Block D: Piping and Components

TRU Open Press

Plumbing Apprenticeship Program Level 1 Series

Block D: Piping and Components

BC Plumbing Apprenticeship, Level 1

SKILLEDTRADESBC

AUDREY CURRAN; MARK OVERGAARD; BC PIPING ARTICULATION AND CURRICULUM SUBCOMMITTEE; AND PAUL SIMPSON

TRU OPEN PRESS, THOMPSON RIVERS UNIVERSITY
KAMLOOPS, B.C.

Block D: Piping and Components Copyright © 2026 by Skilled Trades BC, TRU Open Press is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License (https://creativecommons.org/licenses/by-nc-sa/4.0/), except where otherwise noted.

Original material © SkilledTradesBC, All Rights Reserved. The original material provided by SkilledTradesBC has been adapted and modified with permission. ©COPYRIGHT TRU, 2026. Licensed under a Creative Commons Attribution–NonCommercial–ShareAlike 4.0 International (**CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/deed.en))** licence.

This licence allows you to retain, reuse, copy, redistribute, and revise this resource — in whole or in part — for **non-commercial purposes**, provided that the adapted version is released under the same licence and the original creators are properly attributed as follows:

Block D: Piping and Components (https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/) by SkilledTradesBC, revised by the BC Articulation Curriculum Subcommittee, Audrey Curran, Mark Overgaard and TRU Open Press, is used under a **CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/deed.en))** licence. **Download for free at:** https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/

Suggested citation (APA 7th edition):
SkilledTradesBC. (2026). *Block D: Piping and Components* (Rev. ed.; adapted by Audrey Curran, Mark Overgaard, the BC Articulation Curriculum Subcommittee, & TRU Open Press). TRU Open Press, Thompson Rivers University. https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/

Cover art attribution:

This book was produced with Pressbooks (https://pressbooks.com) and rendered with Prince.

Contents

Introduction 1

Acknowledgements 5

Accessibility xi

Part II. D-2 Install Valves

D-2 Install Valves Introduction 301

D-2.1 Describe Basic Valve Types 304

D-2.2 Install Valves 377

Self-Test D-2.1 Describe Basic Valve Types 390

Answer Key: Self-Test D-2.1 392

Self-Test D-2.2 Install Valve 393

Answer Key: Self-Test D-2.2 395

Version History 683

Plumbing Apprenticeship & Trade Resources in BC 684

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-bcplumbingapprl1.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

Block B: Tools and Equipment (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca)

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-bcplumbingapprl1.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-bcplumbingapprl1.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.
- **Plumbing Apprenticeship Program Level 2 Series (https://openpress.trubox.ca/2024/04/26/bc-plumbing-apprenticeship-level-2/)** can be found in the TRU Open Press Collection.
- **Plumbing Apprenticeship Program Level 3 Series (https://collection.bccampus.ca/search/?q=%22pl3%22)** can be found in the BCCampus Open Collection (https://collection.bccampus.ca/).
- **Plumbing Apprenticeship Program Level 4 Series** (https://bccampus.ca/projects/archives/zed-cred-z-degrees/ztc-open-educational-resources-for-trades/) can be found in the BCCampus Open Collection. (https://collection.bccampus.ca/) (Block F: Commission and Service will be available soon.)

Disclaimer

The materials in these Learning Guides are intended for use by students and instructional staff. They have been compiled from sources believed to be reliable and to represent the best current opinions on these subjects. These manuals are designed to serve as a starting point for good practices and may not cover all minimum legal standards. No warranty, guarantee, or representation is made by the BC Piping Trades Articulation Committee, the Skilled Trades BC authority, or the King's Printer of British Columbia regarding the accuracy or sufficiency of the information contained in these publications. These manuals aim to provide basic guidelines for piping trades practices. Therefore, do not assume that all necessary warnings and safety precautions are included, and additional measures may be required.

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.

[From previous 2021 book – confirm this message with Skilled Trades]

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).

The original materials were produced in collaboration with industry partners and aligned with the Industry Training Authority (ITA)/SkilledTradesBC harmonized program outlines for Plumbing, Steamfitting/Pipefitting, and Sprinkler Fitting. These works were released under a Creative Commons Attribution 4.0 International (CC-BY-NC-SA (https://creativecommons.org/licenses/by-nc-sa/4.0/)) licence, except where otherwise noted.

This TRU Open Press edition includes editorial revisions, updated content, and the addition of new images, alongside selected images carried forward from the original BC Industry Authority BC (SkilledTradesBC). Images in this work are licensed separately under their respective Creative Commons licences or the public domain, as credited in individual figure captions or attribution statements, unless otherwise noted. All images originally copyright the BC Industry Training Authority are licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International licence (CC-BY-NC-SA (https://creativecommons.org/licenses/by-nc-sa/4.0/)).

This adapted version has been reformatted and integrated into the current Thompson Rivers University/TRU Open Press open educational resource in collaboration with the BC Piping Articulation and Curriculum Subcommittee and SkilledTradesBC, in support of open, accessible, and up-to-date apprenticeship training.

The Open Press

The Open Press combines TRU's open platforms and expertise in learning design and open resource development to support the creation and reuse of open educational resources, while encouraging open scholarship and research.

Resource Development Team 2024-2026

Content Review, Revision, and Development: BC Plumbing Articulation Curriculum Subcommittee and Audrey Curran

Final Content Review and Revisions: Audrey Curran and Mark Overgaard, BCIT
Project Lead (TRU Plumbing Trades): Paul Simpson, Curriculum Subcommittee Chair

Author: SkilledTradesBC

Publishing Manager/ Copy Editing: Dani Collins, MEd
Production: Jessica Obando Almache, BCS

- Co-op Students:
  - Greg Vilac
  - Riley Phillips
  - Vansh Sethi
  - Jesse Perkins, BCS Co-op Student
  - Daniel Abdulai
  - Kobe Shimoyama
  - Jose Contreras Antequera

Resources

Content adapted from:

- ©2019, Skilled Trades BC (Harmonized)
- Open School BC
- Camosun College
- Trades Training BC

For the latest BC Plumbing Trades Program Outline (2025), see the SkilledTradesBC website: www.skilledtrades.bc.ca (https://skilledtradesbc.ca/)

To order printed copies of Program Outlines or learning resources (where available) for BC Trades, contact:

Crown Publications, King's Printer
Web: www.crownpub.bc.ca
Email: crownpub@gov.bc.ca
Toll Free: 1 800 663-6105

- Piping Trades Apprenticeship Program – Perform Safety Related Functions – Level 1 Harmonized (2019) (Binder) (ISBN: 978-0-7726-7362-6; product no. 7960000260) Crown Publications Online Catalogue – Piping Trades Apprenticeship Program – Perform Safety Related Functions – Level 1 Harmonized (2019) (Binder) (https://www.crownpub.bc.ca/Product/Details/7960000260_S)
- Piping Trades Apprenticeship Program – Use Tools and Equipment – Level 1 Harmonized (2019) (Binder) (ISBN: 978-0-7726-7362-6; Product no. 7960000261) Crown Publications Online Catalogue – Piping Trades Apprenticeship Program – Use Tools and Equipment – Level 1 Harmonized (2019) (Binder) (https://www.crownpub.bc.ca/Product/Details/7960000261_S)
- Piping Trades Apprenticeship Program – Perform Routine Trade Activities and Apply Electrical Concepts – Level 1

Harmonized (2019) (Binder) (ISBN: 978-0-7726-7362-6; product no. 7960000262) Crown Publications Online Catalogue – Piping Trades Apprenticeship Program – Perform Routine Trade Activities and Apply Electrical Concepts – Level 1 Harmonized (2019) (Binder) (https://www.crownpub.bc.ca/Product/Details/7960000262_S)

- Piping Trades Apprenticeship Program – Prepare Piping and Components – Level 1 Harmonized (2019) (Binder) (ISBN: 978-0-7726-7362-6; product no. 7960000263) Crown Publications Online Catalogue – Piping Trades Apprenticeship Program – Prepare Piping and Components – Level 1 Harmonized (2019) (Binder) (https://www.crownpub.bc.ca/Product/Details/7960000263_S)

The following companies and suppliers have kindly provided copyright permission for selected images throughout these Plumbing Apprenticeship resources:

- RIDGID TOOLS/Emerson Professional Tools
- Anvil International Dutramex
- Copper Development Association Inc.
- Amcorr Products and Services, Inc.
- Canusa-CPS
- Environmental Technology Inc.
- Highland TankPotter
- Electric Signal Company LLC
- International Association of Electrical Inspectors
- McElroy Manufacturing, Inc.
- Victaulic©Viking Corporation
- NIBCO®
- Joseph L Balkan Inc.
- Watts Canada

Any additional adapted versions of this content would require additional copyright permissions from the rights holders.

Creative Commons and site licensed images:

- Cover D-1: Close-up of a plumber's hands installing steel pipes indoors (https://www.pexels.com/photo/plumber-installs-pipe-fittings-6419128/) by Anıl Karakaya at Pexels is used under the Pexels License. (https://www.pexels.com/license/)
- Cover D-2: 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/) by Markus Winkler at Pexels is used under the Pexels License. (https://www.pexels.com/license/)
- Cover D-3: Copper plumbing fittings arranged in a row, showcasing metallic texture and industrial detail (https://www.pexels.com/photo/copper-pluming-fitting-28169591/) by Nic Wood at Pexels is used under the Pexels License. (https://www.pexels.com/license/)
- Cover D-4: Installation of pipe sleeves is from *installation of pipe sleeves #work #plumbing #aboutconstruction* (https://www.youtube.com/watch?v=mLKRYdB2qv4) by About Contstruction (https://www.youtube.com/@louiemendoza4616) (@louiemendoza4616) (2025

All symbol icons are from the Noun Project and are used under a CC BY license:

- Important by Larea from Noun Project (https://thenounproject.com/browse/icons/term/important/) (CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/deed.en))
- Skull and Crossbones by Luis Prado from Noun Project (https://thenounproject.com/browse/icons/term/skull-and-crossbones/) (CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/deed.en))
- Resources by popcornarts from Noun Project (https://thenounproject.com/browse/icons/term/resources/) (CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/deed.en))
- Flammable by yogi rista from Noun Project (https://thenounproject.com/browse/icons/term/flammable/) (CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/deed.en))
- Checkbox by ims.icon from Noun Project (https://thenounproject.com/browse/icons/term/checkbox/) (CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/deed.en))
- Explosive Materials by Ervin Bolat from Noun Project (https://thenounproject.com/browse/icons/term/explosive-materials/) (CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/deed.en))
- Work gloves by perilous graphic from Noun Project (https://thenounproject.com/browse/icons/term/work-gloves/) (CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/deed.en))
- Danger by Alice Design from Noun Project (https://thenounproject.com/browse/icons/term/danger/) (CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/deed.en))
- Electricity by Alice Design from Noun Project (https://thenounproject.com/browse/icons/term/electricity/) (CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/deed.en))

Land Acknowledgement

Thompson Rivers University (TRU) campuses are situated on the ancestral lands of the Tk'emlúps te Secwépemc and the T'exelc within Secwepemcúl'ecw, the ancestral and unceded territory of the Secwépemc. The rich tapestry of this land also encompasses the territories of the St'át'imc, Nlaka'pamux, Tŝilhqot'in, Nuxalk, and Dakelh. Recognizing the deep histories and ongoing presence of these Indigenous peoples, we express gratitude for the wisdom held by this land. TRU is dedicated to fostering an inclusive and respectful environment, valuing education as a shared journey. TRU Open Press, inspired by collaborative learning on this land, upholds open principles and accessible education, nurturing respectful, reciprocal relationships through the shared exchange of knowledge across generations and communities.

TRU Wolves (https://www.flickr.com/photos/thompsonrivers/52667199689/) (Thompson Rivers University/Flickr) CC BY-NC-SA 2.0 (https://creativecommons.org/licenses/by-nc-sa/2.0/)

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.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=713 (https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/?p=713)

AI Use Statement

ChatGPT (https://chatgpt.com/) and other (AI) tools may have been used to assist with the development of glossary definitions, support copy editing for grammar, clarity, and readability, and revise some image content. All content was reviewed, revised, and verified by the authors to ensure accuracy and alignment with course and industry standards.

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

SkilledTradesBC. (2022, December 1). Introducing Skilled Trades BC. YouTube. https://www.youtube.com/watch?v=OQgwdP0rNog

Accessibility

The web version of *Block D: Piping and Components (https://d-pipingcomponents-bcplumbingapprl1.pressbooks.tru.ca/)* has been designed to meet Web Content Accessibility Guidelines 2.0 (https://www.w3.org/TR/WCAG20/), level AA. In addition, it follows all guidelines in Appendix A: Checklist for Accessibility (https://opentextbc.ca/accessibilitytoolkit/back-matter/appendix-checklist-for-accessibility-toolkit/) of the Accessibility Toolkit – 2nd Edition (https://opentextbc.ca/accessibilitytoolkit/).

Includes:

- **Easy navigation.** This resource has a linked table of contents and uses headings in each chapter to make navigation easy.
- **Accessible videos.** All videos in this resource have captions.
- **Accessible images.** All images in this resource that convey information have alternative text. Images that are decorative have empty alternative text.
- **Accessible links.** All links use descriptive link text.

Accessibility Checklist

Element	Requirements	Pass
Headings	Content is organized under headings and subheadings that are used sequentially.	Yes
Images	Images that convey information include alternative text descriptions. These descriptions are provided in the alt text field, in the surrounding text, or linked to as a long description.	Yes
Images	Images and text do not rely on colour to convey information.	Yes
Images	Images that are purely decorative or are already described in the surrounding text contain empty alternative text descriptions. (Descriptive text is unnecessary if the image doesn't convey contextual content information.)	Yes
Tables	Tables include row and/or column headers with the correct scope assigned.	Yes
Tables	Tables include a title or caption.	Yes
Tables	Tables do not have merged or split cells.	Yes
Tables	Tables have adequate cell padding.	Yes
Links	The link text describes the destination of the link.	Yes
Links	Links do not open new windows or tabs. If they do, a textual reference is included in the link text.	Yes
Links	Links to files include the file type in the link text.	Yes
Video	All videos include high-quality (i.e., not machine generated) captions of all speech content and relevant non-speech content.	No
Video	All videos with contextual visuals (graphs, charts, etc.) are described audibly in the video.	Yes
H5P	All H5P activities have been tested for accessibility by the H5P team and have passed their testing.	Yes
H5P	All H5P activities that include images, videos, and/or audio content meet the accessibility requirements for those media types.	Yes
Font	Font size is 12 point or higher for body text.	Yes
Font	Font size is 9 point for footnotes or endnotes.	Yes
Font	Font size can be zoomed to 200% in the webbook or eBook formats.	Yes

Known Accessibility Issues and Areas for Improvement

- Images in H5P self-tests lack alt text, attributions, and licenses to avoid revealing answers.
- Some tables may use merged cells, but they have been structured to work properly with screen readers and there may be long descriptions included in each section if readers prefer to see the table data in a bulleted list.
- Youtube videos do not have edited captions.

Adapted from the Accessibility Toolkit – 2nd Edition (https://opentextbc.ca/accessibilitytoolkit/) by BCcampus, licensed under CC-BY (https://creativecommons.org/licenses/by/4.0/).

Other Formats Available

- In addition to the web version, this book is available in a number of file formats, including PDF. The Print PDF has passed our Accessibility Check.

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

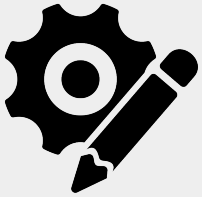
This section introduces the essential knowledge and skills required to install and work with valves in piping systems. You will learn key terminology, materials, and functions of valves, as well as how to select the appropriate valve for specific applications. The section also explores valve service 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.

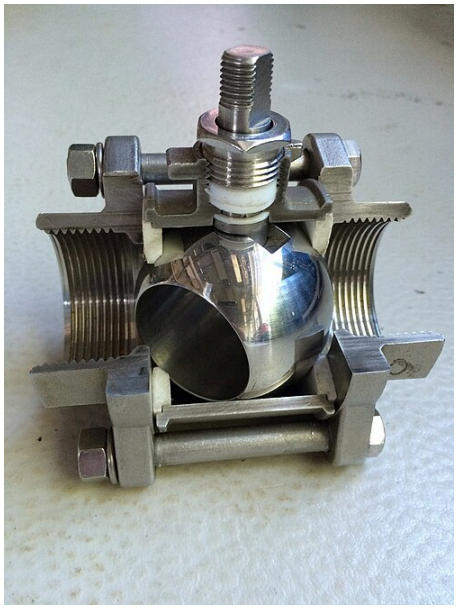


Figure 2 *Ball valve (https://commons.wikimedia.org/wiki/File:Ball_Valve.jpg) by (Bitjungle (https://commons.wikimedia.org/wiki/User:Bitjungle)/Wikimedia Commons) CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0/deed.en)*

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 *Pl control valve (https://commons.wikimedia.org/wiki/File:Pl_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:

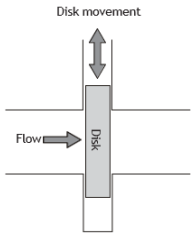
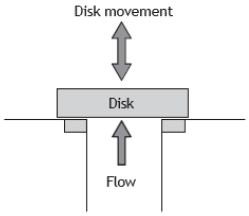
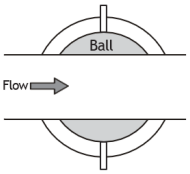
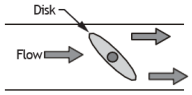
- Limiting pressure
- Regulating pressure
- Controlling flow rate
- Turning flow off and on
- Mixing water of different temperatures
- Limiting maximum temperature
- Preventing reverse direction flow
- Balancing flow across different circuits

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/cm2) (217.6 psi)	2.4 MPa (24 kg/cm2) (348 psi)
Seat & back seat	1.0 MPa (10 kg/cm2) (145 psi)	1.6 MPa (16 kg/cm2) (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). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

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.

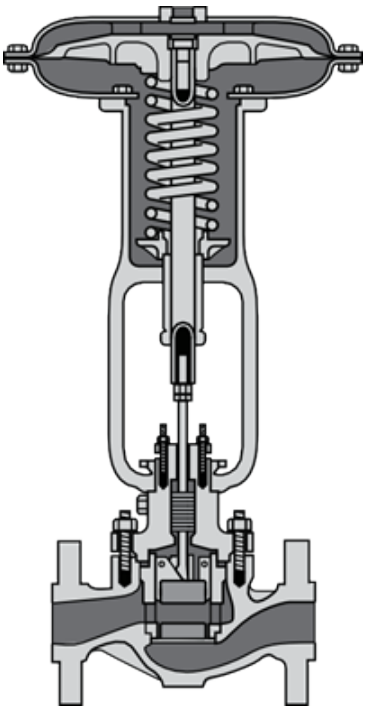


Figure 10 *Pneumatically actuated globe valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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

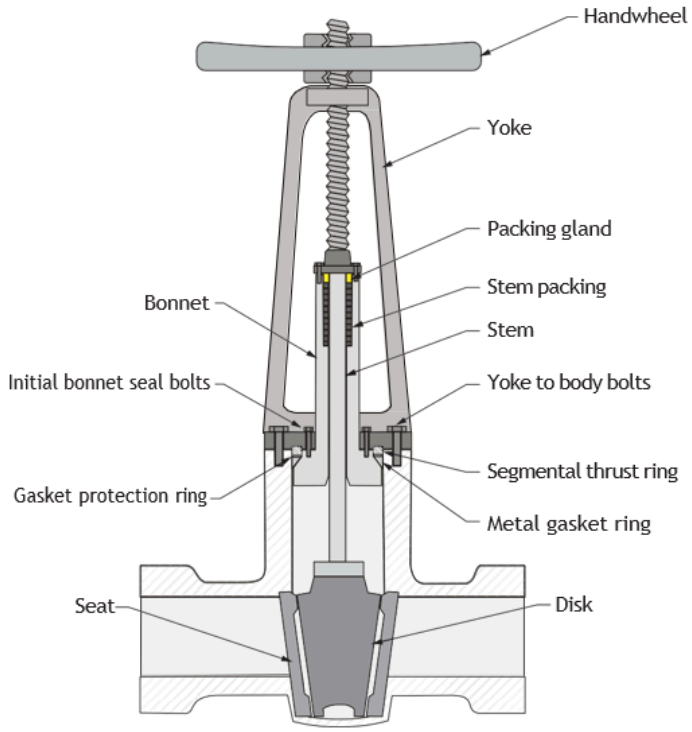


Figure 12 *Gate valve parts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

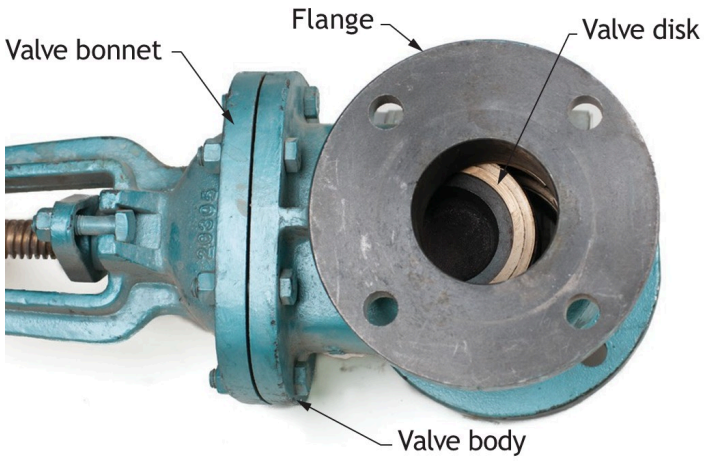


Figure 13 *Cast iron flanged gate valve, bolted bonnet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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

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/)*

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.

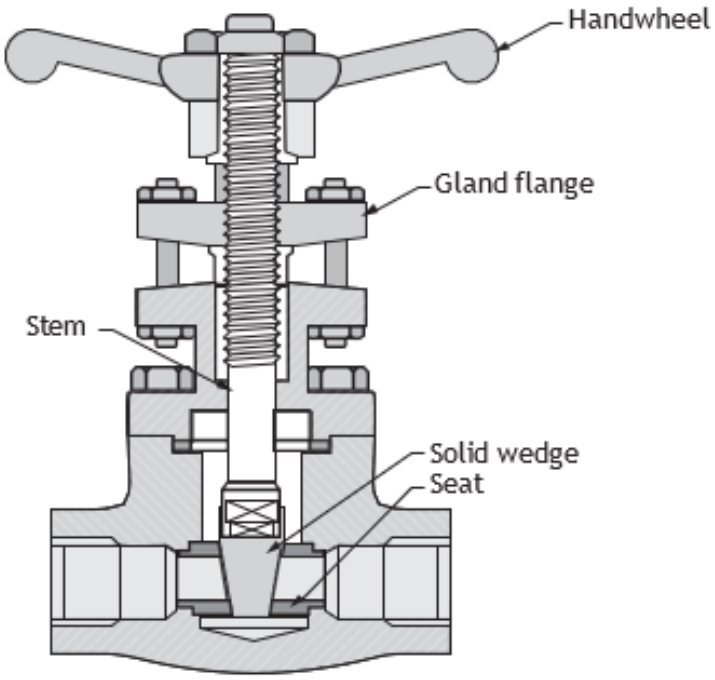


Figure 15 *Solid wedge gate valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

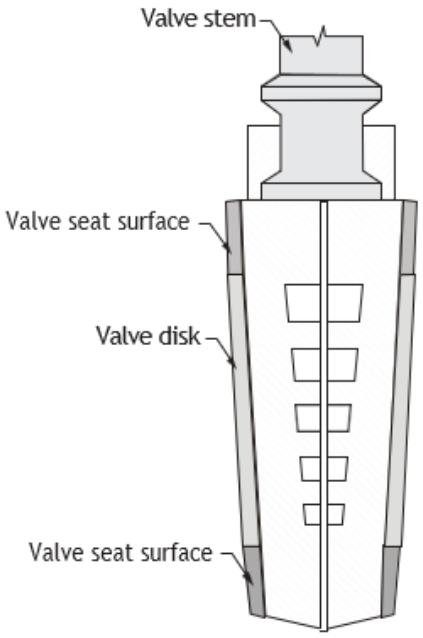


Figure 16 *Flexible wedge disk (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

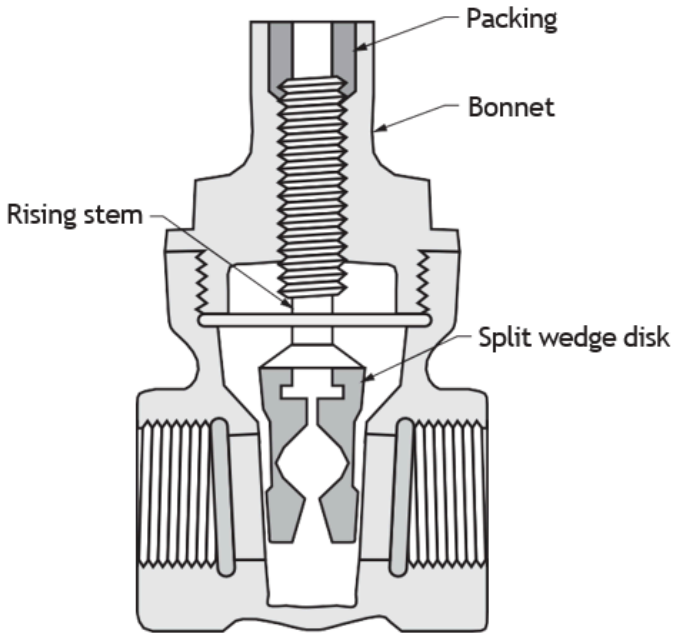


Figure 17 *Split wedge gate valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

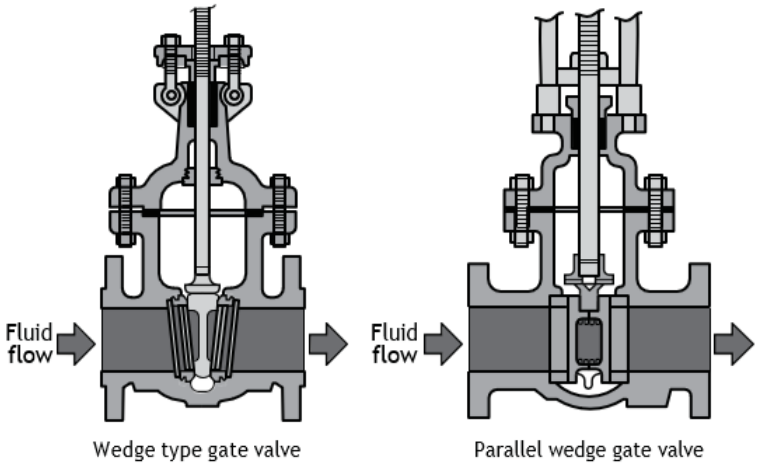


Figure 18 *Wedge gate valve types (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

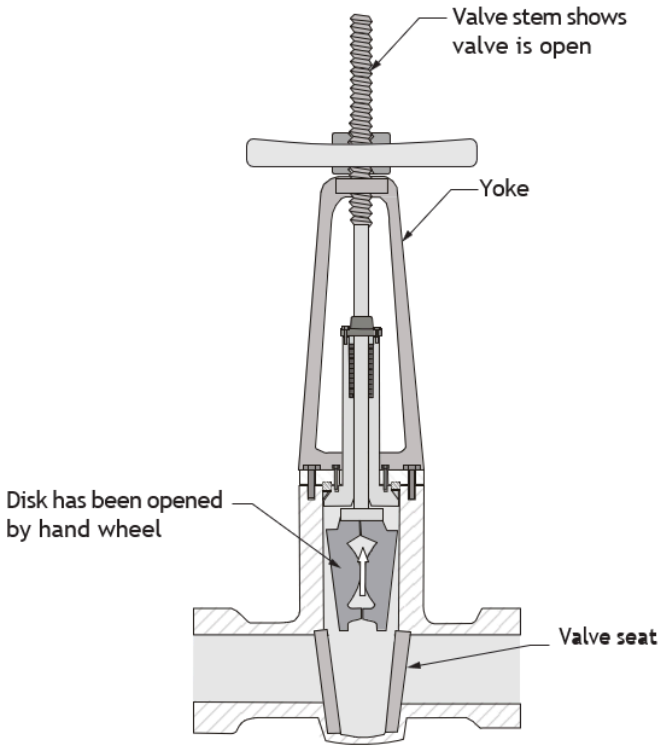


Figure 19 *Rising stem gate valve, outside stem and yoke* (OSY) *(BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

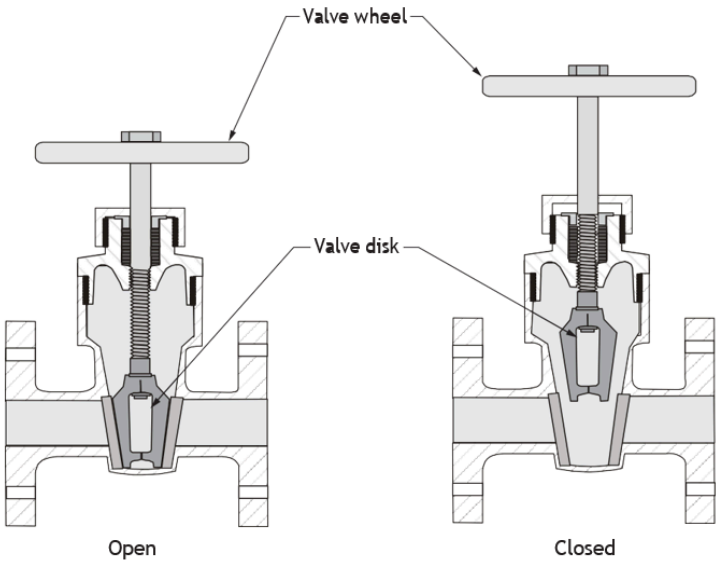


Figure 20 *Rising stem inside screw valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

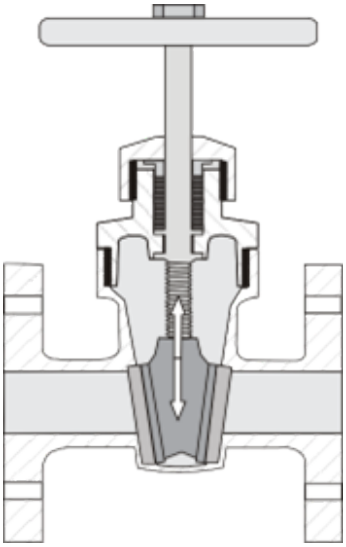


Figure 21 *Non-rising stem gate valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

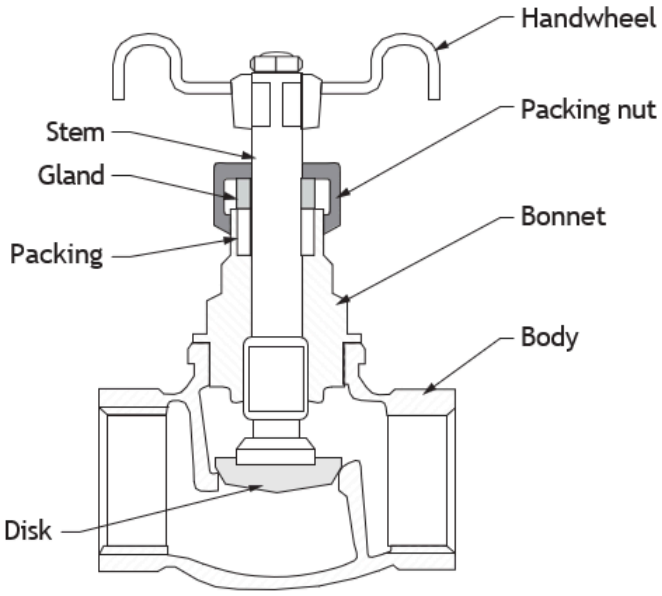


Figure 23 *Parts of a globe valve* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

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.

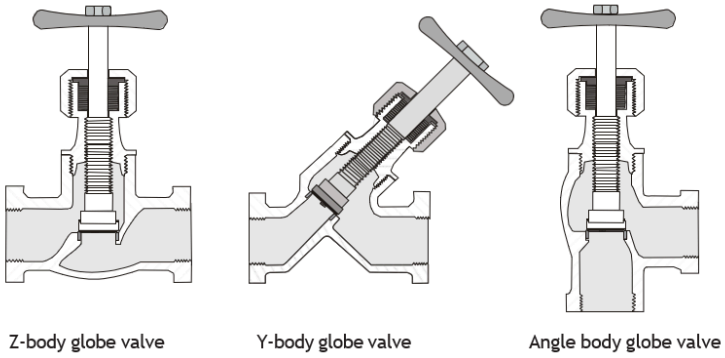
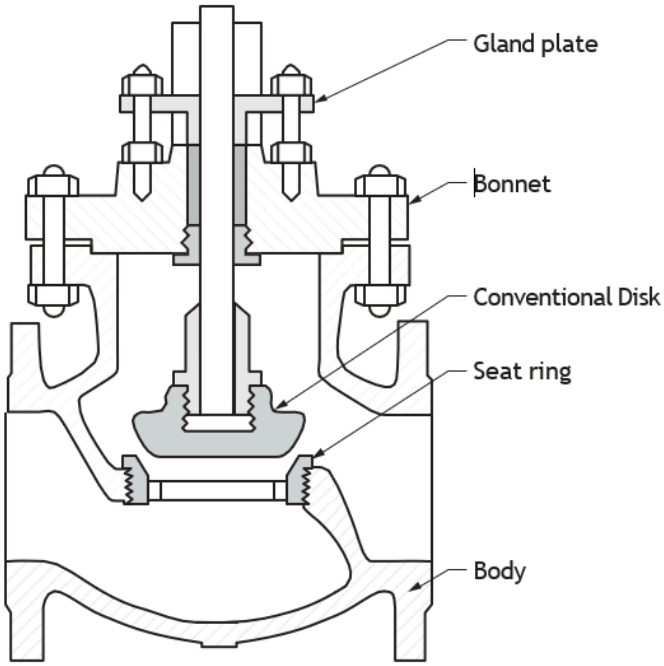


Figure 24 *Types of globe valve body designs (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

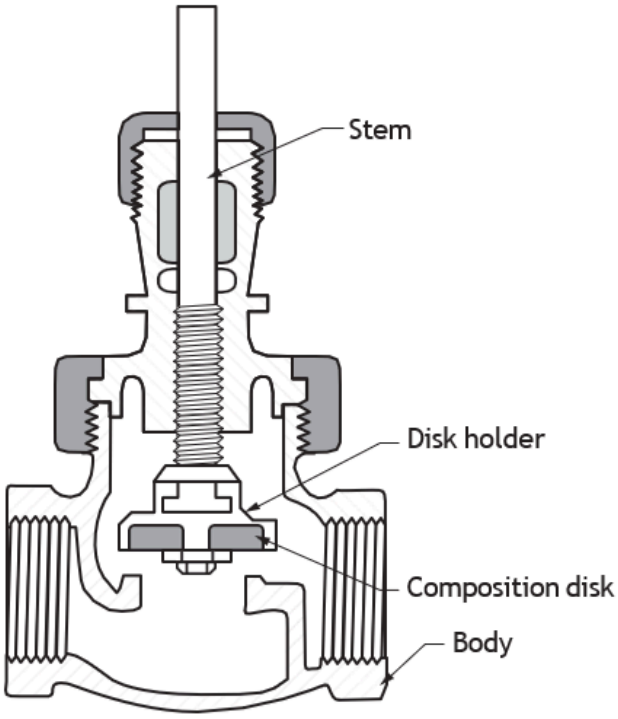
Globe Valve Disks

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

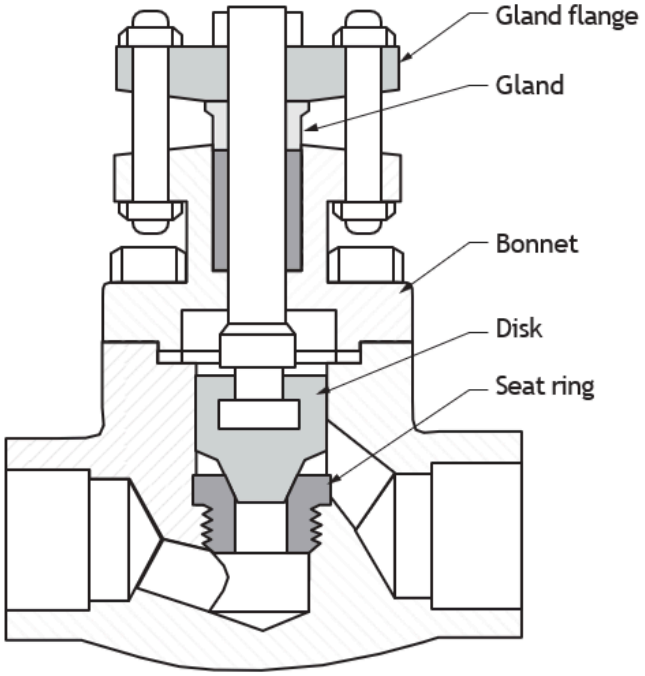


Figure 25 *Types of globe valve disks (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

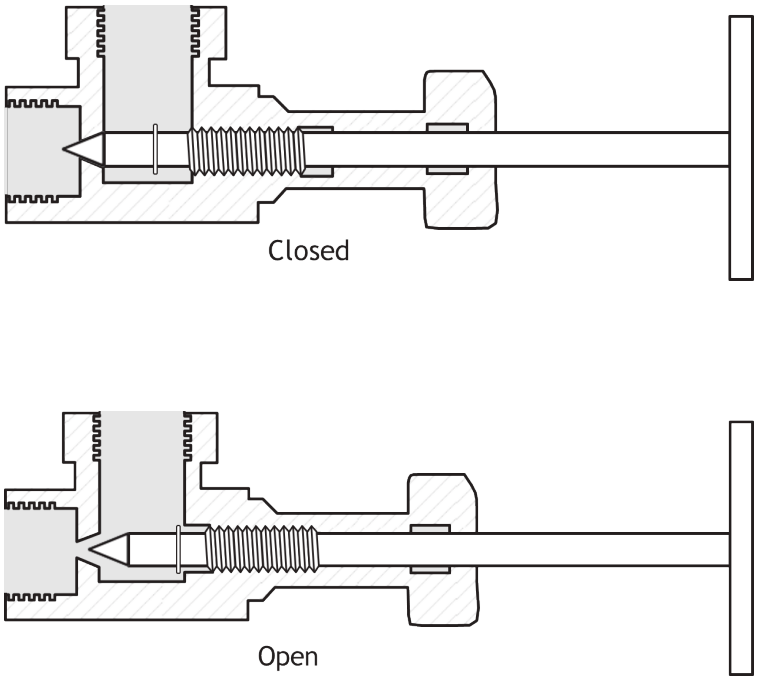


Figure 26 *Needle valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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

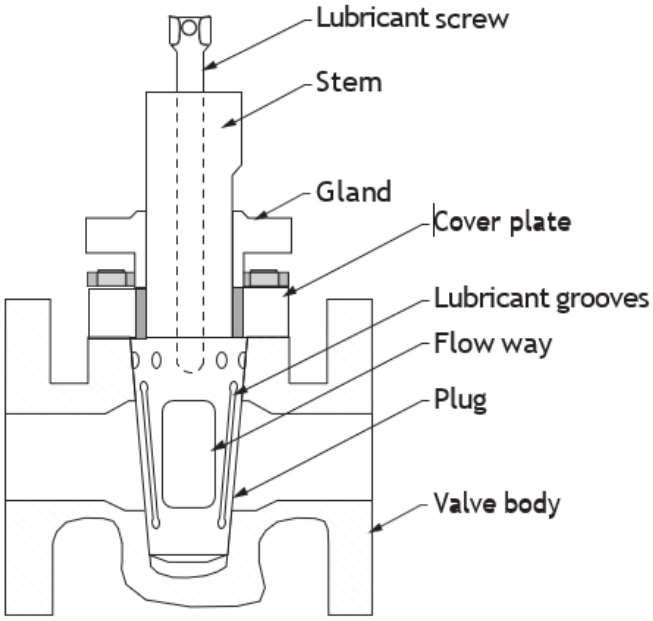


Figure 27 *Parts of a plug valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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/)*

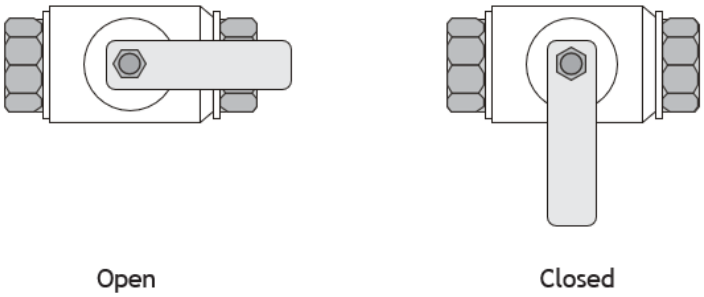


Figure 31 *Handle positions, open and closed (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

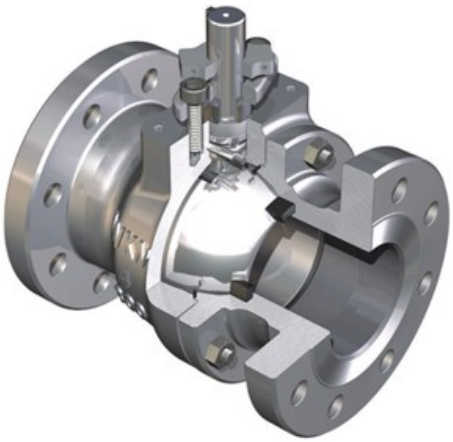


Figure 32 *Full port ball valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

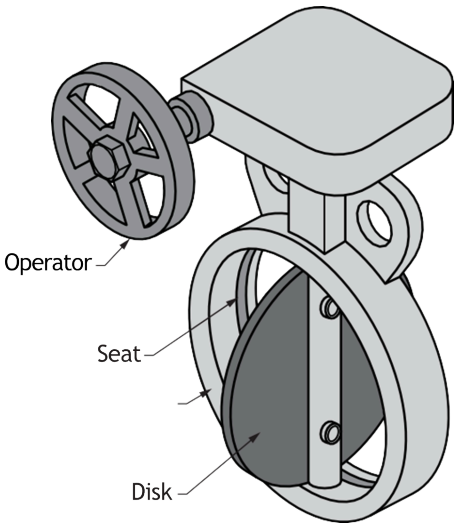


Figure 34 *Butterfly valve components (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

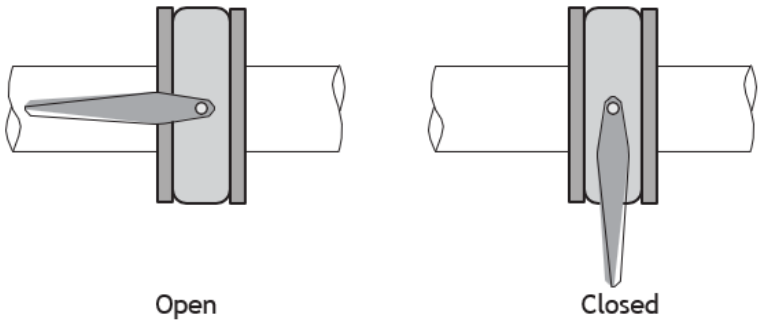


Figure 35 *Handle position, open and closed (BC Industry Training Authority, 2019).*
CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

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.

Figure 42 *Flanged T pattern iron body swing-check (Image courtesy of Watts) Used with permission.*

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 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.

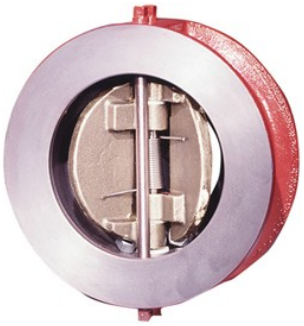
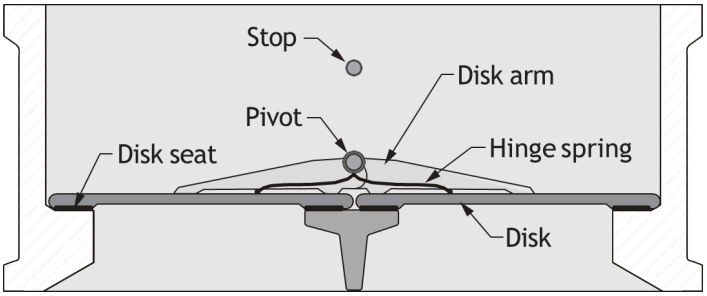


Figure 44 *Split disk wafer check valve (Image courtesy of Watts) Used with permission.*



Closed

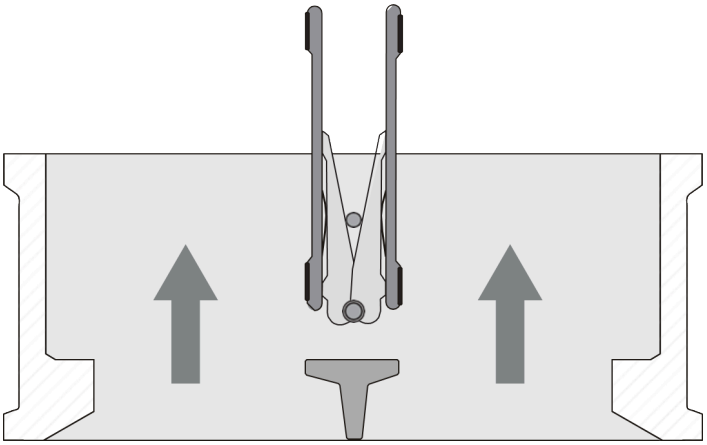


Figure 45 *Open and closed positions of split disk wafer check valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

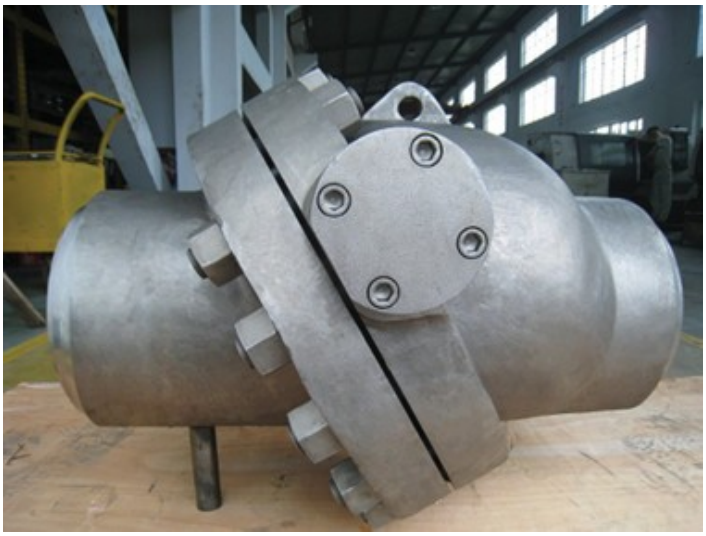


Figure 46 *Tilting-disk swing-check valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

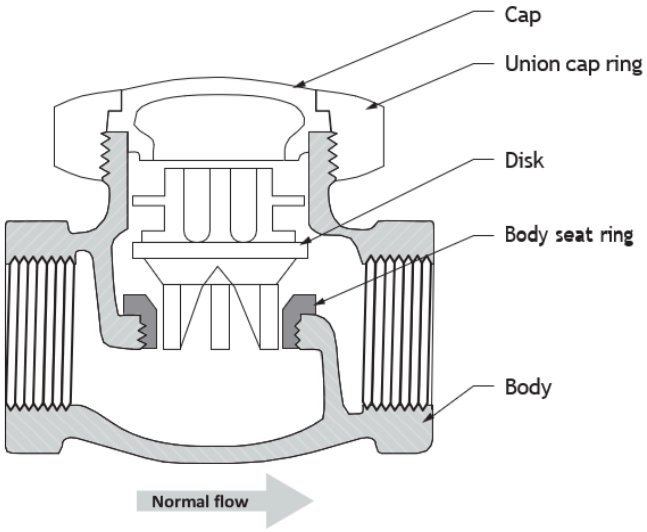


Figure 47 *Parts of a globe-type lift-check valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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/)*

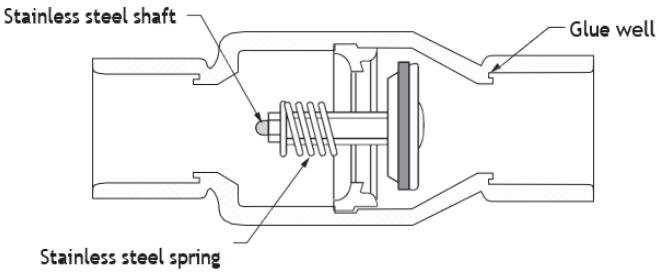


Figure 50 *Silent check valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

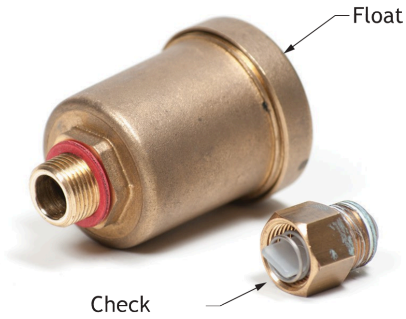


Figure 51 *Service check valve (SCV) for a float vent (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

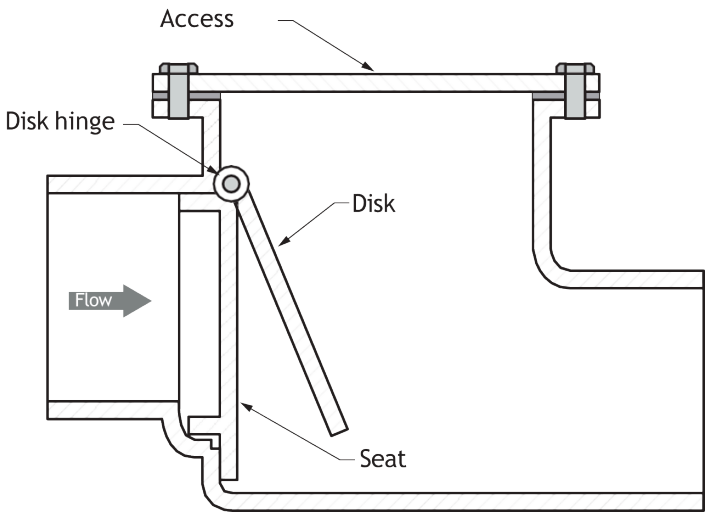


Figure 53 *Backwater valve cutaway (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

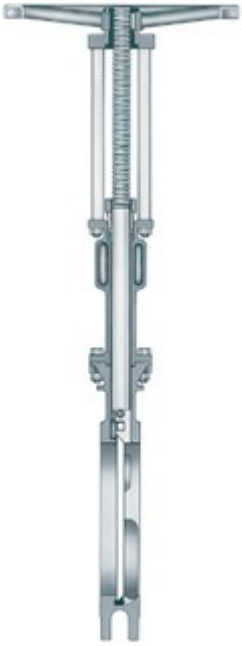


Figure 55 *Knife valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

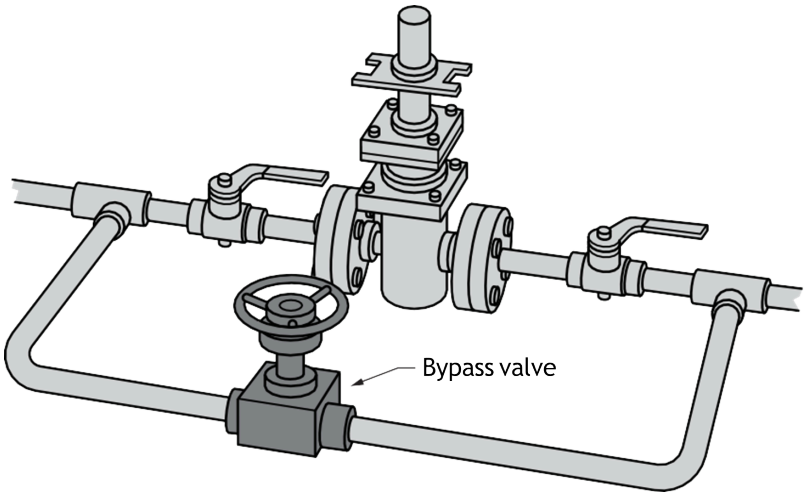


Figure 57 *Bypass valve arrangement with bypass valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

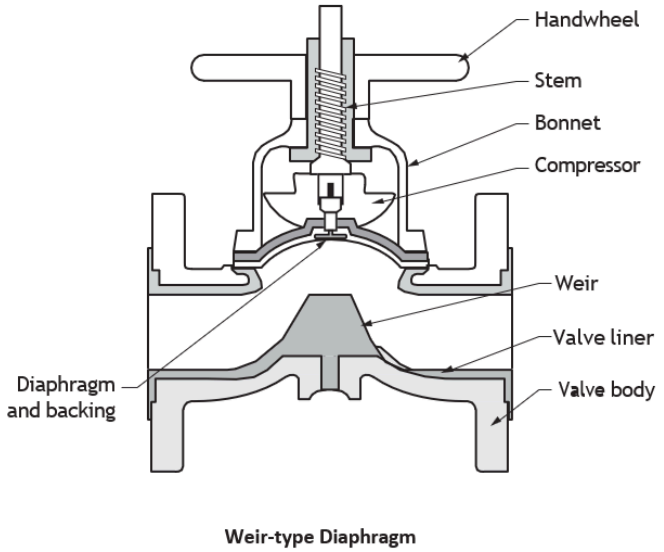


Figure 60 *Diaphragm valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

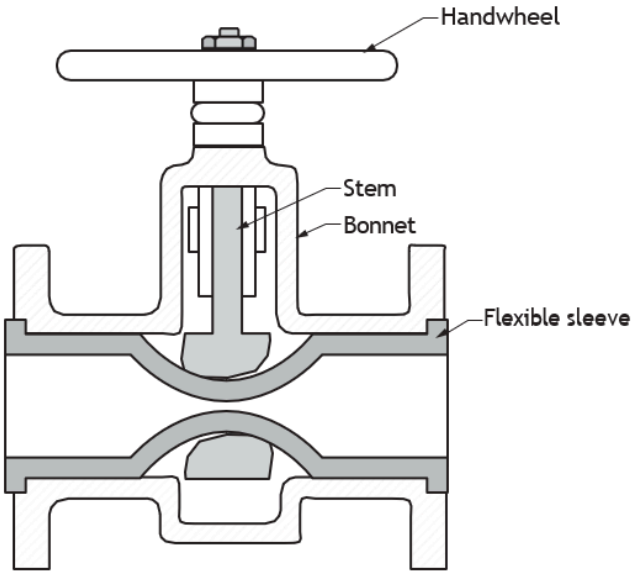


Figure 61 *Manual control pinch valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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

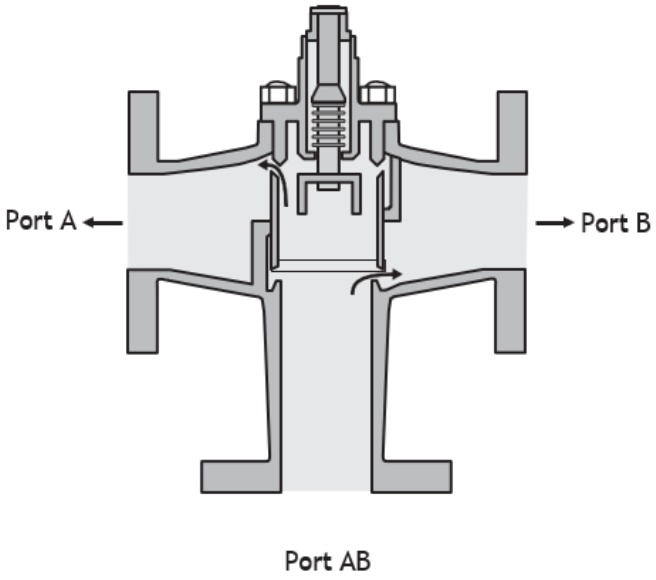


Figure 62 *Piston type diverting valve* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

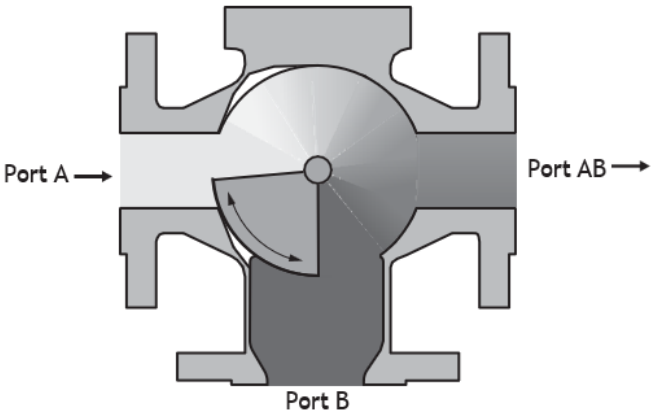


Figure 63 *Rotating shoe on a mixing application* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

There are three basic types of three-port valve:

- *Piston valve* type
- *Globe, plug* type
- ***Rotating shoe type***

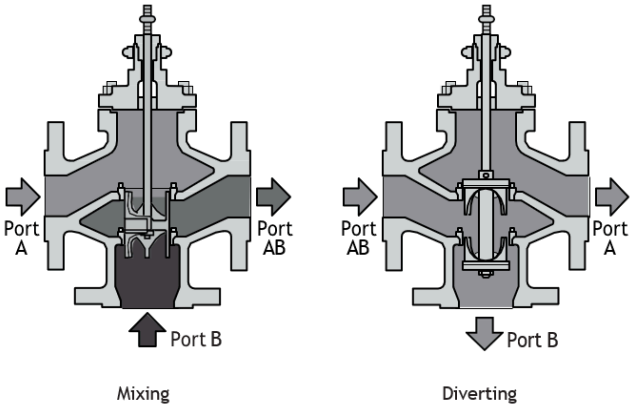


Figure 64 *Globe-type three-port valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

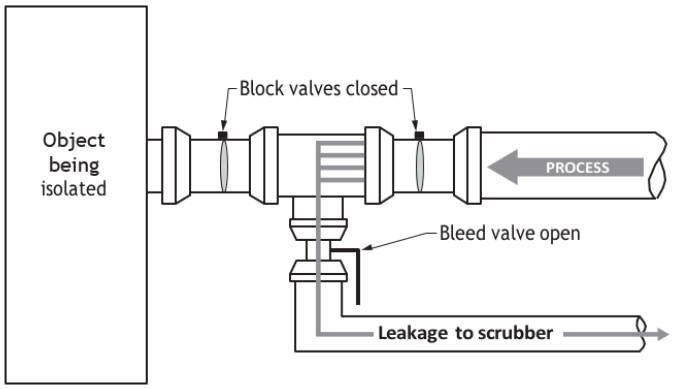


Figure 66 *Double block and bleed valve arrangement (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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).

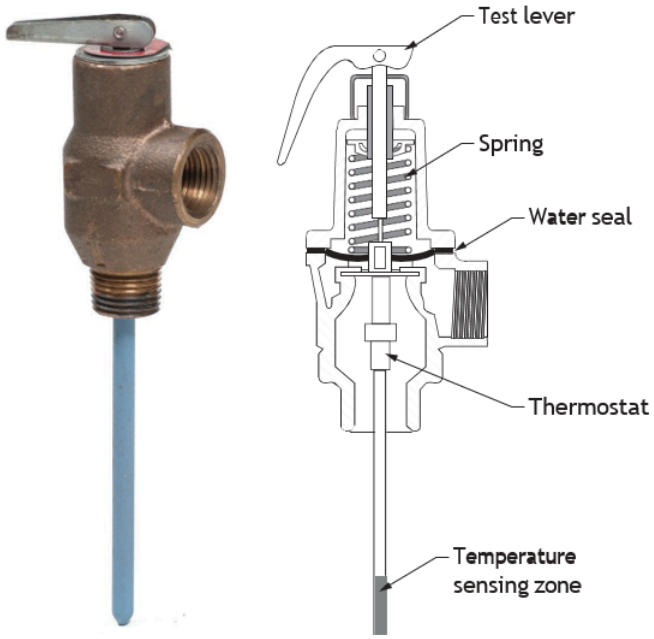


Figure 71 *Parts of a temperature and pressure relief valve used for a domestic hot water heater* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

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

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/)*

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

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.

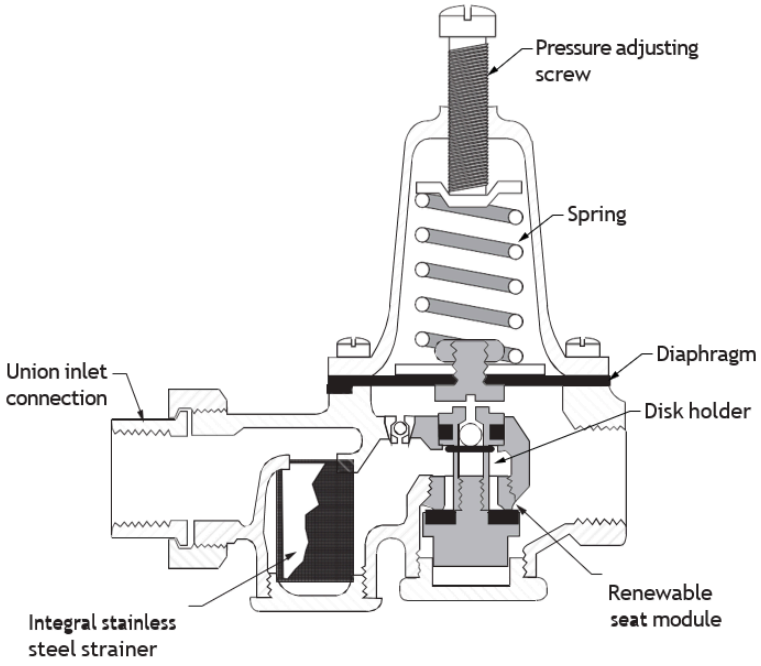


Figure 76 *Pressure-reducing valve cutaway (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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/)*

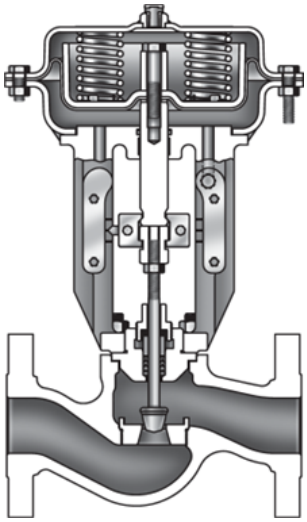


Figure 81 *Cutaway of sliding-stem globe valve with actuator (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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 valve***s. 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.

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.

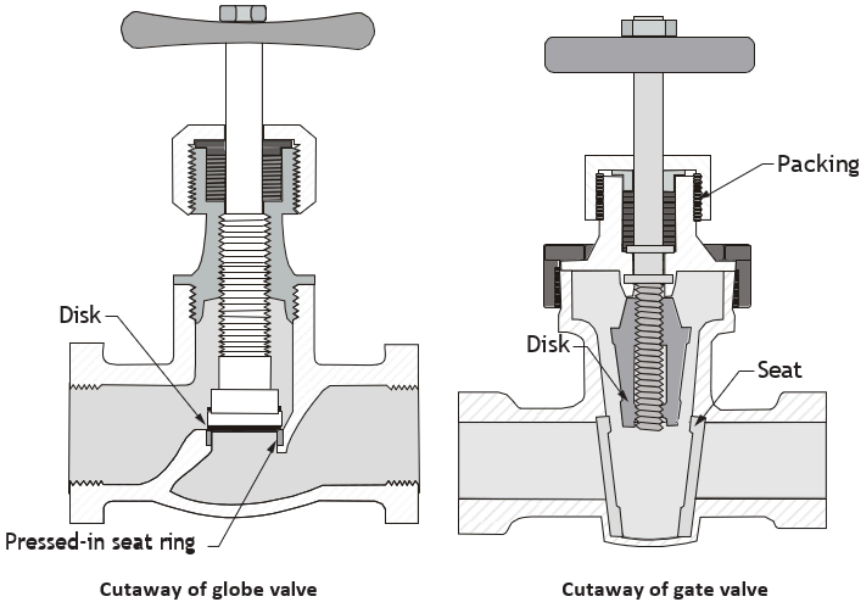


Figure 86 *Disk and seat locations (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

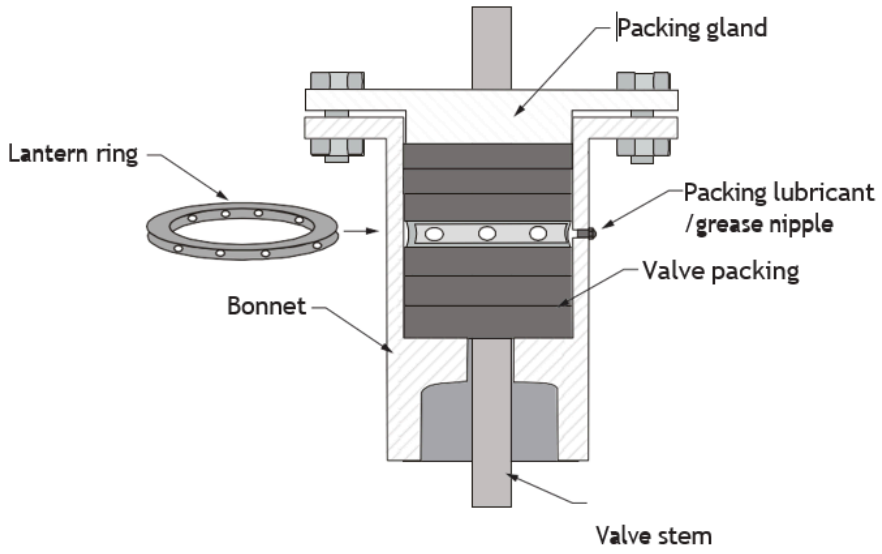


Figure 89 *Partial cross-section of a valve showing stuffing box (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

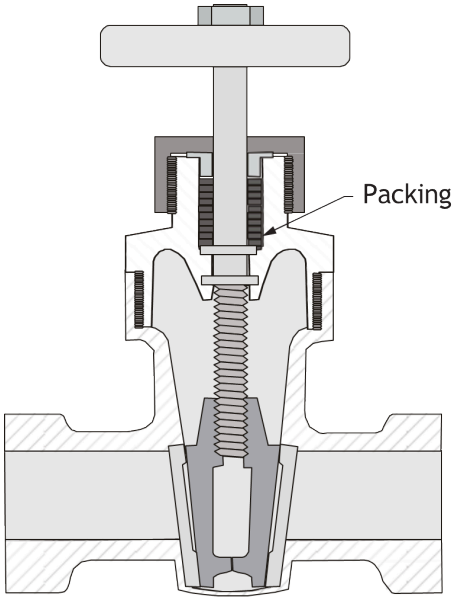


Figure 90 *Stuffing box showing packing inside (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

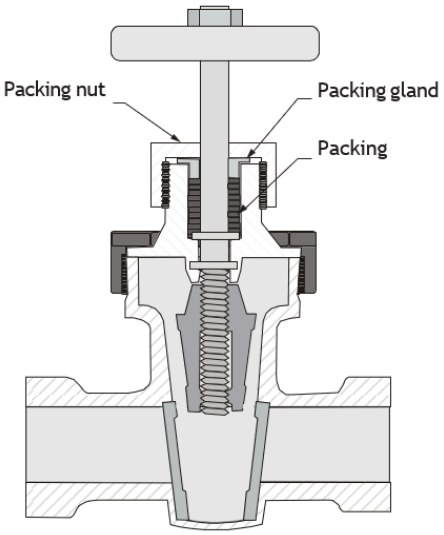


Figure 91 *Cutaway of valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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:

- 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 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

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.

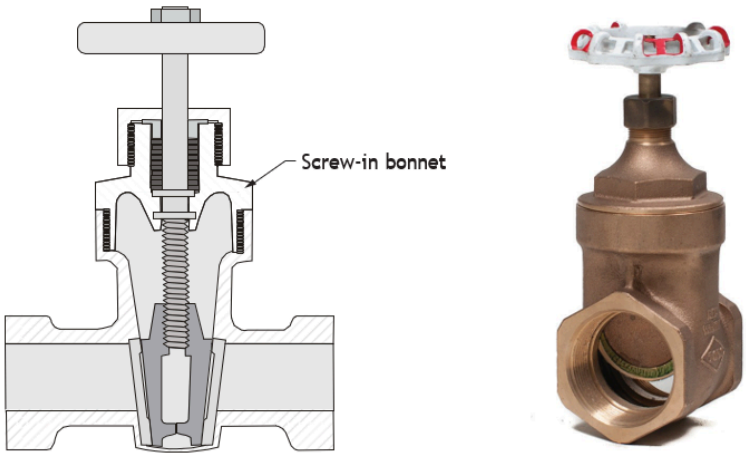


Figure 93 *Gate valve with screwed-in bonnet* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

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.

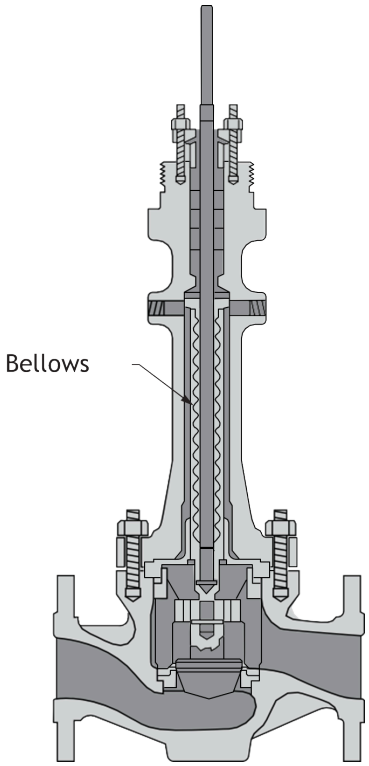


Figure 96 *Bellows seal bonnet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

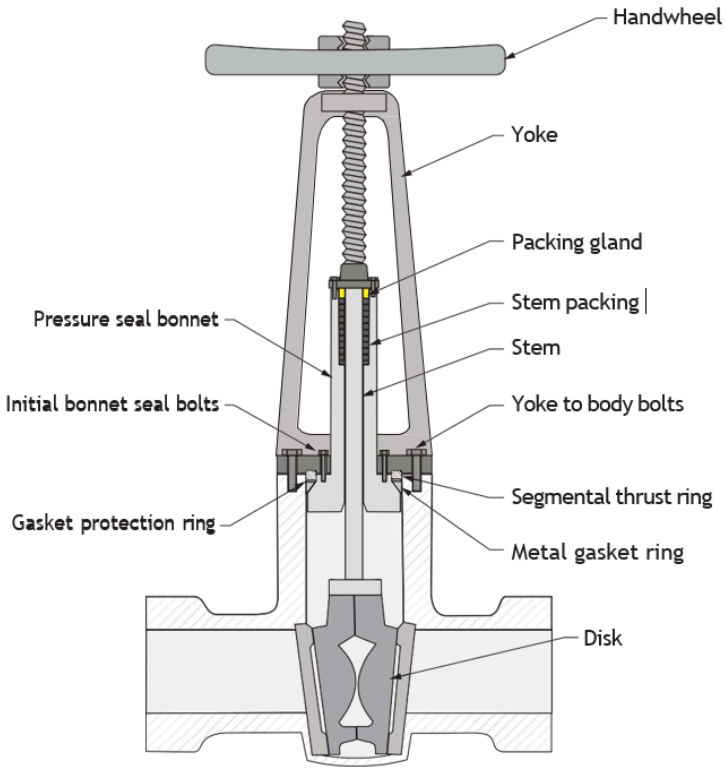


Figure 97 *Cutaway of gate valve with pressure seal bonnet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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

Media Attributions

All figures are sourced from Industry Training Authority (2019) and/or Camosun College (2019) and are used under the Creative Commons Attribution 4.0 (CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/)) licence unless otherwise noted. Images copyrighted by the BC Industry Training Authority are licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 (CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)) licence.

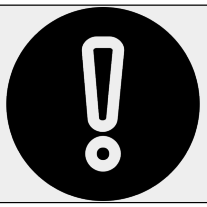
- **Figure 1** High pressure air valve (https://commons.wikimedia.org/wiki/

File:High_pressure_air_valve_P8160049.jpg) by Peter Southwood on Wikimedia Commons is used under the CC0 1.0 (https://creativecommons.org/publicdomain/zero/1.0/deed.en) public domain license.

- **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)
- **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)
- **Figure 4** Pl control valve (https://commons.wikimedia.org/wiki/File:Pl_control_valve.jpg) (Rafał Rygielski/Wikimedia Commons)
- **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)
- **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)
- **Figures 7a and 7b are by** Audrey Curran/TRU Open Press and are subject to the CC BY-NC-SA (https://creativecommons.org/licenses/by-nc-sa/4.0/deed.en) license.
- **Figures 22** Flanged gate valve, non-rising stem, and **Figure 36** Wafer-type butterfly valve, is courtesy of NIBCO INC. Used with permission.
- The following figures are courtesy of Watts and are used with permission:
    - **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.

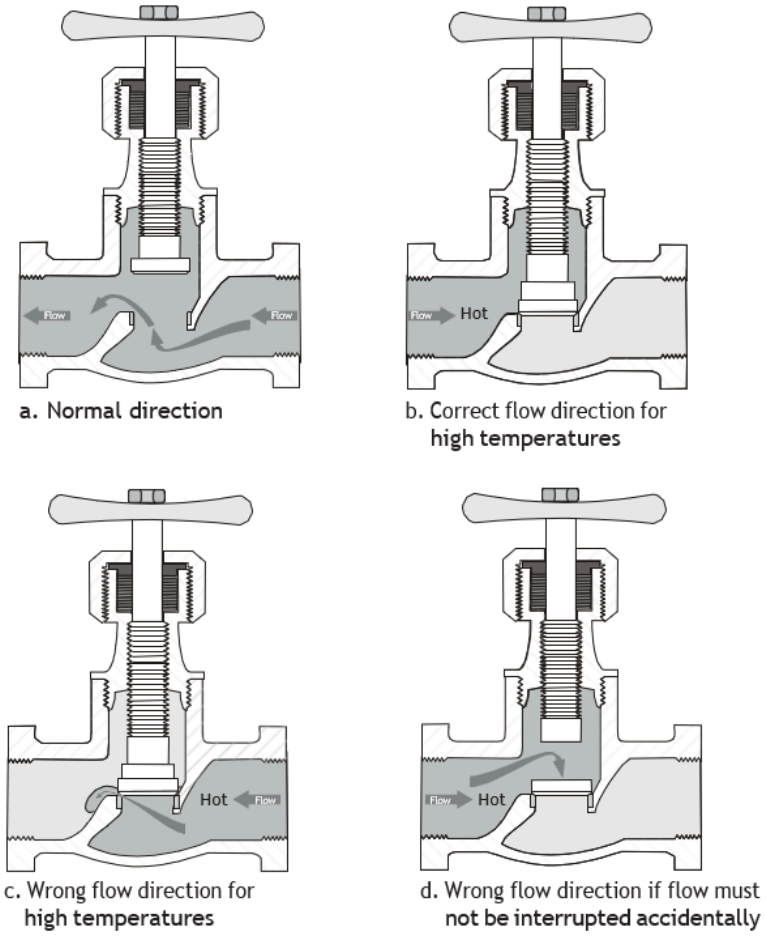


Figure 1 *Correct and incorrect flow directions* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

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*.

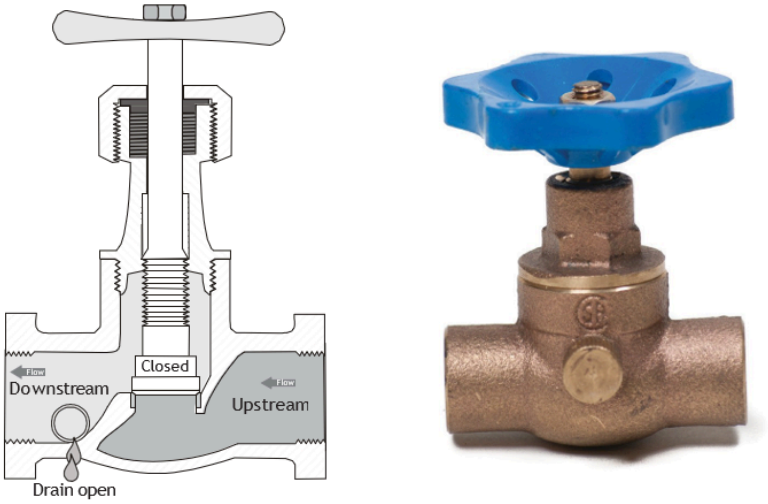


Figure 2 *Stop and waste/drain valve* (*BC Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

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.

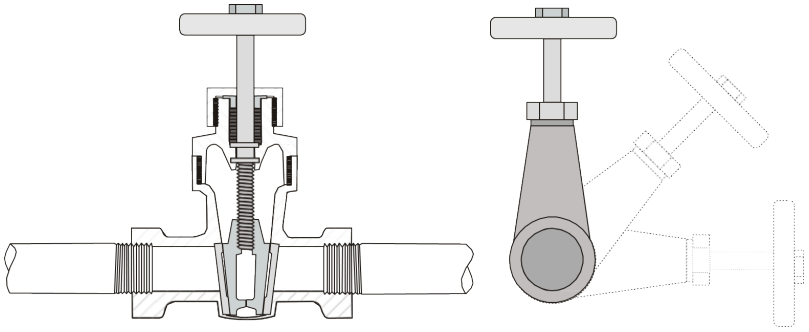


Figure 3 *Acceptable gate valve positions.*
Solid wedge gates can be installed in any position. (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

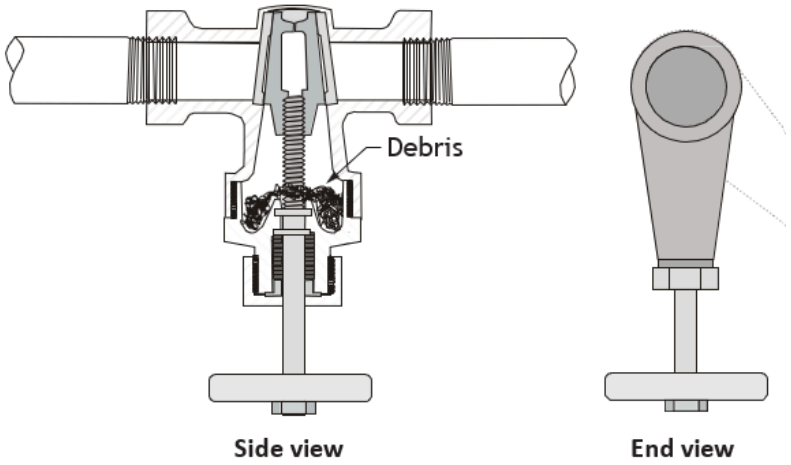


Figure 4 *Unacceptable gate valve positions (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

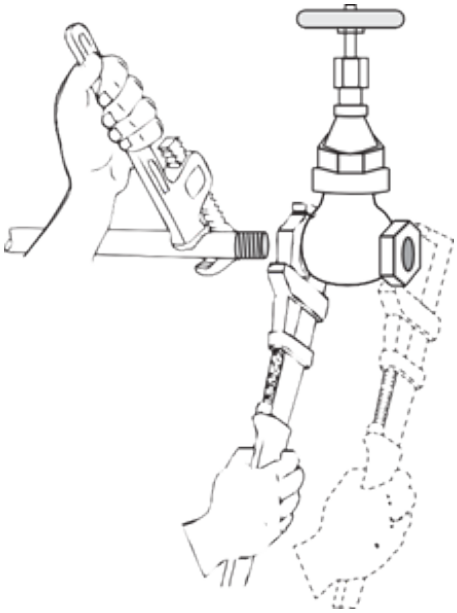


Figure 5 *Proper tightening technique (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

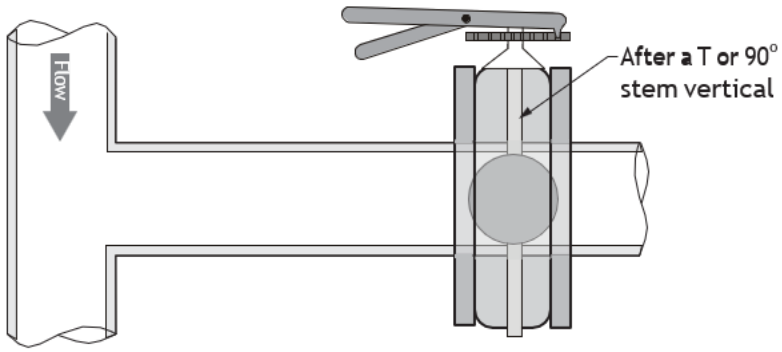


Figure 6 *Butterfly valve located downstream of a bend or a tee (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

- 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.

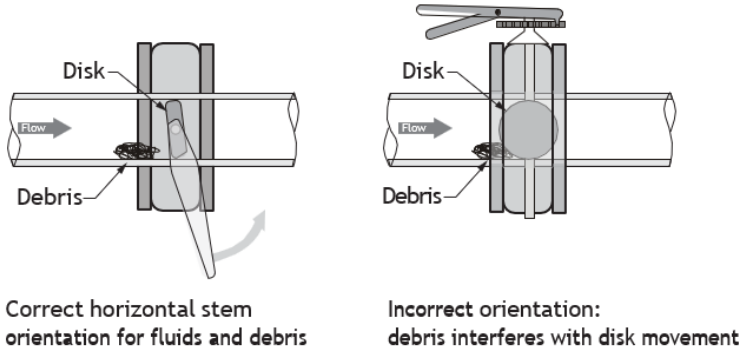


Figure 7 *Butterfly valve installation orientation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

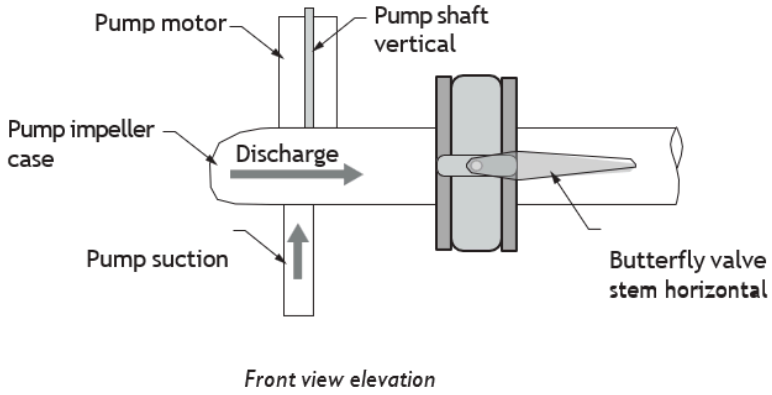


Figure 8 *Butterfly valve located downstream of a pump (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

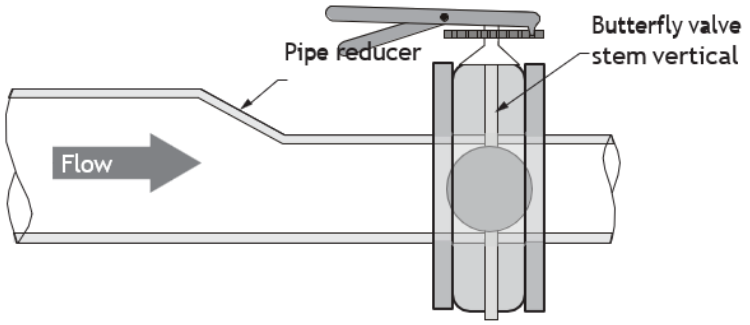


Figure 9 *Butterfly valve located in a pipe reducer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

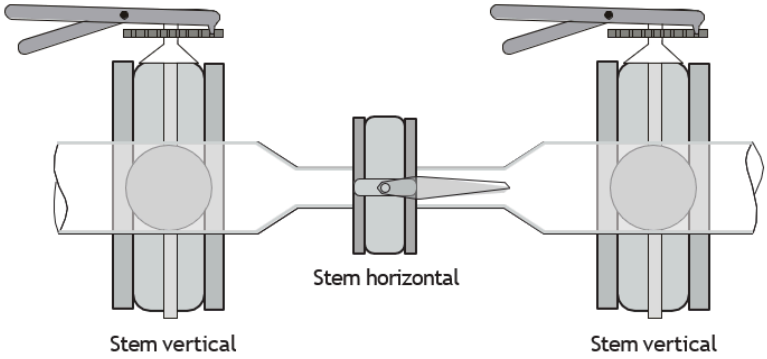


Figure 10 *Butterfly valves in combination for control/isolation applications (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

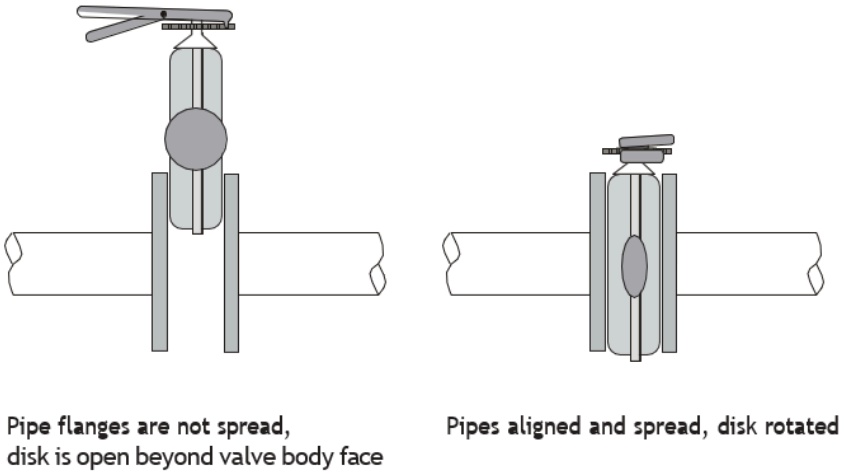


Figure 11 *Butterfly valve flanged installation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

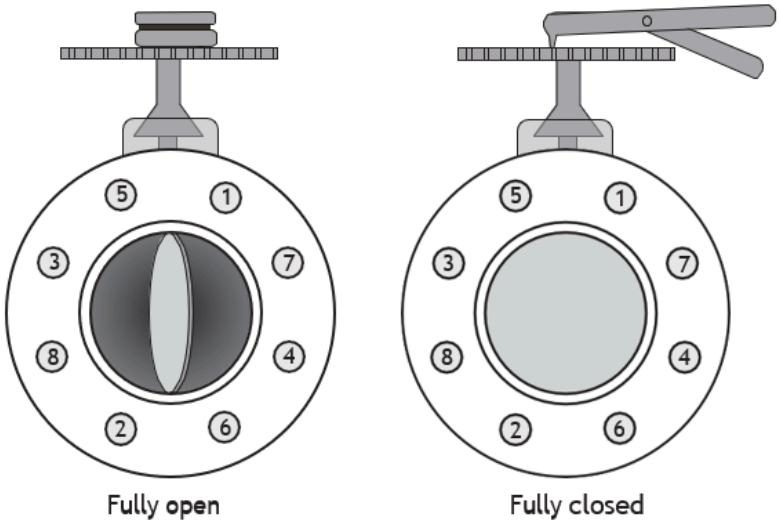


Figure 12 *Butterfly valve in open/closed positions (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

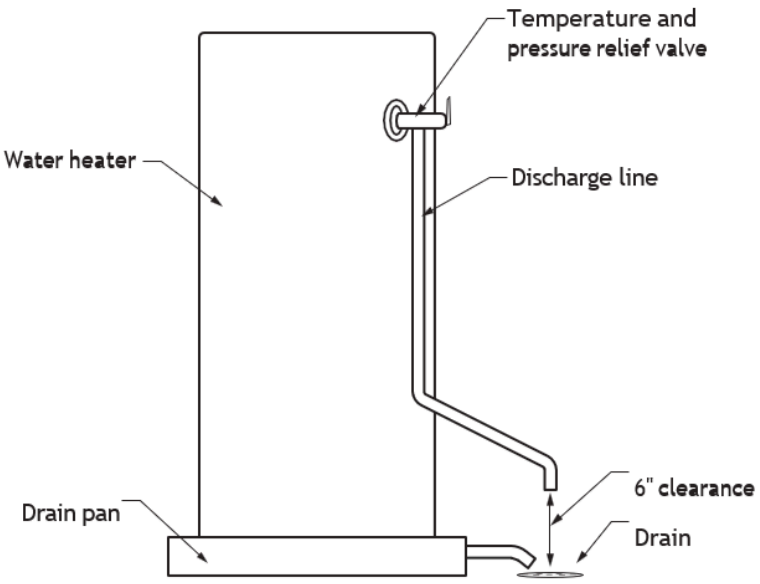


Figure 13 *Temperature and pressure valve installation (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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.

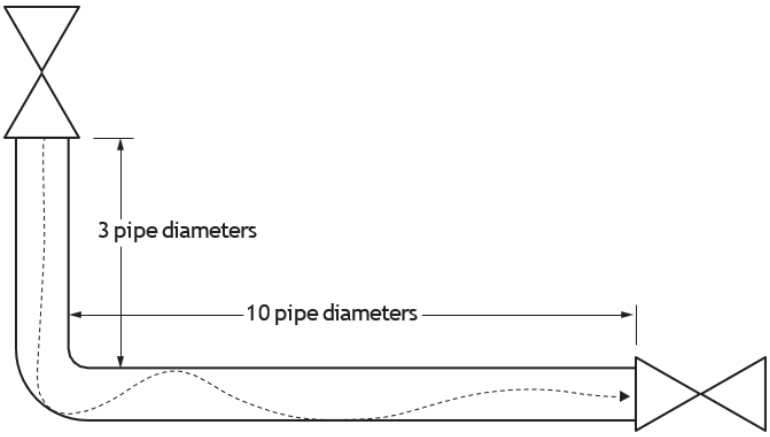


Figure 14 *Valve spacing at sharp turns (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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

Media Attributions

All figures are sourced from Industry Training Authority (2019) and/or Camosun College (2019) and are used under the Creative Commons Attribution 4.0 (CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/)) licence unless otherwise noted. Images copyrighted by the BC Industry Training Authority are licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 (CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)) licence.

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

Answer Key: Self-Test D-2.1 (#chapter-answer-key-self-test-d-2-1) is on the next page.

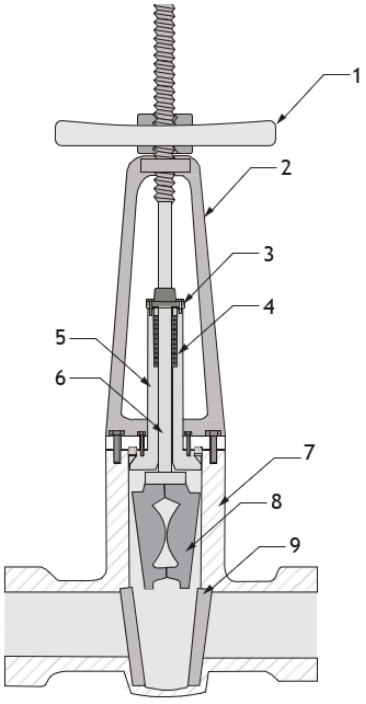


Figure 4 *Illustration for Questions 10 to 13*

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

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.

Important Notice: This book contains content used with permission from Skilled Trades BC, Trades Training BC, and various third-party contributors, with all third-party content identified and attributed throughout. To create your own version, you must obtain explicit permission from Skilled Trades BC and the respective third-party content owners.

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.