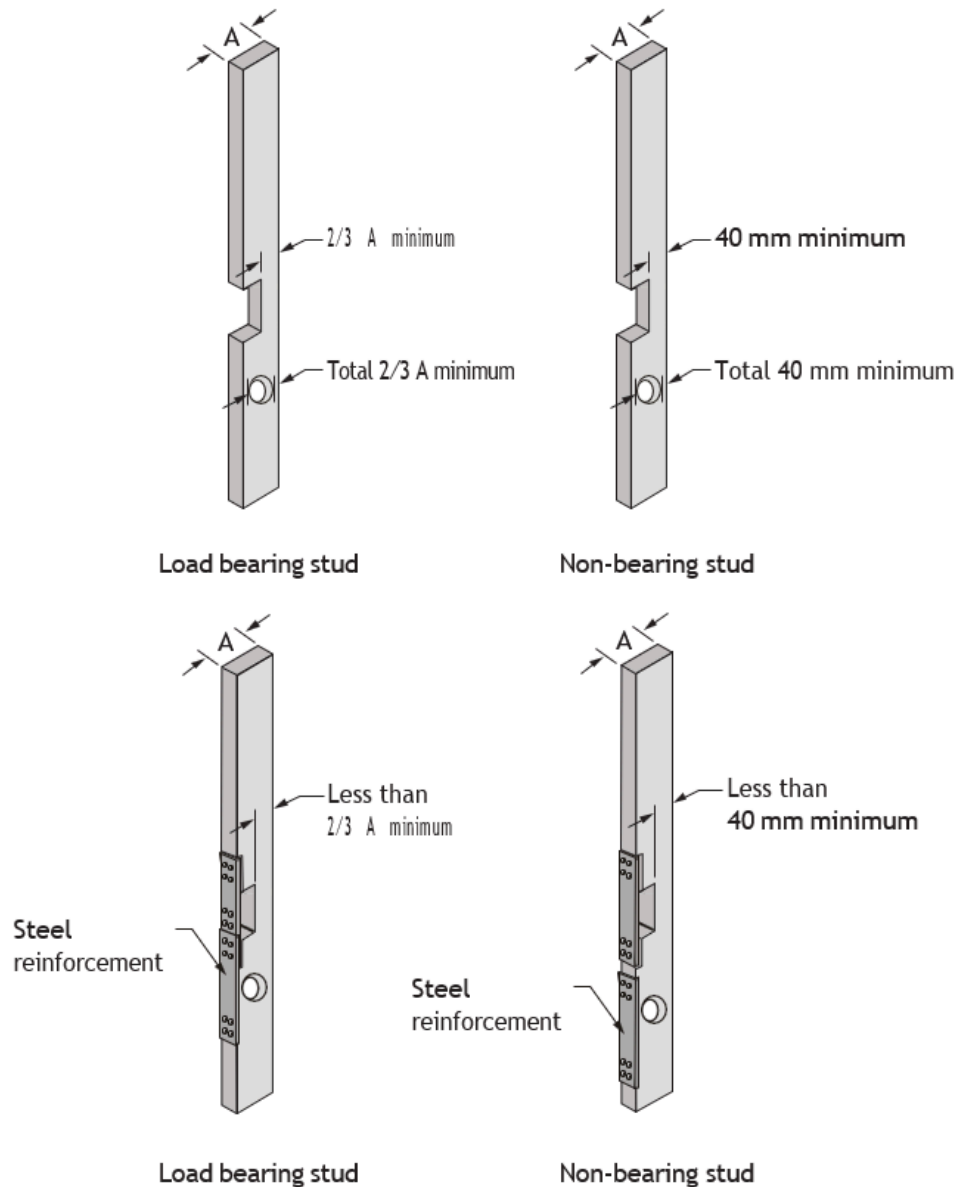
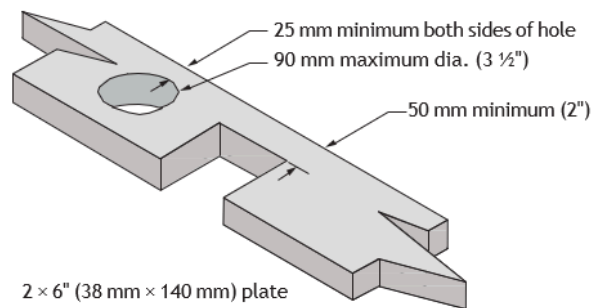
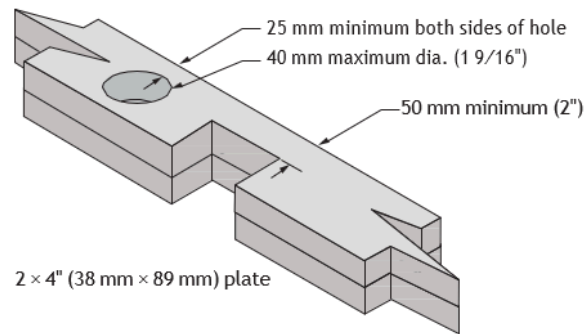


Figure 13 Load-bearing and non-load-bearing stud notching: minimum requirements (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Top Plate Drilling and Notching (BC Building Code clause interpretation)

The top plates in a wall must not be notched, drilled or otherwise weakened by reducing the undamaged width to less than 50 mm (2 in.), unless the weakened plates are suitably reinforced (Figure 14).

Note: A 3 in. pipe cannot be installed through a 2" × 6" plate without additional reinforcement. Likewise, a 1 $\frac{1}{2}$ " in. pipe cannot be installed through a typical 2" × 4" plate without reinforcing.



Typical OD of pipes



Figure 14 Permissible cutting of wall top plate (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Top Plate Reinforcement

When a hole that is larger than permitted is cut in a plate, reinforcing must be installed, as shown in Figure 15.

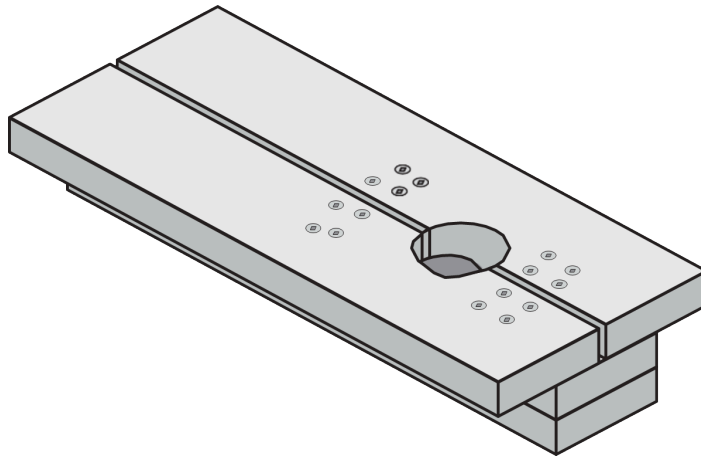


Figure 15 Reinforcing plate added for oversized penetration (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 16 Proper drilling of holes and pipe support (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The top and bottom plates or tracks of the walls are sometimes riddled with openings for pipe and cable penetrations. The extent of such holes can affect the structural integrity of the wall. The practice of installing an excessive number of openings too close together should be avoided.

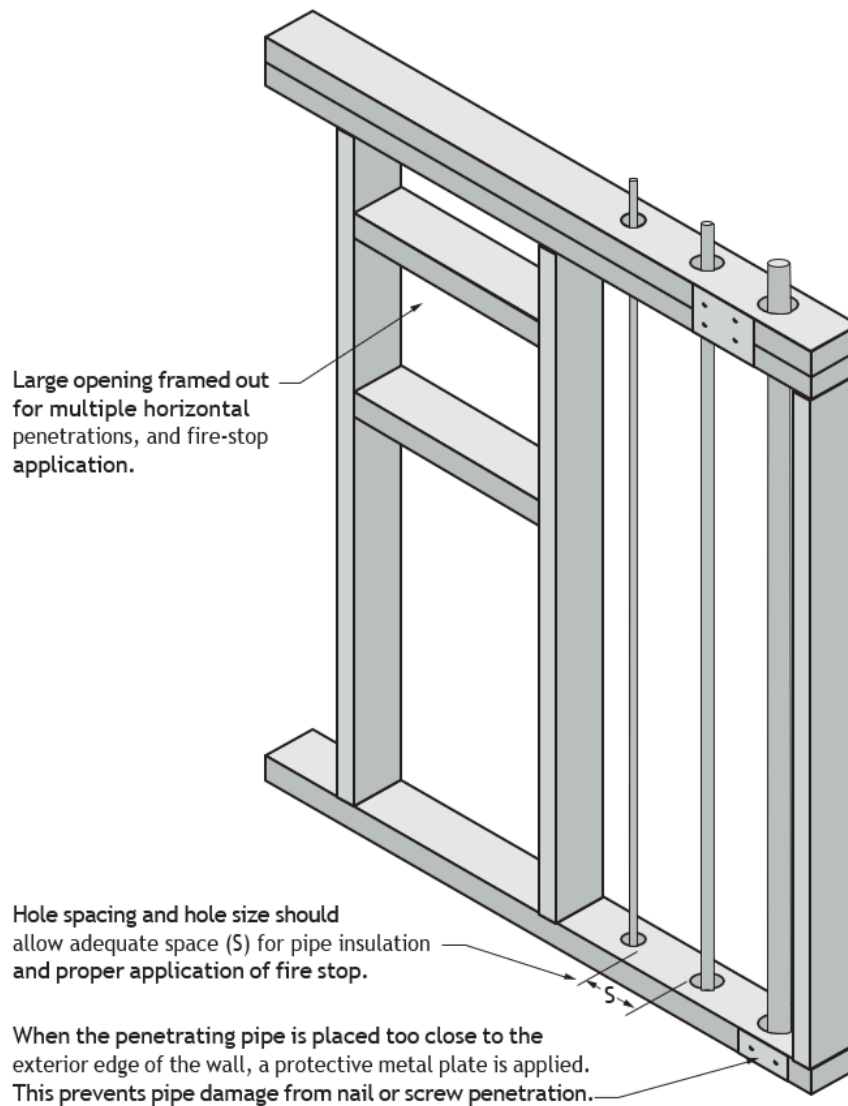


Figure 17 Wood-framed wall hole location and protective metal plates (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

When the penetrating pipe is placed too close to the exterior edge of the wall, a protective metal plate is applied. This prevents pipe damage from nail or screw penetration.

Where the plate and stud wall do not make up a fire separation, they are not affected by firestop requirements. In this situation, the recommended practice is to space the holes so that the minimum distance between them is the same as or larger than the largest adjacent pipe's diameter.

When a number of items are required to penetrate a fire separation, good practice dictates that they be spaced in such a manner that each penetrating item is surrounded by sufficient firestop material and separated by sufficient base construction material to ensure the stability and integrity of the firestop.

Sound Transmission Barrier Penetrations

Another important design feature in a structure is the elimination of **sound transmission** within the building. It is clear that an increase in sound transmission will occur when an opening is provided for the installation of piping. When sound transmission reduction is a component part of the structure then steps need to be taken to maintain the sound transmission integrity.

You need to identify the structural components that may require sound transmission reduction. Identifying locations where a sound barrier component is needed is not easy. Some things you need to look for include:

- Walls between occupancies (e.g., a library and a restaurant)
- Walls between a bathroom and an entertainment room

When pipe penetrates through or contacts a structural member that is acting as sound barrier, the structure's sound integrity can easily be destroyed. Pipe installed within a wall may not penetrate the wall; however, a pipe contacting a structure component can transmit and amplify sound throughout the structure. The use of sealed pipe sleeves, insulators, or **vibration isolators** can eliminate or reduce sound transmission. Avoid direct contact with the structural components.

Some visual indicators to help identify sound transmission barriers include:

- Walls with offset studs
- High-density insulation in interior walls
- Party walls between occupancies; these are usually double-stud wall fire separations containing a 25 mm (1 in.) air space between the stud walls
- Double layer of wall boarding
- Public corridor walls between the corridor and residential suites; these are usually single walls with smaller offset studs on a larger plate
- Firewalls and fire separations often have sound barrier qualities
- Floor assemblies between residential suites

To reduce sound transmission for vertically installed pipes, install the pipes as follows:

- In multi-storey buildings, install the piping in furred outer walls in front of double-stud walls, fire separations or party walls, or other interior walls; or
- Install the pipe in framed-out service spaces.

Note that wastewater flowing through an ABS pipe is considerably noisier than that flowing through a cast iron waste pipe.

For horizontally installed pipes in a multi-storey structure, install the pipe servicing the occupant unit located above within the rated floor assembly. Where possible, provide a false ceiling for services in the occupant unit below.

Typically, installing piping within or through walls, ceiling or floors will increase the possibility of sound penetration. You are responsible for maintaining the sound transmission prevention design integrity of a wall, ceiling or floor you are penetrating.

Protecting Pipe from Nail and Screw Damage

Figures 18 and 19 illustrate the proper application of pipe protection plates on studs where pipe is penetrating. When installing reinforcement on a stud surface, you must be aware of the thickness of the reinforcement plate. The thicker the plate, the more the wall finish will bulge, resulting in a product with a poor finish.



Figure 18 Correct use of pipe protection plates (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 19 Protection plate on a stud over an ABS pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Residential Roof Penetrations

For new residential shingled roof applications, you would need to have the penetrating pipe installed before the roofing contractor arrives. You would supply the **flashing** and **flashing cap**. Place the flashing over the pipe for the roofer. If a

flashing cap is required have that available for the roofer. The sealing of a pipe penetration is best left to the roofing contractor.

For existing shingled roofs, you may be required to waterproof the vent penetration. This may involve the use of counter flashing and waterproof sealing compounds. The plumbing code regulates the dimensions and material used for flashings as well as the size and distance above the roof that a vent pipe and flashing extend. In cold climates and conditions, the size of the penetrating vent pipe vent is increased. The increase in size helps prevent blockage caused by freezing over of the opening.

Figures 20 and 21 show vent pipe penetrations and flashings on sloped shingle roofs.



Figure 20 Roof plumbing vent penetration, lead flashing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 21 Roof plumbing vent penetration, poly flashing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Wood Roof and Floor Trusses

The BC Building Code (<https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/bc-codes/2024-bc-codes#2024>) advises that roof truss members (Figure 22) not be notched, drilled, or otherwise weakened unless such notching or drilling is allowed for in the design of the truss.

A roof or floor truss structural support should never be cut, drilled, notched or otherwise have its structural integrity jeopardized. It is a good idea for the piping installer to plan ahead for the routes that will be taken by the piping system. Conflicts with truss placement need to be solved before installing either trusses or piping.



Figure 22 Wood roof truss (https://commons.wikimedia.org/wiki/File:Defense.gov_photo_essay_100713-A-5170O-167.jpg) (Sgt. Nicholas Olson/United States Army [ID (<https://commons.wikimedia.org/wiki/Commons:VIRIN>) 100713-A-5170O-167 (http://www.defense.gov/dodcmsshare/photoessay/2010-07/hires_100713-A-5170O-167a.jpg)]/Wikimedia Commons) Public Domain (https://en.wikipedia.org/wiki/public_domain)

Metal Roof Trusses

Do not cut, drill, notch, or remove a truss or component from a **metal roof or floor truss**.



Figure 23 Metal roof and floor truss (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Metal Decking

At times, you will work on jobs that use metal trusses and **metal decking**. Often the metal deck is covered with concrete. The floor is usually a fire separation. Firestopping and the installation of pipe sleeves or canning are often required.

Plumbing and mechanical system piping exiting through a roof require flashings to maintain structural integrity against moisture and rain penetration. Poor flashing installation or system design will increase the number of pipe penetrations and thus increase the possibility of jeopardizing the integrity of the roof structure. The trick here is to install the pipe through the roof and provide the flashing for the roofing contractor to install.

Penetrating Steel Columns and I-Beams

Steel columns and I-beams should not normally be cut or otherwise altered on the job.

Any holes required for pipe penetration should be done at the time of manufacturing. When holes are required in a beam or column, it is best to have them punched in the shop when the steel is fabricated.

Field holes may be cut in steel beams or columns; however, the approval of a structural engineer or competent architect would be required. Any holes would be cut in the middle third of the I-beam web. No holes are to be cut at all in the outer thirds of the beam. The hole may need to be reinforced. The specific holes should be approved by a design professional wherever they are to be cut, and they should be cut by a licensed welder.

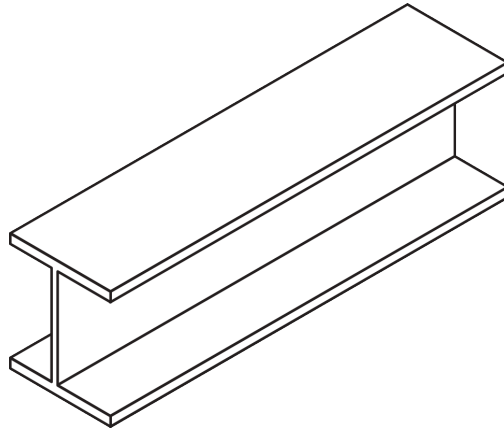


Figure 24 Steel I-beam (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 25 shows an I-beam supporting a wood deck. Do not cut or notch either of these structural support components.



Figure 25 Steel I-beam supporting a wood deck (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Penetrating Steel Wall Studs

Steel studs typically are supplied with a limited number of precut holes. Where precut holes are not useful, new holes can be cut with sheet metal snips or a hole-punch.

Piping penetrating steel stud walls that serve as fire separations will require firestopping. Pipe located within the wall may require isolation from the steel components. Sharp steel edges can physically damage the pipe, especially plastic piping such as cross-link polyethylene (PEX). Copper piping needs to be isolated from contact with the steel studs to avoid damage that contact between dissimilar metals can cause. This can be accomplished by **grommets** or by wrapping with electrical tape. See Figures 26 and 27.

Concrete slab is a fire separation between upper and lower floors. Firestopping is required at all pipe penetrations.

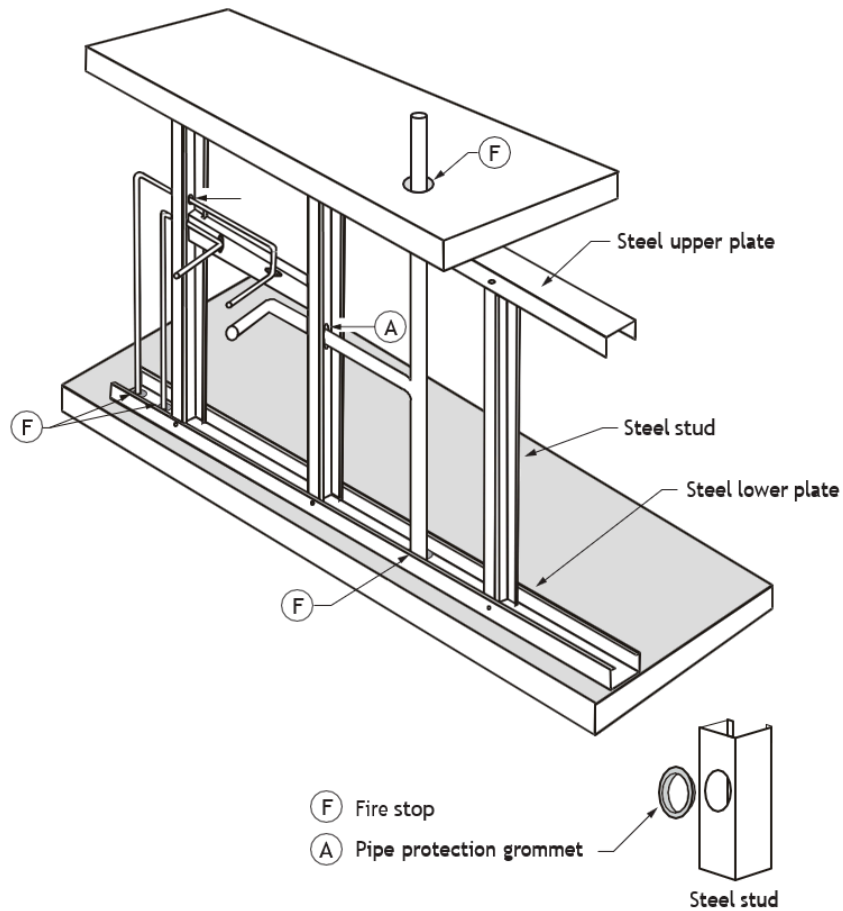


Figure 26 Penetration of steel wall studs (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 27 Plastic grommets (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Penetrating Concrete Walls and Concrete-block Walls

Piping penetrations of concrete or masonry walls may require insulation, waterproofing, firestopping or protective pipe wrap placed around the pipe penetration. These measures ensure the integrity of the wall being penetrated.

You must be aware of the location of the web portion and the hollow portion of a concrete masonry block wall. Any pipe passing through the wall will ideally penetrate the hollow portion of the concrete block and not the web.

Figure 28 shows a concrete block with pre-cut knock-outs which may be used to install a **bond beam**.

When penetrating a concrete block wall after it has been constructed, you need to locate the hidden components before you drill. The concrete block wall cross-section in Figure 29 shows pipe sleeves, bond beam and hidden components. The bond beam ties together and strengthens the concrete block wall. It is located at the last or top course of blocks.



Figure 28 Concrete block with bond beam pre-cuts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

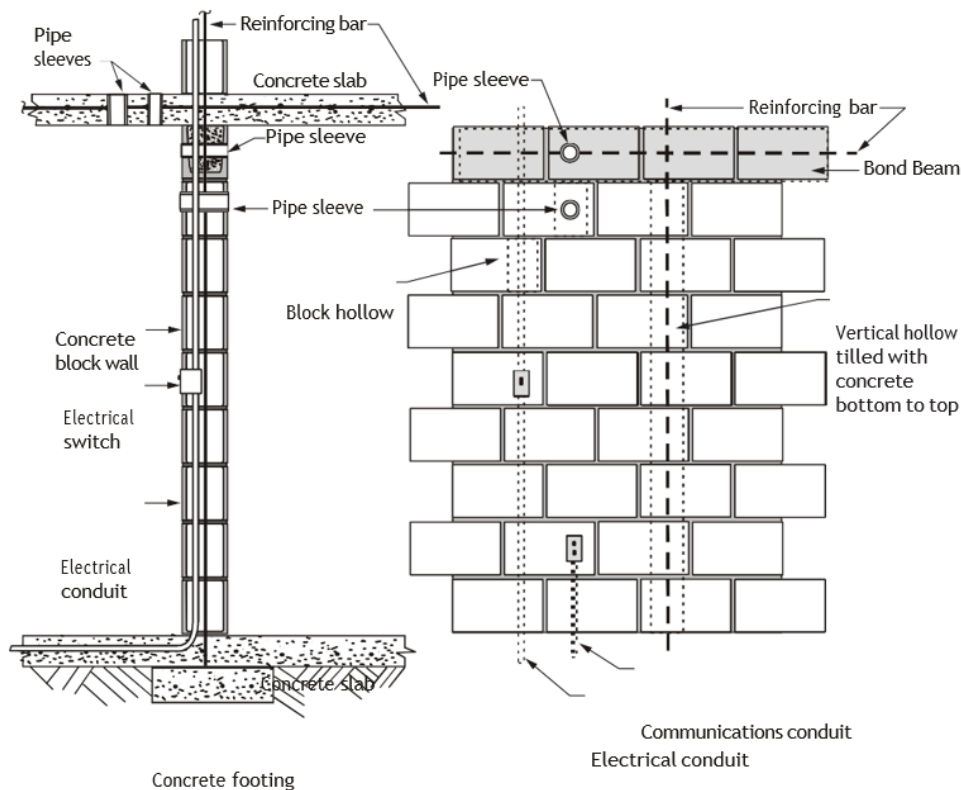


Figure 29 Masonry concrete block wall with hidden components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Concrete Construction Formwork

When you are working on a job site where there is concrete construction, you may be penetrating concrete walls, floors and roof structures with piping. Openings in a concrete structure for the purpose of installing pipe are usually cast into

the concrete by the use of pipe sleeves. This is done at the time of the concrete pour to avoid the expense of having to drill through the concrete after the concrete is cured.

Where holes need to be drilled in existing concrete, you need concrete drilling and breaking equipment and drill bits capable of cutting through **rebar**. The mechanical contractor may have these tools. If not, they can be rented. Companies that specialize in concrete drilling/coring can also be contracted to perform this task.

Before drilling or breaking into an existing concrete wall, you need to do some investigation to locate hidden reinforcing bars, electrical conduit and communication cables buried in the concrete. To avoid contacting these hidden components, locate and review existing construction plans. The building owner or the local government building inspection authority may have original drawings. Look for electrical equipment mounted on a concrete wall or ceiling. The absence of surface-mounted conduit may indicate that conduit is buried in the concrete. Pipe-locating companies may have equipment to detect hidden components.



Figure 30 Rebar, electrical conduit, pipes, and pipe sleeves ready to be buried in concrete (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 31 shows a cross section of a concrete construction. Notice the hidden structural components and the use of pipe sleeves to penetrate the slab.

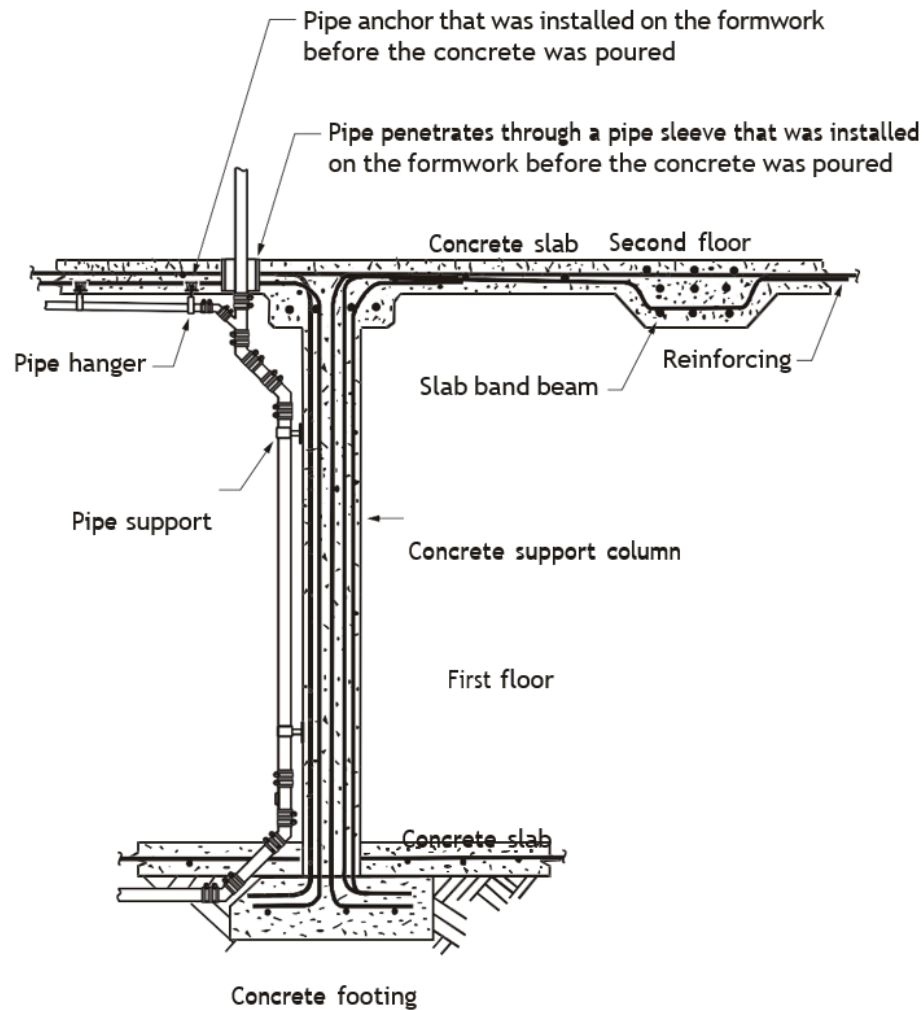


Figure 31 Cross-section of basic structural components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 32 Pipe anchors (concrete hanger inserts) installed before the concrete is poured (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figures 33 and 34 give an idea of the work environment in buildings with concrete structural components. Figure 33 shows the formwork being installed in preparation for the first-floor concrete slab. The **teleposts (telescopic)** support the formwork and the weight when the slab is poured. After the concrete has cured the post will be systematically removed in stages. The photo in Figure 34 was taken from above the posts. You would install pipe sleeves on the deck before the concrete is poured.

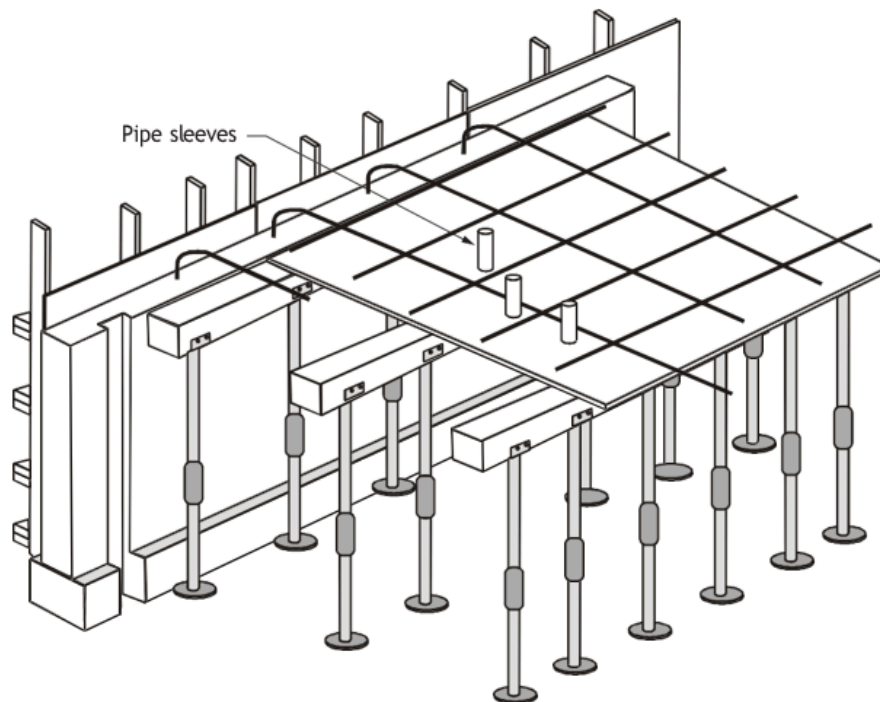


Figure 33 First floor formwork (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 34 Formwork from above jack posts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 35 shows formwork for a foundation and the installation of pipe sleeves and **block-outs**. You would have located these sleeves and block-outs during this stage of construction.



Partial installation of post jacks support and deck not complete. Addition beams and cross bracing not shown. Pipe sleeve, water lines enclosed in sleeves, electrical conduit, reinforcing bar are all being installed. Timing of installation and accurate placement of these components is critical.

Figure 35 Partially complete formwork for a concrete slab, showing pipe sleeves (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

As an alternate method of reinforcing concrete slabs with rebar, **post-tension slabs** can be installed. Cracking due to shrinkage is reduced and cracks that occur will be held together under the tension of the slab. Cables are installed in a slab before the concrete is poured. One end is anchored while the other end protrudes out the other side of the slab. These are referred to as **tendons**.

When the concrete has come to an appropriate strength, the cable will be stretched, cut off and grouted in place. Safety becomes an issue when **coring** or drill post-tension slabs. Cut tendons can cause structural damage and injury or death to workers. Locating tendons before coring is one of the first steps when penetrating a post-tension slab. Small openings can be made using a coring machine. Large penetrations (ex. duct shafts) may require concrete sawing. Consult with a professional engineer before penetrating a post-tension slab.

Pipe Sleeves

A **pipe sleeve** is a hollow, cylindrical insert placed in a wall, floor, structural component or **concrete formwork** to allow a pipe to penetrate the structure.

Pipe sleeves are short pipes or tubes that act as a conduit for pipe that passes through walls, ceilings, floors, foundations, footings, and so on. Sleeves allow the pipe to move through the partition free of building weight, abrasion, or corrosion. In concrete construction a sleeve placed in formwork before a wall or floor is poured is sometimes referred to as a *can*. The process of installing these sleeves is often called **canning**.

The sleeve should be positioned to reflect the orientation of the pipe that will pass through it. A vertically installed pipe will require the pipe sleeve to be positioned vertically (plumb) above the formwork deck.

The term *pipe sleeve* also refers to protective pipe or tubing that surrounds a pipe carrying the fluid to be used. The sleeve protects the internal pipe from damage. Pipe sleeves may be used in corrosive ground conditions, concrete slabs, and under traffic ways. The pipe sleeve will allow the pipe to move freely and maintain a seal at the same time.

Fabrication of Pipe Sleeves (Pipe Chases or Block-Outs)

Pipe sleeves can be fabricated on the job site from materials such as steel, cast iron or plastic pipe, or from sheet metal. Pipe sleeves can also be purchased from a manufacturer as an assembly with firestop components. Pipe sleeves should be strong enough to resist the crushing weight of the surrounding building structure. The pipe should not normally bear weight or place any strain on the structure, unless the sleeve or pipe is designed to do so.

Placement of Pipe Sleeves

Multiple pipes penetrating a sleeve can create issues with application of pipe insulation, maintenance of proper clearances between pipe and the application of firestopping—**avoid this practice!**

Pipe sleeves are ideally positioned so the pipe and the sleeve are centred with each other. The clearance around the pipe and the sleeve is referred to as the annular space. The annular clearance is often specified in the manufacturer's firestop installation requirements.

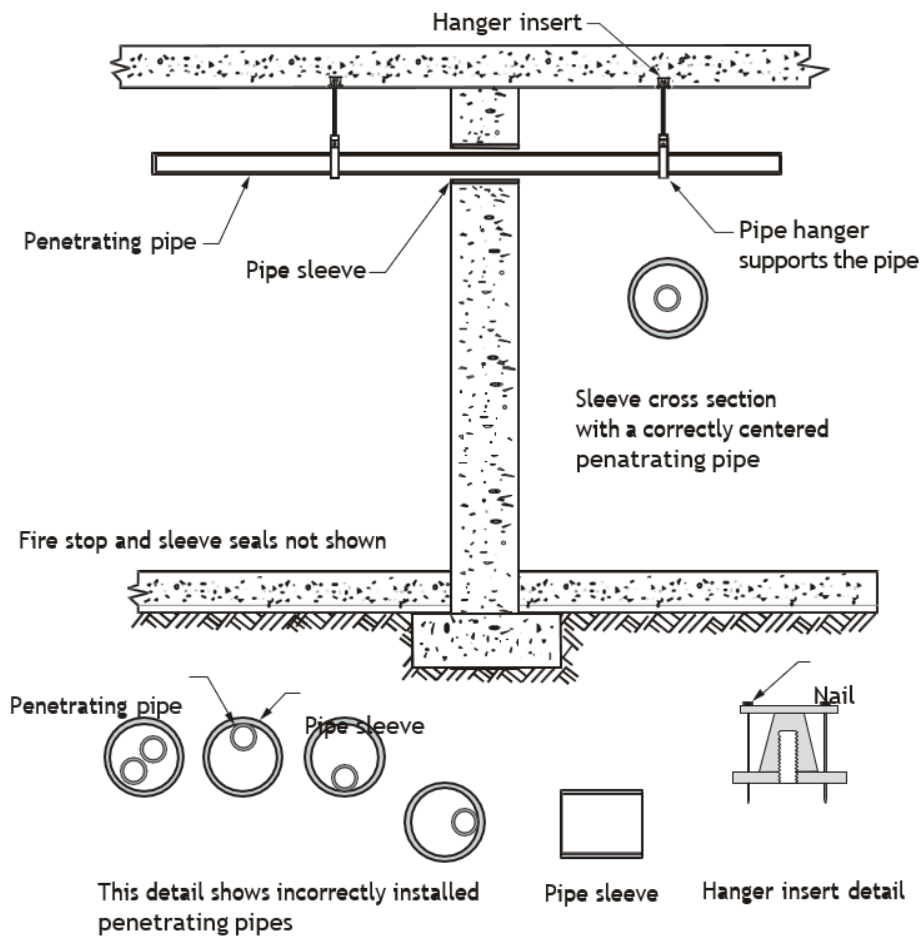


Figure 36 Placement of pipe and pipe sleeve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

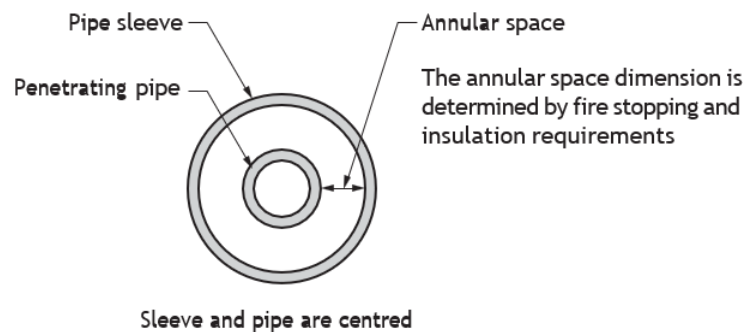


Figure 37 Positioning of pipe within a pipe sleeve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Timing of Sleeve Installation in Interior Walls

Often, interior framed walls are installed after the piping has been installed. Where needed, pipe sleeves would be slipped over the pipe as the pipe is being installed. When the wall is installed, the pipe sleeves are already on the pipe. The sleeve must be positioned to the centreline of the penetrating pipe. Pipe insulation or some other method could be used to centre the pipe sleeve at the time of the pipe installation. If you leave the centring of the pipe sleeve up to another trade, chances are it will not happen. You will be left to centre the sleeve later. If the installation of the wall has locked the sleeve into an off-centre position, you may have some difficulty trying to centre the sleeve.

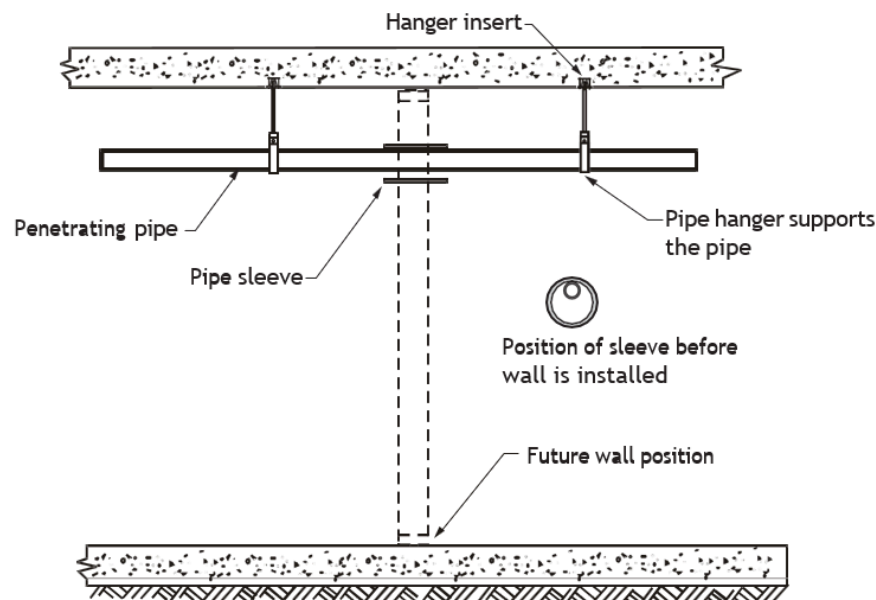


Figure 38 Pre-positioning of pipe sleeve before wall is installed (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Sloped piping will require the sleeve to be sloped, or the sleeve must be sized large enough to allow the penetrating pipe to maintain slope through the sleeve.

Installing Sleeves in Deck Formwork (Canning)

Multi-storey, multi-unit office, and housing structures are often constructed with concrete floors and slabs for structural stability and load-bearing capacity. In these structures, a sleeve is usually a length of pipe or tube that can be installed on or in concrete formwork before the concrete is poured. The sleeve provides an opening for pipe, conduit or communication cables after the concrete is cured.

Figure 39 shows examples of manufactured pipe sleeves that are installed during formwork for concrete structures. These sleeves are installed before the concrete is poured.



Figure 39 Pipe sleeves (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Sizing of Pipe Sleeves

The diameter of a pipe sleeve depends on the following:

- External diameter of the penetrating pipe
- Allowances for expansion and contraction of the pipe
- Allowances for the application of pipe insulation
- Annular space required for firestopping components
- Water and or vapour penetration prevention
- Air movement, drafts

The length of the sleeve will depend on the thickness of the finished wall or floor. In some instances, the sleeve may extend beyond the thickness of the floor to prevent flooding on the surrounding floor. The sleeve may extend to accept a sealing boot (Figure 40).

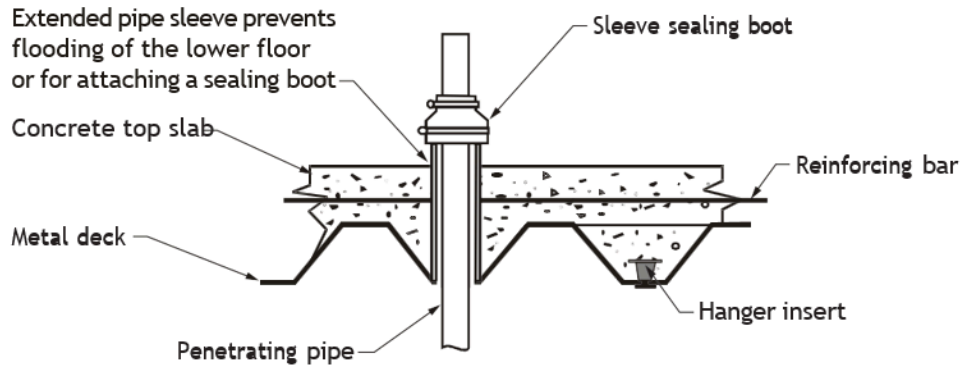


Figure 40 Penetrating pipe with sleeve sealing boot (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Threaded inserts are installed on the formwork deck at the same time as the pipe sleeves. They remain solidly embedded in the concrete after it has cured. The inserts support pipes suspended from the underside of the concrete slab.

Timing of Installation of Pipe Sleeves

The timing of sleeve installation is important. Pipe sleeves are installed when the foundation formwork is being constructed, before concrete slabs or walls are poured. They are also installed during construction of walls, such as concrete block walls.

When the formwork for a concrete slab is completed, several trades will begin work on the deck. The best opportunity to install pipe sleeves is before the reinforcing bar is installed, when the deck is clear of obstructions.

Construction-site scheduling usually has deadlines for specific stages such as the pouring of the concrete. The trades must communicate and cooperate with each other while on the deck to ensure there is no conflict between the placement of the various components. This is an important time for the whole job. It is not a matter of first-come first-served.



Figure 41 Pipe sleeves installed before reinforcing bar (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Positioning of Pipe Sleeves on Formwork

The correct positioning of pipe sleeves, block-outs and pipe support anchors is critical. Repositioning pipe sleeves after the concrete slab has set is costly and time consuming. Concrete walls and floors poured in place for multi-storey structures must be precisely positioned. Straight lines of pipe passing through a series of walls or floors will need pipe sleeves to line up perfectly from floor to floor or wall to wall. Bringing a pipe back into alignment can mean significant time and materials costs, so the alignment must be correct from the beginning.

Usually placement of a pipe sleeve (canning) would depend on the position of walls, structural beams and other building components. The sleeves are normally installed so that the penetrating pipe ends up in a wall. No walls are marked on the formwork deck. To be able to install the sleeve in the correct position, you will need to read the structure's blueprint and specifications first. The blueprint alone will not be enough to locate the position of a sleeve. You will need to talk to the job general supervisor or charge-hand. A reference mark or grid line should be established and marked on the deck. This reference mark can be used by the different trades to establish a baseline from which measurements can be established.

Once you have established the precise location of the sleeve, it can be attached to the deck. This measurement should be double-checked by the construction site supervisor. Laser-type levels are valuable assets for positioning sleeves and pipelines. String lines or chalk lines are used to establish a wall or other reference point on the deck; however, a caulk line does not last long in wet weather. The string line can be attached to the deck at one reference point, then stretched tight to another reference point on the deck.

Figure 42 shows a deck with string lines being used as a reference line to establish the position of the firestop pipe sleeves.



Figure 42 String lines to locate sleeve positions (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Fastening Pipe Sleeves and Protection During the Concrete Pour

Field-cut pipe sleeves are anchored to the formwork deck using **caddy clips**, which clip onto the sleeves (Figure 43). The pipe clips are positioned and securely nailed or screwed to the formwork. The clips can accommodate various sizes of pipe and wall thickness up to schedule 80.



Figure 43 Attaching pipe sleeves using caddy clips (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 44 Caddy clips (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figures 45 and 46 illustrate working conditions and how the piping and pipe sleeves are protected and secured.



Figure 45 Positioning water pipes before pouring concrete (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 46 Pipe sleeve extensions used for thick concrete slabs (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Several turns of tightly applied duct tape can be used to attach a sleeve extension to an existing sleeve. The sleeve can be kept in a vertical position by attaching it to the reinforcing bar using tie wire.

During concrete pouring, activity on the slab deck can dislodge or damage pipe sleeves and hanger inserts. You must be present during the concrete pour to observe and be ready to make quick repairs or reposition and place any sleeves or hanger inserts that are disturbed. If this is not done promptly, the sleeve may not be suitable for use after the concrete has set.

Installing Pipe Penetrations After Concrete Has Set

Omitting a sleeve or incorrectly positioning it during the formwork leads to extra cost and wasted time because the concrete has to be drilled (cored) after the concrete has cured and the formwork has been stripped. Job profitability is jeopardized.

Normally you cannot simply break through a concrete slab or wall with jackhammer-type tools. Instead, the slab or wall will need to be cored with a rotary diamond-tipped core drill bit (Figure 47).

This type of drilling is usually done by specialized drilling companies using specialized concrete coring equipment. Electronic sensing equipment may be required to locate any hidden components before drilling.



Figure 47 Diamond drill coring (BC Industry Training Authority, 2019).
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Sealing Around Sleeves

The openings created where pipes pass through walls and floors can cause problems by allowing water, smoke, fire, drafts, vapours, and sound to enter or pass freely within the structure. Pipe sleeves installed around the pipe may need to be sealed at one or both ends.

Pipe sleeves and the pipe seals installed in fire separations must be fire rated. The fire rating must be equal to the rating of the fire separation. Typically, a fire-rated seal will be made from graphite-impregnated (ethylene propylene-diene monomer). The pressure plates are made of steel. A silicone elastomer is used for penetration seals for temperature applications up to 204°C (400°F).

Pipe penetration seals are available in two types:

- Fixed penetration seals (Figure 48)
- Flexible penetration seals (Figure 48)



Fixed type seal



Pipe sleeve with flexible, watertight seal

Figure 48 Pipe penetration seals (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe **sleeve seals** provide positive seals around pipe sleeves above or below ground to keep out debris, water, and pests.

Sealants used between and around the pipe and sleeve include:

- Flexible caulking
- Masonry mortar
- Mechanical elastomer seals
- Quick-setting bonding cement mixtures
- Pipe wraps

Figure 49 shows various applications of pipe sleeve seals.

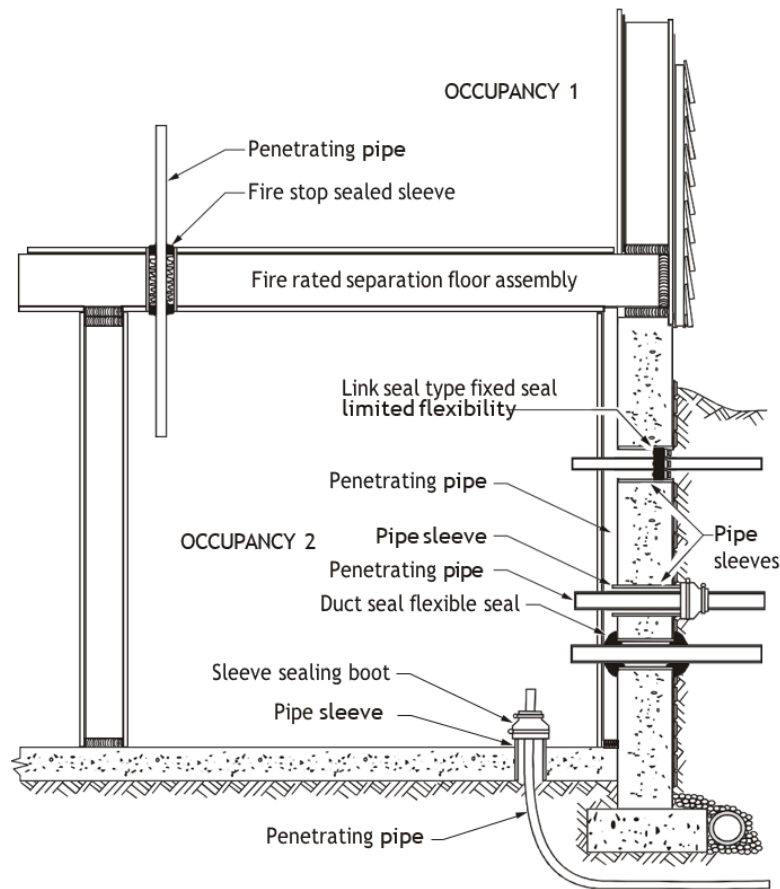


Figure 49 shows various applications of pipe sleeve seals. (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Fixed Penetration Seals

Fixed penetration seals are suitable if flexibility is not needed. A fixed mechanical seal for general service can be made of EPDM (ethylene propylene-diene monomer), which is a synthetic rubber elastomer. Where the seal may come in contact with hydrocarbons, it may be made of nitrile. The pressure plates that hold the seal are generally made of glass-reinforced plastic

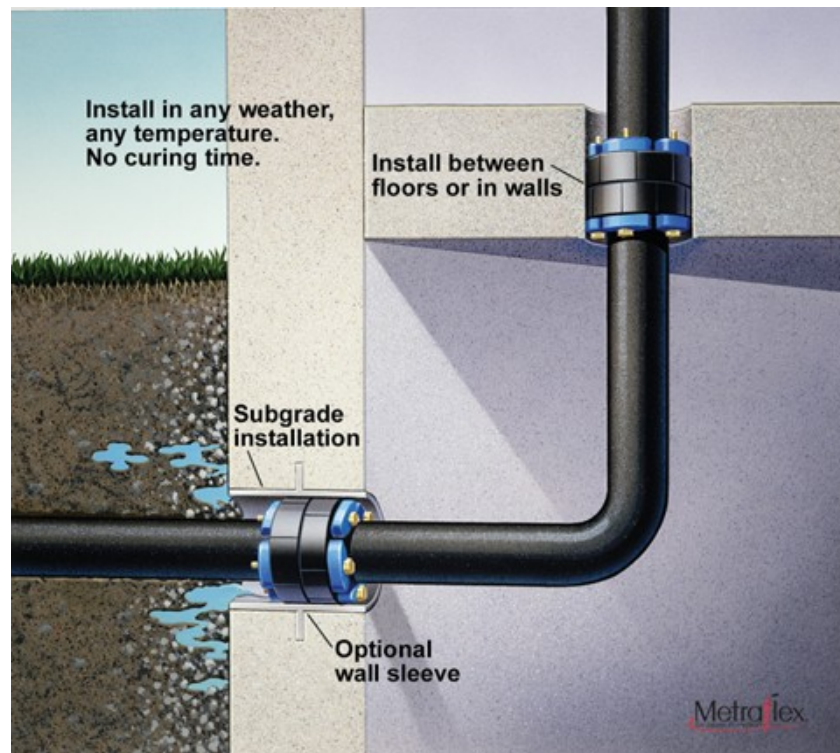


Figure 50 Fixed penetration seal (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Flexible Penetration Seals

Flexible penetration seals are designed to close the pipe sleeve opening while allowing the pipe to move during operation. Flexible seals can absorb misalignments and angular penetrations.

Figure 51 shows a manufactured sleeve seal. This is a fast and economical way to seal a sleeve to a penetrating pipe. No other caulking is required.



Figure 51 Flexible penetration sleeve seal (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 52 shows **Pipetite sleeve boots** designed specifically for sealing around tube-in-tube transitions. They provide good surface contact and eliminate the need for sealants, clamps or fasteners. Flexibility allows the pipes to move significantly without causing damage or breaking the seal. They also provide a finished look for exposed sleeves.



Figure 52 Sleeve boots (BC Industry Training Authority, 2019).
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Sealing Below-Ground Pipe Penetrations and Isolating Groundwater

When pipes pass through foundations and slabs below ground level, unwanted moisture and vapour can enter the structure.

Problems caused by below-ground pipe penetration can include:

- Building and ground movement applying stress to the piping
- Moisture and water penetration
- Vapour penetration
- Expansion and contraction of piping and the foundation
- Corrosion of the piping

A properly placed pipe sleeve will help to avoid these problems. The pipe sleeve can allow some movement between the pipe and the foundation. The sleeve seal can reduce or prevent water penetration, and the application of a pipe wrap can prevent pipe corrosion and leakage through the penetration.

The methods of penetration and use of sleeves are supported by related codes and engineering practice. The following information is a summary only. Refer to each of the codes referenced for detailed requirements.

BC Plumbing Code Regulation

- Where piping passes through or under a wall it shall be installed so the wall does not bear on the pipe.

Gas Code Regulations

- Piping or tubing entering a building shall rise above grade before entry unless otherwise permitted by the authority having jurisdiction. (Gas piping should not enter the building from underground.)
- When gas piping is run in a sleeve, the sleeve shall be of such material and so installed as to protect the piping or tubing from damage and galvanic action.
- When gas piping or tubing passes through an exterior wall above ground, it shall be sealed watertight and the portion of piping that runs through the wall shall be sleeved or double wrapped with a waterproof wrap.

Fire Sprinkler Code

- Clearance shall be provided around all piping extending through walls, floors, platforms and foundations, including drains, fire department connections and other auxiliary piping.
- Unless other code requirements allow no clearance, where pipe passes through holes in platforms, foundations, walls or floors, the holes shall be sized such that the diameter of the holes is nominally 2 in. (50 mm) larger than the holes for pipe 1 in. (25 mm) nominal to $3 \frac{1}{2}$ in. (90 mm) nominal, and 4 in. (100 mm) larger than the holes for pipe 4 in. (100 mm) nominal and larger.
- Where clearance is provided by a pipe sleeve, a nominal diameter 2 in. (50 mm) larger than the nominal diameter of the pipe shall be acceptable for pipe sizes 1 in. (25 mm) through $3 \frac{1}{2}$ in. (90 mm), and the clearance provided by a pipe sleeve of nominal diameter 4 in. (100 mm) larger than the nominal diameter of the pipe shall be acceptable for pipe sizes 4 in. (100 mm) and larger.

Waterproof Pipe Wraps

When piping passes through a pipe sleeve, you must consider the type of materials the sleeve and the pipe are made from. For example, when a copper water line passes through a metal pipe sleeve, the following concerns arise:

- Contact between copper and a dissimilar metal
- Direct contact with the concrete

Contact between copper pipe and a steel pipe sleeve can result in damage to the copper pipe due to erosion caused by electrolysis. A plastic PVC or ABS sleeve can prevent damage caused when metal pipe contacts a pipe sleeve made of a dissimilar metal. Suitable pipe wraps can also be used.

Copper or any metal pipe that is going to be installed directly into concrete must be protected from contacting the concrete with a suitable pipe wrap or flexible continuous pipe sleeves.

Pipe wraps are mainly used to insulate, seal or protect piping from damage. Several manufacturers specialize in pipe wraps for specific jobs, including waterproofing, maintenance and sealing repairs. There are pipe wraps to suit just about any purpose, and there are many available for sealing and protecting pipe penetrations through concrete foundations.

Procedures for applying these products vary; therefore you should read and follow the manufacturer's installation procedures.

Following is a generic example of a manufacturer's instructions for applying waterproof pipe wrap sealant.

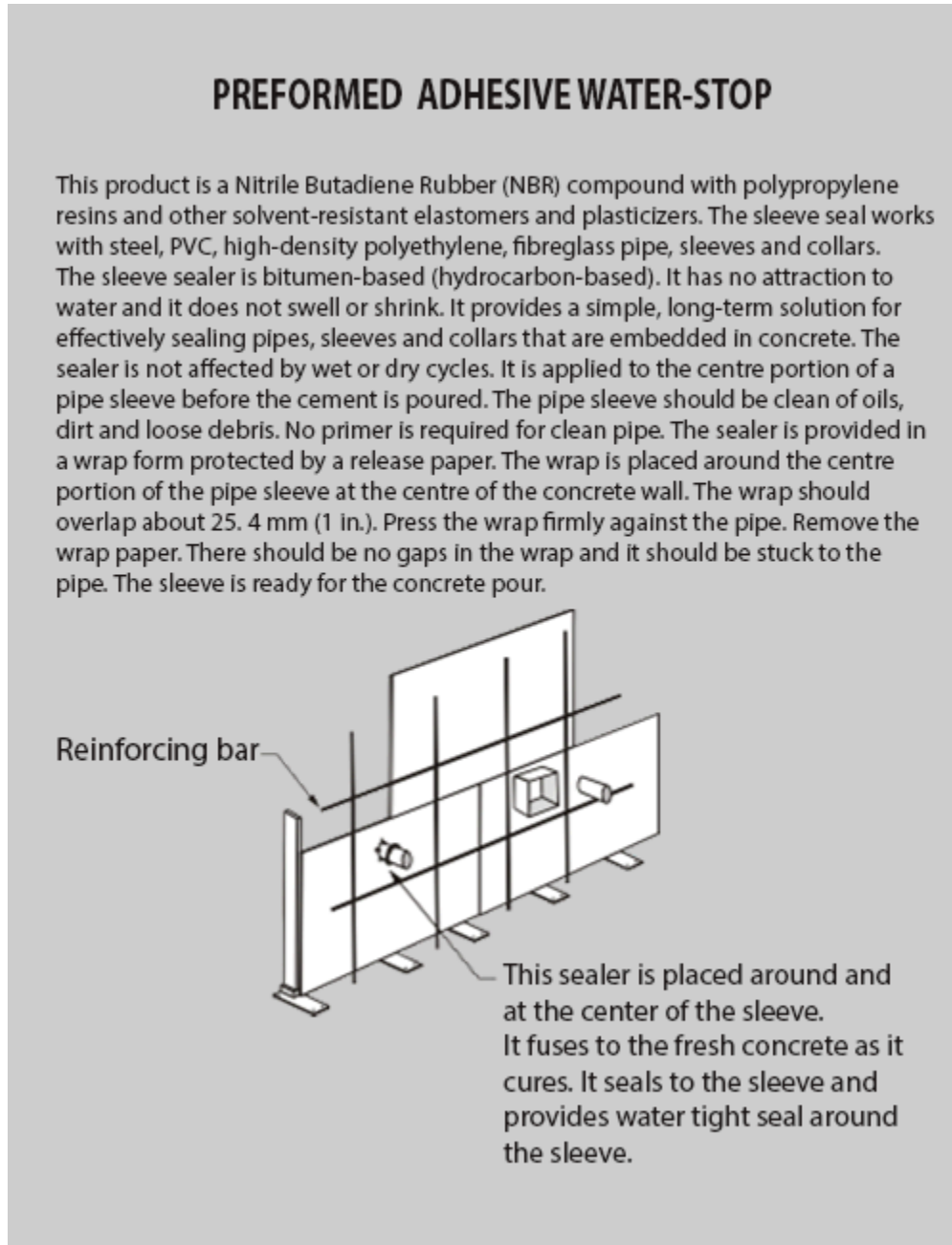


Figure 53 Application of waterproof pipe wrap (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Movement

The penetrating pipe is not likely to stay perfectly centred in the sleeve once **backfill** is placed over the pipe. The pipe can be pushed up against the sleeve wall. Any movement of the pipe against the sleeve can cause abrasions on the pipe. Continued movement caused by expansion and contraction or vibrations over time can cause the pipe wall to fail. The application of a pipe wrap is essential to prevent such damage.

Methods of keeping the pipe centred in a pipe sleeve include:

- Foam type insulation



Figure 54 PMR
(https://commons.wikimedia.org/wiki/File:PMR_63x5.8_125_file2.jpg) by Sönke Kraft aka Arnulf zu Linden
(https://commons.wikimedia.org/wiki/User:Arnulf_zu_Linden) from Wikimedia Commons

- Expanding spray foams



Figure 55 Insulation
(<https://pixabay.com/photos/insulation-izolacja-pur-2389795/>) by justynkalp (https://pixabay.com/users/justynkalp-3428771/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=2389795) from Pixabay

- Fibreglass pipe insulation



Figure 56 Fiberglass pipe covering (https://commons.wikimedia.org/wiki/File:Fs195_cp25_fibreglass_pc.jpg) by Achim Hering (https://commons.wikimedia.org/wiki/User:Achim_Hering) from Wikimedia Commons

- Fabricated centring devices within the sleeve
- Proper support of the pipe independent of the pipe sleeve penetration
- Firestopping

If no sleeve is used, you will need to consider the effect of contact between the copper pipe and concrete or masonry mortar. Direct burial of a copper water line in concrete will cause the copper to corrode.

Sealing Around Boxed-Out Openings

Pipe penetrations through concrete walls including foundations can be boxed out before the concrete is poured or broken out after the concrete is poured. These boxed-out or broken-out holes are usually rectangular or irregularly shaped. Sealing a pipe penetration through a large, irregularly shaped hole becomes a challenge. The chance of finding a supplier of a manufactured seal to fit the hole is slim. If you are working on a job site, there may be a set of specifications and drawings with instructions for how to seal the pipe penetrations. You may also need to research manufacturers that make a product that will do the job.

Two examples of such products are Synko-Flex and Hydro-Flex **waterstops**, manufactured by the Henry Company (<https://www.henry.com/commercial/products/waterstops/hydrophobic/synko-flex-waterstop/>). These provide a watertight seal in reinforced construction cold joints, cast-in-place applications, and through-wall penetrations.

Compatibility of Sealants and Pipe Materials

Pipe sealants such as pipe wraps and coatings can react with the piping they are intended to protect. PE and PEX have been known to let petroleum-based products to leach through the pipe walls and contaminate the water inside the pipe. Waterproofing emulsions form release agents and should not be allowed to contact this plastic pipe.

Firestop system manufacturers test firestop sealants and other components for compatibility with specific types of pipe. The sealants may not be compatible with every type of pipe material they come in contact with. Check with the manufacturer to ensure that the pipe sealants and wraps, including firestop sealant, are compatible with the type of pipe material being used.



Self-Test D-4.1: Describe Factors Affecting Penetrations in Structures

Complete Self-Test 4.1 and check your answers.

If you are using a printed copy, please find Self-Test D-4.1 (#chapter-self-test-d-4-1-describe-factors-affecting-penetrations-in-structures) and Answer Key (#chapter-answer-key-self-test-d-4-1) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2149#h5p-11> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2149#h5p-11>)

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- Describe factors affecting penetrations in structures
- Plumber: Competency D-6 Penetrate Structures
- Steamfitter: Competency D-3 Penetrate Structures

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D-4.2 Describe Acceptable Methods of Structure Penetration

In D-4.1 Describe Factors Affecting Penetrations in Structures (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures), you learned about methods for installing piping through structural components, including walls, floors, concrete foundations, and slabs. You should now be able to identify fire separations. Pipe often penetrates into or through, or is installed in, a fire separation. These pipe penetrations must be firestopped to ensure the integrity of the fire separation. In this section, you will learn to identify firestop materials and the various methods of firestopping pipe penetrations.

The spread of fire in a structure is a major concern. To prevent, stop, or slow down the spread of fire, building codes have included requirements regulating fire suppression, firewalls, fire separations, and firestops. Piping systems installed in the building often pass into or through firewalls, fire separations, and firestops. It is critical that the fire safety of the fire separation not be compromised by the piping systems.

Fire separations, firewalls, and firestops are integral parts of a building. It is important that the piping trade worker become familiar with these components and the installation of piping in, through, and around them. The building code has many regulations regarding fire separations that go far beyond the scope of this program. At Level 1, we will look at some of the basic applications of fire separations and the basic regulations regarding the installation of piping systems.

Firestopping Definitions

ablative: Resisting heat transfer by using the heat of the exposing fire to erode the material. The material, by sacrificing itself, protects the unexposed side from rapid temperature rise until it is spent. A typical example is a silicon-based firestop material.

active fire protection: Fire protection in which the equipment, components, or systems physically move to some extent when performing their design functions.

Examples of active fire-protection systems are:

- Fire sprinkler systems
- Fire suppression systems
- Fire detection systems

annular space: The space between a penetrating item and whatever surrounds it, such as the sides of an opening or a sleeve.

closure: A device or assembly for closing an opening through a fire separation or an exterior wall, such as a door, shutter, wired glass, or glass block. Includes all components such as hardware, closing devices, frames, and anchors.

compartmentalization: A method of building structure that divides the building into individual compartments for the purpose of limiting the spread of fire.

draft stop: A material intended to stop air movement and fire spread.

endothermic: A process or reaction that absorbs energy in the form of heat.

exothermic: A process or reaction that releases energy in the form of heat. The opposite of endothermic.

F rating: Abbreviation of *flame* or *fire* rating. Prevents flame transfer only.

FH rating: Abbreviation of *fire and hose* rating. Prevents passage of flame and fire hose stream.

FP rating: Abbreviation of *fire-protection rating*. The time in minutes or hours that a closure will withstand the passage of flame when exposed to fire under specified conditions of test and performance criteria, or as otherwise prescribed in the building code.

FR rating: Abbreviation of *fire-resistance rating*. The time in minutes or hours that a material or assembly of materials will withstand the passage of flame and the transmission of heat when exposed to fire under specified conditions of test and performance criteria, or as determined by extension or interpretation of information derived from or as prescribed in the building codes.

FT rating: Abbreviation of *fire and temperature* rating. Prevents transfer of flame and high temperatures.

fireblock: A material, component or system installed in a concealed space in a building to restrict the spread of fire, and often smoke, in that concealed space or from that concealed space to an adjacent space.

firestop backing: An approved material such as mineral wool or a foam-backing rod to keep the firestop caulking in place while the firestop material sets.

fire stopping: (sometimes referred to as *firestop*, *fire-block* or *draft stop*) A material, component or system, and its means of support, used to fill gaps between fire separations and other construction assemblies, or used around items that wholly or partially penetrate fire separations, to restrict the spread of fire and often smoke, thus maintaining the integrity of a fire separation.

FTH rating: Abbreviation of *fire, temperature and hose*. Prevents passage of flame, temperature and fire hose stream.

fire compartment: An enclosed space in a building that is separated from all other parts of the building by an enclosing construction that provides a fire separation having a required fire-resistance rating.

fire damper: A closure consisting of a damper installed in an air-distribution system or in a wall or floor assembly, which is normally held open but is designed to close automatically in the event of a fire in order to maintain the integrity of the fire separation.

fire detector: A device that detects a fire condition and automatically initiates an electrical signal to actuate an alert signal or alarm signal. Includes heat detectors and smoke detectors.

fire load: As applied to an occupancy, the combustible contents of a room or floor area expressed as the average weight of combustible materials per unit area from which the potential heat liberation may be calculated based on the calorific value of the materials. Includes the furnishings, finished floor, wall and ceiling finishes, trim, and temporary and movable partitions.

fire-retardant treated wood: Wood or a wood product that has had its surface-burning characteristics, such as flame spread, rate of fuel contribution, and density of smoke developed, reduced by impregnation with fire-retardant chemicals.

firestop flap: A device that operates to close off a duct opening in a horizontal assembly that is required to have a fire-resistance rating and to incorporate protective ceiling membranes.

flame-spread rating: An index or classification indicating the extent of spread-of-flame on the surface of a material or an assembly of materials as determined in a standard fire test as prescribed in the NBCC.

intumescent: A substance that swells as a result of heat exposure, thus increasing in volume and decreasing in density. An intumescent is typically used in passive fire protection. (firestop)

listed firestop system: A specific construction consisting of materials, any penetrating items and their means of support that has met the requirements for an F, FT, FH and/or FTH rating when tested in a fire resistance.

monolithic: A large section of concrete floor construction completed in a single concrete pour.

passive fire protection: Fire protection that attempts to contain fires or slow the spread of fire by dividing the building structure into compartments separated by fire-resistant wall assemblies, floor assemblies and doors. These are designed to keep fires, high temperatures and flue gases within the compartment where the fire originated.

penetrant: Something that penetrates; for example, the mechanical, electrical or structural items that pass through an opening in a wall or floor, such as pipes, conduits, cables, ducting, etc.

Building Code and Fire Code

The building code and fire code each contain provisions that deal with the safety of persons in buildings in the event of a fire and the protection of buildings from the effects of fire. The fire code also applies to other operations besides buildings, such as tank farms and storage yards.

The building code and the fire code have been developed as complementary to one another. This minimizes the possibility of containing conflicting provisions. The building code covers the fire safety and fire-protection features that are required to be incorporated in a building at the time of its original construction. The fire code includes intumescent materials provisions for the ongoing maintenance and use of the fire safety and fire-protection features incorporated into buildings.

The building code sets out technical provisions for the design and construction of new buildings. The code also applies to the alteration, change of use, and demolition of existing buildings. Where piping systems are installed, the provisions of the building code must be complied with, including those for the penetration of structural components. As a piping trade worker, you must become familiar with the code regulations as they relate to your trade.

It is expected that buildings comply with both the building code and the fire code. At some point during your career you will need to reference these codes in some detail.

As you proceed through your training you will learn more about reading, interpreting, and applying code regulations related to your specific piping trade.

Manufacturers' Literature

Manufacturers' specifications and job site and construction specifications must be followed. The installation of firestop systems and the penetration of piping through structural components often involve the manufacturer's design installation.

Your Responsibility

It is important that you follow the installation instructions, related code requirements, and construction specifications. Failure to follow the manufacturers' instructions usually releases them from the responsibility for their product. Responsibility would then transfer to you, the installer, when the product fails to do its job.

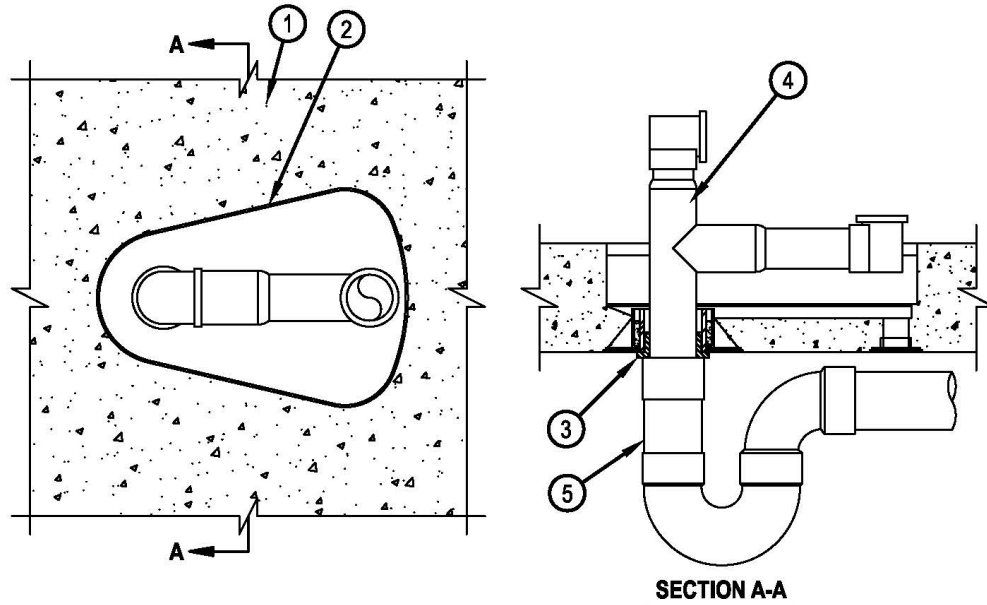
Simply put, you are installing pipe and equipment in buildings. In the process, you are drilling holes and cutting into or through structural members, many of which are fire separations. You can effectively destroy the fire-resistance rating of a passive fire-protection system. It is your responsibility to ensure that the penetration of structural components of a building does not compromise the fire rating by ensuring the use of approved firestopping methods.

The following examples of manufacturers' drawings and specifications are for illustration purposes only. On the job, you must use the drawings and specification supplied directly from the manufacturer.

Review the examples carefully. Pay close attention to the individual components and how to interpret the important notes provided.

System No. F-A-1003

F Rating -- 2 Hr
 FT Rating -- 0 Hr
 FH Rating -- 0 Hr
 FTH Rating -- 0 Hr



System tested with a pressure differential of 50 Pa between the exposed and the unexposed surfaces with the higher pressure on the exposed side.

1. Floor Assembly -- Min 114 mm (4-1/2 in.) thick reinforced lightweight or normal weight 1600-2400 kg/cu m (100-150 pcf) concrete.
2. Firestop Device*- Tub Box -- Nom 216 by 305 by 51 mm (8-1/2 by 12 by 2 in.) deep acrylonitrile butadiene styrene (ABS) tub box with adjustable legs and intumescent coupling. Cast in place firestop device attached to form and permanently embedded during concrete placement or grouted in concrete assembly in accordance with accompanying installation instructions. Min concrete thickness of 51 mm (2 in.) shall be maintained below tub box.

HILTI CONSTRUCTION CHEMICALS, DIV OF HILTI INC -- CP 681 Tub Box Kit

3. Tub Box Seal -- Elastomeric tub box seal (supplied with tub box kit) sized to accommodate 38 mm (1-1/2 in.) brass waste/overflow fitting. Seal seated from bottom within device coupling.

4. Waste/Overflow Fitting -- Nom 38 mm (1-1/2 in.) diam brass waste/overflow fitting installed through device coupling and seal.

5. Drain Piping -- Nom 51 mm (2 in.) diam Schedule 40 polyvinyl chloride (PVC) cemented together and secured to waste/overflow fitting with a compression coupling. Drain piping rigidly supported away from tub box with suitable hangers.

- 5A. Alternate Drain Piping -- (Optional - Not Shown) - Nom 51 mm (2 in.) diam cast iron P trap secured to PVC waste/overflow fitting with a compression coupling. Drain piping rigidly supported away from tub box with suitable hangers.

*Bearing the UL Classification Mark

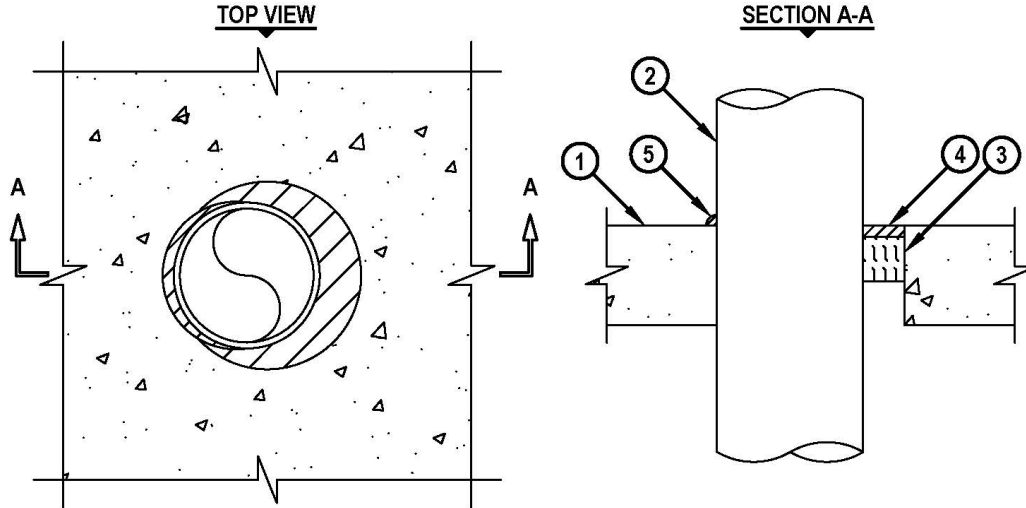
HILTI
 Hilti Firestop Systems

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 September 09, 2005

UL/cUL SYSTEM NO. C-AJ-1435
METAL PIPE THOROUGH CONCRETE FLOOR/WALL OR BLOCK WALL

F-RATING = 2-HR.
 T-RATING = 0-HR.
 L-RATING AT AMBIENT = LESS THAN 1 CFM/SQ. FT.
 L-RATING AT 400°F = LESS THAN 1 CFM/SQ. FT.

CAJ1435c.081110



1. CONCRETE FLOOR OR WALL ASSEMBLY (2-HR. FIRE-RATING) :
 - A. LIGHTWEIGHT OR NORMAL WEIGHT CONCRETE FLOOR OR WALL (MINIMUM 4-1/2" THICK).
 - B. ANY UL/cUL CLASSIFIED CONCRETE BLOCK WALL.
2. PENETRATING ITEM TO BE ONE OF THE FOLLOWING :
 - A. MAXIMUM 30" NOMINAL DIAMETER STEEL PIPE (SCHEDULE 10 OR HEAVIER).
 - B. MAXIMUM 30" NOMINAL DIAMETER CAST OR DUCTILE IRON PIPE.
 - C. MAXIMUM 6" NOMINAL DIAMETER COPPER PIPE.
 - D. MAXIMUM 6" NOMINAL DIAMETER STEEL CONDUIT.
 - E. MAXIMUM 4" NOMINAL DIAMETER EMT.
3. MINIMUM 2" THICKNESS MINERAL WOOL (MIN. 4 PCF DENSITY) TIGHTLY PACKED.
4. MINIMUM 1/2" DEPTH HILTI CP 606 FLEXIBLE FIRESTOP SEALANT.
5. MINIMUM 1/2" BEAD HILTI CP 606 FLEXIBLE FIRESTOP SEALANT AT POINT OF CONTACT.

NOTES : 1. MAXIMUM DIAMETER OF OPENING = 31-7/8".
 2. ANNULAR SPACE = MINIMUM 0", MAXIMUM 1-7/8".
 3. MINIMUM 1/2" DEPTH HILTI CP 606 FLEXIBLE FIRESTOP SEALANT IS REQUIRED ON BOTH SIDES OF A WALL ASSEMBLY.



HILTI, Inc.
 Tulsa, Oklahoma USA (800) 879-8000

Sheet 1 of 1
 Scale 5/32" = 1"
 Date Aug. 11, 2010

Drawing No.
**CAJ
 1435c**

Saving Lives through Innovation and Education

Deck and Bulkhead Penetration

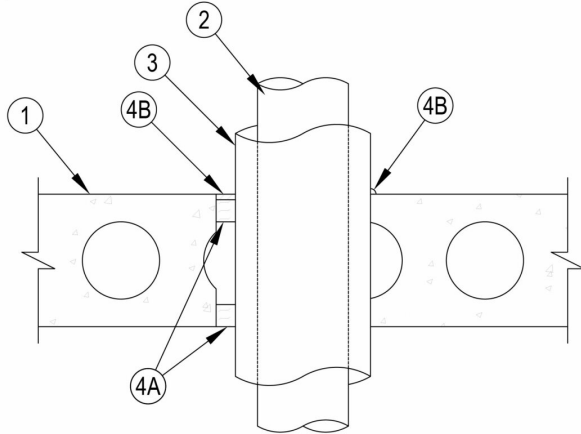
CLASSIFIED
C  US

Classified by
Underwriters Laboratories, Inc.
to UL 1479 and CAN/ULC-S115

System No. C-BJ-5013

ANSI/UL1479 (ASTM E814)	CAN/ULC S115
F Rating - 2 Hr	F Rating - 2 Hr
T Rating - 1 Hr	FT Rating - 1 Hr
	FH Rating - 2 Hr
	FTH Rating - 1 HR

CBJ 5013



1. Floor Assembly — Min 8 in. (203 mm) thick reinforced lightweight or normal weight (100-150 pcf or 1600-2400 kg/m³) concrete. Floor assembly may also be constructed of any 8 in. (203 mm) thick UL Classified hollow-core Precast Concrete Units*. Max diameter of opening is 7 in. (178 mm).
See Precast Concrete Units CFTV category in the Fire Resistance Directory for names of manufacturers.
2. Through Penetrants — One metallic pipe or tube to be installed concentrically or eccentrically within the firestop system. Annular space between pipe or tube and edge of opening to be min 0 in. (point contact) to max 7/8 in. (22 mm). Pipe or tube to be rigidly supported on both sides of floor-ceiling assembly. The following types and sizes of metallic pipes or tubes may be used:
 - A. Steel Pipe — Nom 4 in. (102 mm) diam (or smaller) Schedule 10 (or heavier) steel pipe.
 - B. Copper Tubing — Nom 4 in. (102 mm) diam (or smaller) Type L (or heavier) copper tubing.
 - C. Copper Pipe — Nom 4 in. (102 mm) diam (or smaller) Regular (or heavier) copper pipe.
3. Pipe Covering Materials* — Nom 1 in. (25 mm) thick hollow cylindrical heavy density (min 3.5 pcf or 56 kg/m³) glass fiber units jacketed on the outside with an all service jacket. Longitudinal joints sealed with metal fasteners or factory-applied self-sealing lap tape. Transverse joints secured with metal fasteners or with butt tape supplied with the product. The annular space shall be min 0 in. (point contact) to max 7/8 in. (22 mm).
See Pipe and Equipment Covering - Materials - (BRGU) category in the Building Materials Directory for names of manufacturers. Any pipe covering material meeting the above specifications and bearing the UL Classification Marking with a Flame Spread of 25 or less and a Smoke Developed Index of 50m or less may be used.
4. Firestop System — The firestop system shall consist of the following:
 - A. Packing Material — Min 1 in. (25 mm) thickness of 4 pcf (64 kg/m³) mineral wool insulation tightly packed into the opening as a permanent form. Packing material to be installed flush with the bottom surface of floor assembly and recessed from the top surface of the assembly to accommodate the required thickness of fill material.
 - B. Fill, Void or Cavity Materials*-Sealant — Min 1/4 in. (6 mm) thickness of fill material applied within the annulus, flush with top surface of floor. An additional 1/4 in. (6 mm) bead shall be installed at penetrant/concrete interface on top surface of floor.
HILTI CONSTRUCTION CHEMICALS, DIV OF HILTI INC — FS-ONE Sealant or FS-ONE MAX Intumescent Sealant.

* Indicates such products shall bear the UL or cUL Certification Mark for jurisdictions employing the UL or cUL Certification (such as Canada), respectively.



Hilti Firestop Systems

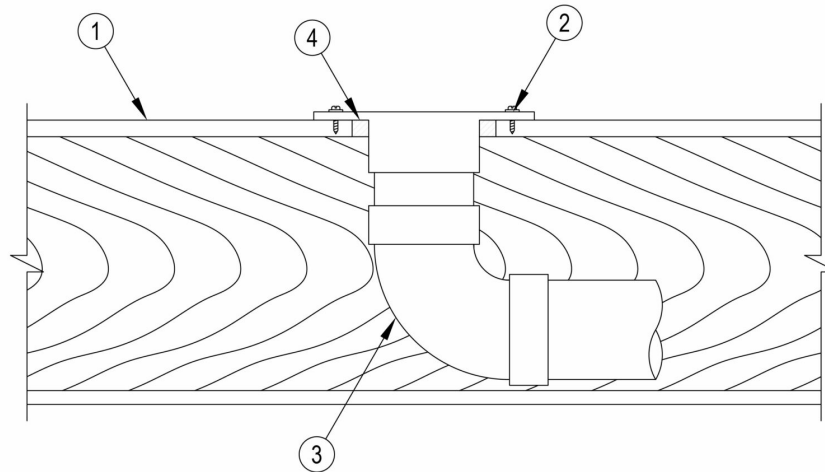
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January 16, 2015

To interpret this manufacturer's data sheet you might want to review the definitions of F, FT, FH and FTH ratings.

System No. F-C-2010

F Rating -- 1 Hr
 FT Rating -- 3/4 Hr
 FH Rating -- 1 Hr
 FTH Rating -- 3/4 Hr

FC 2010



System tested with a pressure differential of 50 Pa between the exposed and the unexposed surfaces with the higher pressure on the exposed side.

1. Floor-Ceiling Assembly — The 1 hr fire-rated solid or trussed lumber joist floor-ceiling assembly shall be constructed of the materials and in the manner specified in the individual L500 Series Floor-Ceiling Designs in the UL Fire Resistance Directory. The general construction features of the floor-ceiling assembly are summarized below:

A. Flooring System — Lumber or plywood subfloor with finish floor of lumber, plywood or Floor Topping Mixture* as specified in the individual Floor-Ceiling Design. Max diam of opening shall be 127 mm (5 in.).

B. Wood Joists* — Nom 254 mm (10 in.) deep (or deeper) lumber, steel or combination lumber and steel joists, trusses or Structural Wood Members* with bridging as required and with ends firestopped.

C. Gypsum Board* — Nom 16 mm (5/8 in.) thick, 1.22 m (4 ft) wide as specified in the individual Floor-Ceiling Design.

2. Closet Flange — Acrylonitrile butadiene styrene (ABS) or polyvinyl chloride (PVC) closet stub sized to accommodate drain pipe. Closet flange installed over drain piping within floor opening with flange secured to plywood floor with steel screws. Annular space between closet flange and periphery of opening shall be 6 mm (1/4 in.).

3. Drain Piping — Nom 104 mm (4 in.) diam Schedule 40 acrylonitrile butadiene styrene (ABS) or polyvinyl chloride (PVC) drain pipe and 90 degree elbow for use in vented (drain, waste or vent) piping systems. Pipe installed concentrically within firestop system.

4. Fill, Void or Cavity Materials* - Sealant — Min 19 mm (3/4 in.) thickness of fill material applied within the annulus, flush with the bottom surface of floor.

HILTI CONSTRUCTION CHEMICALS, DIV OF HILTI INC — CP 606 Flexible Firestop Sealant or FS-ONE Sealant or FS-ONE MAX Intumescent Sealant.

5. Water Closet — (Not Shown) - Floor mounted vitreous china water closet.

* Indicates such products shall bear the UL or cUL Certification Mark for jurisdictions employing the UL or cUL Certification (such as Canada), respectively.



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 January 20, 2015

The final line appears at the bottom of each page of the manufacturer's specification sheet.

Conflicts between documents can occur, so consultation between code officials, the building design engineers, and the manufacturer's representative will be required.

Firestops

Firestops are a passive fire-protection system consisting of various components used to seal openings and joints in fire resistance-rated wall and/or floor assemblies, based on fire testing and certification listings.

Unprotected openings in fire separations void the fire-resistance ratings of the fire separations. Firestops are designed to restore fire-resistance ratings by impeding the spread of fire through the opening by filling the openings with fire-resistant materials. A firestop's fire-resistance rating will be the same as that of the assembly it is used in.

The objectives of a firestop system are to:

- Prevent the spread of fire, smoke, and hot gases through a building by containing them in the compartment of origin.
- Maintain the integrity of escape routes from a building.
- Reduce loss of or damage to property from the effects of fire and smoke.
- Maintain pressure differential between compartments and ventilation channels.

Many elements combine together to provide fire protection in a building. Some of the components of a fire-protection system may include the following:

- Constructing the building of non-combustible materials.
- Firewalls may be provided to divide a building into a number of smaller buildings.
- Fire separations may be provided at the following locations:
 - ▶ at floors levels
 - ▶ between suites
 - ▶ between suites and public corridors
 - ▶ at roof/ceiling level
 - ▶ around exit stairs
 - ▶ around service and elevator shafts
 - ▶ around other rooms requiring protection
 - ▶ at exterior walls for spatial separation purposes and to support the structural system of the building
- Firestopping using cast-in-place construction or firestop systems to seal openings where they pass through fire separations.
- Concealed space barriers (fire-blocks), built in the concealed spaces within walls and at floor levels.
- Fire alarm, detection and suppression systems, fire sprinkler systems.

Firestop Ratings

Firestops are tested for a number of criteria to establish a fire rating. The ratings are as follows:

F rating: The minimum rating required for all firestops. The F rating required is the same as a closure, which is one level below the fire-resistance rating required for the fire separation.

An F rating is required for all fire stops involving combustible drain, waste and vent pipe. The firestop F rating required is the same as the fire-resistance rating for the fire separation. The pipe must also meet a pressure differential of 50 Pa (0.01 psi) on the fire-exposed side during the test. This pressure simulates the pressures that occur during a fire condition.

FT rating: the FT rating is required for all firestops in horizontal fire separations above storage garages classified as separate buildings and firewalls.

The firestop FT rating is the same as the fire-resistance rating for the fire separation. The rating test also requires the firestop to limit the rise in temperature on the unexposed surface of the fire separation to less than 181°C (358°F) above ambient room temperature. This temperature-rise component makes obtaining an FT rating more difficult.

Cast iron, steel, and copper pipes may need firestop systems that require these pipes to be insulated.

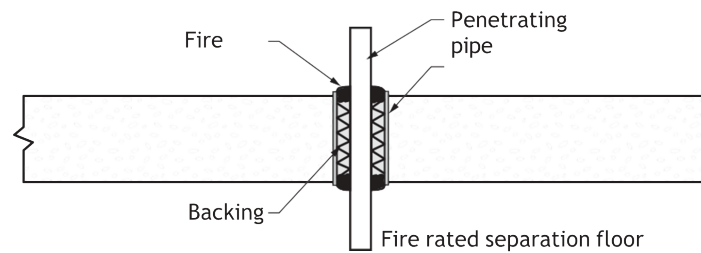


Figure 1 Typical parts of a firestop (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Firestop Configurations

Through-Penetration Firestops

Through-penetration firestops are those that are employed when a penetrating item passes entirely through a fire separation. Such an opening creates the opportunity for fire and smoke to spread directly from one fire compartment to another. A through-penetration firestop system consists of a fire-rated wall or floor, a penetrating item (pipe, cable, conduit, etc.) and the firestop material.

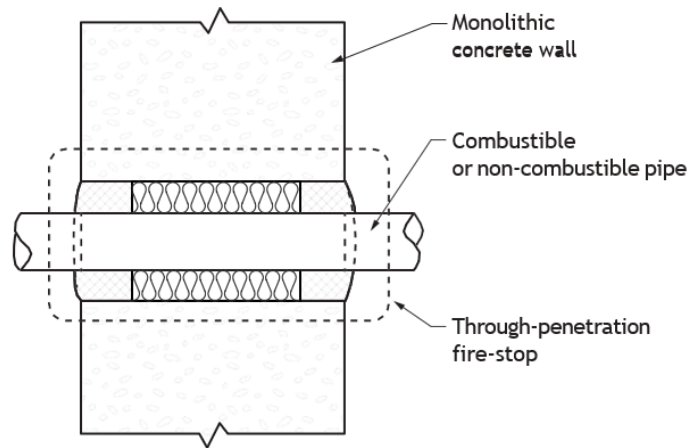


Figure 2 Example of a through-penetration firestop (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Membrane-Penetration Firestops

Membrane-penetration firestops are those that are employed when a penetrating item passes through only one membrane of a fire-rated assembly (made up of multiple materials) but does not pass through the entire assembly.

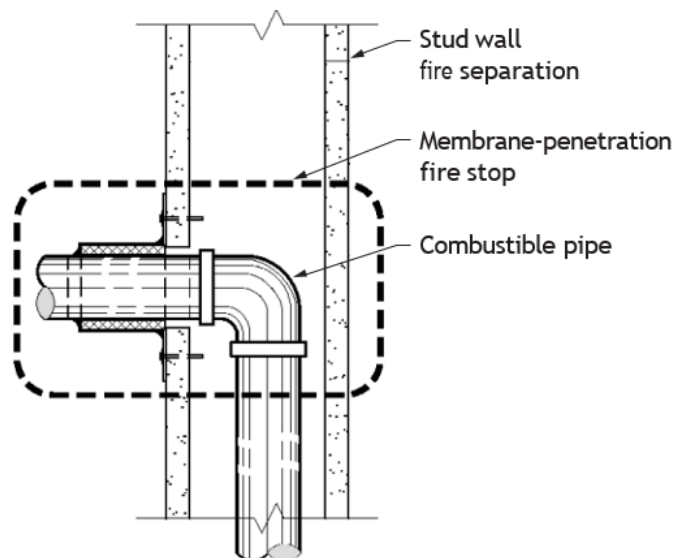


Figure 3 Example of a membrane-penetration firestop (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Types of Firestops

There are various types of firestops, including:

- Collars
- Pillows
- Caulking
- Sealants
- Mortars
- Mineral wool
- Foams
- Putties
- Fire-blocks
- Composite sheets and boards

Firestop Collars

Firestop collars are devices used to provide effective firestopping for plastic pipes. They typically consist of a steel or plastic canister, filled with a predetermined amount of **intumescent material** (material that expands upon exposure to excessive heat).

During a fire scenario, as the plastic pipe begins to soften, the intumescent material expands to several times its original volume, helping crush the plastic pipe and fill the void, thereby providing an effective seal against the passage of flames and hot gases.

Traditionally, fire collars for use on PVC pipes were supplied in size increments to match the common pipe sizes, namely 40, 50, 65, 80, 100 and in some cases 150 mm nominal diameter. In recent times, to cater for other plastic pipe sizes, where the outer diameter of the plastic pipe varies and to reduce model numbers and stock holdings, many proprietary fire collars can be used on more than one size and type of plastic pipe.

Fire collars designs consist of the following generic types:

- Retrofit or surface-mounted collars
- Cast-in-place floor slab collars
- Wall collars
- Ceiling collars
- Wraps

Retrofit or Surface-Mounted Collars

Retrofit or surface-mounted collars are usually fixed to the underside of a floor slab or to both sides of a wall, after the plastic pipe has been placed through the fire-resistant barrier. Retrofit collars are easy to identify during subsequent maintenance or inspection regimes.



Figure 4 Retrofit wall collars (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

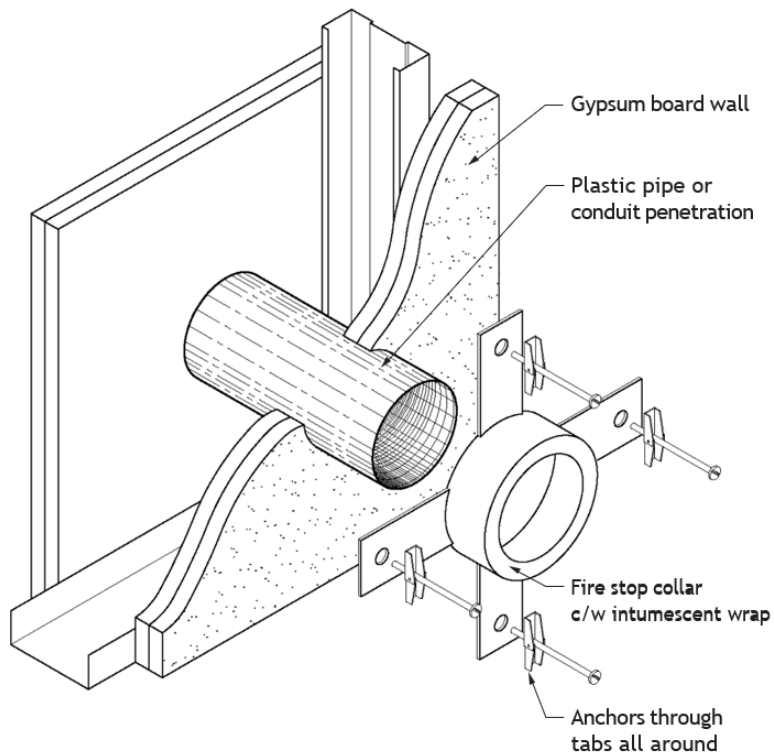


Figure 5 Retrofit fire collar installation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Hilti Firestop Collar

Hilti firestop collars are used on combustible pipes up to 4 in. in diameter in penetrations through firewalls and floors. They are suitable for use with the following pipe materials: PVC, CPVC, ABS, PVDF and FRPP (fibreglass-reinforced pipe).

Ceiling collars are collars fire-tested and used for breaches in fire-resistant ceilings where special temperature-rise requirements are called for.



Figure 6 Hilti firestop collar (Courtesy of Hilti)
Used with permission.

Cast-in-Place Floor Slab Collars

For this fire protection used for pipes penetrating concrete floor slabs, the collar is cast in place around the pipe.



Figure 7
Cast-in-place sleeve collar
(Courtesy of Hilti)
Used with permission.

Wall collars are cast into the wall upon pipe penetration.

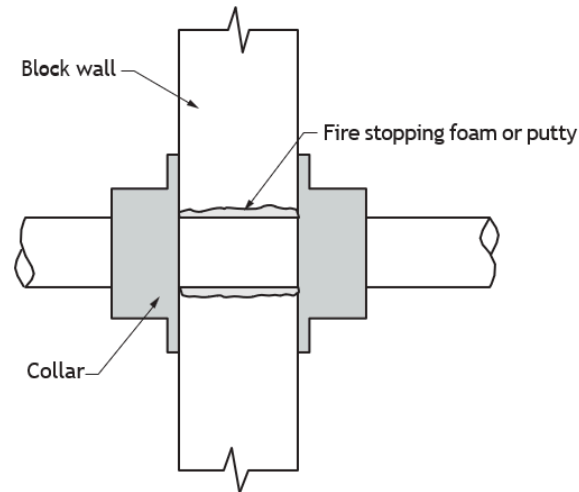


Figure 8 Collars for wall application (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Wraps are effectively fire collars without the outer casings or canisters. They typically consist of a pre-manufactured quantity of intumescent material. Because there is no canister, they are typically limited to concrete or masonry openings, where the fire-resistant barrier provides the necessary constraints to prevent the intumescent from expanding anywhere except into the opening as the pipe softens.



Figure 9 Firestop wrap (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Blocks, Pillows and Bags

Fire-resistant pillows were originally developed as a temporary form of firestopping and were used extensively during construction of telephone exchanges. They consist of an outer covering and an infill material, just like the pillows we sleep on. The conventional fire pillow consists of a fire-retardant cotton cover (typically coloured for ease of

recognition), with a mineral-fibre infill material. These pillows must be packed firmly into openings to ensure that there are no gaps that would allow the passage of flames and hot gases. They are often used together with sealants to ensure that the integrity of an opening's fire separation is maintained.



Figure 10 Fire-resistant pillows (BC Industry Training Authority, 2019).
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Types of fire-resistant pillows include:

- Rock-wool batts with intumescent resin inside plastic bags
- Vermiculite with intumescent graphite inside fibre bags
- Intumescent foam rubber

Pillows may present an opportunity for vandalism if they are not properly secured. Repairs must conform to the original certification listing.

Figure 11 illustrates the placement of firestop pillows. Always refer to the manufacturer's instructions and the authority having jurisdiction.

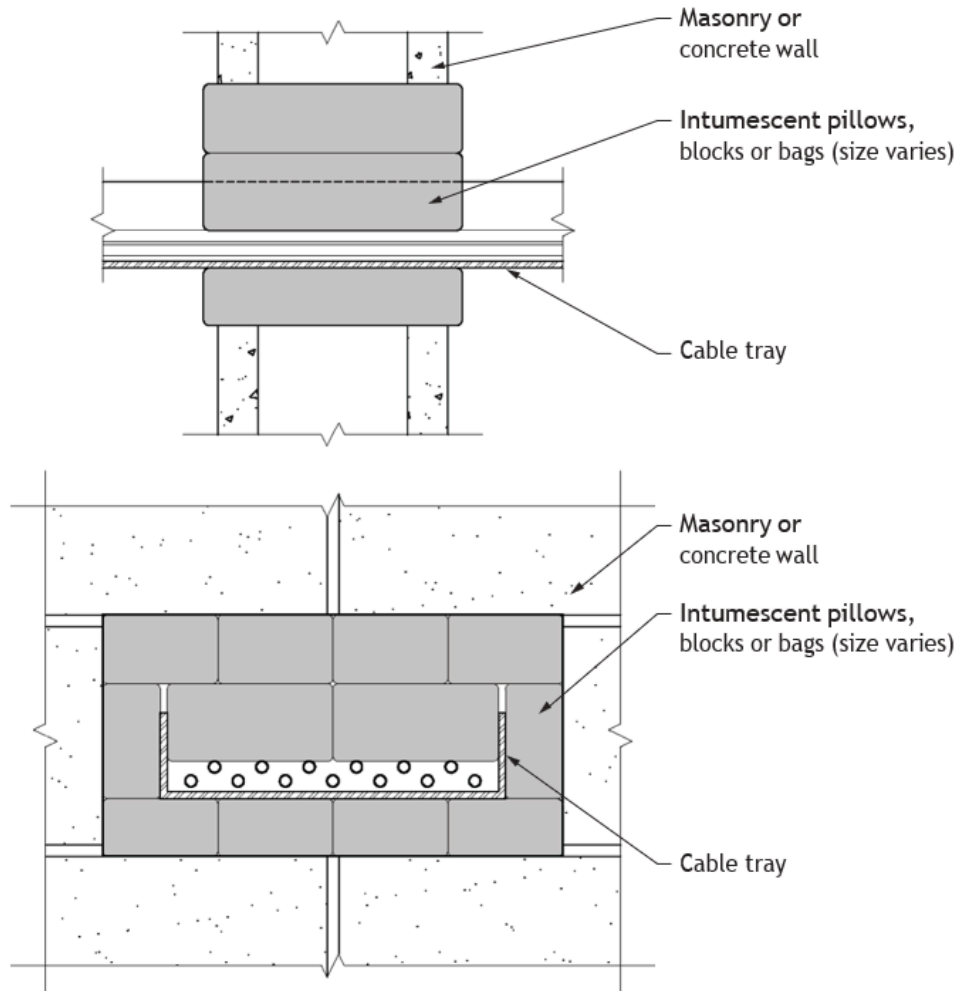


Figure 11 Placement of firestop pillows, blocks or bags (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Firestop Sealants

Sealants are compounds typically applied by caulking from a plastic cartridge, sausage or bulk container into an opening by way of a caulking gun. They come in different chemical formulations, of which the following are more common generic types:

- Acrylic (water-based or latex)
- Polyurethane
- Silicone
- Hybrids of acrylic, polyurethane and silicone

Many of the sealants used for firestopping purposes contain intumescent additives that allow them to expand to many times their original volume during fire conditions (exposure to extreme heat). This is not a mandatory design attribute.

The uses of the different generic types of sealants depend on many factors, which include but are not limited to:

- Flexibility
- Availability
- Tack-free time
- Adhesion to substrates
- Requirement for surface preparation
- Resistance to water
- Resistance to UV
- Design life
- Ease of cleaning of equipment after use
- Aesthetics
- Cost

Caulks and sealants are often used for single and multiple penetrations in an opening because they are adaptable to more complex and unusual penetrations and openings. Caulks are normally applied around a penetrating item in an opening with a caulking gun to form a seal. A sealant is a similar material to a caulk that is applied with a trowel or putty knife or is sprayed on. Caulks and sealants can possess intumescent or endothermic properties, depending on the specific material used. Caulks are used to seal the annular space around a penetration (e.g., pipe, cable, duct), or to cover a mineral fibre or similar material used in a construction joint.



Figure 12 Latex firestop sealant installation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Firestop Foams and Foam Blocks

Fire-stop foams are similar to caulks but expand during installation to fill openings in fire-rated assemblies. Foam fire-stop systems are typically used for small or medium-sized openings, often where an opening is difficult to reach. Some foam products are used with a packing or damming material. When using a foam, check the manufacturer's technical literature, as some foam remains liquid for several minutes before foaming occurs. In this situation, damming or packing is necessary.



Figure 13 Firestop brick based on a two-component polyurethane foam (Courtesy of Hilti) Used with permission.



Figure 14 Spray filler foam (Courtesy of Hilti) Used with permission.

Fire-Resistant Foams

Fire-resistant foams are specially formulated and modified foams that are fitted into linear gaps under compression and provide a fire rating in their own right. They may be used in conjunction with standard non-rated sealant in some jurisdictions.

Firestop Mortars

Mortars are powders that are mixed with water to form a compound that can be poured or towelled into an opening. When set, they form a homogeneous and usually lightweight barrier. They are similar to concrete but are free of the cracking, fissuring and spalling seen in concrete under fire conditions.

Fire-resistant mortars are usually much lighter when cured than conventional concrete and can be readily drilled through to form openings for additional cables or other penetrations over the life of the opening. They do not typically require any additional steel reinforcing and are not typically load-bearing.

Fire-stop mortars, including quick-setting compounds, are most typically used to firestop large openings in walls and floors that are required to have a fire-resistance rating.

Many proprietary fire-resistant mortars have red or blue dye additives to make them easier to recognize as a fire-resistant material in the field. This is similar to the coloured fire-resistant plasterboard and other building boards. This trend is encouraged.

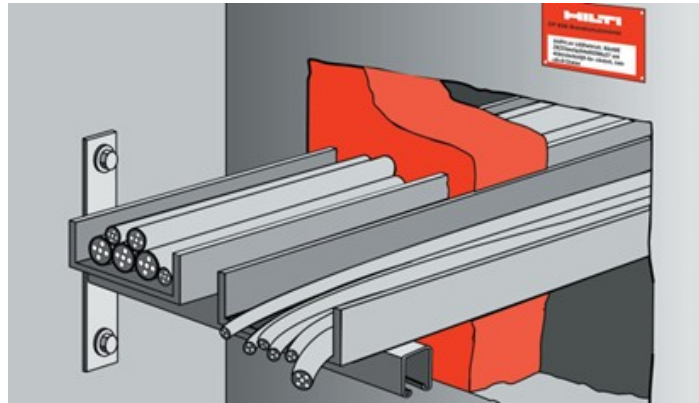


Figure 15 Application of firestop mortar (Courtesy of Hilti) Used with permission.



Figure 16
Quick-setting
mortar in package
(Courtesy of Hilti)
Used with
permission.

Coatings and Sprays

Coatings and sprays are sprayed or brushed on, usually over mineral wool insulation that has been tightly compressed. The mineral wool holds the spray in place or dams it and helps to block heat transmission. Sprays and coatings consist of intumescent or ablative materials.

Because they are quicker to apply, coatings and sprays are often used instead of caulks in applications such as covering construction joint firestop systems. When dry, most coatings or sprays form a flexible seal that can withstand some movement and water penetration.

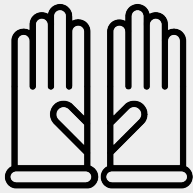
Mineral Wool and Backboards

Mineral wool is made of fibres of natural or synthetic minerals or metal oxides such as fibreglass, ceramic and rock

or stone. These materials can break down under very high heat, but they do provide sufficient fire resistance to be commonly used as passive fire protection. While bacteria can grow in wet mineral wool, rats and mice do not find these materials appetizing.



Figure 17 Mineral wool batts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Safety Precautions When Handling Mineral Fibre

You must take safety precautions when you handle mineral wool or other fibre products. The fibres can float in the air and be inhaled, irritating the eyes, skin and respiratory tract. Prolonged exposure could lead to long-term effects. Mineral wool is considered a possible carcinogen to humans, similar to asbestos. This effect may depend upon the fibre structure, chemical composition and persistence within the body.

Firestop Putties

Putties are normally installed as firestops in similar situations as caulks and sealants. Putties are fire-stop materials that are mouldable. They can be pressed manually into an opening in a fire-rated assembly. Putties may possess either intumescent or endothermic reaction properties.

Putties are sometimes used to create a fire-stop envelope over electrical boxes embedded in stud walls. Putties are mouldable, so are easy to install near obstructions, bent pipes and close running pipes, where collars cannot be installed. They also provide ease of entry as they remain pliable and reusable for years. Putty is available in tubes or as strips premeasured to fit around most schedule 40 plastic pipes.



Figure 18 Firestop putty (Courtesy of Hilti) Used with permission.

Composite Sheets and Boards

Composite sheets and boards consist of panels sandwiched around an intumescent material. They are typically cut to fit closely around penetrating items and are fastened to the fire separation.

Caulk or putty is provided to seal the opening around the penetrating item. They are commonly used for openings that are too large to be sealed by caulks or putties alone. Figure 19 shows a general application of a composite sheet. Always consult the manufacturer's instructions and authority having jurisdiction.

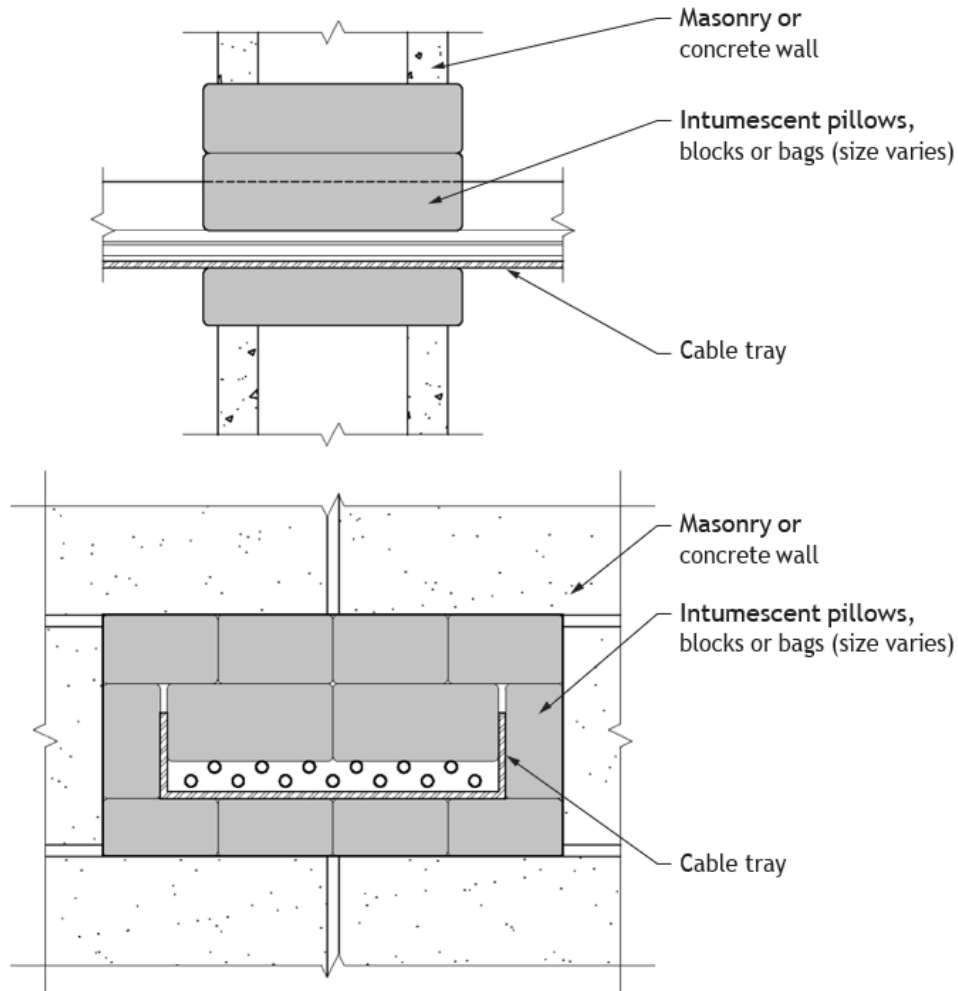


Figure 19 Composite sheet firestop (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Generic Firestop Materials

There are a number of generic materials that may be used as part of a firestop system. **Fibre insulations**, which may be generic materials, are commonly used in many fire-stop systems. The specific types of insulations used for these applications include mineral wool, ceramic fibre and, in some cases, glass fibre. For all fire-stop systems, the appropriate type of insulation must be used. When using these insulation materials in firestop systems, it is important to ensure that the thicknesses and densities meet those of the manufacturer's directions and that any compression requirements are closely followed.

Mineral wool is a mineral-fibre insulation processed from rock or slag. It is often used to fill spaces where its compressibility and resilience are needed to address structural movement in fire-stop systems. It is commonly used as an insulating material in many systems as well as for building-perimeter fire stops. Mineral wool begins to melt at approximately 1100°C (2000°F).

Note: The term **mineral-fibre** is used to describe a family of fibre insulation products that includes glass fibre.

Cerami-fibre is a space-age, high-temperature insulation product commonly used in the refractory industry. Ceramic fibre products are available in blanket or board form. Ceramic fibres are also incorporated into mastics to create a hard, non-flexible fire stop that can withstand high temperatures. The major advantage of ceramic-fibre blanket or board products is their ability to withstand high temperatures. Ceramic fibre begins to melt at approximately 1800°C (3270°F). On the other hand, fibres from these products are possible carcinogens, so users should wear appropriate protective clothing and masks.

Glass-fibre is a mineral fibre insulation made of glass fibres rather than rock or slag. Some fire-stop systems incorporate glass fibre insulation as a forming or packing material. The maximum temperature-resisting capabilities of glass fibre insulation are typically less than those of rock, slag or ceramic fibre insulations.

Fire Dampers

Fire dampers are devices used specifically for firestopping where ducts penetrate through fire-resisting barriers. The conventional fire damper is a gravity mechanical device consisting of metal pivoted dampers. The dampers are held in the open position by a **fusible link**. The fusible link melts during a fire and the dampers close tight, providing a barrier to the passage of hot flames and gases.



Figure 20 Fire damper with fusible link (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Insulated Pipe Penetrations

Piping is often insulated for various reasons, including reducing heat loss and heat gain. Pipe insulations may or may not be fire rated. You must ensure that the correct fire-stop system is selected for the type of insulation being used when pipe passes through a fire separation. Firestops must be designed to account for the impact of they have on the insulation around the pipe while at the same time maintaining the fire rating of the assembly.

Different arrangements for firestops are required for different types of pipe insulation and pipe materials. Firestops for such insulated pipes are currently available for both non-combustible and combustible pipes.

In Figure 21, the fire stop must be able to seal the opening either at the outer surface of the insulation or at the non-combustible pipe if the insulation can be damaged by fire.

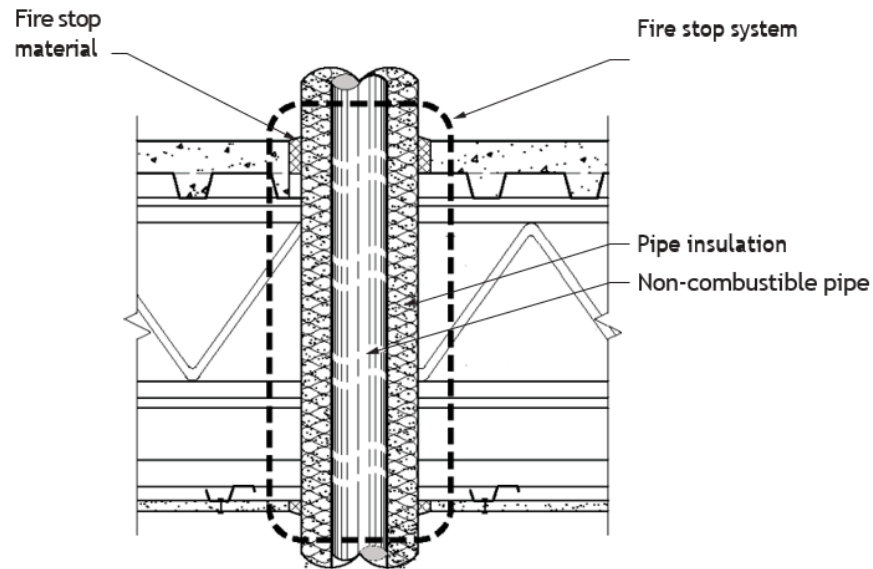


Figure 21 Firestop in non-combustible pipe penetration through metal-supported concrete deck (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In Figure 22, the firestop must be able to seal the opening in such a way that the void created by the fire-damaged combustible pipe is also sealed when the combustible pipe collapses from the heat of fire.

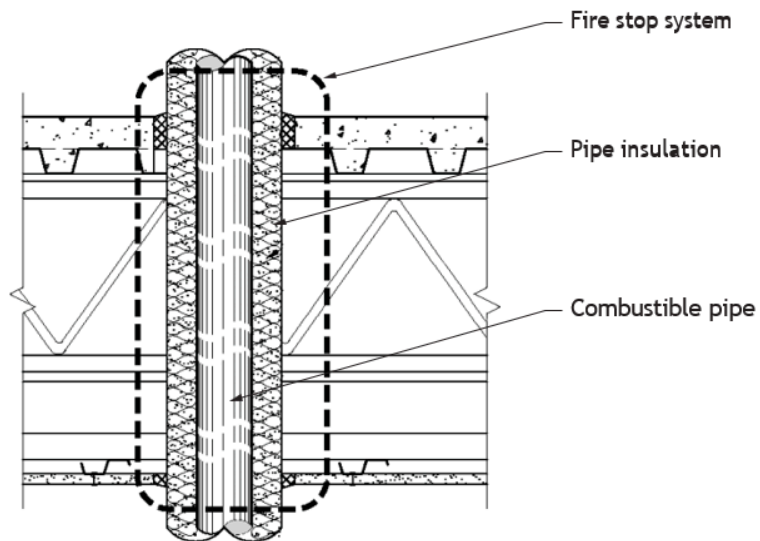


Figure 22 Fire stop in combustible pipe penetration of metal-supported concrete deck (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Penetrations Through Monolithic Concrete Floor Assemblies

The difference between an F rating and an FT rating requirement depends upon the type of pipe used. In Figure 23, F-rating-only combustible pipe will not conduct heat, so no insulation is needed for an FT rating.

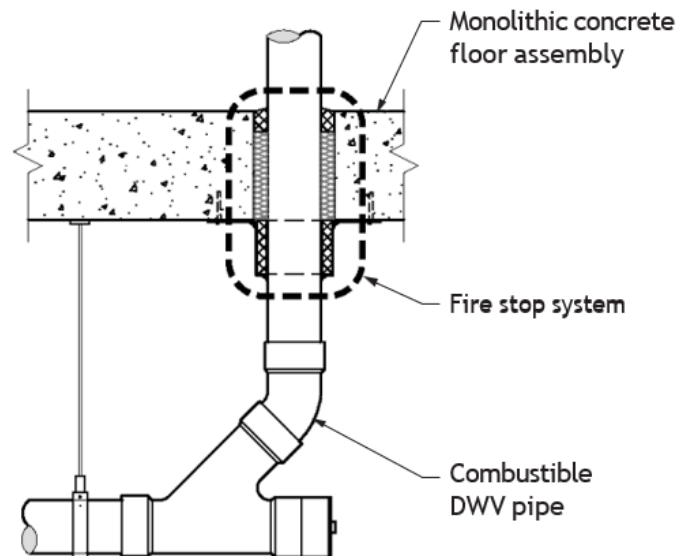


Figure 23 Combustible pipe penetration through monolithic concrete slab (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 24 shows insulation placed on the pipe below the slab. This insulation is fire rated and forms part of the firestop assembly. An FT (*temperature transmission*) rating is required for this non-combustible penetration. The insulation limits the metal pipe from conducting heat from a fire in an area below the slab, such as a parking garage, into the floor above. The specifications for this application and manufacturer's installations must be followed. Consult the local authority having jurisdiction before using this arrangement.

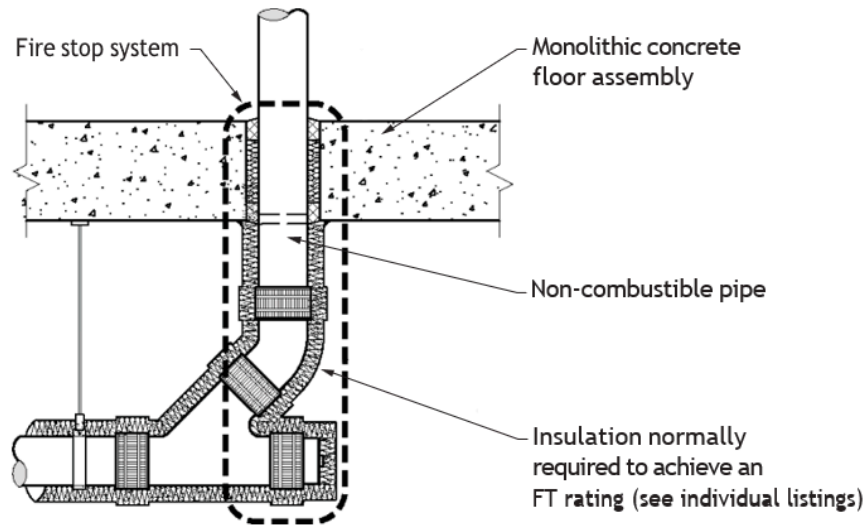


Figure 24 Non-combustible pipe penetration through monolithic concrete slab (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Floor Penetrations for Toilets Above Monolithic Concrete Floor Assemblies

DWV piping for toilets may pass through a monolithic concrete floor assembly from a parking garage to a wood-framed residence area (Figure 26). This situation would require firestop solutions similar to those in Figure 25. The parking garage is classified as a separate building. The extent to which a non-combustible pipe would need to be insulated for an FT rating is dictated by the listed firestop system installation requirements. If combustible pipe is used, a listed firestop system rated for combustible pipe would be required.

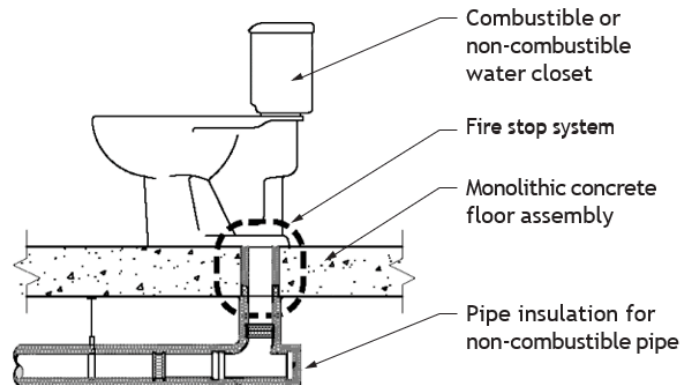


Figure 25 Penetration for toilet in a wood-frame area above a monolithic concrete floor, for FT rating (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

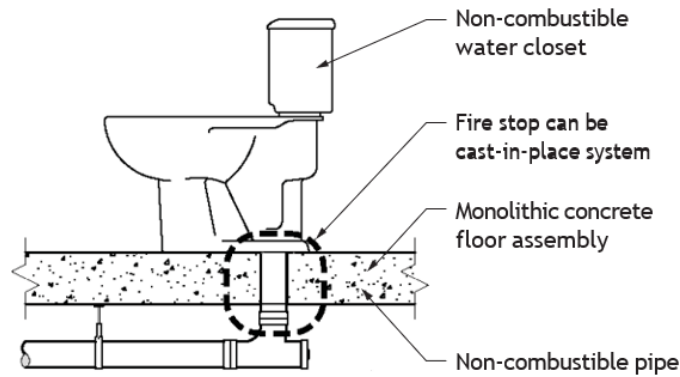


Figure 26 Penetration for toilet above a monolithic concrete slab for F rating only (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Where the parking garage is part of the building above it, the penetration through the monolithic concrete floor assembly using combustible pipe is permitted by the national building code. The water closet must be non-combustible. For such combustible pipe penetrations, a listed firestop system with an F rating would be required. For non-combustible pipe, the national building code would not require a listed fire-stop system if the pipe were cast in place. A listed firestop system with an F rating could also be used instead of casting the pipe in place.

Floor Penetrations for Toilets Above Wood Sleeper Floors on Monolithic Concrete Floor Assemblies

When a wood sleeper floor system is installed above a monolithic concrete floor assembly, a somewhat different arrangement of firestops may be required, depending on whether a parking garage is considered a separate building or not. There are several available options.

Figure 27 illustrates one option when a non-combustible pipe penetrates an assembly that requires an FT rating. The insulation will cover the pipe for a specified distance from the firestop to ensure that the FT rating is achieved. The pipe is not cast in place, so a firestop system is also used to attain an F rating. Inside the dashed line, you can see the firestop system required. When using this type of wood sleeper floor system, you may be required to subdivide the area of the wood sleeper floor.

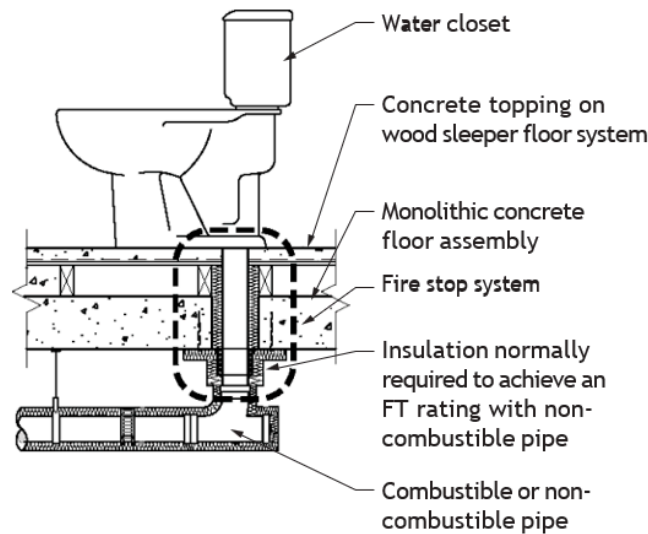


Figure 27 Penetration for toilet on wood sleeper floor system above a monolithic concrete slab for an F or FT rating (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Recall the definitions of the following terms:

F Rating: A firestop system that remains in the opening during the fire test for the rating period (for example, $\frac{3}{4}$ hour, 1 hour, etc.), without permitting the passage of flame through the opening or any flaming on any element on the unexposed side of the firestop system. F ratings may be at the level of a fire-protection rating or fire-resistance rating, depending on the type of service penetration being protected.

FT Rating: A firestop system that remains in the opening during the fire test, without permitting the passage of flame through the opening or any flaming on any element on the unexposed side of the firestop system. It also limits the temperature rise on the unexposed surface to less than 181°C (358°F) above ambient room temperature.

Monolithic Concrete Floor Penetrations for Tubs and Showers

Figure 28 illustrates an arrangement where a monolithic concrete floor is penetrated by piping for a tub or shower. The left side shows a combustible pipe penetration, and the right side shows a non-combustible pipe penetration.

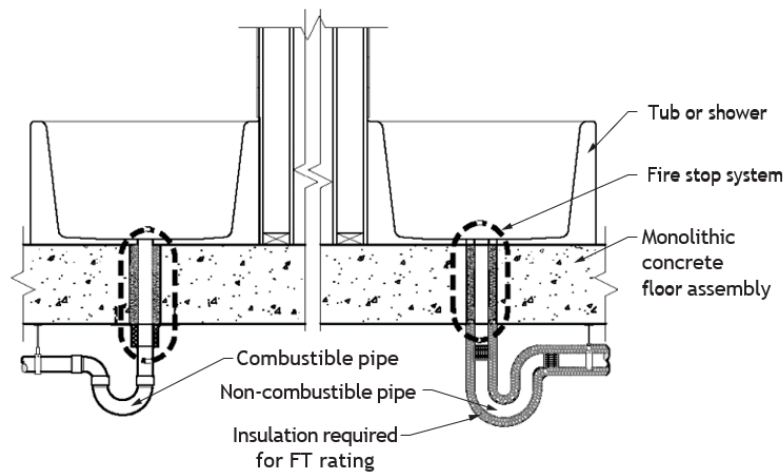


Figure 28 Pipe penetration for a tub or shower above a monolithic concrete slab for F or FT ratings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 28 illustrates a plumbing penetration through a slab where the parking garage is a separate building or where the parking garage and the floors above are considered to be in the same building. If non-combustible pipe penetrates an assembly and the fire stop is required to have an FT rating, insulation may be required to cover the pipe for a specified distance to and from the fire stop to achieve the FT rating.

Pipe Penetrations Through Monolithic Concrete Slab or Masonry Walls

Figures 29 to 31 show pipe penetrations through a monolithic concrete or masonry wall fire separation and firewall.

When penetrating a firewall, piping must be designed in such a manner that its collapse will not cause the collapse of the firewall. Any fire stop must take that requirement into account. As well, any pipe penetration of a firewall must be provided with a fire stop with an FT rating not less than the fire-resistance rating of the firewall. Recall that an FT rating requires the non-combustible pipe to be insulated for a specified distance on both sides of the firewall. The distance for the insulation is specified in the listed firestop system design. This insulation could also extend equally on both sides of the firewall.

When penetrating a monolithic concrete or masonry wall that is a fire separation, only an F rating is required.

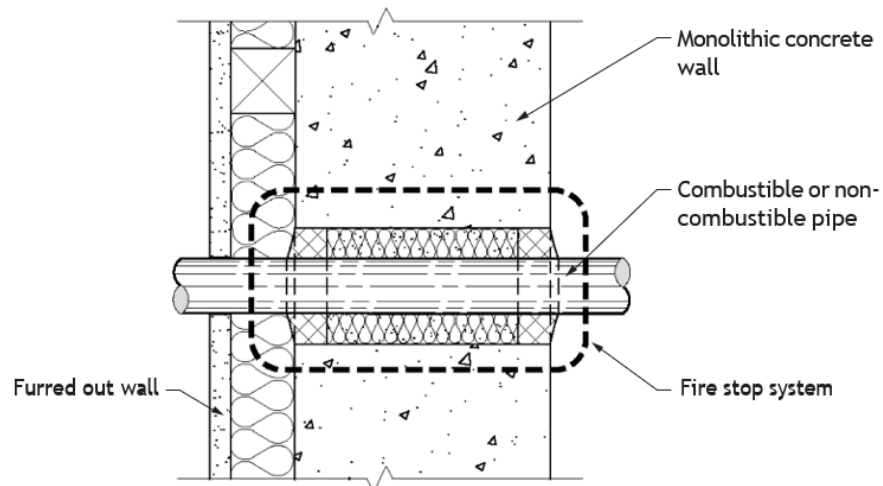


Figure 29 Penetration of pipe through monolithic concrete wall assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

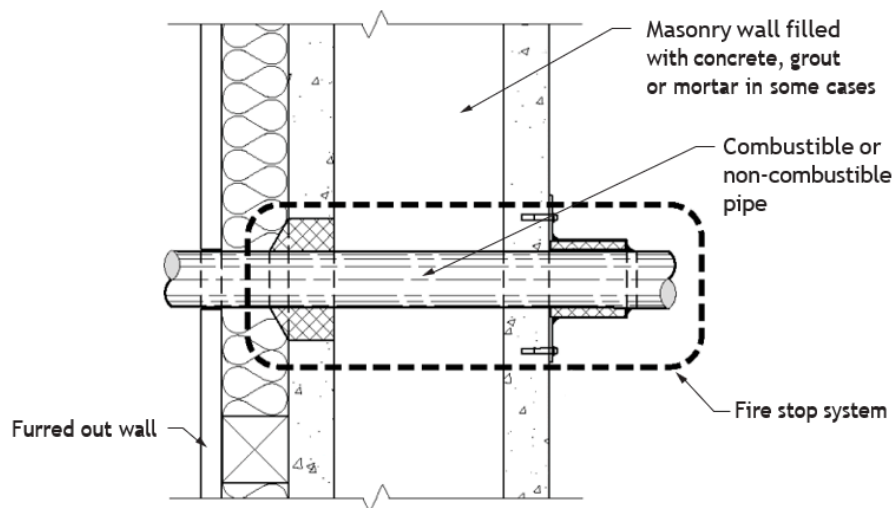


Figure 30 Penetration of pipe through wall assembly without using a sleeve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

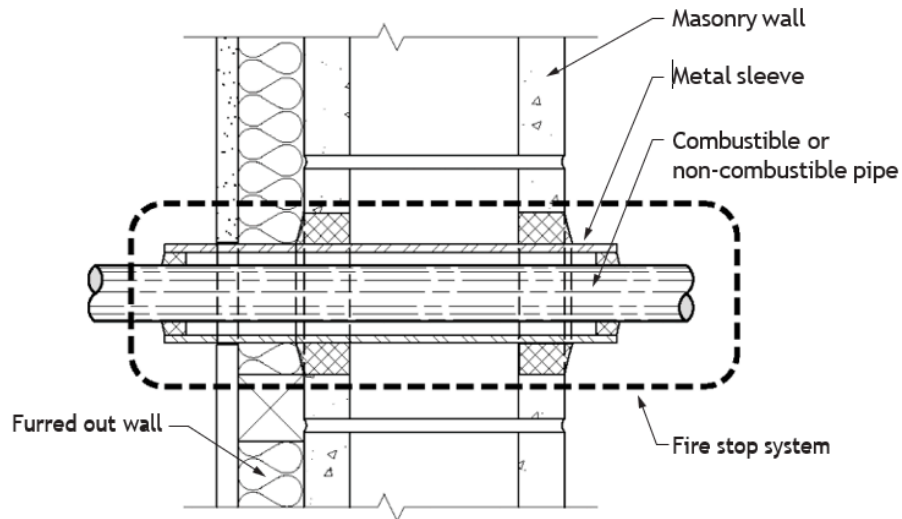


Figure 31 Penetration of pipe through wall assembly using a sleeve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Penetrations Through Wood-Framed Fire-Separation Assemblies

Figure 32 shows an example of piping arrangement and firestopping locations through a framed floor assembly. When penetrating a fire-rated framed floor assembly, firestops are required at the ceiling membrane and at the floor level. Follow the manufacturer's firestop directions, the job specifications and building code requirements. The building code will determine the appropriate use of non-combustible piping when penetrating horizontal fire separations.

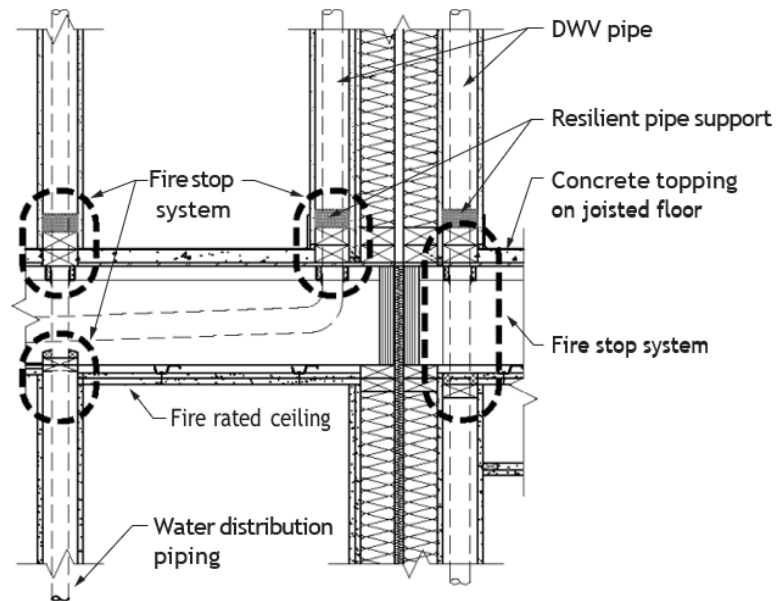


Figure 32 Firestop locations for pipe penetration through a framed floor assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Combustible Sprinkler Pipe

Figure 33 shows an example of how combustible sprinkler piping is permitted to penetrate a horizontal fire separation. No fire stop is required at the lower, non-fire-rated ceiling.

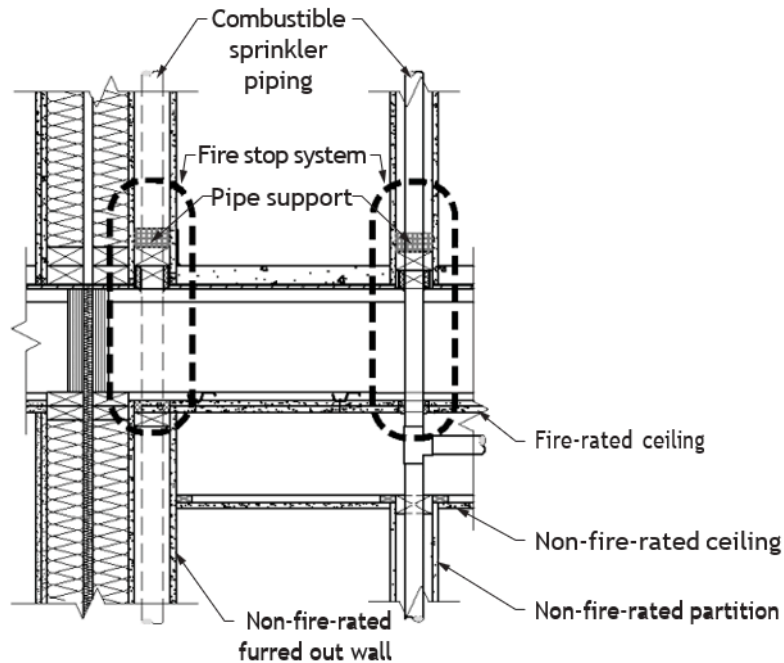


Figure 33 Penetration of combustible sprinkler piping through a framed floor assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Where combustible or non-combustible sprinkler piping penetrates a fire-rated ceiling membrane and leads directly to a sprinkler (Figure 34), that penetration should be tightly fitted and covered with an escutcheon on the room side. Changes to the installed sprinkler with a fire stop in the annular space between the pipe and the ceiling could impede sprinkler operation. Fire stops are often not provided at this ceiling penetration as they may potentially interfere with the distribution pattern of the sprinkler spray if the sprinkler position moves as a result of fire-stop intumescent action.

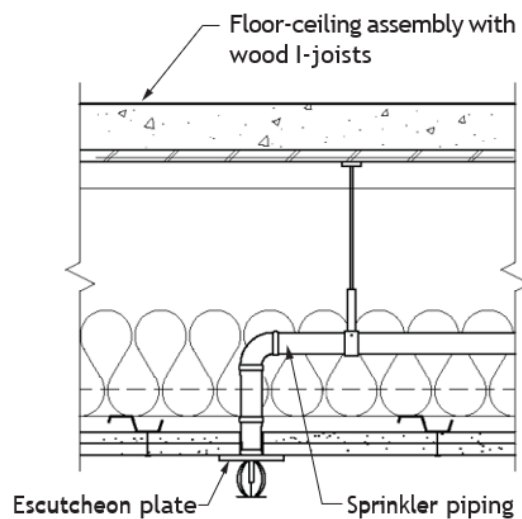


Figure 34 Penetration of sprinkler piping through ceiling membrane of fire-rated assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

If used, firestops selected for this application in Figure 35 should not deform under fire temperatures. Contact the manufacturer of the sprinkler to determine if firestops can be used in this application.

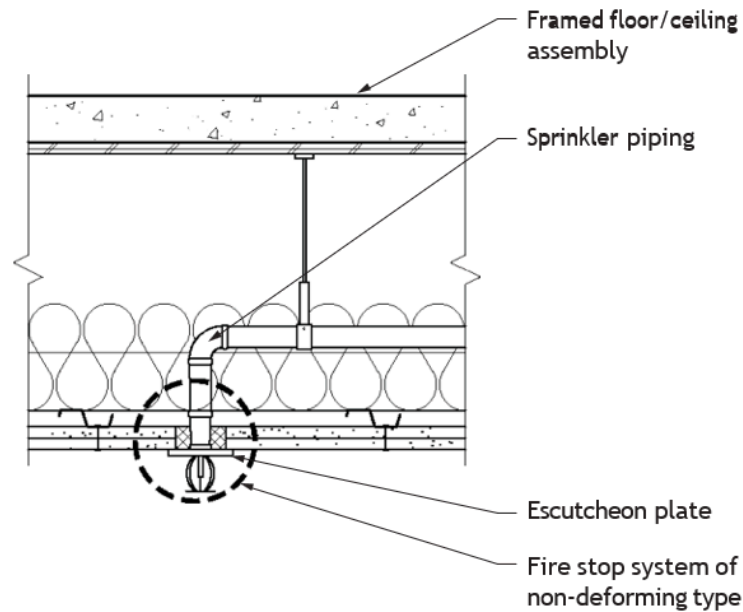


Figure 35 Penetration of sprinkler piping through ceiling membrane of fire-rated assembly with a firestop (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Penetrations Through Framed Floor Fire-Separation Assemblies

Figure 36 shows two water-closet piping arrangements and fire-stop locations.

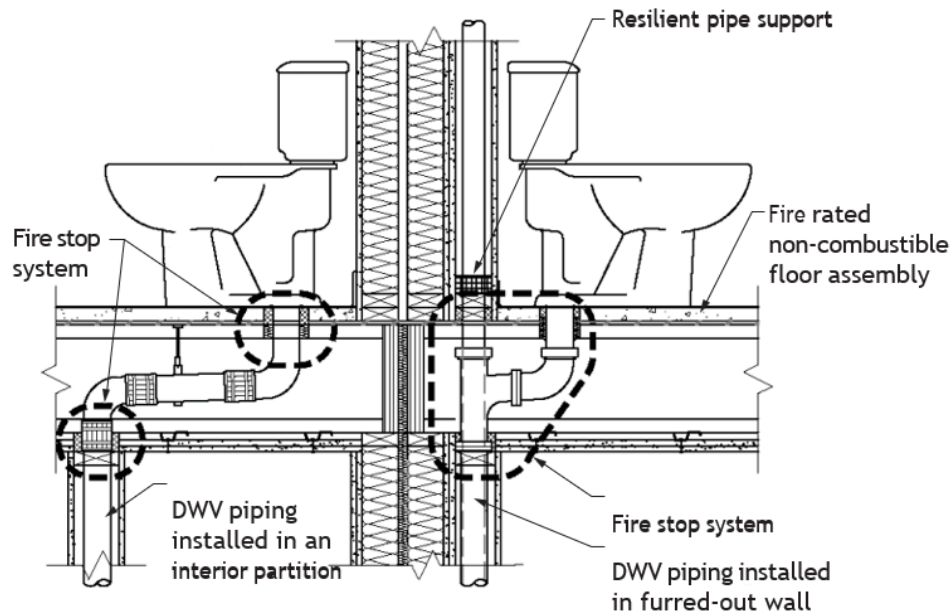


Figure 36 Penetration of DWV pipe for toilet through a framed floor assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Note: Piping configurations in these illustrations may not be correct to plumbing code requirements. Drawings are not for plumbing design purposes.

Pipe Penetrations Through Framed Floor Assemblies for Tubs And Showers

Figure 37 shows two bathtub piping arrangements and firestop locations.

Typically the waste and overflow drain opening in the floors is cut rectangular. The firestop board here would be cut to fit tight to the shape of the drain assembly. **Gypsum board**, cement board, plywood or **oriented strand board (OSB)** may be acceptable to the authority having jurisdiction. The exact board product may be specified for the listed firestop system. Since moisture could be an issue here, a water-resistant board may be required.

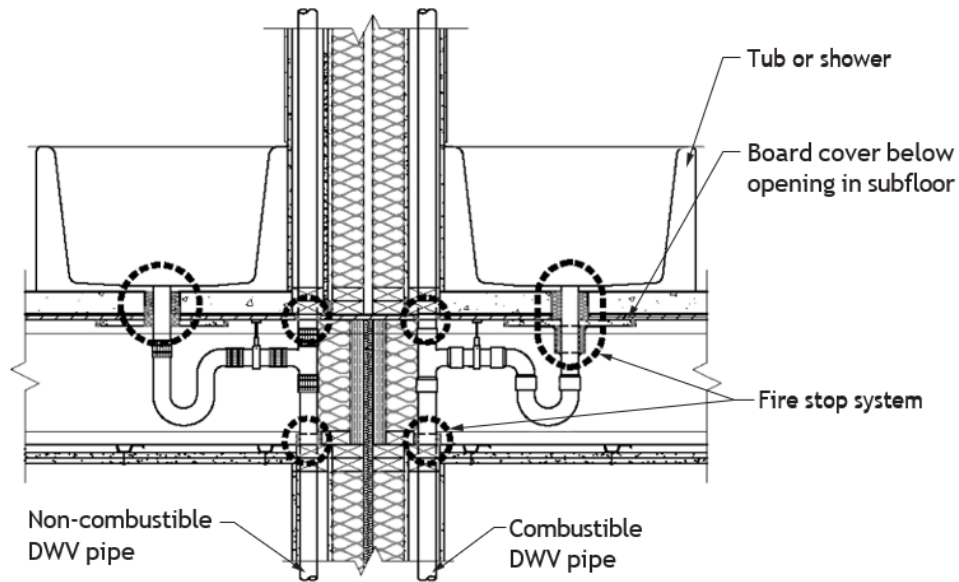


Figure 37 Penetration of pipe for tubs or showers through a framed floor assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Penetrations Through Framed Walls

Figure 38 shows piping installed in a framed wall and the location of firestops. Firestops are required at the location where the pipe penetrates the wall membrane and at the point where it penetrates the wall bottom plate or track.

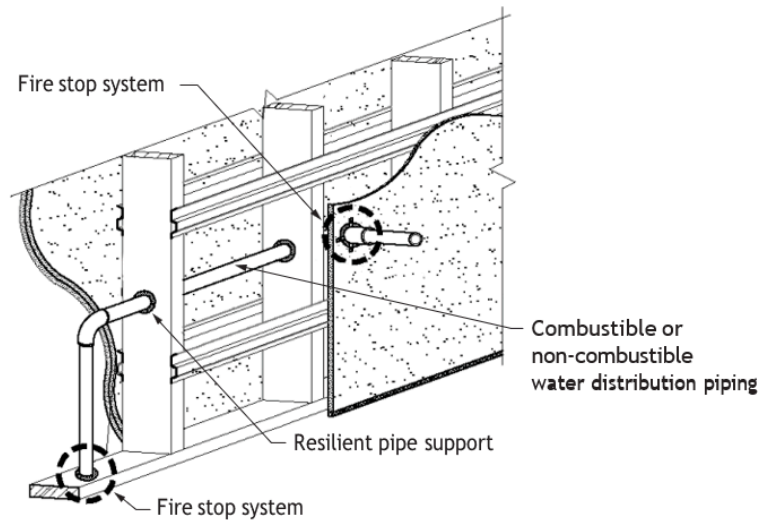


Figure 38 Penetration of water supply pipe through membrane of wall assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figures 39 and 40 show pipe penetrations through framed-stud fire separations. Firestops are required at both membranes since interior fire separations are rated from both sides. In Figure 40, an FT rating would require insulation on both sides of the separation.

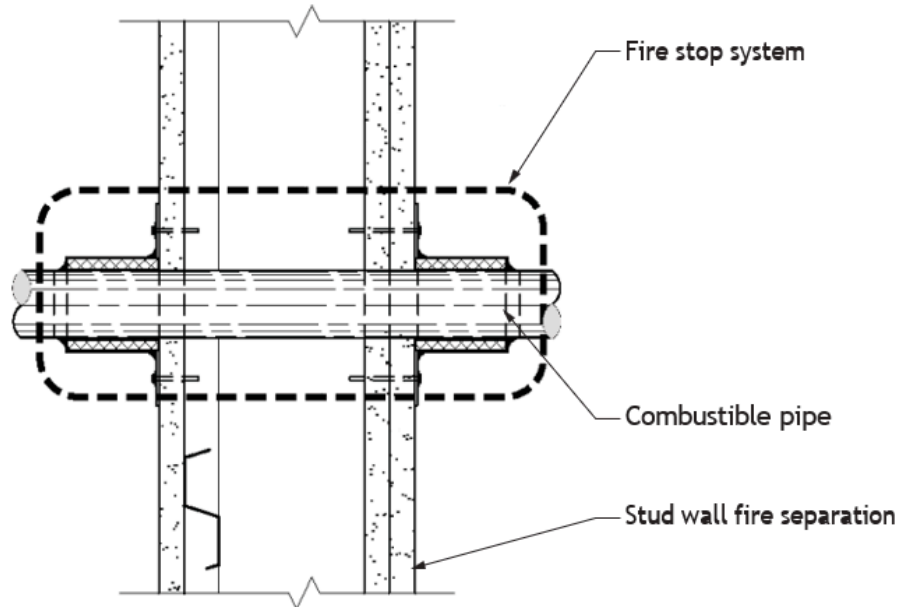


Figure 39 Penetration of a combustible pipe through an interior fire-rated wall assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Note: The use of retrofit fire stops on both sides of the fire separation.

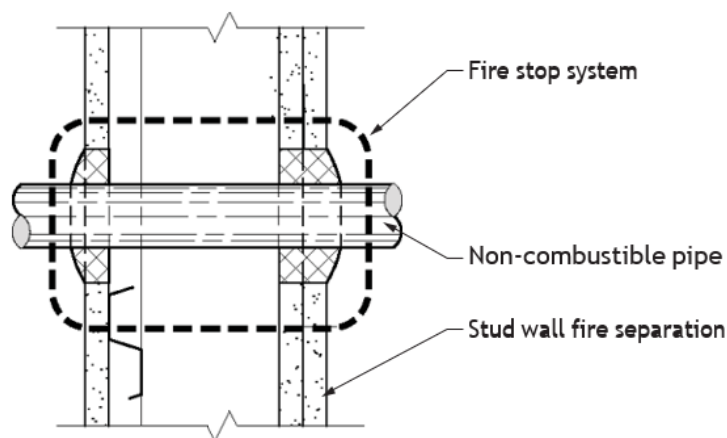


Figure 40 Penetration of a non-combustible pipe through an interior fire-rated wall assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 41 shows combustible pipe and firestop locations installed in a furred-out wall outside of the fire-separation shaft. Vertical combustible piping is not permitted in a vertical fire-separation shaft. Fire stops are required at the top

and bottom penetrations of the furred-out wall. (Only the bottom plate firestop is shown.) Fire stops may not be required at the furred-out wall penetrations since the wall chase is not a fire-rated wall. If the pipe were located in a vertical fire-separation shaft, it would need to be non-combustible and listed firestop systems would have to be provided at the wall penetrations.

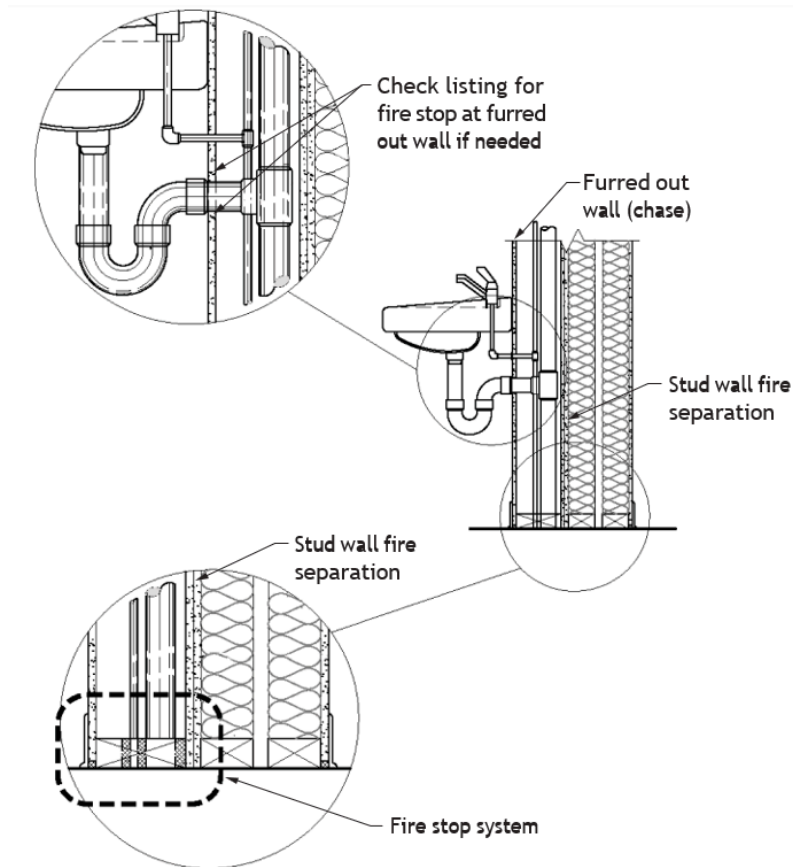


Figure 41 Combustible piping in a furred-out wall (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 42 shows a pipe penetration through a fire-rated membrane and the location of the firestops. Note that some listed fire-stop systems require the DWV piping to be located only inside a fire-rated wall, so care must be taken to ensure that walls are fire-rated where these firestops are used. Details are provided in the literature for the listed fire-stop system.

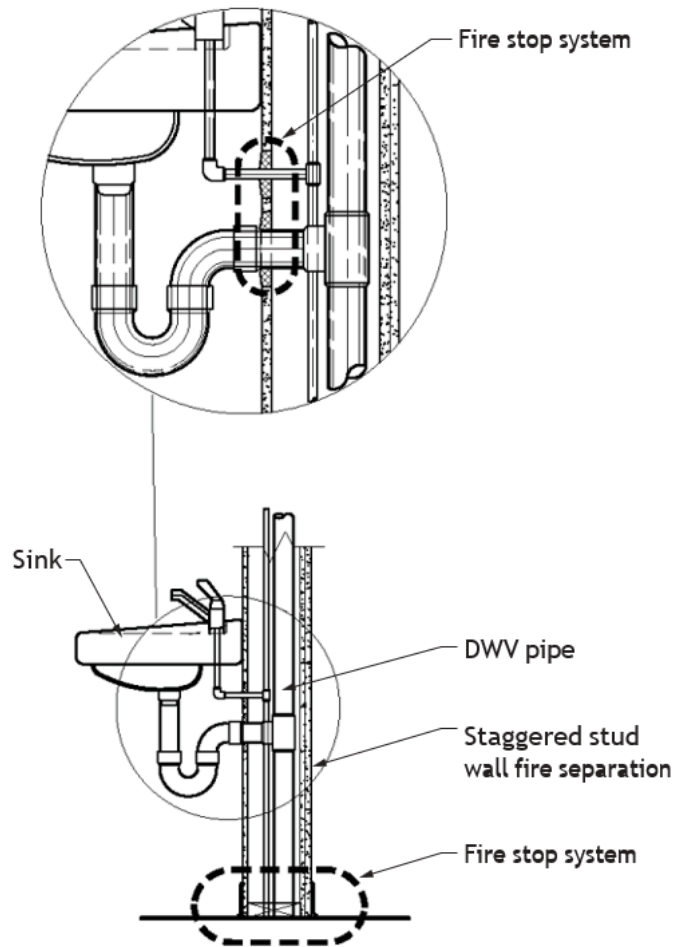


Figure 42 Penetration of a pipe through a fire-rated wall assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe Penetrations for Laundry Rooms

Figure 43 shows a pipe penetration through a fire-rated membrane and the location of the firestops for a laundry tray. The difficulty for firestopping is at the clothes-washer hose connecting to the drainage pipe inside the wall. Follow the instructions for the listed firestop system used. You should be aware whether the firestop system requires the washer drain piping to be located only inside a fire-rated separation.

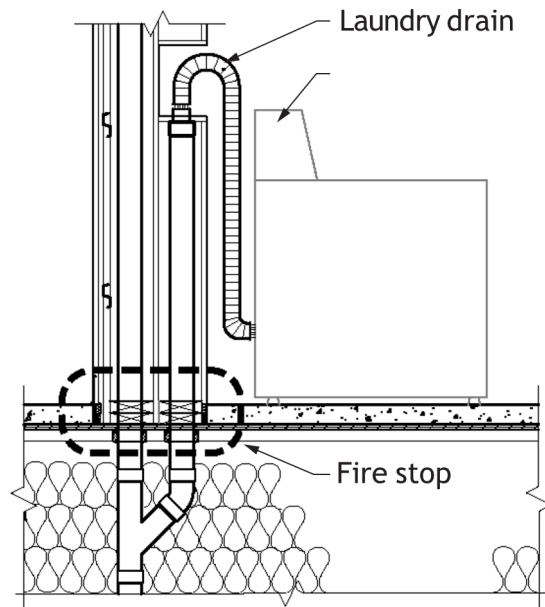


Figure 43 Penetration of a drainpipe through a furred-out wall assembly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Note: Piping configuration may not be correct to plumbing code requirements. Drawings are not for plumbing design purposes.

Multiple Pipe Penetrations Through Framed Stud Walls

Figure 44 shows a framed opening in a fire-separation stud wall. The framed opening should provide the same fire rating as the fire separation. Refer to the details for the listed firestop system selected. Recall the spacing requirements for multiple penetrations discussed earlier.

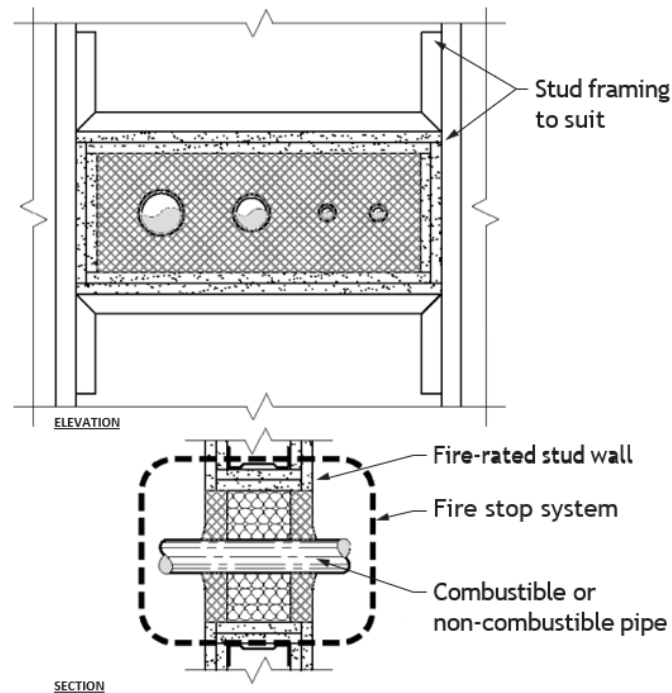


Figure 44 Multiple pipe penetrations through a fire-rated stud wall (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Multiple penetrations through a fire separation should be spread out to the greatest extent possible to achieve best practice. Where multiple penetration openings are needed through a gypsum board wall, many installations will require a frame around the larger openings to support the listed fire-stop system and the penetrating item. An alternative to using individual listed firestop systems, each with its penetrating item(s), is to use a specifically listed fire-stop system for multiple penetrations— especially if the penetrations must be close together.

Sometimes, openings may contain combinations of penetrating items, such as both pipes and cables. When these situations occur, select a listed firestop system design that accommodates the assembly construction materials and the various penetrating items to ensure the integrity of the fire-stop system.

Pipe Penetrations Through Framed Roof Spaces

Figure 45 shows a combustible or non-combustible plumbing vent pipe penetrating a fire-rated ceiling into an attic space. Firestopping is required, as shown. Many buildings are required to have fire-rated roof assemblies. Where these fire-rated roof assemblies are present, pipe penetrations into the concealed roof space must be equipped with firestops at the fire-rated membrane ceiling level. Firestops for sprinkler piping, except those connecting to a sprinkler head, must be installed in the same manner as shown in Figure 45.

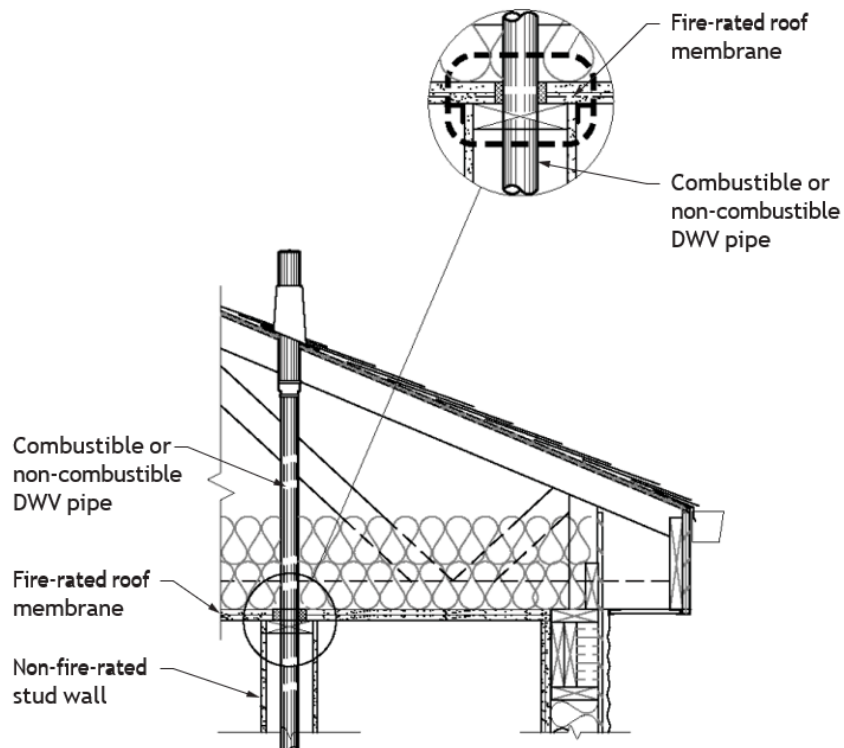


Figure 45 Penetration of a pipe through a fire-rated ceiling membrane (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Transitions Between Combustible and Non-Combustible Pipe

Sometimes both combustible and non-combustible pipes are used in the same structure. The transitions from combustible pipe to non-combustible pipe must be made in the right location to ensure the fire-protection integrity of the structure (Figure 46). The building code allows combustible DWV pipe to penetrate a horizontal fire separation if it leads directly from a non-combustible water closet through a concrete floor slab. The building code also permits combustible DWV piping to penetrate a fire separation, provided it is equipped with a listed firestop system tested with a 50 Pa (0.01 psi) pressure differential and the pipe is not located in a vertical shaft. Before applying the above arrangement, discuss the application with the authority having jurisdiction in your location. Interpretation of the code may differ in some jurisdictions.

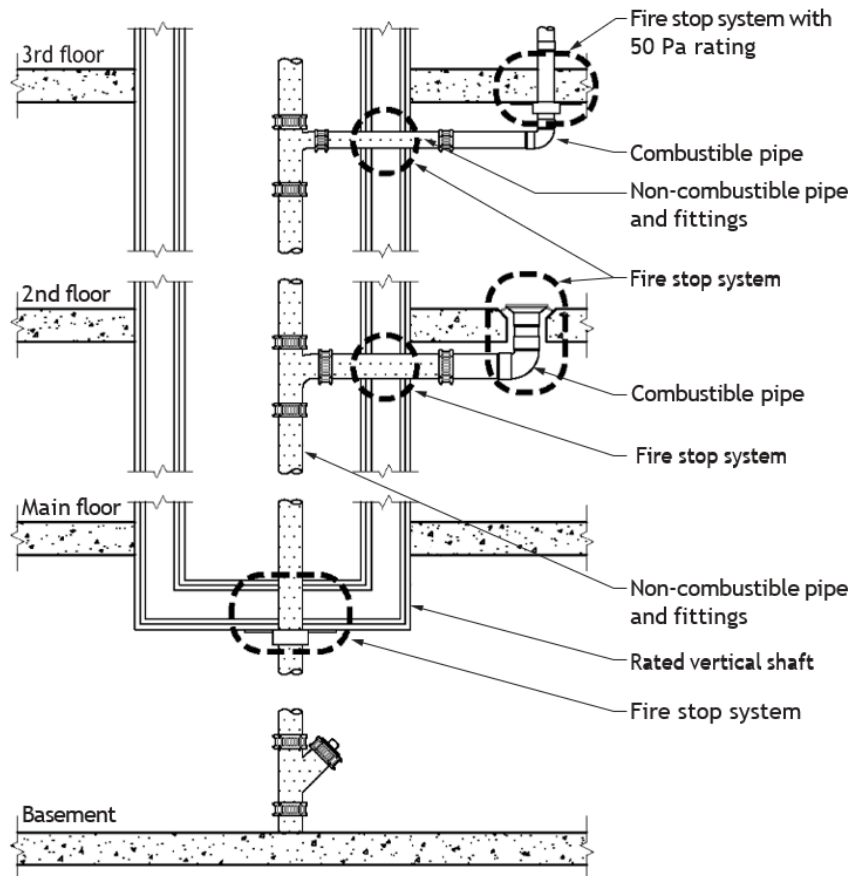


Figure 46 Piping transition locations and required locations of firestops in a vertical fire-separation shaft (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Note: In both horizontal pipe arrangements, the pipe penetrating the wall of the vertical shaft and the pipe in the shaft itself are non-combustible. A vertical fire-separation shaft passes through several stories. Vertical chase is located within a single storey.

Figure 47 shows combustible DWV piping installed in a vertical chase, as allowed by the building code. The combustible DWV pipe is allowed to penetrate a vertical fire separation, provided that the combustible pipe is not located in a vertical shaft. The vertical run of pipe is located in a chase inside a wall and not in a vertical shaft. The type of firestop chosen will depend on whether or not the wall is fire-rated.

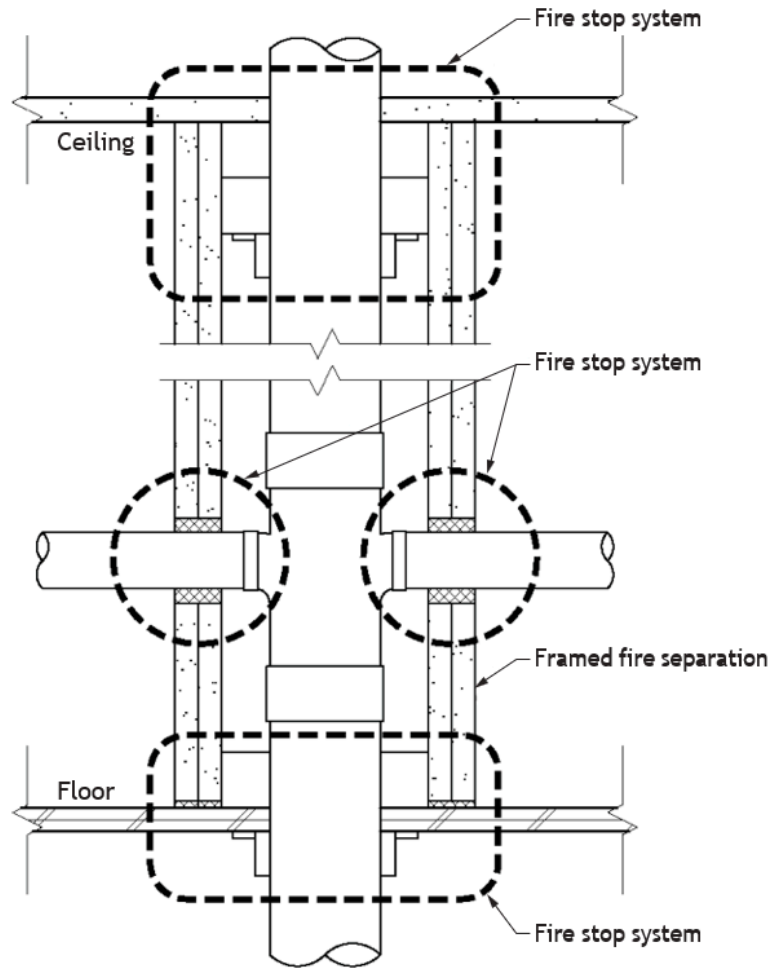


Figure 47 Combustible DWV pipe penetrating a vertical fire chase separation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The combustible pipe is located in a chase inside a fire-rated wall and not in a vertical shaft.

Figure 48 shows combustible DWV pipe installed in a parking garage and passing up through a concrete slab. The firestopping required is as shown. The location of the transition is not clear. Opinions vary on this application. Some firestops may require a minimum distance above the slab before the pipe transition can occur. There are numerous other possible variations of combustible/ non-combustible pipe transitions that can occur in a plumbing system, including those for water pipes. Consult the local authority having jurisdiction before beginning any installations involving such transitions.

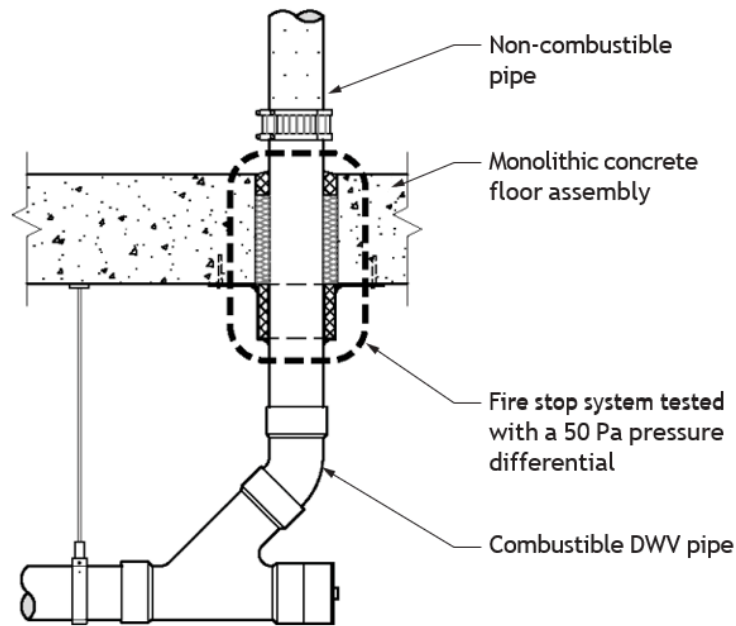


Figure 48 Transition from combustible pipe in the parking garage below the slab, to non-combustible pipe above the slab (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Maintenance of Firestop Systems

Fire-stop systems require regular inspection and testing to ensure that the components will inhibit fire spread as intended. Moving parts must be adjusted and lubricated.

Labelling Firestop Assemblies

Where practical, all firestopping systems should be labelled for identification purposes to assist with ongoing maintenance, inspection and testing (Figure 49). In some jurisdictions, this is a requirement.



Figure 49 Fire stop label (Courtesy of Hilti) Used with permission.

Manufacturer's Installation Instructions

Manufacturers supply installation instructions specific to their product. The instructions typically include photographs or drawings to demonstrate the correct installation methods. Technical data sheets are usually supplied with the installation instructions. These list the important limitations relating to the fire-stopping product, such as:

- Fire-resistant barrier types
- Maximum opening sizes
- Compatible penetrating services
- Surface or other preparation
- Fixing details

Manufacturers and suppliers should provide adequate instruction on the correct installation of their products in line with the as-tested specimens. Adequately detailed installation instructions should ensure that the product is installed correctly.

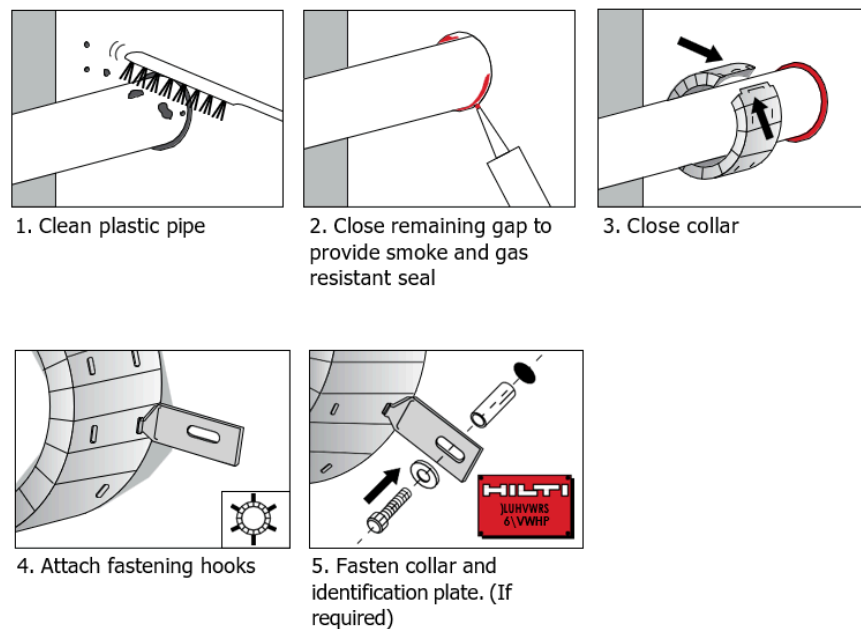


Figure 50 Typical installation instruction diagrams (Courtesy of Hilti) Used with permission.

Examples of Firestop Applications

Figure 51 shows piping passing through a concrete block firewall.



Figure 51 Fire stop in concrete (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure 52 shows the underside of a concrete slab above an underground parking garage. The garage is considered a separate building from the floor above.



Figure 52 Firestop in parking garage ceiling (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In Figure 52, the single grey combustible plastic pipe on the right does not require insulation for the FT rating. A firestop sleeve that was precast into the concrete slab is visible where the plastic pipe penetrates the slab. The two steel non-combustible pipes on the left are insulated back a specified distance from their fire stop to provide the FT rating. Although not visible, these pipes also have a firestop sleeve precast into the slab.

Figure 53 shows an example of a pipe passing through a concrete slab next to two unused fire stops. Notice the firestop material (putty) used to plug the unused firestop sleeves. Also note the use of a fire-stop collar on the plastic pipe on the left.

The hole for the plastic pipe on the left was cored after the slab had been poured, so a retrofit collar was used. The intumescent collar will expand to fill the hole if the plastic melts. Insulation for FT rating on plastic is not required, as the plastic pipe will not conduct heat in the way steel pipe would.

The two unused sleeves may have been placed incorrectly before the concrete pour. The tops of these unused fire-stop sleeves will also be plugged.



Figure 53 Fire-stop application (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In Figure 54, notice the putty used as firestop material.



Figure 54 Pipe passing through a drywalled steel stud wall (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In Figure 55, insulation provides an FT rating. The importance of accurately placing the sleeves before the slab is poured is clear here. The extra cost of coring the slab reduces the profit margin, and the error in sleeve placement is there for everybody to see.



Figure 55 Insulated water pipe passing through the underside of a concrete slab in an underground parking lot (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

In Figure 56, the plastic ABS DWV pipe on the left is boxed out, so it can be used outside of the fire separation.



Figure 56 Gypsum board used in fire-blocking (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Ventilation Vapour Barriers and Moisture Penetration

Moisture and ventilation are important considerations in construction. As air moves into and out of buildings, temperature and pressure differences can occur with the building. Moisture in the air can condense on cold surfaces inside rooms or walls and over time can cause superficial and structural damage and pose a risk to the health of the occupants.

To prevent moisture problems and provide good air quality, buildings today employ heating systems, ventilation system and often air-conditioning systems. Many buildings employ construction methods involving the use of moisture barriers, vapour barriers and rain-screen technology. All of these construction methods strive to maintain an energy-efficient and comfortable environment within the structure.

Mechanical system installers, including the plumbing and pipe trades, must ensure that the piping they install does not jeopardize the efficiency of vapour or moisture barriers and rain-screen technology. Just as for firestopping practices, any piping penetration of vapour and moisture barriers, including rain-screen systems, must maintain the integrity of these systems.

Piping to exterior hose faucets and gas service will penetrate the house wrap. The penetrations must be sealed to prevent moisture penetration. Exterior grade flexible caulking is used to seal around any pipe penetration. The caulking should not react with the piping, such as cross-link polyethylene (PEX) piping. A protective wrap may be needed on the pipe before applying the caulking.

Water pipes exiting an exterior wall that incorporates rain-screen technology must meet these requirements:

- It must be sloped down and the penetration must be sealed. There is no regulation regarding the degree of slope.
- The pipe should be held secure to the structure to withstand the strains applied during use.



Figure 57 Exterior wall assembly with rain-screen (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Summary

You should now be better equipped to deal with piping penetrations and firestopping. Review the following learning outcomes. Upon completion of this section, you will be able to:

- Install piping systems in structures using various acceptable methods of structure penetrations without jeopardizing the structural integrities of the building.
- Describe acceptable installation methods of structural penetration and read and interpret the related manufacturer's specifications, code regulations and job specifications.

If you feel confident that you have met these outcomes along with the individual topic objectives you are ready to move on. If you do not feel confident, find the time to review the material again.



Self-Test 4.2 Describe Acceptable Methods of Structure

Penetration

Complete Self-Test 4.2 and check your answers.

If you are using a printed copy, please find Self-Test D-4.2 (#chapter-self-test-d-4-2-describe-acceptable-methods-of-structure-penetration) and Answer Key (#chapter-answer-key-self-test-d-4-2) in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2154#h5p-12> (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=2154#h5p-12>)

References

BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S

- Describe factors affecting penetrations in structures
- Plumber: Competency D-6 Penetrate Structures
- Steamfitter: Competency D-3 Penetrate Structures

Hilti Canada. (n.d.). *Hilti Canada*. <https://www.hilti.ca/>

Hilti Canada. (n.d.). *Firestop collars, wraps and bandages*. https://www.hilti.ca/c/CLS_FIRESTOP_PROTECTION_7131/CLS_FIRESTOP_COLLARS_WRAPS_BANDAGES_7131

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- The following figures are courtesy of Hilti Canada (<https://www.hilti.ca/>) and are used with permission:
 - **Figure 6** Hilti firestop collar
 - **Figure 7** Cast-in-place sleeve collar
 - **Figure 13** Firestop brick based on a two-component polyurethane foam
 - **Figure 14** Spray filler foam
 - **Figure 15** Application of firestop mortar
 - **Figure 16** Quick-setting mortar in package
 - **Figure 18** Firestop putty
 - **Figure 49** Fire stop label
 - **Figure 50** Typical installation instruction diagrams

Self-Test D-4.1 Describe Factors Affecting Penetrations in Structures

Complete Self-Test D-4.1 and check your answers.

1. What word is defined as the ability of a structural component to perform its designed purpose?
 1. Strength
 2. Agility
 3. Malleability
 4. Integrity
2. What words define a structural construction assembly that acts against the spread of fire?
 1. Fire separation
 2. Fire hose
 3. Fire extinguisher
 4. Fire sprinkler
3. What section of a wood laminated I-beam can be cut?
 1. End of the flange
 2. Centre of the flange
 3. Centre of the beam web
 4. Within 300 mm (12 in.) of the beam end
4. What structural wood-frame component cannot be drilled, notched or altered?
 1. Stud
 2. Truss
 3. Joist
 4. Beam
5. What structural hidden component is used in a concrete block wall to tie together and strengthen the wall?
 1. Tie wire
 2. Grade beams
 3. Bond beam
 4. Snap ties
6. What devices are installed before a concrete deck slab is poured?
 1. Pipe hangers
 2. Grid stakes
 3. Cast iron drainage fittings
 4. Concrete inserts for hangers
7. What is the name of a reference point for locating sleeves when canning a formwork deck in preparation for the concrete pour?
 1. Grid line
 2. Datum point
 3. Slab band line
 4. Reinforcing bar line
8. What word describes the space between the inside wall of a pipe sleeve and the outside wall of the penetrating



Figure 1 Wood I-Beam

pipe?

1. Annual
 2. Annular
 3. Gap
 4. Root
9. What premise service piping cannot enter the building from underground?
1. Water
 2. Gas
 3. Electrical
 4. Storm-water
10. What is used to cut a hole for a pipe penetration in a structural concrete slab above a parking garage?
1. Diamond drill coring
 2. Jackhammer
 3. Cutting torch
 4. Laser coring
11. What criteria are used to size a pipe sleeve?
1. Liner pipe expansion and internal sleeve diameter
 2. Thickness of penetrating pipe wall and firestop diameter
 3. Internal diameter of penetrating pipe and insulation thickness
 4. External diameter of penetrating pipe and insulation thickness
12. When should you install pipe sleeves during the construction of the formwork of a concrete slab?
1. Before the formwork is complete
 2. Before the reinforcing bar and conduit are installed
 3. After all reinforcing and conduit have been installed
 4. During the pour of the concrete slab
13. What is the minimum width of undamaged wood in the top plate of a wood stud wall that is permitted without additional reinforcement?
1. 25 mm (1 in.)
 2. 40 mm (1 ½ in.)
 3. 50 mm (2 in.)
 4. 75 mm (3 in.)
14. What is the minimum total undamaged dimension of a notched wood stud in a load-bearing wall that is permitted without additional reinforcement?
1. 1 ½ in. (40 mm)
 2. One-quarter the depth of the stud
 3. One-third the depth of the stud
 4. Two-thirds the depth of the stud

Answer Key: Self-Test D-4.1 (#chapter-answer-key-self-test-d-4-1) is on the next page.

Answer Key: Self-Test D-4.1

1. d. Integrity
2. a. Fire separation
3. c. Centre of the beam web
4. b. Truss
5. c. Bond beam
6. d. Concrete inserts for hangers
7. a. Grid line
8. b. Annular
9. b. Gas
10. a. Diamond drill coring
11. d. External diameter of penetrating pipe and insulation thickness
12. b. Before the reinforcing bar and conduit are installed
13. c. 50 mm (2 in.)
14. d. Two-thirds the depth of the stud

Self-Test D-4.2 Describe Acceptable Methods of Structure Penetration

Complete Self-Test D-4.2 and check your answers.

1. What name defines a substance that swells as a result of heat exposure?
 - a. Intumescent
 - b. Exothermic
 - c. Endothermic
 - d. Active fire-protection expansive
2. What word defines the space between a penetrating item and whatever surrounds it, such as the sides of an opening or a sleeve?
 - a. Void
 - b. Granular
 - c. Annular
 - d. Sealant
3. What abbreviation defines fire prevention rating for a firestop with a flame transfer and high temperature rating?
 - a. F
 - b. FR
 - c. FP
 - d. FT
4. What type of fire prevention system is a firestopping system?
 - a. Active
 - b. Passive
 - c. Aggressive
 - d. Preventive
5. What fire rating is required for a firestop located in a horizontal fire separation above a parking garage classified as a separate building?
 - a. F only
 - b. FT
 - c. FR
 - d. FP
6. What is the design application of the firestop collar shown here?
 - a. Wall and ceiling installation
 - b. Installation after the concrete is poured
 - c. Installation requiring an FT rating of four hours
 - d. Installation before the concrete is poured
7. What type of penetration is one where the fire stop is used for a penetrating item that passes through only one membrane of a fire-rated assembly?
 - a. Membrane
 - b. Through
 - c. One side penetration



Figure 1 Hilti firestop collar

- d. Partial separation fire stop
- 8. What type of fire stop consists of a steel or plastic canister, filled with a predetermined amount of intumescent that expands to many times its original volume, helping crush plastic pipe and fill the void?
 - a. Mineral wool
 - b. Firestop collar
 - c. Surface-mounted collar
 - d. Composite sheet board
- 9. What type of fire stop is often used for single and multiple penetrations in an opening because it is adaptable to more complex and unusual penetrations and openings?
 - a. Caulking
 - b. Collar
 - c. Pillow
 - d. Foam blocks
- 10. What fire rating is required for non-combustible pipe penetration through a monolithic concrete slab between separate occupancies?
 - a. F
 - b. FT
 - c. FR
 - d. FP
- 11. What additional protection is required, besides the firestop, for a non-combustible pipe penetration through a monolithic concrete slab between separate occupancies such as a parking garage and the occupancy above?
 - a. Insulation placed on the pipe below the slab
 - b. Insulation placed on the pipe above the slab
 - c. Insulation placed on the pipe above and below the slab
 - d. Firestop collar place above and below the slab
- 12. What is required for a non-combustible sprinkler pipe that penetrates a fire-rated ceiling membrane and is connected directly to a sprinkler head?
 - a. Collar
 - b. Intumescent putty
 - c. Silicone caulking
 - d. Tightly fitted escutcheon
- 13. What is required for a non-combustible pipe penetration passing through an FT-rated firewall?
 - a. Fire collar on one side of the wall
 - b. Insulation placed on the pipe on one side of the wall
 - c. Insulation placed on the pipe on both sides of the wall
 - d. Firestop pillows placed on both sides of the wall
- 14. What is required for a water pipe exiting an exterior wall that incorporates rain-screen technology?
 - a. Sloped down in the direction of flow and the penetration sealed
 - b. Sloped down opposite the direction of flow and the penetration not sealed
 - c. Sloped up in the direction of flow and the penetration not sealed
 - d. Installed with no slope and the penetration left open to ventilate the air space

Answer Key: Self-Test D-4.2 (#chapter-answer-key-self-test-d-4-2) is on the next page.

Answer Key: Self-Test D-4.2

1. a. Intumescent
2. c. Annular
3. d. FT
4. b. Passive
5. b. FT
6. d. Installation before the concrete is poured
7. a. Membrane
8. b. Fire-stop collar
9. a. Caulking
10. b. FT
11. a. Insulation placed on the pipe below the slab
12. d. Tightly fitted escutcheon
13. c. Insulation placed on the pipe on both sides of the wall
14. a. Sloped down in the direction of flow and the penetration sealed

Glossary - Block D: Piping and Components

ablative

Resisting heat transfer by using the heat of the exposing fire to erode the material. The material, by sacrificing itself, protects the unexposed side from rapid temperature rise until it is spent. A typical example is a silicon-based firestop material. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

ABS double wye

A plastic DWV fitting that connects four pipes using two angled (typically 45°) branches for smoother flow and reduced blockages. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

acid core

A type of solder with an acidic flux inside that helps clean metal surfaces during soldering. (Section D-1.6 (#chapter-d-1-6-section-6))

acrylonitrile-butadiene-styrene (ABS)

A strong, lightweight plastic used to make pipes and fittings, especially for drainage, waste, and vent systems. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

active fire protection

Systems that respond to fire through movement or activation, such as sprinklers or alarms. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

actuator

A device that moves a valve open or closed, either by hand or using power such as air, electricity, or hydraulic pressure. (Section D-2.2 (#chapter-d-2-2-install-valve))

adapters fittings

(sometimes called *transition fittings*); A fitting used to connect pipes with different connection types. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

air barrier

A system that prevents air leakage through building assemblies. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

air inlet valve

A valve that allows air to enter a system to prevent vacuum or pressure problems. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

air valve

A valve used to control the flow of air. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

air vent

A device that removes trapped air from a piping system. (Section D-1.4 (#chapter-d-1-3-section-4))

angle body globe valve

A globe valve valve design where the inlet and outlet are at a right angle; allows fluid to change direction only once as it flows through, and can also function as both a valve and a piping elbow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

annealed

Heated and cooled metal to make it softer and easier to shape. (Section D-1.6 (#chapter-d-1-6-section-6))

annealed temper

A soft and flexible type of copper tubing made by heating the metal and then slowly cooling it. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

annular space

The gap between a pipe and the sleeve or opening it passes through. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

anode

A metal through which current flows. (In an electrochemical reaction, the anode is the metal that corrodes.) (Section D-1.4 (#chapter-d-1-3-section-4))

apartment tee

A DWV fitting used in multi-unit buildings to connect a branch line to a vertical stack, designed to help control flow and reduce blockages. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

armour conduit

A protective tube or covering placed around piping or tubing to shield it from damage, such as impacts, abrasion, or punctures. (Section D-1.6)

as-installed piping geometry

The final position and layout of pipes after they have been installed. (Section D-1.6 (#chapter-d-1-6-section-6))

austenitic grades

A type of stainless steel that contains chromium and nickel, making it strong and very resistant to rust and corrosion. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

authorities having jurisdiction (AHJ)

Organizations or officials (such as inspectors) who enforce codes and regulations and approve whether work meets required standards. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

backfill

Material, such as soil or gravel, placed back into an excavation around a pipe or structure to provide support and restore the ground surface. (Section D-4.1)

backflow preventer valve

A valve designed to stop contaminated water from flowing backward into a clean water supply. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

backpressure

The pressure exerted on the downstream side of a valve seat. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

backwater valve

A check valve designed for use in a sanitary drainage system. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

ball valve

A quarter-turn valve with a ball-shaped closing element held between two seats. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

bead

A raised line or ring of melted material formed along a joint during welding or fusion, showing that the materials have joined properly. (Section D-1.6)

beam clamp

A device used to attach piping or supports to a steel beam without drilling, by gripping the beam securely. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

bell and spigot (lead and oakum) joint

A pipe connection where the plain end (spigot) is inserted into the enlarged end (bell), then sealed with oakum and molten lead to create a watertight joint. (Section D-3.1)

bell crank lever

A mechanical device that helps change the direction of movement and balance loads. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

bellows

A sealing device that prevents line media from leaking between the stem and the body. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

bellows seal bonnet

A valve bonnet that uses a flexible bellows to prevent leakage around the valve stem. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

bend

A pipe fitting used to change direction, often used instead of the term elbow in DWV systems. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

bidirectional valve

A valve that moves or operates in two usually opposite directions. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

billet (or tube round)

A solid piece of metal that is heated and shaped into pipe or tubing. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

blind pipe flange

A solid flange used to close off the end of a pipe or opening. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

block-out

An opening intentionally formed in concrete or other structural components during construction to allow space for pipes, ducts, or other services to be installed later. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

bolted bonnet

A valve bonnet that is attached to the valve body using bolts, allowing easy access for maintenance. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

bond beam

A reinforced horizontal element in a masonry wall that strengthens and ties the wall together. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

bore

The inside space of a pipe where fluid flows. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

Boston fitting

A DWV fitting that combines a wye and a 1/8 bend in one piece, allowing a smooth change in direction and connection of pipes. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

branch (lateral)

The pipe that connects off the main run of a fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

brazed fitting

A fitting joined by heating and melting a filler metal to create a strong, high-temperature joint. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

brazing

Joining metal using heat and a filler metal at high temperatures. (Section D-1.6 (#chapter-d-1-6-section-6))

brinelling

Damage to a metal surface caused by too much pressure, leaving dents or marks. (Section D-1.6 (#chapter-d-1-6-section-6))

bullhead tee

A tee fitting where flow enters through the branch and splits in opposite directions through the run, often causing turbulence and pressure loss. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

buoyancy

The upward force that pushes objects up when they are in water. (Section D-1.4 (#chapter-d-1-3-section-4))

bushing

A fitting used to reduce the size of a pipe opening, usually with threaded ends. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

butt fusion

A method of joining plastic pipes by heating the ends and pressing them together to form one solid piece. (Section D-1.6 (#chapter-d-1-6-section-6))

butterfly valve

A quarter-turn valve that has a circular disk as its closing element. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

bypass valve

A small-bore valve fitted in parallel to a larger main valve. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

cable-brace attachment

A support system that uses tensioned cables to hold piping in place and resist movement, especially during seismic activity. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

caddy clip

A fastening device used to secure pipe sleeves to formwork or structural surfaces. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

cams

When a disk moves into the seat in a slightly angled or rolling motion, rather than straight in. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

canning

The process of installing pipe sleeves in formwork before concrete is poured. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

cap

A fitting used to close the end of a pipe with internal threads. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

capillary action

The movement of liquid solder into the small gap between a pipe and fitting; caused by attraction between the metal surfaces and the solder. (Section D-1.6 (#chapter-d-1-6-section-6))

carburizing flame

A type of torch flame with extra fuel that adds carbon to the metal surface and produces a softer, lower-temperature flame. (Section D-1.6)

cast brass

A metal material used to make fittings, with a rougher surface and lower flexibility than copper. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

cast iron threaded drainage fitting (Durham fitting)

A threaded cast iron fitting used in drainage systems that can be taken apart and reused. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

cathode

A metal from which current flows. (Section D-1.4 (#chapter-d-1-3-section-4))

cathodic protection

A method used to control the corrosion of a metal surface by ensuring that the metal is the cathode in an electrochemical process. Normally, this process requires attaching or connecting the metal to a less-noble metal. (Section D-1.4, Table 5 (#chapter-d-1-3-section-4))

caulking gun

A tool used to apply sealants into joints or openings. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

cavitation

The formation of air bubbles in a liquid that can damage pipes. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

ceiling collars

A firestop collar specifically designed and tested for use in ceiling penetrations, often to meet additional temperature-rise (FT rating) requirements. (Section D-4.2)

centre-to-centre

The distance from the middle of one fitting to the middle of another. (Section D-1.6 (#chapter-d-1-6-section-6))

centre-to-face

The distance from the centre of a fitting to the end (face) of the pipe or fitting. (Section D-1.6 (#chapter-d-1-6-section-6))

centreline

An imaginary line that runs through the centre of a pipe or fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

centrifugal casting process

A method of making pipe by pouring molten metal into a spinning mould so the material spreads evenly along the inside surface. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

cerami-fibre (ceramic fibre)

A high-temperature insulation made from fine fibres, used to resist extreme heat and help prevent the spread of fire. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

chamfering

Cutting or smoothing the edge of a pipe at an angle to remove sharp edges and help it fit into a connection. (Section D-1.6 (#chapter-d-1-6-section-6))

check valve (non-return valve)

A valve designed to allow fluid to flow in one direction only and prevent reverse flow. The valve closes to prevent backflow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

chlorinated polyethylene (CPE)

A type of plastic material used for seals and linings that resists chemicals such as chlorine and bleach solutions. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

chlorinated polyvinyl chloride (CPVC)

A type of plastic pipe that can handle higher temperatures than regular PVC and is used in hot and cold-water systems. (Section D-1.6 (#chapter-d-1-6-section-6))

cleanout

An access point in a pipe system used to remove blockages. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

clevis hanger

A type of pipe support that uses a U-shaped metal bracket and pin to hold and suspend a pipe from above. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

close nipple

A very short threaded pipe with threads running nearly the entire length, used to connect two fittings closely together. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

closure

A device or assembly for closing an opening through a fire separation or an exterior wall, such as a door, shutter, wired glass, or glass block. Includes all components such as hardware, closing devices, frames, and anchors. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

closure (fire-rated)

A device such as a door or shutter used to close an opening in a fire separation. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

coefficient of friction

A measure of how easily one surface slides over another. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

cold spring

A slight bending of pipe during installation to reduce stress during use. (Section D-1.6 (#chapter-d-1-6-section-6))

cold-worked

Metal that has been shaped or strengthened without using heat, usually by bending or pressing it. (Section D-1.6 (#chapter-d-1-6-section-6))

combination valve

A valve that combines two functions, such as shutting off flow and relieving pressure, in one unit. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

companion flange

A flange used to connect a pipe to equipment or another flanged component, often matching the bolt pattern of the mating flange. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

compartmentalization

The division of a building into sections to limit fire spread. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

composite sheets and boards

Rigid panels made of layered materials, consisting of sheets sandwiched around an intumescent material, used to seal large openings and maintain fire resistance around penetrations. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

compression bending

A method of bending pipe where force is applied to push the pipe into shape using a die. (Section D-1.6 (#chapter-d-1-6-section-6))

compression-type fitting

A fitting that uses a nut and compression ring (ferrule) to squeeze and seal a pipe without the need for heat or threading. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

concrete formwork

Temporary structures used to shape and support concrete until it hardens. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

constant spring support

A pipe support that uses a spring mechanism to provide the same supporting force even as the pipe moves. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

control valve

A valve that regulates the flow or pressure of a fluid; control valves normally respond to signals generated by independent devices such as flow meters, temperature gauges, etc.; control valves are normally fitted with actuators and positioners. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

core drilling (coring)

A method of drilling circular holes in concrete using a specialized drill. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

corporation valve

A valve installed on a water main that allows a service line to be connected or shut off, often designed for underground use. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

corrosion

The gradual breakdown of metal caused by chemical reactions, such as rust. (Section D-1.4 (#chapter-d-1-3-section-4))

corrugated Stainless-Steel Tubing (CSST)

A flexible metal pipe used to carry natural gas or propane, designed with ridges so it can bend easily during installation. (Section D-1.6 (#chapter-d-1-6-section-6))

coupling

A fitting used to connect two pieces of pipe or tubing together in a straight line. (Section D-1.6)

crimp ring

A metal ring that is compressed around PEX tubing to hold it tightly onto a fitting and create a watertight seal. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

cross-connection

A connection between clean water and contaminated water that can allow pollution to enter the system. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

cross-linking

A chemical process that joins plastic molecules together to make the material stronger. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

crossover method

A way of tightening bolts in a crisscross pattern to ensure even pressure and a proper seal. (Section D-1.6 (#chapter-d-1-6-section-6))

cryogenic valve

A valve designed for use at temperatures below -40°C (-40°F). (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

cupola furnace

A type of furnace used to melt metal, especially iron, by heating it with coke and air to produce molten metal for casting. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

curb stop

A valve located near the property line that is used to shut off the water supply to a building from the main. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

dashpots

Devices that slow down the movement of a valve disk using fluid resistance to reduce shock, noise, and wear. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

dauber

A small applicator tool with a brush or sponge tip used to apply primer or solvent cement to pipes and fittings. (Section D-3.2)

deburring

The process of removing rough edges from a cut pipe. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

defect

A flaw or damage that makes a product less safe or effective. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

diaphragm valve

A valve that uses a flexible rubber-like part to control the flow and keep the fluid separate from the valve parts; a bidirectional valve operated by applying an external force to a flexible element, or diaphragm (typically an elastomer). (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

dielectric

A substance with a small amount of electrical conductivity. (Section D-1.4 (#chapter-d-1-3-section-4))

dielectric (cathodic) protection

A method used to reduce corrosion by separating different metals and controlling electrical current so the pipe is protected from rusting. (Section D-1.4 (#chapter-d-1-3-section-4))

direct acting pressure relief valve

A pressure relief valve that opens directly when system pressure exceeds a set level, usually using a spring. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

disbondment

The separation of a protective coating from a pipe's surface; accelerated when cathodic protection systems are operated with excessively polarized negative potentials, especially in systems operating at high temperatures. (Section D-1.4 (#chapter-d-1-3-section-4))

dissimilar metals

Different metals that can react with each other and cause corrosion when in contact. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

dissolved gases

Oxygen and carbon dioxide can be readily dissolved by water. These gases are aggressive instigators of corrosion. (Section D-1.4 (#chapter-d-1-3-section-4))

dissolved solids

These are substances that will dissolve in water. The principal ones are the carbonates and sulphates of calcium and magnesium, which are scale-forming when heated. There are other dissolved solids, which are non-scale forming. In practice, any salts forming scale within the boiler should be chemically altered so that they produce suspended solids, or sludge, rather than scale. (Section D-1.4 (#chapter-d-1-3-section-4))

diverter valve

A valve that can change the direction of the flow of a medium to two or more different directions. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

DN (diameter nominal)

A standard way of naming pipe size using metric units (millimetres) instead of inches. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

double block and bleed valve

A valve configuration in which positive shut-off is achieved at both the inlet and outlet sides, with a pressure bleed off between the two. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

double flange type butterfly valve

A butterfly valve with flanges on both sides that bolt directly to pipe flanges for a secure connection. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

double roll-back bead

A raised ring of melted material on both sides of the joint. (Section D-1.6)

double submerged arc welded (DSAW)

A pipe welding method where both the inside and outside seams are welded under a protective layer. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

double wye

A fitting that connects four pipes with angled branches. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

double-disk wafer-type check valve (split disk or dual plate check valve)

A check valve with two spring-loaded plates that open with flow and close quickly to prevent reverse flow and reduce water hammer. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

draft stop

A material intended to stop air movement and fire spread. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

draw bending

A method of bending pipe by pulling it around a form to create a smooth, controlled bend. (Section D-1.6 (#chapter-d-1-6-section-6))

drawn temper

A hard and strong type of copper tubing made by pulling the metal through a die without heating it. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

ductility

The ability of a metal to bend or stretch without breaking. (Section D-1.6 (#chapter-d-1-6-section-6))

duriron pipe

A type of cast iron pipe that is specially made to resist strong acids and corrosive liquids, often used in chemical and industrial systems. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

DWV (drainage, waste, and vent)

Pipes and fittings used to remove wastewater and allow air to flow in plumbing systems so drains work properly. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

DWV cross (double sanitary tee)

A fitting used in drainage systems to connect four pipes at 90-degree angles, allowing flow in multiple directions. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

DWV fittings

Fittings used to carry drainage, waste, and vent fluids by gravity. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

elastomer

Any material, such as natural or synthetic rubber, that is able to resume its original shape when a deforming force is removed. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

elastomeric

A material that is flexible and rubber-like, able to stretch and return to its original shape. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

elastomeric gaskets

Flexible rubber-like seals used between pipe connections to prevent leaks. (Section D-1.6 (#chapter-d-1-6-section-6))

elbow

A fitting used to change the direction of a pipe. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

electric resistance weld (ERW)

A method of making pipe by heating and welding the edges of steel together using electricity. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

electrical tester pen

A small handheld tool that detects if electrical voltage is present in a wire or device without touching exposed metal parts. (Section D-1.4 (#chapter-d-1-3-section-4))

electrochemical corrosion

Corrosion caused by an electrical reaction between metals and their environment. (Section D-1.4 (#chapter-d-1-3-section-4))

electrochemical process

A chemical reaction that involves electricity. (Section D-1.4 (#chapter-d-1-3-section-4))

electrochemical reaction

A reaction either caused or accompanied by the passage of an electric current and involving the transfer of electrons between two substances. (Section D-1.4 (#chapter-d-1-3-section-4))

electrode

An electrical conductor used to make contact with a part of a circuit. In an electrochemical cell, the electrode is referred to as either an anode or a cathode. Each electrode can be either the anode or the cathode depending on the current direction. (Section D-1.4 (#chapter-d-1-3-section-4))

electrolytic action

A reaction between different metals that can cause corrosion when they touch. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

elongation properties

Ability of the metal to stretch without breaking. (Section D-1.6 (#chapter-d-1-6-section-6))

endothermic

A reaction that absorbs heat energy. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

EPDM (ethylene propylene diene monomer)

A type of rubber used for seals and gaskets that resists heat, water, and weather. (Section D-1.6 (#chapter-d-1-6-section-6))

erection (field installation)

The process of assembling and installing piping systems on-site at the job location. (Section D-1.6 (#chapter-d-1-6-section-6))

erosion

The wearing away of material caused by fluid movement. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

ethylene propylene diene monomer (EPDM)

A type of synthetic rubber used for seals and gaskets that resists heat, water, and many chemicals, but is not suitable for oils or fuels. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

eutectic

A mixture having the lowest liquefaction point possible with a tin/lead mix. Alloys are eutectic when the solidus and liquidus are the same. (Section D-1.6 (#chapter-d-1-6-section-6))

exothermic

A reaction that releases heat energy. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

expansion

When a pipe gets bigger because of heat. (Section D-1.4 (#chapter-d-1-3-section-4))

expansion anchors (quick-bolts)

Fasteners that expand inside a hole to hold objects securely in place. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

extracted tee joints

A method of joining pipes where a collar is formed from the pipe itself to create a branch connection, which is then brazed for strength. (Section D-1.6)

extrusion

A process where heated material is pushed through a shaped opening to form pipe. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

face (flange)

The flat surface of a flange where it meets another flange or gasket to form a seal. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

female iron pipe (FIP)

A threaded pipe connection with internal threads that receives a male threaded pipe or fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

ferritic grades

A type of stainless steel that resists corrosion and is magnetic, but cannot be hardened by heat. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

ferrule

A small metal ring that fits around a pipe or tube to help create a tight seal and hold the connection securely when tightened. (Section D-1.6)

fibre insulation

Insulation made of fibrous materials such as mineral wool, glass fibre, or ceramic fibre, used to resist heat and help prevent the spread of fire. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

filler metal

A metal added to a joint to help join two pieces together. (Section D-1.6 (#chapter-d-1-6-section-6))

fillet

A visible ring of filler metal around the joint. (Section D-1.6)

fire damper

A device that automatically closes to prevent fire spread through ducts. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

fire load

The amount of combustible material present in a space. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

fire rating

The length of time that a building component or assembly can resist the spread of fire while maintaining its structural integrity, usually measured in minutes or hours. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

fire separation

A construction assembly designed to resist the spread of fire. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

fire-block

A material installed to prevent the spread of fire through concealed spaces. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

fire-rated assembly

A construction system designed to resist fire for a specified period of time. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

fire-resistant foam

A foam material designed to resist fire and provide a fire rating when used to seal gaps or joints. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

fire-resistant pillows

Soft, fire-resistant bags or cushions packed into openings around pipes or cables to help prevent the spread of fire and smoke. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

fire-stop foam

A fire-resistant foam that expands to fill openings around pipes or cables, helping to seal the space and prevent the spread of fire and smoke. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

firestop

A sealing system used to prevent fire and smoke from passing through penetrations. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

firestop collar

A device placed around a pipe at a wall or floor penetration that expands when exposed to heat to seal the opening and prevent the spread of fire and smoke. (Section D-4.2)

firestop mortar

A fire-resistant compound mixed with water and applied to seal large openings around pipes or cables, helping prevent the spread of fire and smoke. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

firestop putty

A soft, mouldable firestop material used to seal openings around pipes, cables, or boxes, helping prevent the spread of fire and smoke. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

firewall

A fire-resistant wall that separates buildings or sections of a building. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

fit-ups

The process of aligning and positioning pipes or parts correctly before joining them together. (Section D-1.6 (#chapter-d-1-6-section-6))

fitting allowance (takeoff)

The amount of pipe length lost inside a fitting when making a connection. (Section D-1.6 (#chapter-d-1-6-section-6))

flanged

A type of connection where pipes are joined using flat edges (flanges) that are bolted together. (Section D-1.6 (#chapter-d-1-6-section-6))

flanged fitting

A threaded cast iron fitting used in drainage systems that can be taken apart and reused. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

flare fitting

A fitting that seals by pressing a flared (widened) pipe end against a matching surface to create a tight connection. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

flare nuts

Nuts used with flare fittings that tighten onto the fitting to press the flared pipe end and create a tight seal. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

flashing

A material installed to prevent water penetration at roof or wall openings. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

flashing cap

A protective cover placed over a pipe penetration on a roof, used with flashing to prevent water from entering around the pipe. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

flexible penetration seals

A seal that closes a pipe sleeve opening while allowing pipe movement and absorbing misalignment, maintaining a watertight, airtight, or fire-resistant seal. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

float-control valve

A valve that automatically controls the level of liquid in a tank using a float. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

flotation

When a pipe rises or lifts out of the ground due to water pressure. (Section D-1.4 (#chapter-d-1-3-section-4))

fluorocarbon rubber (FKM or FPM) (Viton)

A type of synthetic rubber used for seals and gaskets that resists high temperatures, oils, and many chemicals, but may not perform well with certain strong bases. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

flux

A material used during welding to protect the metal from air and impurities. (Section D-1.2; (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing) Section D-1.6 (#chapter-d-1-6-section-6))

freeze protection

Methods used to stop pipes from freezing and bursting. (Section D-1.4 (#chapter-d-1-3-section-4))

friction loss

The reduction of pressure in a pipe due to resistance as fluid flows. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

full port ball valve

A ball valve with an opening the same size as the pipe, allowing full flow with little or no restriction. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

full-face gasket

A gasket that covers the entire face of a flange, including the bolt holes, to provide a complete seal between two flanged surfaces. (Section D-3.2 (#chapter-d-3-2-section-2))

fusible link

A heat-sensitive component that melts to activate a fire damper. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

fusion welding

A method of joining materials by heating them until they melt and fuse together as one piece. (Section D-1.6 (#chapter-d-1-6-section-6))

fusion welding (continuous weld)

A process of joining metal by heating it until it melts and fuses together, often forming a continuous seam along the pipe. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

galling

A severe form of metal wear caused when sliding surfaces make contact, tearing areas of the metal surface. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

galvanic corrosion

Damage that occurs when different metals touch and react in the presence of moisture. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

galvanic series

A list that indicates the relative stability of different metals and alloys in seawater, based on the measurement of corrosion potentials. (Section D-1.4 (#chapter-d-1-3-section-4))

gasket

(Sometimes referred to as a *compression type fitting* or *connection*); A flat sealing material placed between two surfaces to prevent leaks when they are joined together. (Section D-3.2 (#chapter-d-3-2-section-2))

gasket union

A union that uses a washer to create a seal. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

gate valve

A valve used to fully open or fully close flow by raising or lowering a flat gate inside the pipe. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

gear clamp

A metal band clamp with a screw mechanism that tightens around a pipe or hose to hold it securely in place. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

geotextile

A protective fabric used to cover pipes and prevent damage during installation. (Section D-1.4 (#chapter-d-1-3-section-4))

glass-fibre

A type of mineral-fibre insulation made from fine glass fibres, used to resist heat and help prevent the spread of fire. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

globe valve

A valve used to control or regulate flow by moving a disk against a seat inside the valve. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

glue-glycerin solution

A mixture used as a lubricant to help gaskets or pipe joints slide into place and form a proper seal during assembly. (Section D-3.2)

glued-laminated beam

(Also called *glulam* and *paralam*); An engineered wood beam made by bonding together layers of lumber with adhesive to create a strong, stable structural member. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

Go/No-go gauge

A tool used to check if a crimp connection is properly sized by confirming whether it passes or fails specific measurement limits. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

graphite thread compound

A type of thread sealant that contains graphite to provide lubrication and sealing for threaded connections, especially in high-temperature applications. (Section D-3.2 (#chapter-d-3-2-section-2))

grommet

A protective insert used to prevent damage to pipes passing through metal or other materials. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

grooved-end piping

A pipe connection method where a groove is formed near the pipe end so a clamp and gasket can be used to join pipes without heat. (Section D-1.6 (#chapter-d-1-6-section-6))

grooving

The process of cutting or forming a groove near the end of a pipe so it can be joined using a grooved coupling or fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

ground union (ground joint union)

A type of union that forms a tight seal using smooth, tapered metal surfaces, allowing pipes to be connected and disconnected without a gasket. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

gypsum board

gypsum board: A panel made of gypsum plaster pressed between layers of paper, commonly used for walls and ceilings and providing fire resistance. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

H grades (austenitic stainless steel)

Stainless steel with higher carbon content that helps maintain strength at high temperatures; contain a minimum of 0.04% and a maximum of 0.10% carbon; primarily used when the material will be used at extreme temperatures. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

hard soldering (brazing)

Brazing at temperatures **above** 450°C (840°F). (Section D-1.6 (#chapter-d-1-6-section-6))

hard-drawn tube

Copper tubing that has not been heat-treated, making it stronger and more rigid but harder to bend. (Section D-1.6 (#chapter-d-1-6-section-6))

heat trace

An electrical cable used to keep pipes warm and prevent freezing. (Section D-1.4 (#chapter-d-1-3-section-4))

heating irons (heaters)

Tools used to heat pipe and fittings so they can be joined together by melting and fusing the material. (Section D-1.6)

high-build single-coat application

A coating that can be applied in one thick layer to provide full protection, instead of needing several thinner coats. (Section D-1.4 (#chapter-d-1-3-section-4))

high-density polyethylene pipe (HDPE)

A strong, flexible plastic pipe used for water, gas, and other piping systems. (Section D-1.6 (#chapter-d-1-6-section-6))

Hilti firestop collars

A proprietary firestop collar made by Hilti, designed to be installed around combustible pipes at wall or floor penetrations, containing intumescent material that expands in a fire to seal the opening. (Section D-4.2)

hinge pin

A metal pin that allows a valve disk or part to pivot or swing open and closed. (Section D-2.2 (#chapter-d-2-2-install-valve))

hose

Portable and flexible pipe made from flexible material such as natural rubber, synthetic rubbers, plastics and composites with metal reinforcing. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

hub end (socket or bell end)

The end of a fitting that receives another pipe or fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

hub-to-spigot piping

A pipe system where one end (spigot) fits into a wider end (hub) of another pipe or fitting. (Section D-1.6 (#chapter-d-1-6-section-6))

hydraulic shock arrestor

A device that protects pipes from sudden pressure changes, such as water hammer. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

hydro-pneumatic testing

A method of testing pipes using both water and air pressure to check for leaks. (Section D-1.6 (#chapter-d-1-6-section-6))

I-joist

(Also called I-beam); A lightweight engineered wood beam shaped like the letter “I,” commonly used in floors and roofs. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

ID

inner diameter

injection-moulded CPVC thermoplastic fittings

Fittings made by injecting molten CPVC plastic into a mould to form durable shapes used in piping systems, especially for hot and cold water applications. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

insert fitting

A fitting used to join *polyethylene (PE)* tubing by inserting into the tubing and securing it with clamps or compression rings to create a tight seal. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

insert sleeve

A small tube, made out of plastic or metal, placed inside a pipe to support it and help maintain its shape when making a connection. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

insulation

Material used to keep heat in or out of a pipe. (Section D-1.4 (#chapter-d-1-3-section-4))

interference fit

A tight connection where a pipe is pressed into a fitting so the surfaces bond together, often using solvent cement that softens the material and allows it to fuse. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

intumescent material

A material that swells when heated to block fire and smoke. (Section D-4.2)

inverted flare

A type of flare fitting where the flared end of the pipe is folded inward, providing a strong, leak-resistant connection commonly used in automotive and refrigeration systems. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

IPS (iron pipe size)

Used to identify standard dimensions of a carbon steel pipe which is often referred to as “iron pipe.” (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

JIC flare

A type of flare fitting with a 37-degree angle, commonly used in hydraulic systems. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

joint

The place where two pipes or fittings are connected. (Section D-1.6 (#chapter-d-1-6-section-6))

jointing (joining)

The process of connecting pipes or fittings together to form a complete piping system. (Section D-1.6 (#chapter-d-1-6-section-6))

knife valve

A type of gate valve with a sharp-edged blade designed to cut through thick or solid-containing fluids to stop flow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

L grades (austenitic stainless steel)

Stainless steel with low carbon content that helps prevent corrosion, especially after welding; the letter L after a stainless steel type indicates low carbon (as in 304L). The carbon is kept to 0.03% or under to avoid carbide precipitation. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

lantern ring

A metal ring in a valve that provides for uniform distribution of stem packing pressure over the packing. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

lap joint pipe flange

A flange used with a stub end that can rotate, making it easier to align bolt holes during installation. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

lead-based compound

A thread sealant that contains lead, formerly used to seal pipe connections but now restricted or banned in many applications due to health and safety concerns. (Section D-3.2 (#chapter-d-3-2-section-2))

lead-free solder

Solder that does not contain lead and is safe for drinking water systems. (Section D-1.6 (#chapter-d-1-6-section-6))

lift-check valve

A check valve where the disk lifts up to allow flow and drops back down to prevent reverse flow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

linear movement valves

Valves where the internal parts move in a straight line to open or close the flow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

lip-seal bonnet

A valve bonnet that seals tightly using metal-to-metal contact and pressure from the system. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

liquid thread compound

A liquid sealant applied to threaded connections to prevent leaks and help seal and protect the joint. (Section D-3.2 (#chapter-d-3-2-section-2))

liquidus

The temperature at which 100% of the alloy is in a fluid, non-crystalline form. The liquidus temperature is the minimum temperature at which soldering or brazing will take place. (Section D-1.6 (#chapter-d-1-6-section-6))

load-bearing structural member

A structural element designed to hold up the load above it, such as a second storey or roof. Cutting, drilling, or removing this support will weaken the structure. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

long nipple

A longer length of threaded pipe used to connect fittings that are spaced farther apart. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

long radius (long sweep)

A fitting with a gradual curve that allows smoother flow and reduces pressure loss. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

lubricated gas cock

A type of plug valve used in gas systems that requires lubricant to reduce friction and maintain a tight seal. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

makeup-type joints

Pipe connections that require the pipe to be inserted into a fitting, which affects the overall length of the pipe. (Section D-1.6 (#chapter-d-1-6-section-6))

male iron pipe (MIP)

A threaded pipe connection with external threads that screws into a female threaded fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

malleability

The ability of a metal to be shaped or bent without breaking. (Section D-1.6 (#chapter-d-1-6-section-6))

malleable iron fittings

A strong, flexible fitting that resists cracking and is often used in gas piping. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

mandrel

A tool placed inside a pipe during manufacturing to shape and size it. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

martensitic grades

A type of stainless steel that is strong and can be hardened by heat, often used where strength and wear resistance are important. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

material takeoff lists

A list of materials needed for a job. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

materials list

A list of materials needed to complete a job, used to communicate with suppliers or plan work on site. (Section D-3.3 (#chapter-d-3-3-select-fittings))

materials takeoff (materials takeoff list)

(Sometimes referred to as a *quantity survey* or *quantity cost sheet*); A detailed list of materials and quantities required for a job, often used for estimating costs and planning. (Section D-3.3 (#chapter-d-3-3-select-fittings))

mechanical joint (MJ) coupling

A pipe coupling that uses bolts, a gland, and an elastomeric gasket to compress and seal the connection without welding or threading. (Section D-3.1)

mechanical joint (zip coupling)

A pipe connection that uses a clamp and gasket tightened with bolts or screws to create a seal. (Section D-1.6 (#chapter-d-1-6-section-6))

mechanical joint fittings

A fitting that connects pipes using bolts, gaskets, or clamps to create a tight seal without welding or threading. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

membrane-penetration firestop

A firestop system used when a pipe or other item passes through only one side (membrane) of a wall or floor assembly, designed to seal the opening and prevent the spread of fire and smoke. (Section D-4.2)

metal decking

Corrugated steel panels used as a structural base for floors or roofs, often supporting concrete or roofing materials and providing strength and stability to the structure. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

metal gaskets

Gaskets made of metal that are used in high-pressure or high-temperature systems to create a strong, durable seal. (Section D-3.2)

metal roof or floor truss

A structural framework made of steel members designed to support loads in roofs or floors, typically engineered for strength, stability, and efficient load distribution. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

microbiologically influenced corrosion (MIC)

Corrosion caused or sped up by bacteria. (Section D-1.4 (#chapter-d-1-3-section-4))

mineral wool

A fire-resistant insulation made from rock or slag fibres, commonly used to fill openings and help prevent the spread of fire and heat. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

mineral-fibre

A type of insulation made from fine fibres of rock, slag, or glass, used to resist heat and help prevent the spread of fire. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

MJ clamp (mechanical joint clamp)

A clamp used with mechanical joint fittings to compress a gasket and secure the pipe connection, creating a tight seal. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

moment critical zone

A section of a structural beam where stress is highest and drilling is restricted. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

Monel steel

A corrosion-resistant metal alloy made mainly of nickel and copper, commonly used in harsh environments such as marine or chemical systems. (Section D-3.2 (#chapter-d-3-2-section-2))

NB (nominal bore)

Another name for nominal pipe size that refers to the approximate inside diameter of a pipe. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

nitrile (acrylonitrile-butadiene copolymer, NBR) (buna-n)

A type of synthetic rubber used for seals and gaskets that resists oil and petroleum products and has good abrasion resistance, but is not suitable for strong acids or oxidizing chemicals. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

no-stop coupling

A coupling without an internal stop that allows pipe to slide through. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

noble

Possessing outstanding qualities. (Section D-1.4 (#chapter-d-1-3-section-4))

noise (in piping systems)

Unwanted sound made by water or air moving through pipes, often caused by high flow, pressure changes, or rough pipe surfaces. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

non-load-bearing structural member

A support that is installed as a partition to divide space in a structure and does not support the weight above it. Cutting, drilling or removing this support will not weaken the structure. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

non-makeup type joints

Pipe connections where the pipe ends meet directly and do not change the overall length. (Section D-1.6 (#chapter-d-1-6-section-6))

NPS (nominal pipe size)

This is the approximate inside diameter. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

NPT (national pipe thread)

The standard developed in North America for tapered threads is ANSI/ASME standard B1.20.1; may be referred to as MPT (male pipe thread) for external threads, and FPT (female pipe thread) for internal threads. **(Note that FPT and MPT are not authorized designations according to the ANSI standard.)** (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

o-rings

Round rubber seals placed between pipe parts to prevent leaks. (Section D-1.6 (#chapter-d-1-6-section-6))

OD

outer diameter

offset multiplier (1.414)

A number used to calculate pipe length when pipes change direction at an angle, such as 45 degrees. (Section D-1.6 (#chapter-d-1-6-section-6))

oriented strand board (OSB)

A structural panel made from compressed wood strands bonded with adhesive, commonly used for sheathing in walls, floors, and roofs. (Section D-4.2 (#chapter-d-4-2-describe-acceptable-methods-of-structure-penetration))

out-of-round

When a pipe is no longer perfectly circular in shape. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

outside screw and yoke (OSY) valve

A valve with a stem that moves up and down outside the valve body, making it easy to see if the valve is open or closed. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

oxidation

A chemical reaction where a material (often metal) reacts with oxygen, often causing rust or surface buildup. (Section D-1.6 (#chapter-d-1-6-section-6))

oxygen barrier

A layer in some piping (such as PEX) that prevents oxygen from passing through the pipe wall and entering the system, helping to reduce corrosion. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

oxygen corrosion

Corrosion caused by oxygen reacting with metal. (Section D-1.4 (#chapter-d-1-3-section-4))

packing

A sealing material made of flexible (pliable) materials that provides a dynamic seal between a moving part and a stationary part, such as around a valve stem to prevent leaks. Common types include graphite packing. (Section D-3.2 (#chapter-d-3-2-section-2))

party wall

A shared wall between two adjoining buildings or units that acts as a fire separation and may also provide sound insulation. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

PEX (cross-linked polyethylene)

A flexible plastic pipe made stronger by a chemical bonding process. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

PEX crimp fitting

A fitting used with PEX tubing that is secured using a crimp ring to form a tight, leak-resistant connection. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

PEX fitting

A fitting used to connect PEX (cross-linked polyethylene) tubing, typically secured with a crimp ring, clamp, or expansion method to create a watertight seal. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

PEX-A (peroxide [Engel] method)

A type of PEX tubing made using the peroxide (Engel) method, known for being flexible and able to be repaired with heat. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

PEX-B (silane method)

A type of PEX tubing made using the silane (moisture cure) method, known for its strength and resistance to pressure. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

PEX-C (electron beam method)

A type of PEX tubing made using an electron beam process, known for being more rigid and less evenly cross-linked than other types. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

PEX/AL/PEX (cross-linked polyethylene/aluminum/cross-linked polyethylene)

A multilayer pipe made of PEX with a thin aluminum layer in the middle, providing added strength, shape retention, and resistance to oxygen entering the system. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

pH

This is a measurement of the acidity or alkalinity of a substance. You may need to adjust the pH level of water in a hydronic heating system by adding an acid to stabilize a condition that is too alkaline or by adding a base (alkali) if the solution is too acidic. Hot water boiler manufacturers normally suggest a solution that is very mildly alkaline

(pH of approximately 7.8) rather than neutral (pH of 7) to prevent corrosion caused by acidic water. (Section D-1.4 (#chapter-d-1-3-section-4))

pilot operated pressure relief valve

A pressure relief valve that uses a smaller control valve (pilot) to control when the main valve opens. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

pinch valve

A valve that controls flow by squeezing a flexible tube to stop or allow fluid to pass. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

pinhole leak

A very small hole in a pipe that can cause leaks. (Section D-1.4 (#chapter-d-1-3-section-4))

pipe

Pipe is generally specified by a nominal inside diameter with a constant outside diameter (OD) and a schedule rating that defines its thickness. Pipe is generally manufactured to one of several international and national industrial standards. In general, “pipe” is the more common term in most of the world, whereas “tube” is more widely used in the United States. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

pipe anchors

Devices used to hold pipes firmly in place and prevent movement. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

pipe chase

A framed or enclosed space within a building used to conceal and protect pipes as they run vertically or horizontally through the structure. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

pipe facer (trimmer)

A tool used to cut and smooth the ends of a pipe so they are flat, clean, and ready to be joined. (Section D-1.6)

pipe nipple

A short length of pipe with threads on one or both ends used to connect fittings or extend piping. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

pipe or thread engagements

The length of pipe or threads that fit inside a fitting when making a connection. (Section D-1.6 (#chapter-d-1-6-section-6))

pipe sleeve

A protective tube that allows a pipe to pass through a structure safely; also refers to protective pipe or tubing that surrounds a pipe carrying the fluid to be used. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

Pipetite sleeve boots

Flexible, pre-manufactured seals designed to fit around pipes passing through walls or floors, providing a watertight and durable seal without the need for additional sealants or fasteners. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

piping geometry

The shape, direction, and layout of a piping system. (Section D-1.6 (#chapter-d-1-6-section-6))

plain-ended piping

Pipe with straight, smooth ends that require joining methods such as welding or fusion. (Section D-1.6 (#chapter-d-1-6-section-6))

plastic clips and grommets**plastic range (melting [pasty] range)**

The temperature range between the solidus and liquidus, where some portion of the alloy is solid, but the majority is liquid; also called the melting (pasty) range; may be of importance when selecting a filler metal; indicates the width of the working range for the filler metal and the speed with which the filler metal will become fully solid after brazing; filler metals with narrow ranges, with or without silver, solidify more quickly and therefore require careful application of heat. (Section D-1.6 (#chapter-d-1-6-section-6))

plug

A fitting with external threads used to seal the end of a pipe. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

plug valve

A quarter-turn valve that uses a solid plug with a hole through it to start or stop flow by rotating the plug inside the valve body. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

plumber's putty

A soft, moldable sealing compound used to create watertight seals around fixtures such as sinks and drains. (Section D-3.2 (#chapter-d-3-2-section-2))

plumbing trap (P-trap)

A curved section of pipe that holds a small amount of water to prevent sewer gases from entering a building. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

polybutylene (PB) plastic pipe

A flexible plastic pipe once used for water supply systems, known for being easy to install but no longer commonly used due to failure issues over time. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

polyethylene (PE)

A type of plastic commonly used to make pipes. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

polyvinyl chloride (PVC)

A strong plastic material used to make pipes for water and drainage systems. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

polyvinyl chloride (PVC) Schedule 80 fittings

Strong plastic fittings with thicker walls than standard PVC, designed to handle higher pressure in piping systems. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

positioner

A device used to ensure that the valve is at the correct position of opening as the control signal indicates. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

post indicator valve

A valve connected to an above-ground indicator that shows whether an underground valve is open or closed, often used in fire protection systems. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

post-tension slab

A concrete slab reinforced with tensioned steel cables to increase strength and reduce cracking. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

post-tensioned

Concrete that has steel cables inside it to make it stronger. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

potable water

Water safe for human consumption. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

powder shot pins

Metal pins driven into hard materials using a powder-actuated tool, often used for quick fastening into concrete or steel. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

power-actuated or power-driven fasteners

Fasteners that are driven into materials like concrete or steel using a tool powered by explosive charges or compressed force. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

press-connect (press-fit)

A method of joining pipes using a special fitting and tool that presses the connection together to form a tight seal. (Section D-1.6 (#chapter-d-1-6-section-6))

pressure fittings

Fittings designed to carry fluids under pressure. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

pressure relief valve (PRV)

A safety valve that opens to release pressure when it gets too high, protecting the system from damage. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

pressure-seal bonnet

A valve bonnet that uses system pressure to create a tight metal-to-metal seal, making it suitable for high-pressure and high-temperature applications. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

print-line

The line of markings printed on a pipe that identifies its size, type, approvals, etc. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

ProPEX propex (formerly quick and easy)

A PEX connection system that uses expansion fittings and rings to create a tight seal as the tubing shrinks back to its original size. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

PTFE (poly-tetra-fluoro-ethylene)

A smooth plastic material that reduces friction and allows parts to slide easily. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

purge gas

A gas (usually nitrogen) used to remove air from inside pipes during brazing to prevent oxidation. (Section D-1.6)

push-connect

A type of pipe connection that uses a gasket and grab ring to create a seal when the pipe is pushed into the fitting, without the need for heat or tools. (Section D-1.6 (#chapter-d-1-6-section-6))

push-fitting system

A connection system that allows pipes or tubing to be joined by pushing them into a fitting, where internal seals and gripping rings create a secure, leak-resistant connection without tools. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

push-on joint

A pipe connection where the spigot end is pushed into a bell with a rubber gasket to create a watertight seal without threading or welding. (Section D-3.1)

PVC Schedule 40 fittings

Standard plastic fittings with moderate wall thickness, commonly used for drainage, waste, vent, and some low-pressure piping systems. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

pyrometer

A tool used to measure high temperatures, especially on heating surfaces. (Section D-1.6 (#chapter-d-1-6-section-6))

quarter-turn valve

A valve in which the handle and stem move from fully closed to fully open in one-quarter of a 360° turn (90°). (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

quick-connect fitting

A fitting that allows pipes or tubing to be connected and disconnected quickly without the use of tools. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

radius

The curved part of a fitting that determines how sharply it changes direction. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

raised face flange

A type of flange with a slightly raised sealing surface that helps concentrate pressure on the gasket to create a better seal. (Section D-3.2)

ram bending

A method of bending pipe using a pushing force (ram) to shape the pipe. (Section D-1.6 (#chapter-d-1-6-section-6))

reaming

The process of smoothing the inside edge of a pipe after cutting. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

rebar (reinforcing bar)

Steel bars embedded in concrete to provide strength and support. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

rectifier

An electrical device that changes alternating current (AC) into direct current (DC). This current is then impressed on an underground metallic piping system to protect it against corrosion. (Section D-1.4 (#chapter-d-1-3-section-4))

reduced port ball valve

A ball valve with a smaller opening than the pipe, which reduces flow and increases pressure loss. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

reducer or increaser

An MJ cast iron fitting that changes a pipe size. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

reducing elbows

An elbow that changes both the direction and size of a pipe. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

reducing fitting

A fitting used to connect pipes of different sizes. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

resilient seat

A valve disk or seat that is soft-seated rather than a metal-to-metal hard seat. An example is a Teflon seat. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

retrofit or surface-mounted collars

A firestop collar installed around a pipe after it has been placed through a wall or floor, typically attached to the surface of the structure. (Section D-4.2)

return bend

A fitting that changes direction by 180 degrees. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

ring gasket

A circular gasket that fits within the flange faces to create a seal, often used where higher pressure or more precise sealing is required. (Section D-3.2)

rising stem inside screw valve

A valve where the stem moves up and down inside the valve body as it turns, showing whether the valve is open or closed. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

rising stem outside screw valve

A valve with threads located outside the valve body, where the stem moves up and down as the valve is opened or closed, making it easy to see the valve position. (Section D-2.1)

rod hanger

A threaded metal support used to hang pipes from a structure; other common names: hang-up anchors, Sammy super screws, vertigo anchors, hanger mates, and titan anchors. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

roll bending

A method of bending pipe by passing it through rollers to create a curved shape. (Section D-1.6 (#chapter-d-1-6-section-6))

roll groove joining

A method of forming a groove on the outside of a pipe using a rolling tool so it can be connected with a clamp and gasket. (Section D-1.6 (#chapter-d-1-6-section-6))

rolled and welded (pyramid roll method)

A method of making pipe by rolling a flat steel plate into a round shape using three rollers, then welding the seam to form a cylinder. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

rosin core

A type of solder with a mild flux inside that helps clean metal without causing corrosion. (Section D-1.6 (#chapter-d-1-6-section-6))

rotary movement valves

Valves where the internal parts rotate (turn) to open or close the flow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

rotary piercing

A method of making pipe by rotating a heated solid metal piece and pushing it over a tool to form a hollow tube. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

rotating shoe type valve

A type of three-port valve that uses a rotating internal part to direct or mix flow between ports. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

run

The straight-through portion of a fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

sacrificial anode

A metallic anode intended to be dissolved to protect other metal components. (Section D-1.4 (#chapter-d-1-3-section-4))

saddle fusion

A method of joining a branch pipe to a main pipe by heating and fusing them together. (Section D-1.6 (#chapter-d-1-6-section-6))

SAE flare

A type of flare fitting with a 45-degree angle, commonly used in automotive and refrigeration systems. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

san (sanitary) tees

A fitting used in drainage systems to connect pipes at a 90-degree angle, designed with a curved shape to guide flow smoothly. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

sanitary cross (double sanitary tee)

A fitting used in drainage systems to connect four pipes at 90-degree angles, designed to guide flow smoothly and reduce blockages. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

schedule numbers

Numbers used to show the wall thickness of a pipe, which affects how strong it is and how much pressure it can handle. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

scissor beam clamp

A temporary clamp that grips onto a steel beam using a scissor-like action to create a secure attachment point for lifting or supporting equipment. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

screwed union ring bonnet

A valve bonnet held in place by a threaded ring, allowing easier removal for maintenance. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

screwed-in bonnet

A valve bonnet that is threaded directly into the valve body to create a tight seal. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

scum-forming substances

The use of water softeners, iron filters, UV-sterilization, and other water treatment devices may be necessary in order to correct any conditions that are undesirable for the water's intended use. Mineral impurities that foam or scum: usually soda in the form of a carbonate, chloride or sulphate. (Section D-1.4 (#chapter-d-1-3-section-4))

SDR (standard dimension ratio)

A number that compares a pipe's outside diameter to its wall thickness to show how strong it is and how much pressure it can handle. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

SDR number

SDR number is determined by dividing the outside diameter of the tube or pipe by its minimum wall thickness. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

sealant

A material used to fill gaps and create a watertight or airtight seal between surfaces. (Section D-3.2 (#chapter-d-3-2-section-2))

seamless (SMLS) steel pipe

A type of steel pipe made from a solid piece of metal with no welded seams, making it strong and able to handle high pressure. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

seat ring

A part of a valve that provides a smooth surface for the valve disk to seal against, helping to stop the flow and prevent leaks. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

seismic activity

Movement of the ground caused by an earthquake. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

seismic braces

Supports used to prevent pipes from moving during earthquakes or vibrations. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

seismic restraint

A system used to keep pipes and equipment secure during an earthquake. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

service check valve

A valve that allows components (such as gauges or expansion tanks) to be removed or serviced without draining the entire system. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

shim

A thin piece of material (such as paper, plastic, or metal) used to fill a gap or adjust the fit between parts. (Section D-1.6)

short radius

A fitting with a tighter curve that changes direction quickly but may cause more flow resistance. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

shoulder (short) nipple

A short pipe with a small unthreaded section (shoulder) between the threaded ends, allowing better wrench grip during installation. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

side inlet fitting

A fitting with an additional opening on the side that allows another pipe to connect to the main fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

side inlet tee

A fitting with an extra connection on the side. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

silent flow check valve

A check valve designed to close smoothly and quietly, reducing or preventing water hammer. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

silicone caulking

A flexible sealant and adhesive compound used to fill gaps and create a watertight seal around fixtures, joints, and surfaces, often containing mildew-resistant chemicals. (Section D-3.2 (#chapter-d-3-2-section-2))

skelp

A strip of steel that is formed into pipe during manufacturing. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

sleeve seal

A sealing device used to close the gap between a pipe and a pipe sleeve. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

sleeve type gasket

A gasket that fits around a pipe inside a joint to help seal the connection and prevent leaks. (Section D-3.2)

slide plates

Flat surfaces that support equipment while allowing it to move easily. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

sliding-stem valve

A valve where the stem moves in and out in a straight line without threads, often operated by a lever or actuator. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

slip-on joint

A type of pipe connection where one pipe slides into or over another and is sealed with a gasket or O-ring. (Section D-1.6 (#chapter-d-1-6-section-6))

slip-on pipe flange

A flange that slides over the pipe and is then welded in place to secure it. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

socket fused

A method of joining plastic pipe where a heated fitting (socket) is used to connect the pipe. (Section D-1.6 (#chapter-d-1-6-section-6))

socket weld pipe flange

A flange with a recessed socket that the pipe fits into before being welded, providing a strong and aligned connection. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

socket welded fitting

A fitting with a recessed socket that a pipe is inserted into and then welded around the joint to create a strong, leak-proof connection. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

soft soldering

Soldering at temperatures below 450°C (840°F). (Section D-1.6 (#chapter-d-1-6-section-6))

soldered fitting (sweat)

A fitting joined by heating and melting solder to seal and connect the pipe. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

soldering

Joining metal using a lower-temperature filler metal. (Section D-1.6 (#chapter-d-1-6-section-6))

solid wedge gate valves

A type of gate valve that uses a single, solid wedge-shaped gate to close tightly against the valve seats and stop flow. (Section D-2.2 (#chapter-d-2-2-install-valve))

solidus

The temperature at which 100% of the alloy is in a solid, crystalline form but starts to melt when additional heat is applied; soldering begins upon reaching the solidus. (Section D-1.6 (#chapter-d-1-6-section-6))

solvent cement

A chemical adhesive used to join plastic pipes by softening and fusing the surfaces together to form a permanent bond. (Section D-3.2)

solvent cementing (solvent welding)

A method of joining plastic pipes by using a chemical that softens the surfaces so they fuse together as one piece. (Section D-1.6 (#chapter-d-1-6-section-6))

sound transmission

The movement of sound through building materials or structures. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

spigot end

The end of a pipe or fitting that fits into a hub end. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

spindle

A rod inside a valve that connects the handle to the internal parts and turns or moves to open or close the valve. (Section D-2.2 (#chapter-d-2-2-install-valve))

spiral-weld pipe

A type of steel pipe made by rolling a strip of steel into a spiral shape and welding the seam along its length. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

spring relief valve (pop safety valve)

A pressure relief valve that uses a spring to hold it closed and “pops” open quickly when pressure gets too high, releasing fluid to protect the system. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

spring support

A support that allows pipes to move up and down while still holding their weight. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

spring sway brace

A support that controls pipe movement while allowing limited motion using a spring, helping the pipe return to its original position. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

standard

A body of rules or principles established and agreed upon as valid and fundamental in a certain field or industry. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

standard port ball valve

A ball valve with an opening slightly smaller than the pipe, resulting in some reduction in flow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

standard turn

A common fitting bend used to change direction, typically referring to a standard radius elbow. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

stop and drain valve (stop and waste valve)

A valve that shuts off water flow and allows the system to drain, either automatically or through a drain opening. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

straight grades (austenitic stainless steel)

Stainless steel with a maximum of 0.08% carbon that provides good corrosion resistance and strength. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

straight tees

A fitting that connects three pipes at a 90-degree angle, typically used in pressure piping systems. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

strap iron (plumber's tape or metal hanger strap)

A thin strip of metal used to support and secure pipes. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

stray current

The portion of a current that flows over a path other than the intended path. There are two types of stray current: direct current (DC) and alternating current (AC). Stray currents found in the ground and in water promote corrosion of piping and metal components. (Section D-1.4 (#chapter-d-1-3-section-4))

street elbow

An elbow with male threads on one end and female threads on the other. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

stretch bending

A method of bending pipe by pulling it while applying force to shape it. (Section D-1.6 (#chapter-d-1-6-section-6))

striker plates

Metal plates installed over or near pipes or tubing in walls to protect them from being punctured by nails or screws. (Section D-1.6 (#chapter-d-1-6-section-6))

structural component

A part of a building that supports loads or contributes to the strength and stability of the structure, such as beams, columns, walls, floors, and foundations. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

structural integrity

The ability of a building or structure to remain strong, stable, and safe under loads without failure or damage. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

stuffing box

An enclosure containing packing to prevent leakage around a moving machine part. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

submerged arc welded (SAW)

A welding method where the weld is protected by a layer of material during the process. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

suspended solids

These are substances that exist in water as suspended particles. They are usually mineral or organic in origin. These substances are not generally a problem as they can be filtered out. (Section D-1.4 (#chapter-d-1-3-section-4))

swage

A tool, die, or stamp for bending and shaping wrought iron, etc., by hammering or pressure (Canadian Oxford Dictionary, 2004) (Section D-1.6)

sway brace

A support that prevents pipes from moving side to side. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

swing-check valve

A check valve with a hinged disk that swings open with forward flow and closes to prevent reverse flow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

tapped

A process where threads are cut into a hole so a pipe or fitting can be screwed into it. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

tapped side inlet

A side opening on a fitting that has internal threads to allow connection to another pipe or fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

tapt (tapped) opening

A threaded opening in a fitting used to connect to another pipe. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

tapt side outlet

A side opening on a fitting that is internally threaded to allow connection to another pipe or fitting. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

tee wye

A fitting that combines a tee and a wye, with a longer-radius curve to direct flow more smoothly than a standard sanitary tee. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

teflon gaskets

Gaskets made from PTFE (Teflon) that resist heat and chemicals and provide a low-friction sealing surface. (Section D-3.2 (#chapter-d-3-2-section-2))

teflon polytetrafluoroethylene (PTFE)

A type of plastic used in valves and seals that resists heat and chemicals and provides a low-friction surface that does not require lubrication. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

teflon thread compound

A type of thread sealant that contains PTFE (Teflon) to help seal threaded connections, reduce friction, and prevent leaks. (Section D-3.2 (#chapter-d-3-2-section-2))

teleposts (telescopic)

Adjustable steel support posts used to temporarily support structures such as formwork or beams during construction, allowing height to be changed as needed. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

temper

The hardness and strength of metal, based on how it is heated and cooled. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

temperature and pressure relief valve (TPRV/T&P)

A safety valve that releases water if temperature or pressure becomes too high, commonly used on water heaters. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

Tempilstik

A temperature-indicating stick that melts at a specific heat level to show if a surface has reached the correct temperature. (Section D-1.6)

tendon (post-tension)

A steel cable used in post-tension concrete to apply compressive force. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

tensile load applications

Situations where a fastener or support must hold forces that are pulling or stretching it apart. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

tensile strength

The ability of a material to resist being pulled apart. (Section D-1.6 (#chapter-d-1-6-section-6))

thermal expansion

The increase in size of a material when it is heated. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

thermal expansion relief valve

A valve that releases excess pressure caused by water expanding as it is heated, helping to protect the plumbing system from damage. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

thermo-set

A plastic capable of becoming permanently rigid when heated or cured. It cannot be reheated and re-melted. Fibreglass pipe is an example of a thermo-set plastic pipe. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

thermoplastic

A plastic capable of softening or fusing when heated and which hardens once cooled. Can be reheated and melted. Polyethylene and polyvinyl chloride (PVC) are examples of a thermoplastic. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

thermosetting resins

Plastics that become permanently hard when heated and cannot be melted or reshaped again. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

thermostatic mixing valve

A valve that mixes hot and cold water to maintain a safe and steady outlet temperature. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

thread compound (pipe dope)

A paste applied to threaded pipe connections to seal gaps, prevent leaks, and make assembly easier. (Section D-3.2 (#chapter-d-3-2-section-2))

thread engagement

The length of pipe threads that connect inside a fitting. (Section D-1.6 (#chapter-d-1-6-section-6))

threaded fitting

A fitting with internal or external threads that is screwed onto a pipe to form a connection. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

threaded pipe flange

A flange with internal threads that screws onto a pipe, eliminating the need for welding. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

three-port diverting valve

A valve with one inlet and two outlets that directs flow from one path to another. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

three-port mixing valve

A valve with two inlets and one outlet that combines flows, such as hot and cold water, into one stream. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

three-port valve

A valve with three openings (ports) that can be used to mix or divert flow depending on the piping setup. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

throat

The inside curved portion of a fitting where flow changes direction. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

through-penetration firestops

A firestop system installed where a penetrating item passes entirely through a fire-rated assembly, maintaining the assembly's fire-resistance rating. (Section D-4.2)

tilting-disk swing-check valve

A type of swing-check valve with a disk that tilts to open and close, allowing faster response and improved flow compared to standard swing-check valves. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

timing flanges

The process of aligning flange bolt holes so they match correctly before tightening. (Section D-1.6 (#chapter-d-1-6-section-6))

toilet fill valve

A valve in a toilet tank that controls the flow of water to refill the tank after flushing. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

torque wrench

A tool used to tighten bolts or nuts to a specific amount of force to ensure a proper and secure connection. (Section D-1.6 (#chapter-d-1-6-section-6))

trench

A long, narrow hole dug in the ground to install pipes. (Section D-1.4 (#chapter-d-1-3-section-4))

trunnion

A valve component such a pin or pivot on which something can be rotated, such in a trunnion ball valve, which has additional mechanical anchoring of the ball at the top and the bottom, suitable for larger and higher pressure valves. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

tube

Most often specified by the outside diameter (OD) and wall thickness, but may be specified by any two of OD, inside diameter (ID), and wall thickness. Although standards exist for tube, it's often made to custom sizes and a broad range of diameters and tolerances. (Section D-1.1 (#chapter-d-1-1-describe-piping-and-tubing-materials))

Tyton® joint

A type of push-on pipe joint that uses a rubber gasket inside a bell to create a watertight seal when the spigot end is inserted. (Section D-3.2 (#chapter-d-3-2-section-2))

U&O process

A method of making large steel pipe by pressing a flat steel plate into a “U” shape and then into an “O” shape before welding it into a cylinder. (Section D-1.2 (#chapter-d-1-2-describe-the-methods-of-manufacture-of-piping-and-tubing))

ultraviolet (UV) rays

Invisible rays from the sun that can damage materials over time. (Section D-1.5 (#chapter-d-1-5-describe-the-inspection-of-pipes-and-tube-before-installation))

union

A fitting that allows pipes or equipment to be easily connected and disconnected without cutting or rotating the pipe. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

upright wye

A wye fitting installed in a vertical position to connect horizontal piping into a vertical stack with smooth flow. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

V-port ball valve

A ball valve with a V-shaped opening that allows more precise control of flow. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

vacuum relief valve

A valve that allows air into a system to prevent vacuum conditions that could damage equipment. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

valve actuator

A device used to open, close, or control a valve, such as manual handles and electrical, hydraulic, and pneumatic actuators. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

valve chatter

The noise created when the water flow causes loose valve components to rattle or chatter in rapid succession. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

valve packing

A sealing material, usually graphite, used to seal around a valve stem to prevent leakage of system fluids. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

valve stem

The part of a valve that connects the handle or actuator to the internal closing part (such as a disk or gate) and moves to open or close the valve. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

variable spring support

A pipe support that uses a spring to carry the load, where the supporting force changes slightly as the pipe moves. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

vegetable fibre gaskets

Gaskets made from plant-based fibres that are compressed to form a seal, commonly used in low-pressure applications. (Section D-3.2)

vibration isolator

A device used to reduce the transfer of vibration and noise between components. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

Vic-press

A patented press-connect piping system, manufactured by the Victaulic Co., that uses special fittings and a pressing tool to create a secure, leak-resistant connection without welding or threading. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

Victaulic's Zero-Flex coupling

A rigid grooved coupling designed to join pipes with no movement at the joint, providing strong support and maintaining alignment. (Section D-3.1)

volatile organic compounds (VOCs)

Chemicals that easily turn into gases and can be harmful to people and the environment. They are often found in paints, coatings, and solvents. (Section D-1.4 (#chapter-d-1-3-section-4))

wafer lug type butterfly valve

A butterfly valve with threaded or unthreaded lugs that allow it to be bolted between flanges and support one side of the piping when the other side is removed. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

wafer-type butterfly valve

A butterfly valve designed to fit between two pipe flanges, usually without the need for separate gaskets, for quick and compact installation. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

wall cladding

A layer of material added to the outside or inside of a wall to protect it and improve its appearance (such as siding, drywall, or panels). (Section D-1.6 (#chapter-d-1-6-section-6))

water hammer (hydraulic shock)

A pressure surge or high-pressure shockwave that occurs when water in motion is forced to stop or change direction suddenly. It produces a distinct banging or hammering sound, caused by the shockwave traveling back through the pipe. This effect can damage pipes, joints, and appliances. (Section D-1.3 (#chapter-d-1-3-describe-the-methods-of-pipe-and-tubing-support))

water pressure reducing valve

A valve that lowers incoming water pressure to a safe level for a plumbing system. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

water table

The level below ground where the soil is fully saturated with water. (Section D-1.4 (#chapter-d-1-3-section-4))

waterstop

A material used to prevent water from passing through joints in concrete. (Section D-4.1 (#chapter-d-4-1-describe-factors-affecting-penetrations-in-structures))

wax gaskets

Soft wax rings used to seal toilet connections to prevent leaks and sewer gases from escaping. (Section D-3.2 (#chapter-d-3-2-section-2))

weld-neck pipe flange

A flange with a long neck that is welded to the pipe, providing strong support and smooth flow. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

welded fittings

A fitting that is permanently joined to a pipe by melting and fusing the metal together to create a strong, leak-proof connection. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

wingback elbow (lug ear elbow; drop-ear elbow; drop elbow)

An elbow with mounting tabs used to secure piping to a surface. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

wire drawing

The visual effect of erosion of a valve seat or disk. Wire drawing occurs when a valve is not closed perfectly tight. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

wrought copper (streamline fitting)

A smooth, flexible copper fitting made by shaping metal rather than casting, commonly used in pressure piping systems. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

wrought copper solder pressure female adapter

A copper fitting used to connect soldered copper pipe to a female threaded connection in pressure systems. (Section D-3.1 (#chapter-ch-3-install-fittings-3-1))

wyes

Y-shaped pipe fittings that allow flow to split or join at an angle. (Section D-1.6 (#chapter-d-1-6-section-6))

Y-body globe valve

A globe valve design with the seat and stem set at an angle (about 45°), which reduces pressure drop and is suited for high-pressure or demanding service. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

Z-body globe valve

The simplest globe valve design, with a symmetrical shape that makes it easy to manufacture, install, and repair, and is commonly used for water applications; the fluid changes direction twice as it flows through the valve, creating more resistance and pressure loss. (Section D-2.1 (#chapter-d-2-1-describe-basic-valve-types))

Version History

This page provides a record of changes made to this learning resource, Plumbing Apprenticeship Level 1, Block D (<https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/>). Each update increases the version number by 0.1. The most recent version is reflected in the exported files for this resource.

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If you identify an error in this resource, please report it using the TRU Open Education Resource Error Form ([#back-matter-tru-open-education-resource-error-form](#)).

Table 1: Version History Table

Version	Date	Change	Details

Plumbing Apprenticeship & Trade Resources in BC

A successful career in plumbing requires a strong foundation of skills, knowledge, and workplace safety awareness. Below are key resources to support plumbing apprentices in BC, including educational pathways, trade certifications, workplace safety guidelines, and mental health and wellness support.

Plumbing Apprenticeship & Certification Resources

- **SkilledTradesBC – Plumbing Apprenticeship** (<https://skilledtradesbc.ca/plumber>) – Overview of plumbing training, certification requirements, and apprenticeship pathways in British Columbia.
- **Red Seal Program – Plumber** (<https://www.red-seal.ca/eng/trades/plumbers/overview.shtml>) – National certification program with exam prep guides and trade mobility information.
- **BC Building Codes & Standards** (<https://www.bccodes.ca/>) – Official building and plumbing codes for British Columbia.

Workplace Safety & Regulations

- **WorkSafeBC** (<https://www.worksafebc.com/en>) – Essential safety resources for plumbers, including:
 - Health & Safety – WorkSafeBC (<https://www.worksafebc.com/en/health-safety>)
 - Report Unsafe Working Conditions (<https://www.worksafebc.com/en/contact-us/departments-and-services/health-safety-prevention>)
 - Report a Workplace Injury or Disease (<https://www.worksafebc.com/en/claims/report-workplace-injury-illness>)
 - Submit a Notice of Project Form (<https://www.worksafebc.com/en/for-employers/just-for-you/submit-notice-project>)
 - Get Health and Safety Resources (Videos, Posters, Publications, and More) (<https://www.worksafebc.com/en/resources-health-safety>)
 - Search the OHS Regulations (and Related Materials) (<https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation>)
 - Conduct an Incident Investigation (<https://www.worksafebc.com/en/health-safety/create-manage/incident-investigations/conducting-employer-investigation>)
- **CCOHS: OHS Answers Fact Sheets – Plumber** (https://www.ccohs.ca/oshanswers/occup_workplace/plumber.html) – Safety guidelines and best practices for plumbers in various work environments.

Financial Supports

- **Financial Support (SkilledTradesBC)** (<https://skilledtradesbc.ca/financial-support>) – Information about grants, tax credits, Canada apprentice loans, employment insurance, and the Indigenous Skills and Employment Training

(ISET) program.

- **StudentAidBC** (<https://studentaidbc.ca/>) – Complete post-secondary education through student loans, grants, and scholarships. There is also programs that help with loan repayment.
- **WorkBC (Government of BC)** (<https://www.workbc.ca/find-loans-and-grants/students-and-adult-learners/services-apprentices-and-employers>) – Services for apprentices and employers.

Mental Health & Wellness Support

- **HealthLink BC – Mental Health and Substance Use** (<https://www.healthlinkbc.ca/mental-health-and-substance-use>) – HealthLink BC resources for mental health and wellness support.
- **Here2Talk** (<https://here2talk.ca/>) – Free and confidential counseling services available to all post-secondary students registered at a BC school.
- **Help Starts Here** (<https://helpstartshere.gov.bc.ca/>) – A database with over 2,500 listings of services related to mental health and substance use supports.
- **Hope for Wellness Helpline** (<https://www.hopeforwellness.ca/>) – 24/7 online chat and phone line with experienced and culturally competent counselors available to all Indigenous people in Canada.
 - First Nations Health Authority Mental Health Supports Info Sheet [PDF] (<https://www.fnha.ca/Documents/FNHA-mental-health-and-wellness-supports-for-indigenous-people.pdf>) by First Nations health Authority – List of culturally safe services for Indigenous people.
- **HeretoHelp – BC** (<https://www.heretohelp.bc.ca/>) – Mental health resources, including videos, articles, and support services in BC.
- **BC Construction Industry Rehabilitation Plan** (<https://www.constructionrehabplan.com/>) – Mental health and substance use services for CLRA and BCBT members and their families.
- **Virtual Mental Health Supports (Government of BC)** (<https://www2.gov.bc.ca/gov/content/health/managing-your-health/mental-health-substance-use/virtual-mental-health-supports>) – Virtual services are available for British Columbians who are experiencing anxiety, depression, or other mental health challenges.

Crisis Support

- **Interior Crisis Line Network** – Call 1-888-353-2273 (tel:+1-888-353-2273) for 24/7 emotional support, crisis intervention, and community resource information.
- **Talk Suicide Chat Service** (<https://talksuicide.ca/>) – An alternative if calling is difficult; available for crisis intervention.
- **310Mental Health Support** – Call 250-310-6789 (tel:+1-250-310-6789) for emotional support, information, and resources specific to mental health.
- **1-800-SUICIDE** – Call 1-800-784-2433 (tel:+1-800-784-2433) if you are experiencing feelings of distress or despair, including thoughts of suicide.
- **Opioid Treatment Access Line** – Call 1-833-804-8111 (tel:+1-833-804-8111) between 9 am and 4 pm to connect with a doctor, nurse, or healthcare worker who can prescribe opioid treatment medication that same day.
- **KUU-US Crisis Response Service** – Call 1-800-588-8717 (tel:+1-800-588-8717) for culturally-aware crisis support for Indigenous peoples in BC.
- **Alcohol and Drug Information and Referral Service** – Call 1-800-663-1441 (tel:+1-800-663-1441) to find resources and support.



Emergency Services — For life-threatening situations, call 911 or visit your nearest emergency department.