Block B: Tools and Equipment

TRU
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Plumbing Apprenticeship Program Level 1 Series

Block B: Tools and Equipment

BC Plumbing Apprenticeship, Level 1

SKILLEDTRADESBC

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

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Version History 806

Plumbing Apprenticeship & Trade Resources in BC 807

Block B: Tools and Equipment of the Plumbing Apprenticeship Program Level 1 Series features Skilled Trades BC industry-authority content that builds on the safety foundations introduced in Block A by focusing on the correct selection, use, and care of essential plumbing tools and equipment. Safe work practices remain central, but the emphasis in this block is on developing hands-on technical competence in the tools apprentices use every day on the job.

In Block B, apprentices learn how to safely and effectively use hand tools and measuring tools; operate portable power tools; access work areas using ladders, scaffolds, and other access equipment; and perform rigging, hoisting, lifting, and positioning tasks. This block also introduces the safe use of soldering, brazing, oxy-fuel cutting, and welding equipment. Mastery of these skills supports workplace efficiency, reduces the risk of injury or equipment damage, and lays the groundwork for more advanced plumbing tasks in later levels of the apprenticeship.

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/).
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Safety Advisory

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

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Symbol Legend

Important Information

Potentially Toxic/ Poisonous Situation

Required or Optional Resources

Potentially Flammable Situation

Complete a Self-Test

Possibly Explosive Situation

Use Protective Equipment

Potential Electric Shock

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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.

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- Line C: Tools and Equipment: Competency C-3: Describe Rigging and Hoisting Equipment (https://collection.bccampus.ca/resource/hDUEqpfn)
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Starting December 1, 2022, Industry Training Authority was officially renamed to SkilledTradesBC. Hear more in this video from SkilledTradesBC CEO, Shelley Gray, on what this means for the trades industry and British Columbians. Closed captioning and transcripts are available with this video, Introducing Skilled Trades BC (https://www.youtube.com/watch?v=OQgwdP0rNog) (2022) on YouTube.

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References

Camosun College. (n.d.). *Line C: Tools and Equipment*. BCcampus. https://collection.bccampus.ca/resource/BzEe9fcq/

SkilledTradesBC. (2025). Plumber program outline (Implementation date: August 18, 2025; Last revised: December 16, 2025) [PDF]. Province of British Columbia. https://skilledtradesbc.ca/media/2776/download

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PART I

B-1 USE HAND TOOLS AND MEASURING TOOLS

Plumber Apprenticeship Program – Level 1

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B-1 Use Hand Tools and Measuring Tools Introduction

Hand tools are used in almost every trade, though many are designed for specific tasks within particular industries and trades. You may have already used some of these tools at work, at school, or at home. However, this may be your first opportunity to examine their design, function, and applications in greater detail. Understanding how tools are designed and why they are used in certain ways will help you work more safely, efficiently, and confidently in your trade.

Learning Objectives

After completing this section, you should be able to:

- Recognize and identify common hand tools and their proper uses.
- Describe the care and maintenance of common hand tools.

You will be required to reference publications and videos available online at WorkSafeBC (https://www.worksafebc.com/en). Supplementary videos by Camosun College: Trades Access Common Core Line C: Tools and Equipment Videos – BCcampus (https://media.bccampus.ca/playlist/details/0_3g8xp22x/categoryId/175673) by Camosun College.

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 for Section B-1 can be found in the **Glossary.**

- **bevel:** A slanted or angled edge cut into a material, often used to prepare surfaces for cutting, joining, or welding. (Section B-1.1)
- **burr:** A rough edge or small metal fragment left on a material after cutting, drilling, or machining. (Section B-1.1)

- **chalk-line bob:** The weighted end of a chalk line tool that helps keep the string tight and straight. It allows workers to snap a straight chalk line on a surface for marking and layout. (Section B-1.1)
- **chamfer:** A beveled edge that removes the sharp corner of a material, usually to make assembly easier or safer. (Section B-1.1)
- **combination square:** A measuring tool used to check right angles (90°) and measure distances. It has a ruler and an adjustable head. (Section B-1.1)
- **crimping:** A method of joining pipe or tubing by squeezing a metal ring or fitting tightly around it with a special tool. (Section B-1.1)
- **deburring:** The process of removing burrs or rough edges from metal, plastic, or other materials after cutting or drilling. (Section B-1.1)
- **flaring:** The process of spreading the end of a pipe or tube outward so it can connect securely to a fitting. (Section B-1.1)
- **kerf:** The width of material removed by a cutting tool such as a saw blade. (Section B-1.1)
- **National Pipe Thread:** A standard type of pipe thread used in North America. The threads are slightly tapered so they seal tightly when pipes are screwed together. (Section B-1.1)
- **PEX:** Cross-linked Polyethylene (PEX) is a type of flexible plastic pipe used for plumbing and heating systems. (Section B-1.1)
- **pitch (thread pitch):** The distance between corresponding points on adjacent threads, often measured as threads per inch (imperial) or millimeters (metric). (Section B-1.1)
- **plumb bob:** A pointed weight attached to a string that is used to find a perfectly vertical (plumb) line. When the weight hangs freely, the string shows a straight up-and-down direction. (Section B-1.1)
- **reamer:** A precision tool used to enlarge, smooth, or finish an existing hole or pipe end to an accurate diameter. (Section B-1.1)
- **spiralling (pipe cutting):** A cutting problem that occurs when a pipe cutter does not stay in a straight line around the pipe. Instead of following the same groove, the cutter wheel gradually moves along the pipe in a spiral pattern, resulting in an uneven or angled cut that is not square to the pipe; sometimes referred to as a barber's pole. (Section B-1.1)
- **spirit level:** A tool used to check if something is level or plumb. It has a small bubble inside a liquid-filled tube. (Section B-1.1)
- **square cut:** A cut made at a 90-degree angle to the length of a pipe or material. (Section B-1.1)
- **swaging:** A process used to change the shape or size of a pipe or tube end, usually to make it fit inside another pipe. (Section B-1.1)
- **tang (file tang):** The narrow-pointed section at the end of a file that fits into the handle. (Section B-1.1)
- **tangent chart:** A printed chart on some pipe layout tools that helps workers find angles and measurements when laying out cuts or fittings on pipe. It uses tangent values to calculate distances needed for accurate pipe layouts. (Section B-1.1)
- **tapered thread:** A thread that gradually decreases in diameter along its length to create a tighter seal as it is tightened. (Section B-1.1)
- **tempered steel:** Steel that has been heat-treated to increase hardness and durability. (Section B-1.1)
- **thread:** A spiral ridge formed on a bolt, screw, or pipe used for fastening or sealing. (Section B-1.1)
- **torque:** A twisting force applied to a fastener or tool. (Section B-1.1)
- **tubing:** Thin-walled pipe used to transport fluids or gases. (Section B-1.1)
- **vise:** A mechanical tool used to securely hold a workpiece during cutting, drilling, or assembly operations. (Section B-1.1)

B-1.1 Describe Hand Tools Used in the Pipe Trades

This section presents the hand tools most commonly used by pipe trades workers. Many of these tools are used during your in-school training, while others may be encountered on a job site or in a fabrication shop. While reading, pay special attention to the safety precautions required when using hand tools.

Cutting Tools

Cutting tools are used by pipe trades workers to shorten a piece of material to a desired length, or to remove part of a material from an object.

Compass and Keyhole Saws

Compass and keyhole saws have narrow, tapered blades.

Figure 1 *Keyhole saw (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

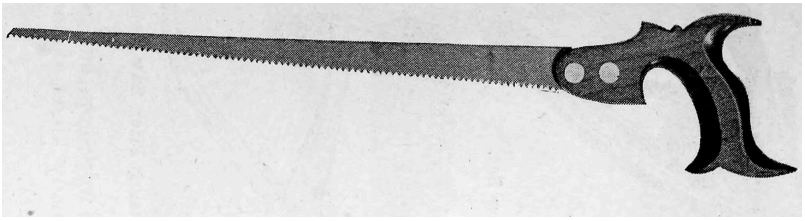

Figure 2 *Compass saw (Cassells' Carpentry and Joinery/Wikimedia) Public Domain (https://en.wikipedia.org/wiki/Public_domain)*

The section of blade used depends on the curve to be cut. The wide part of the blade should be used for large-radius curves and the narrow part for small cutouts. Because the blade is so narrow, care must be taken to prevent it from buckling. The blade on these saws varies in length from 250 mm (9.8 in.) to 350 mm (13.8 in.), and the teeth are filed in the same manner as the teeth on a crosscut saw.

Hacksaws

The hacksaw consists of a handle, metal frame, and saw blade. The adjustable type accommodates different sizes of blades, from 200 mm (8 in.) to 400 mm (16 in.) in length. The non-adjustable type holds only one size of blade, typically 300 mm (12 in.) in length. A hacksaw has a protective handle that helps guard your fingers in case the blade breaks or your hand slips while you are using the saw.

Figure 3 *Hacksaw (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hacksaw blades are made of hard, tempered (***heat-treated***) steel. The blade may be "***all-hardened***" or flexible. The flexible blade has only the teeth hardened, while the all-hardened blade has been tempered throughout. Since hacksaw blades are tempered, they are too hard to be resharpened. Once a blade becomes dull, it must be discarded.

The ***pitch*** (number of teeth per inch) may be 14, 18, 24 or 32. The part number, stamped on each blade, is occasionally a code number that may indicate the blade length and number of teeth per inch. For example, code number 1018 identifies a blade 10 in. (250 mm) long with 18 teeth per inch, while code number 1032 identifies a 10 in. (250 mm) blade with 32 teeth per inch. The blade below shows that there are 18 teeth per inch and a blade length of 10 in. (25 cm).

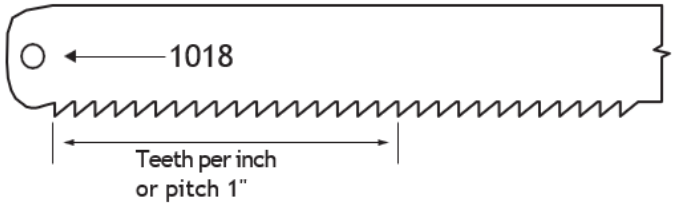

Figure 4 *Hacksaw blade (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Wood Handsaw

The tool most people think of as the handsaw is either a ***crosscut saw*** or a ***ripsaw***. The crosscut saw is designed to cut across the grain of wood, and the ripsaw is designed to cut with the grain. The number of points, usually shown on the saw, indicates the number of points per 25 mm (per inch) of cutting edge.

Figure 5 *Crosscut saw and ripsaw (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The blade of the saw is made of spring steel, tempered to provide a longer-lasting edge on the teeth after they are filed and *set* (offsetting of the teeth). The face of the blade is ground and polished. The smooth surface reduces friction between the saw and the wood. A handsaw of good quality has a taper-ground blade, where the back of the blade is thinner than the tooth edge. With this design, less set is required.

The set of the saw is just as important as the sharpness of the teeth, for the set is the clearance the saw blade has when it cuts wood. The width of the cut is called the ***kerf***. The kerf is important.

Handsaws are generally specified by the shape of the teeth (i.e., crosscut or rip).

The length of the blade and the number of points per 25 mm (or per inch). The number of points (which are the valleys between the teeth) is usually stamped on the heel or printed with the manufacturer's label on the side of the saw. Figure 6 shows a diagram of 7 points and 6 teeth in 25 mm (1 in.). The number of teeth is always one fewer than the number of points.

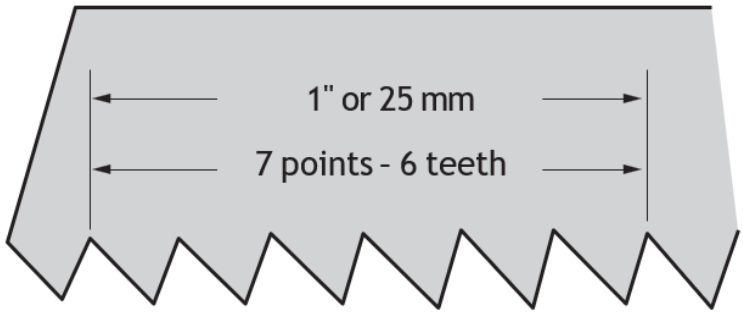

Figure 6 *Teeth/points (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Crosscut Saw

The crosscut saw varies in length from 500 mm to 700 mm (20 in. to 28 in.). The points also vary from 6 to 14 per 25 mm (1 in.). The crosscut saw used for framing has fairly coarse teeth. The saw used for finishing work has finer teeth.

The framing saw is normally 700 mm (28 in.) long and has 7 or 8 points per 25 mm (1 in.). It is used mostly for cutting common lumber and making the rougher cuts for framing.

The finishing saw, also called a panel saw, is about 550 mm (22 in.) long, with 10 to 11 points. It is mostly used for making fairly precise cuts through exterior and interior trim and through panelling.

The teeth of a crosscut saw are shaped like knives to give a scoring action for cutting across the grain of wood. Most of the cutting is done on the forward stroke of the saw. The images below show the cutting action of the crosscut.

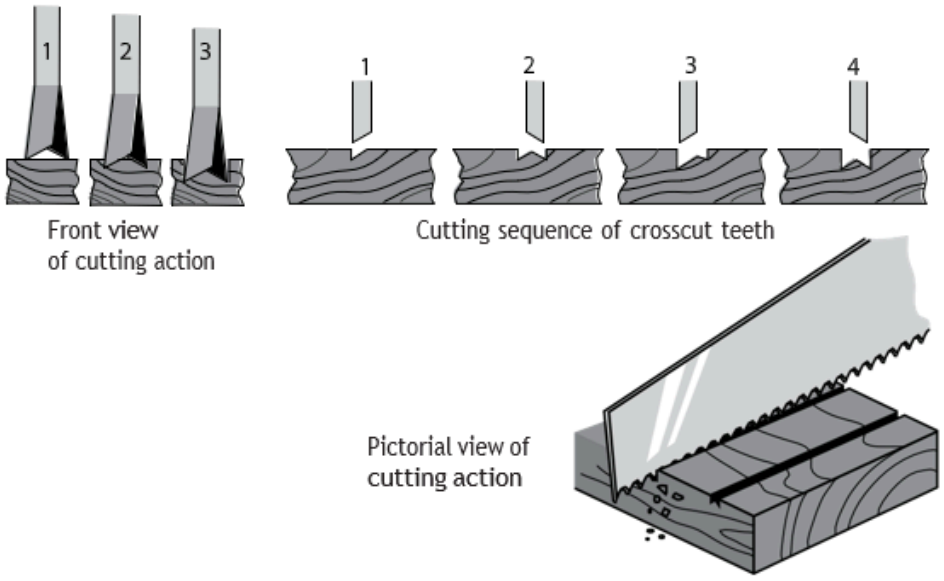

Figure 7 *Crosscutting (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Ripsaw

The ripsaw is designed to cut with the grain of wood. Its teeth are shaped like tiny chisels. A common ripsaw for carpenters has 5 $\frac{1}{2}$ points per 25 mm (1 in.) and the blade is about 700 mm (28 in.) long. Figure 8 shows its cutting action. The portable circular handsaw has made the use of the ripsaw virtually obsolete.

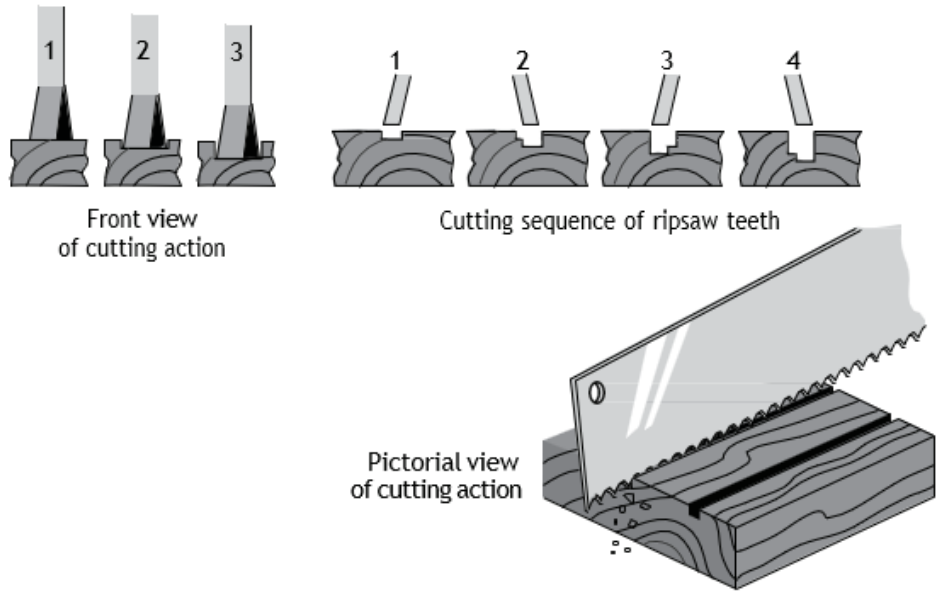

Figure 8 *Ripsaw cut (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Files

There are many different kinds, sizes, and cuts of files available. Only the more common ones are discussed here. While files can be used for both metal and wood, in the piping trades we generally use files primarily for metal.

Files have the following general uses:

- Removing excess material
- Fitting materials together more accurately
- Correcting errors resulting from inaccurate machining (for example, ***threads*** on bolts)
- Creating a flat or smooth surface
- Forming an edge
- Creating a notch or slot
- Creating a square or round hole

The size of a file is determined by its length from point to heel; the ***tang*** is not included in this measurement.

Each part of a file has a particular name. You will need to be familiar with these names as they will be referred to in descriptions of the different kinds of files and their characteristics.

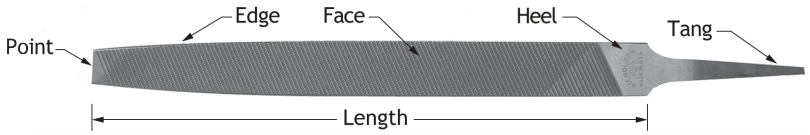

Figure 9 *Parts of the file (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

All files are classified by shape and by cutting face. The most common shapes of files are flat, round, half-round, and triangular and are used in the piping trades, primarily on metals. The flat file has teeth on both edges and is used for general-purpose filing. The round file (also known as the rat-tail file) has teeth covering the full circumference. This file is used primarily for enlarging circular openings or filing curved surfaces. The half-round file has one flat side and teeth on all surfaces. The triangular or three-square file is used to clean out corners of a square shape or to file at odd angles. All faces have teeth and the corners between the faces are left sharp.

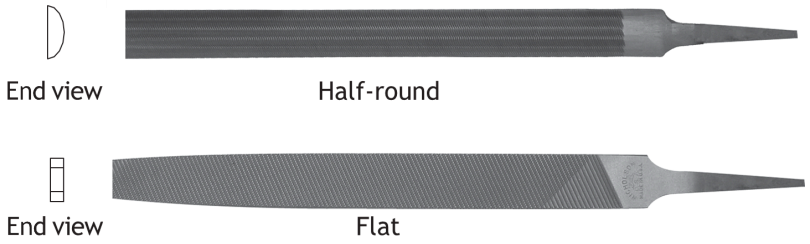

Figure 10 *Types of file (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Cutting Faces

Cutting faces are classified according to the design of the cutting and according to the grade of their teeth.

There are three designs of cutting face: the single-cut, the double-cut and the curved tooth.

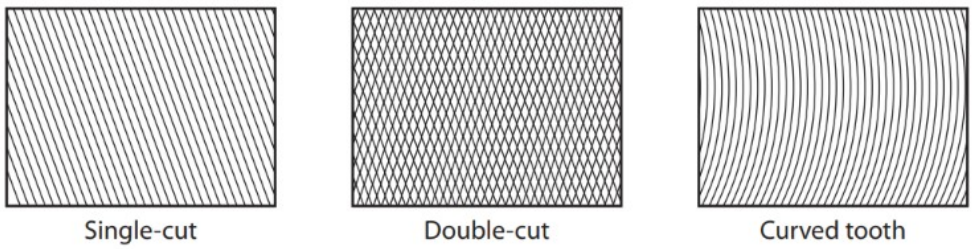

Figure 11—File Faces

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

The single-cut file has one unbroken course of teeth running across the face of the file and is used when a smooth finish is desired. The double-cut file has two broken courses of teeth crossing each other. It is used for rough, fast metal

cutting or where large amounts of material must be filed off. The curved tooth file is used to file soft metals such as lead or aluminum. It removes material very quickly and produces a smooth surface after each filing stroke.

The second classification identifies the grade of the file teeth. There are six different grades for both single- or double-cut files. However, the curved tooth file is available in only three grades: the bastard cut, second cut and smooth cut.

- Rough cut
- Second cut
- Coarse cut
- Smooth cut
- Bastard cut
- Dead-smooth cut

The only difference in the grades is the spacing between the teeth. The rough-cut file has the greatest space between the teeth. As the spacing decreases, the cut becomes smoother. Remember, though, the spacing is in relation to the overall size of the file. For example, a large bastard-cut file has more space between the teeth and larger teeth than a small bastard-cut file, even though both are bastard-cut files. Figure 12 shows different grades of a single-cut file.

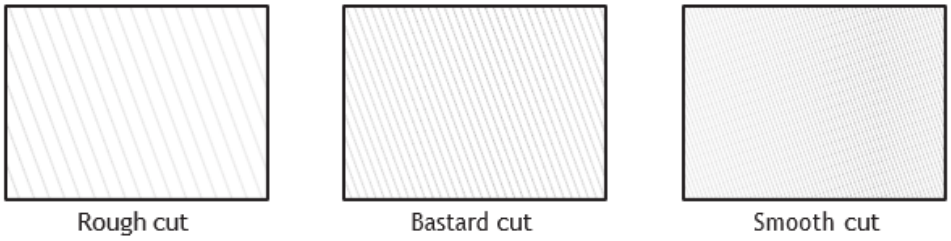

Figure 12 *Single-cut file grades (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hand Shears

Hand shears are also called tin snips or aviation shears. They will generally cut sheet metal up to 1.5 mm ($\frac{1}{16}$„ in.) thick.

The construction of hand shears varies greatly; some are made to cut only straight, while others are made to cut left or right curves.

Yellow-handled snips are used for straight cuts and general purpose tin work, red-handled snips have blades that are designed for left-curved cuts, and green-handled snips are designed for right-curved cuts.

Figure 13 *Hand shears: (red) left cuts, (green) right cuts, (yellow) straight cuts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Chisels

Chisels are made of ***tempered steel*** and have a sharp ***beveled*** edge for cutting or shaping different types of material. To do so, place the sharp edge against the material and push or pound the end. The size, shape, and sharpness vary with the different types of material to be cut.

Cold Chisels

Cold chisels are forged from square, rectangular, hexagonal and octagonal high carbon steel stock and are used for metals. The steel is ***machined*** and then hardened (cold tempered). The body and head are softer than the cutting edge so that they can withstand a striking force without chipping. The upper end of a chisel has a slight taper (***chamfer***) to compensate for the mushrooming caused by repeated hammer blows.

Pipe trades workers generally use chisels for the removal of rusted machine parts, shearing of bolts, chipping metal and removing pins. Cold chisels are generally used for metal and not wood.

Figure 14 *Cold chisel (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The flat cold chisel is used for most general cutting and chipping work. The cutting edge is bevelled (tapered) from both sides toward the center. The angle of the bevel is generally between 60° and 70°. For soft metals, the angle should be reduced; for very hard metals, it should be increased.

Flat cold chisels have cutting edges that vary in width from 6 mm to 25 mm ($\frac{1}{4}$ in. to 1 in.) and they are usually from 150 mm to 200 mm (6 in. to 8 in.) in length.

Figure 15 *Types of chisels (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Wood Chisels

Wood chisels are classified according to length, width and thickness of the blade. They are also classified according to purpose, type, blade shape and method of holding the handle.

Types of wood chisels:

- framing chisels: the heaviest of the chisels
- finishing chisels: for lighter specific work
- gouges: a curved chisel with different blade sweeps or patterns

Framing chisels are usually used for heavy-duty type framing work, so they are referred to as such.

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

The framing chisel is made so that it can be driven with a steel hammer. The steel continues from the blade to the end of the handle, and the handle is moulded on each side of the steel. The framing chisel is the heaviest of the chisels. It varies in width from 20 mm to 50 mm and in blade length from 150 to 200 mm.

Check Your Knowledge: Saws, Files, and Chisels

Complete the Complete the interactive knowledge test below.

If you are using a printed copy, you can scan the QR code with your digital device to go directly to the interactive knowledge test.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-23 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-23)

Pipe Cutters

Pipe cutting may be done either by hand or with power accessories. Cutters are available in a number of designs and sizes. Their use depends on the situation and on the size and material of the pipe being cut.

For any type of jointing operation, it is very important that the pipe end be cut squarely. The correctly selected cutter provides the best results, quickly and accurately. A hacksaw should never be used to cut pipe, because it's difficult to achieve a square end. Chips from the cut may fall into the pipe and, if not removed, can cause problems with joints (especially if the piping is the type that is glued together). Chips can also contaminate the fluid that will eventually be carried through the pipe.

Most pipe cutters have a hook-shaped frame, with a cutter wheel at the end of the hook. On the stem of the hook, a sliding housing containing two rollers is mounted. These rollers hold the pipe in position against the cutter wheel. The sliding housing is moved by a long feed-screw, which is tightened as the tool is rotated around the pipe, forcing the cutter wheel into the pipe. The rollers tend to roll down the external ***burr*** that is usually raised on the pipe as the cutter wheel moves the metal. Note that these types of cutters don't actually remove any material, but rather they *spread* the material into two sections. Note that wider rollers create less chance of the cutter wheel spiralling up the pipe. This provides for better cutting performance and greater accuracy when cutting pipe.

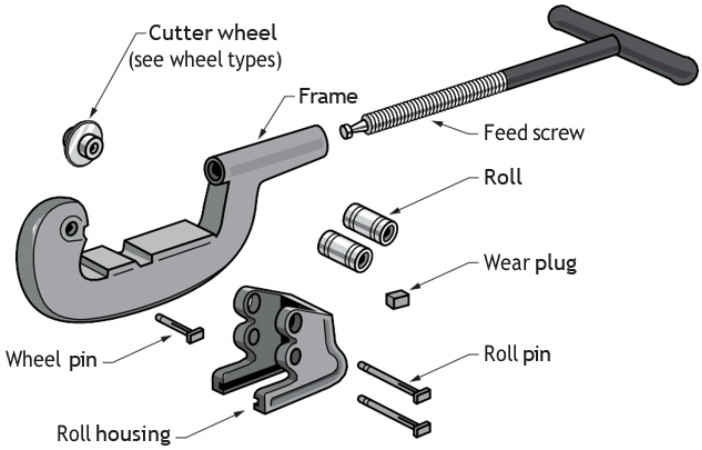

Figure 17 *Parts of a standard wheel-and-roller cutter for steel pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Care must be taken that the cutter wheel is appropriate for the cutter being used and is suited to the material being cut. The illustration below shows the main types of cutter wheels. The standard thin wheel is designed for cutting ordinary steel pipe; stronger, heavier wheels are for cutting heavy-walled steel pipe; and thinner wheels are used for materials like thin-walled ***tubing*** or soft materials like plastic pipe.

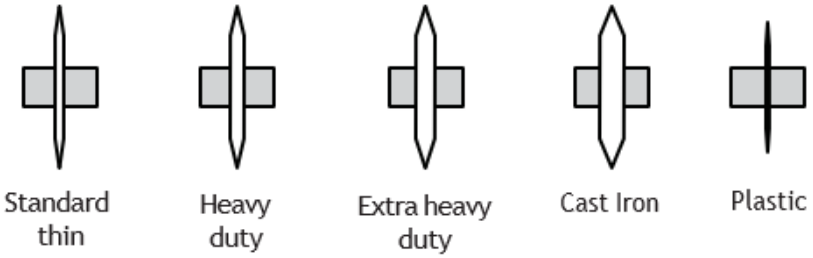

Figure 18 *Types of cutter wheels (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Before using a cutter wheel, always inspect it to make sure that it is not blunt or damaged. A blunt or dulled cutter tends to crush rather than cut the pipe. Also, ensure that no rollers and screw ***fasteners*** on the cutters are loose or missing. Misalignment or an incomplete cut could result.

Cutters may be classed as:

- Standard wheel-and-roller cutters
- 3-wheel or 4-wheel cutters (without rollers, only cutting wheels)

Heavy-Duty Pipe Cutters

These cutters can be used as single-wheel-and-roller cutters for work on heavier piping materials like steel. For cutting in confined areas, these cutters can be converted to 3-wheel cutters by replacing the two rollers with extra cutter wheels.

Figure 19 *Heavy-duty pipe cutters (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

As shown in Figure 20, a 360° rotation of the wheel-and-roller cutter is necessary to cut pipe. With a three-wheel cutter, a rotation of just over 120° is all that is required. However, more care must be taken when starting a cut with the three-

wheel cutter to make sure the cut is straight. These cutters can be challenging to line up correctly to achieve ***square cuts***. The three-wheel cutter also leaves more of an outside burr, which must be removed on every cut to avoid difficulty when using threading or grooving equipment.

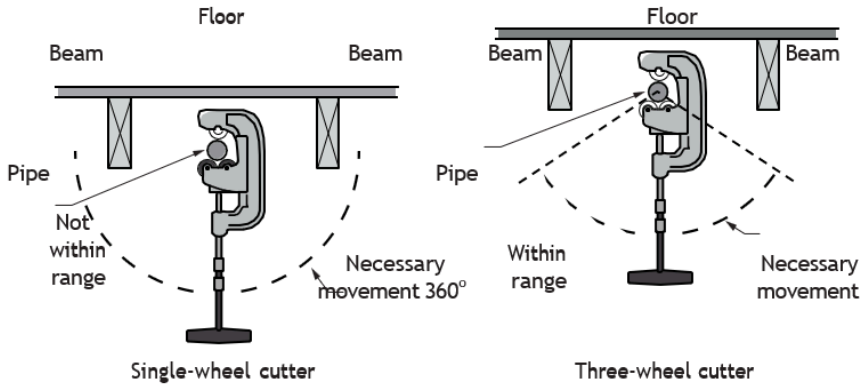

Figure 20 *Wheel-and-roller cutters (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Four-Wheel Cutters

This cutter is designed for work in areas where a complete turn is not possible.

One style has a short handle for extra-tight areas where only a 130° turn can be accomplished. Pipe capacity is for this style of cutter is often 20 mm ($\frac{3}{4}$ in.) to 50 mm (2 in.).

Figure 21 *Styles of four-wheel cutters (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Some larger options are available with the addition of a second handle, making it possible for two people to cut large pipe sizes in confined areas. Pipe capacity can easily be in the range of 6.5 cm (2 $\frac{1}{2}$ in.) to 10 cm (4 in.).

Heavy-Duty Wide Roll Cutter

This style of cutter was developed for use with a power ***vise***. The extra wide rollers prevent the cutter from wobbling during the cutting operation, and prevent ***spiralling*** (or what is sometimes referred to as a barber's pole). Pipe capacity is typically 3 mm ($\frac{1}{8}$ in.) to 50 mm (2 in.).

Figure 22 *Heavy-duty wide roll cutter (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hinged Cutter

Hinged cutters are used for pipe in the ranges of 10 cm (4 in.) to 30 cm (12 in.). They can be used in tight quarters where cutter rotation is limited, like in a ditch or trench. A hinged cutter has four cutter wheels, a long handle for ***leverage***, and a latch to engage the cutter head around the pipe. A second handle may be added for extra cutting leverage.

Soil Pipe Cutters

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

These types of *non-rotational* cutters (often simply called snap cutters) are designed for cutting straight lengths of cast iron soil pipe and other materials that are brittle, or easily broken. Each "wheel" is actually more like a tooth that bites into the pipe, applying even pressure at multiple points until the cutting process is achieved.

Operating the handle of the ratchet type cutters tightens the chain until the pipe is snapped by the cutting wheels between the chain links. This style has an advantage in confined quarters or when making a cut on an existing pipe that must be cut in-position.

Figure 24 *Ratchet type soil pipe cutters (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The scissor-type cutters open and close quickly and are suited to multiple cuts in new construction work. To make the cut, squeeze the handles toward each other until the cutting wheels in the chain have completed the cut.

Figure 25 *Soil pipe cutters (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Both cutters cut 5 cm to 15 cm (2 in. to 6 in.) clay tile pipe, cast iron drainage pipe, and water mains up to 10 cm (4 in.) made from these types of brittle materials.

External Glass Pipe Cutter

External glass pipe cutters are available as small, pocket-size tools having a chain with cutting wheels to cut glass tubing, glass pipe, and other fragile, tubular material. The chain is wrapped around the tube. Twist of the wrist and squeeze of the handles, the material is cut. Maximum pipe capacity is often 38 mm (1 $\frac{1}{2}$ in.).

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

Internal Glass Pipe Cutter

This type of cutter is used for scoring the inside of a glass pipe prior to heating and breaking it. The cutter is inserted in the pipe and the cutter wheel is set to the desired length. The cutter is rotated one full turn only and then carefully removed. The glass pipe is then heated with a small gas torch, and the pipe will break cleanly along the internally scored line. Cutters are available for pipe from 13 mm to 25 mm ($\frac{1}{2}$ in. to 1 in.) and from 38 mm to 150 mm (1 $\frac{1}{2}$ in. to 6 in.).

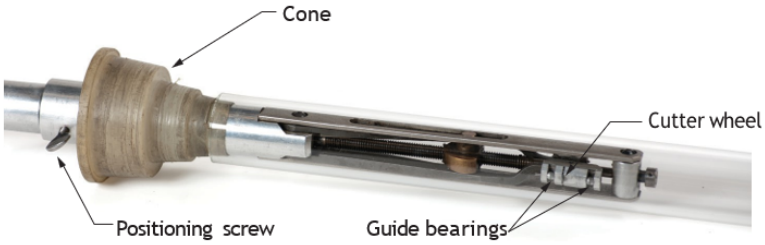

Figure 27 *Internal glass pipe cutter (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Internal Pipe Cutter

This cutter is available in models that will cut either plastic pipe or metallic tubing.

It can be used for trimming tubing below floor ***level*** for shower, floor drain or floor flange installations, or above the ceiling for sprinkler-head installations.

Tubing Cutters

The tubing cutter is used to make clean, square cuts on copper, brass, aluminum, and thin-walled conduit. These light-weight cutters commonly have a foldaway ***reamer*** attached to them that may often have a small square hole in it to operate the valve stem of a B-size acetylene tank. Other tubing cutters will have a slide-out ***deburring*** tool with a small blade that spins as it is rotated inside the pipe.

Figure 28 *Tubing cutter (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

It is extremely important that tubing cutters not be used to cut pipe, as the thin cutting wheel used for tubing would be immediately damaged.

A tube is a thin-walled pipe, commonly made of copper, aluminum, brass, carbon steel, stainless steel, or plastic. Because of the thin wall, standard ***pipe thread***s cannot be formed on tubing. Instead, procedures such as soldering or brazing may be utilized. Special fittings are also available for tubing that use compression or flared connections, for example.

Close-Quarters Tubing Cutters

These miniature cutters are specifically designed for use in restricted spaces on small diameter, hard and soft copper, aluminum, brass and plastic tubing. They are designed with rollers with grooves in them. The grooves allow the cutter to make a cut close to the end of a tube that has been flared. They have common capacities of 6 mm to 29 mm ($\frac{1}{4}$ in. to $1\ \frac{1}{8}$ in.).

Plastic Tubing Cutters

These scissor-style quick-opening cutters are designed for speedy cuts on all sorts of plastic tubing up to about 4 cm (1 $\frac{5}{8}$ in.) outside diameter (OD). To complete a square cut, rotate the handle slightly while applying pressure.

Larger ratcheting cutters of a similar design are also available for cutting plastic tubing, or plastic pipe, up to approximately 6 cm (2 $\frac{3}{8}$ in.) OD.

Figure 29 *Plastic tubing cutters (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Pipe Reamers and Deburring Tools

A reamer is a precision tool used to slightly enlarge and smooth an existing hole or pipe end to a specific diameter. A deburring tool removes rough edges, burrs, or sharp fragments left after cutting, drilling, or threading. The objective is to bring the interior diameter of the pipe back to its original full bore, avoiding turbulent flow and unwanted restriction to fluid flow. Reaming and deburring can be done by hand. Certain types of reamers are designed for use on power vises. Reaming is always done before threading to avoid deforming or ***flaring***-out the threaded end.

Straight Fluted Ratchet Reamer

This reamer works fast and clean, with light pressure. It is designed for use when pipe is to be held stationary in a vise or when the pipe is being rotated in a power vise. It is the only reamer discussed that is safe for using with a power vise.

Two models of the straight ratchet reamer are available. One has a pipe capacity of 3 mm to 2.5 cm ($\frac{1}{8}$ in. to 2 in.). The other has a pipe capacity of 10 mm to 8 cm ($\frac{3}{8}$ in. to 3 in.).

Spiral Ratchet Reamer

This reamer is designed for hand use only. This tool is made for reaming large pipe by hand up to 10 cm (4 in.) in size. The type of work being done will dictate the size and type of reamer to be used.

Hand-held spiral reamers should not be used in conjunction with power vises because the reamer may bind into the pipe and be pulled from your hand, possibly causing a serious injury.

Deburring Tools

For light-wall tubing and soft materials like plastic pipe, other styles of deburring tools are available.

Blade-type deburring tools are ideal for removing internal burrs in copper, plastic, aluminum and steel tubing. Most types feature long-lasting replaceable steel blade attached to a small handle with a built-in pocket clip. Some have a larger handle that can be used for storing of surplus blades.

Figure 30 *Articulating blade deburring tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Plastic pipe deburring ***chamfering*** tools are lightweight and easily fit in your hand (chamfering means to cut off the edge, or bevel). These tools can quickly smooth out rough edges from the inside diameter (ID) and outside diameter (OD) of materials like ABS and PVC. A few spins of the tool can easily produce a 15° bevel for a smooth, chamfered pipe end so that solvent spreads evenly as pipe is joined.

Figure 31 *Plastic pipe deburring/reaming tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Check Your Knowledge: Pipe Cutters, Reamers, and Deburring Tools

Complete the interactive knowledge test below

If you are using a printed copy, you can scan the QR code with your digital device to go directly to the interactive knowledge test.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-24 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-24)

Utility Knife

The utility knife is used for general-purpose or utility tasks. The utility knife was originally a fixed blade knife with a cutting edge suitable for general work such as cutting hides and cordage, scraping hides, butchering animals, cleaning fish, and other tasks. Today, the term "utility knife" also includes small folding or retractable-blade knives suited for use in the general workplace or in the construction industry.

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

Gasket Cutters

A tool incorporating a blade and designed to pivot around a center pin. It is used to make accurate circular cuts in a variety of materials that are used for ***gaskets*** in the piping industry. One design is the extension-style blade cutters shown in the figure below.

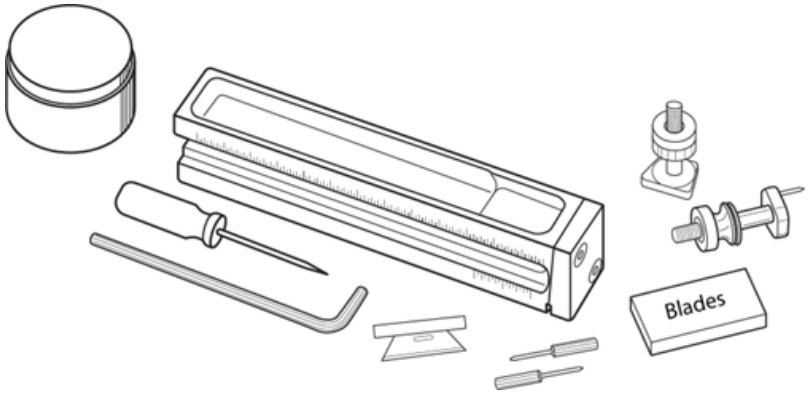

Figure 33 *Extension-style blade cutters (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Measuring Tools

Measuring tools allow the pipe trades worker to verify accurate positions and dimensions. When using measuring tools, you may be required to use both metric and imperial measurement systems.

Imperial

Feet (ft or ‘) are divided into 12 equal parts called inches (in. or “). Inches may be further divided into equal parts called fractions. These fractions can be as large as $\frac{1}{2}$, but greater accuracy is achieved by dividing these parts of an inch into quarters, eighths, sixteenths or thirty-seconds.

The degree of accuracy you are likely to require in the pipe trade is generally no more than $\frac{1}{32}$ of an inch.

Metric

The base unit in metric measurement is the metre (m). A metre is divided into 100 centimetres (cm) or 1000 millimetres (mm). A millimetre is one-tenth of a centimetre. Millimetres are the most commonly used unit for precise metric measurement in construction and the pipe trades.

There is a wide range of measuring instruments used for checking clearances and tolerances. These include:

- Measuring tapes
- Steel rule
- Calipers
- Gauges

Pocket Measuring Tape

The pocket tape shown in Figure 34 is used to measure large layouts. It is the most widely used measuring instrument in the construction trades.

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

This tape is usually made from steel and is spring-loaded, allowing it to retract into its carrying case when released. The zero end of the tape is equipped with a hook that should slide along the tape a distance equal to the thickness of the hook. The sliding of the hook permits accurate internal and external measurements.

Pocket tapes range in length from 2 m to 7.5 m (6 ft to 25 ft.). Metric tapes are marked in one-millimetre graduations, while imperial tapes are graduated in thirty-seconds of an inch for the first 6 in. or 12 in., and in sixteenths of an inch for the remainder of the tape.

Pocket tapes often feature a retraction lock and belt clip and often have the case length indicated so that it can be used to measure inside dimensions (though not very accurately). Construction-grade pocket tapes are available in extra-wide widths to allow for greater standout length and to avoid buckling when taking long measurements unassisted.

Steel Tape

Although it is still commonly called the steel tape, it may be made of either flexible spring steel or plastic and is housed in a case with a crank-type handle for rewinding. Usually, it is 30 to 50 metres (100 to 165 ft.) long. It is ideal for large layouts in construction.

Figure 35 *Steel tape (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

At the end of the steel tape is a combined ring and hook. When taking measurements, the hook is placed over the end of the object or, if possible, a nail is inserted through the ring to hold it in place. It is important when placing the nail that the very end of the ring marks the start of the measurement.

Figure 36 *Steel tape ends (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

When you pull the tape out of its case, it is important to pull it out as shown in Figure 37. Rewind the tape in the same direction. Winding the wrong way stretches one side of the tape, causing the tape to curl when it is pulled from its case.

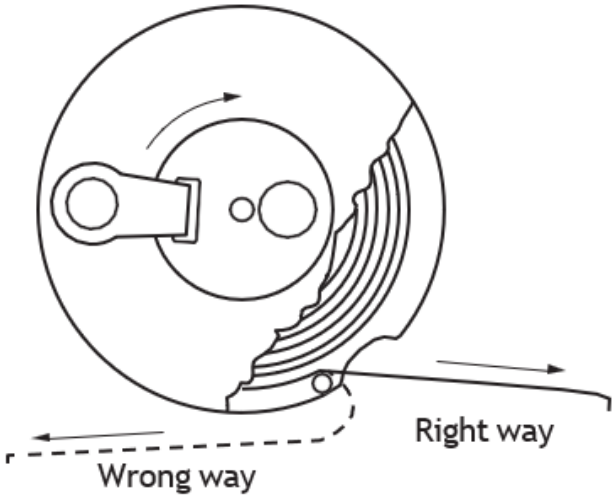

Figure 37 *Right way and wrong way to extend and rewind steel tape (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The winding handle of the steel tape is released by pushing a button on the opposite side of the case. If the tape seems to stick during rewinding, tap the case slightly on the side. If it continues to stick, pull out the tape fully and rewind it.

Circumference Tape/Pipe Diameter Tape

These tape measures typically have dual scales. Most models have a diameter scale on one side and a pocket tape measure scale on the other side used for measuring circumference at the same time. The user wraps the tape around a pipe and reads the number at the point where the tape overlaps.

Figure 38 *Circumference tape (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Wrap-Around

The wrap-around is an inexpensive, yet indispensable pipe layout tool. It is often used by pipe trades workers who fabricate steel pipe. Wrap-arounds are about 12.5 cm (5 in.) wide and come in various lengths.

Figure 39 *Wrap-around pipe wrap (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

This tool is used for marking straight lines around pipe or as a straightedge. It is made of a flexible gasket-like material that has reasonable resistance to heat and cold. All wrap-a-rounds are available in two colours that designate material type and service temperature. Black material has a service temperature up to 175°C (350°F). Grey material is used for high-temperature applications up to 290°C (550°F).

Both material types are asbestos-free and are printed with a scale in inches or millimetres, a pitch chart, a ***tangent chart*** and other useful layout markings.

Carpenter or Framing Square

Another tool frequently used to measure and lay out larger dimensions on sheet and plate is the carpenter's or ***framing square***. It is also frequently used for layout and squaring large pipe. These squares can be marked in either imperial or metric measurements. The square has two blades set at 90° to each other. One blade (known as the body) is approximately 600 mm by 50 mm (24 in. × 2 in.), and the other, known as the tongue, is approximately 400 mm by 37.5 mm (16 in. × $1\frac{1}{2}$ in.).

Various angles can be laid out with a framing square. For example, a 45° angle can be accurately laid out if you place the framing square so that the edge of a board intersects the sides of the framing square at equal measurements along each side.

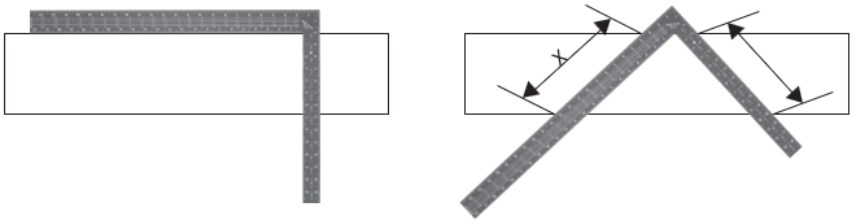

Figure 40 *Carpenter or framing square* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Combination Squares

A ***combination square*** consists of a tempered steel blade onto which three interchangeable heads can be mounted. The three heads are the square head, the protractor head, and the centre head. The blade has scales engraved on it, and the heads slide on the blade in a central groove for easy adjustment. The heads can be adjusted to any position along the blade, or they can be removed easily so the blade can be used as a ***steel rule***.

Pipe trades workers make regular use of the combination square (or *combination set*, as it is often called) because it can be used for many different purposes. Fitters use the combination set to:

- Square work
- Transfer measurements
- Lay out work
- Level surfaces
- Determine plumb
- Establish centres
- Lay out and check angles
- Measure recesses

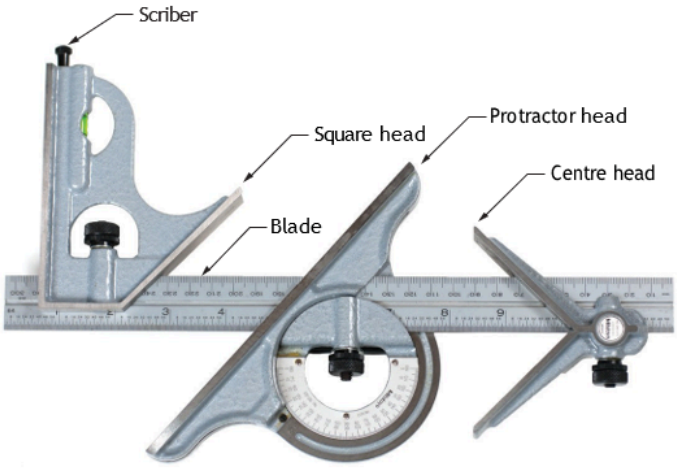

Figure 41 *Combination square* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Square Head (Set Square)

Square heads have a 90° square face and a 45° ***mitre*** face. Most square heads are equipped with a ***spirit level*** and a ***scriber***. The square head can be used separately as a level. The figure below shows how the square head of a combination square is used to hold the blade at right angles to the edge of stock or flat bar.

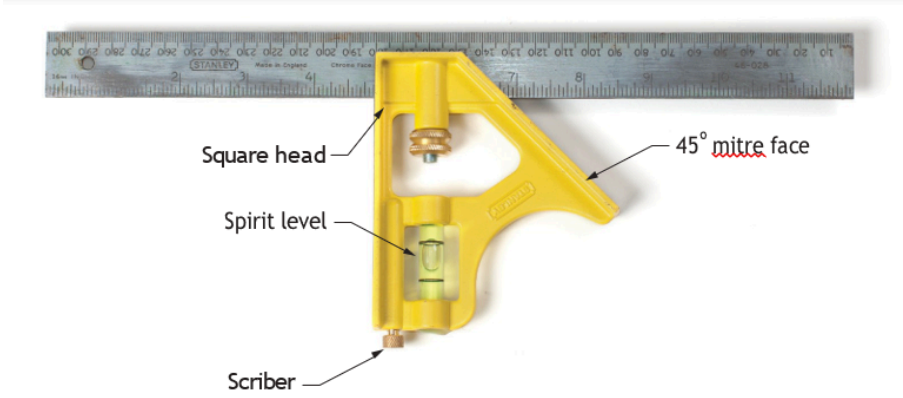

Figure 42 *Square head (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Centre Head

Centre heads have two equal arms that permit you to find the centre of large or small ***round stock***. The centre head is used in combination with the steel blade to quickly locate the centre of the piece. To use the centre head, place it firmly against the round stock and scribe several lines in the stock along the blade, rotating the stock about 60° between each scribing. The point where the lines intersect marks the centre of the stock.

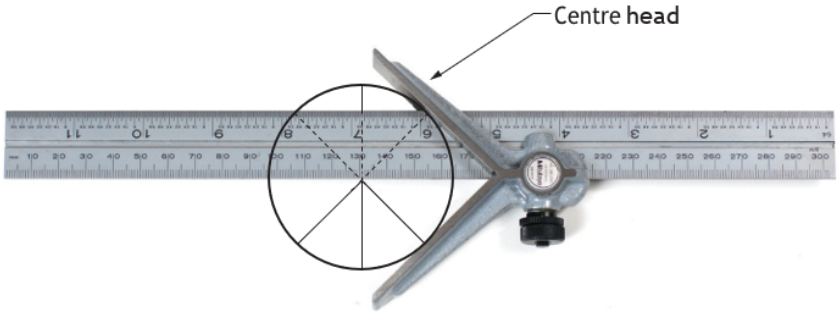

Figure 43 *Centre head (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Protractor Head

The ***protractor head*** is marked in degrees from 0 to 180°. With this head you can determine and check layout angles.

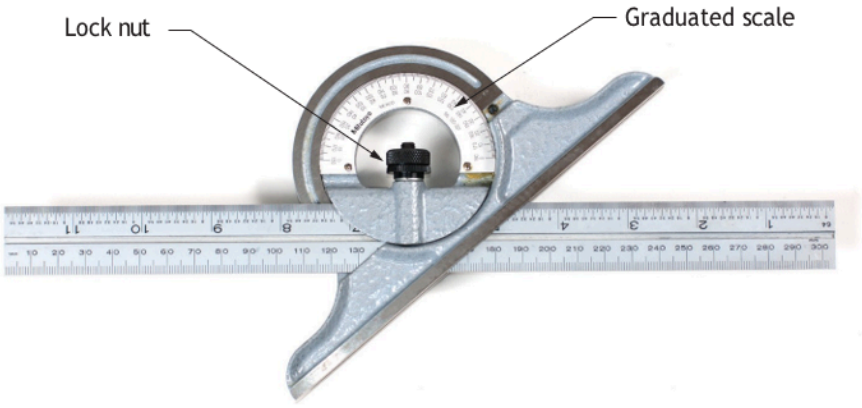

Figure 44 *Protractor head (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Thread Gauge

A ***thread gauge*** or *screw pitch gauge* is used to determine the pitch of various thread forms on bolts, screws, studs, or any threaded component.

Figure 45 *Thread gauge (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Screw threads are spiral grooves of uniform shape and size formed on the inside of a hole or on the outside of a rod or pipe. Some types of thread taper to form a tight seal (pipe thread) while others don't (bolt thread). These threads are measured as the number of threads per inch on imperial fasteners and as a direct measurement of pitch on metric fasteners.

The pitch of a screw thread is the distance from a point on one thread to the same or corresponding point on the next

thread. Expressed in *threads per inch*, the pitch is equal to 1 divided by the number of threads per inch. For example, a screw with 10 threads per inch has a pitch of $\frac{1}{10}$ -inch (1 divided by 10).

In the metric system, the pitch is not expressed in inches or threads per inch, but as the distance between threads in millimetres, such as 1.0 mm, 1.25 mm, or 1.75 mm.

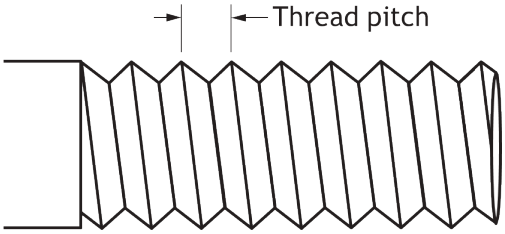

Figure 46 *Thread Pitch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

With a thread or screw pitch gauge, you can find pitch without using direct measurement or calculation.

These instruments are made up of a number of thin blades, each having V-shaped teeth cut along one edge that match a standard thread shape. Each blade also has a number indicating the number of teeth per inch or the pitch in millimetres.

To find the pitch of a screw thread, try to fit the appropriate gauge blade to the threads of the fastener being measured. Read the number on the gauge blade that matches your sample. The gauge blade must be held parallel with the fastener to get a correct reading.

Centring heads (Figure 47) are used for fitting up welded pipe fittings and aiding in the setting of centre lines, establishing angles and marks for butt-ins, and locating points on pipes and tanks, One model, the Curv-O-Mark™ Standard Model, is used on pipe $\frac{1}{2}$ -in. diameter and larger. It has a 4-in. Y-type head and is fitted with an adjustable dial bubble protractor and a manually operated hardened centring pin.

Figure 47 *Centring head (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Contour Marker

A contour marker tool is used for fitting up welded pipe fittings and may be used on almost any wye, tee, lateral or mitre joint directly on the pipe. This eliminates the time-consuming job of laying out a template. These instruments are very accurate but require some practice to use effectively when making fittings. These instruments consist of a frame that rests on the pipe or flange, a calibrated protractor, and a triple joint marking arm with a soapstone marking point (Figure 48).

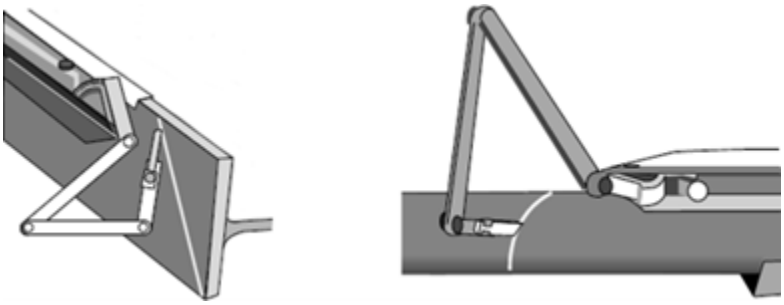

Figure 48 *Contour marker (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Refractometer

Refractometers are handheld, lightweight, portable instruments that utilize the measurement of ***refractive index*** to determine the concentration of ethylene glycol or propylene glycol antifreeze in sprinkler and heating/cooling systems. The two commonly used types of refractometers are analog and digital handheld units.

Figure 49 *Refractometer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hydrometer

A ***hydrometer*** is an instrument used to measure the relative density of liquids based on the concept of buoyancy. They are typically calibrated and graduated with one or more scales, such as specific gravity.

The hydrometer makes use of ***Archimedes' principle***, so the lower the density of the fluid, the deeper a hydrometer of a given weight sinks. Hydrometers are calibrated for different uses, including measuring the concentration of ethylene glycol or propylene glycol antifreeze in sprinkler and heating/cooling systems.

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

Levelling and Plumbing Tools

Levelling and plumbing tools include the ***hand level***, ***torpedo level***, ***line level***, ***plumb bob***, and ***chalk-line plumb bob***. It is important that all levels be kept accurate. In a well-constructed project, every member is properly located, every horizontal pipe is level or properly graded, and every vertical pipe is ***plumb***.

The Spirit Level

The ***spirit level*** (Figure 51) is a glass vial that indicates level or plumb. Some models use four glass vials for the spirit levels, while others use three (horizontal, vertical/level, and 45°).

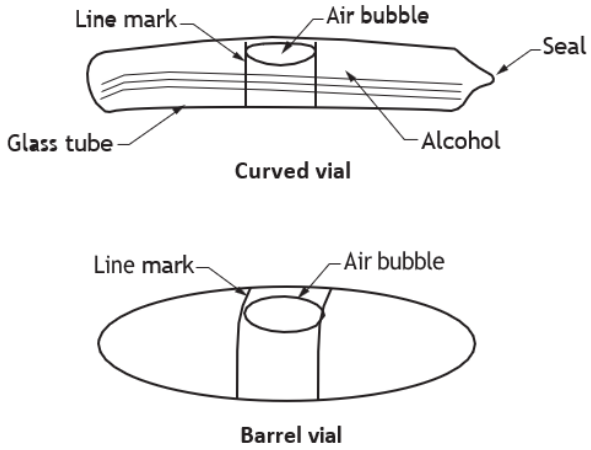

Figure 51 *Spirit level (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

When four vials are used, the vials are slightly curved and filled with alcohol containing a small air bubble. When three vials are used, they are barrel-shaped, that is, wider in the middle. These vials are also filled with alcohol. Some levels may have an additional fourth vial used to check the pitch or grade of drainage pipe.

Figure 52 *Four-vial and three-vial hand levels (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hand Levels

Popular hand levels are about 600 mm (24 in.) long, but there are 1200 mm (48 in.) and 1800 mm (72 in.) types. Modern models are made from aluminum or plastic; older types were made of wood.

Hand levels should be checked regularly for accuracy. Hand levels that are not accurate should be adjusted or repaired.

To check the hand level for straightness, sight along the edge or place the level on a known flat surface, such as the top of a table saw, to see if it is in full contact with the surface. Then turn the level over and check again.

When using the hand level, take care not to drop it or bang it about, as this can move the bubbles out of position and make readings inaccurate. Make a habit of hanging the level up when you are not using it.

Torpedo Level

The ***torpedo level*** is a small aluminum level 200 to 300 mm (6 in. to 9 in.) long. It has a bubble for level, a bubble for plumb, and a bubble for 45°. Plumbers commonly use this tool, but in the carpentry trade it is also handy for checking spaces too small to accommodate a long level.

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

Line Level

The line level is a very short level with hooks at each end that allow it to be attached to a string line. The line should be as tight as possible, and the level placed near the centre of the line. One end of the line should be attached at the height desired, and the other raised or lowered until the bubble is centred. The line level is good for approximate measures only, such as for excavations, fence posts, or building lines.

Figure 54 *Line Level (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Optical Levels

The ***optical level*** (also called a *builders level* or *dumpy level*) is a high-powered telescope equipped with crosshairs (similar to a telescopic sight for a rifle) centrally mounted on a bearing so that it can rotate only horizontally. A very sensitive spirit bubble is mounted on the telescope. When this bubble is centred, the instrument is level with the line of sight.

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

When mounted on a tripod, the optical level is adjusted with foot screws to centre the spirit bubble. As the optical level is rotated through a horizontal circle, the bubble may or may not have to be reset to centre, depending on the type of optical level being used.

Optical levels are used to establish horizontal reference points and to determine elevations and benchmarks.

Optical levels used in the pipe trades are typically used with what is known as a ***level (or levelling rod)***.

There are many types of level rods. They can be made of wood, fibreglass, or aluminum alloy. They can be telescopic, or can come in sections that are bolted together or that fit one segment into the end of another. There are several different methods of displaying the scales. The type most suited to construction is the segmented type with a reflective face. These levels are easily dismantled for use in confined spaces, and a light source can be reflected on the scales for easy reading in poor light conditions.

Figure 56 *Imperial (left) and metric (right) levelling rods (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Laser Levels

Laser is a word derived from Light Amplification by Simulated Emission of Radiation (LASER). A mixture of helium and neon gases is used to emit a very narrow beam of light that does not grow larger as it moves away from the source, which in this case is the ***laser level***. The beam can be directed to any point, or it can be rotated continuously at various speeds. Laser beams used in these levels can be either red or green; red is most common but is harder to see than a green beam in bright environments. If used in very bright conditions, a sensor or detector may be required.

Figure 57 *Laser Level (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Do not look directly into a laser beam! Looking directly into the beam may be hazardous to your eyes. A quick flash of the beam is not a problem, but prolonged exposure should be avoided. The instrument must be positioned either above or below the worker's line of sight.

The instruments can be supported in several ways. The most usual supports are tripods of various heights. They can also be clamped to columns or have small feet attached so that they can be set into or on pipes. Suspension frames are available to hold the instruments and aim them into pipes.

Sensors or Receivers

Only one person is required when using a laser levelling instrument. When the instrument is set up and the beam is rotating, it creates a level reference plane that can be detected with the sensor or receiver.

The sensors or receivers operate on batteries and have a narrow window through which the beam can be detected. When the beam is sensed, the detector shows a small coloured light or emits a sound. Sensors or detectors can be attached to the levelling rod or used by themselves to locate instrument height on walls, forms, or pipe work.

Plumb Bob

The ***plumb bob*** is used to establish a vertical line or a point directly above or below another point. Most plumb bobs are made of steel or brass and have a small threaded point that can be replaced if it becomes damaged. Some plumb bobs are hollow and filled with mercury, which adds weight and helps dampen movement without increasing size.

Plumb bobs vary in size from 250 g (9 oz) to 500 g (18 oz). On very large jobs, plumb bobs can weigh as much as 30 kg (65 lbs). These are held by piano wire and suspended in a large pot of oil to dampen movement.

Nothing should be allowed to touch a plumb bob line when it is suspended. The string should be attached through the centre hole of the bob and tied with the knot underneath.

The plumb bob is useful for plumbing piping, walls, posts, concrete forms, and other vertical objects.

Plumb bobs that use lasers are also widely available to save time when laying out pipe runs. Laser plumb bobs can be rested on the floor to transfer marks upward to the ceiling, for example.

Figure 58 *Conventional and laser plumb bobs (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Layout and Marking Tools

Marking tools are used by tradespeople to indicate exact points of reference for various procedures such as cutting or drilling.

Soapstone

Soapstone is a chalk-like substance used to mark heat-resistant ***layout lines*** on steel. The disadvantage of soapstone is that it can wipe off easily. Because of its brittle nature, soapstone is best used in holders, which may be round or flat.

Figure 59 *Soapstone in a soapstone holder (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Scriber (or Awl)

The *scriber* is a marking tool made with a hardened, tempered steel point that scratches mild steel and other relatively soft metals. The scriber or awl is used to make layout lines that are accurate and that have greater permanence than lines made with soapstone. Scribers are precision tools and should not be used for any other purpose (for example, as a toothpick).

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

Chalk Line

Chalk lines are used to lay out straight lines on a dry surface. A chalk line consists of a string on a retractable reel contained within a case. The case has a filler opening through which powdered chalk is poured. Every time the string is pulled from the case, it gets a coating of chalk, which is often red, yellow, or black.

The line is stretched tightly between two points on a surface, raised straight above the surface of the material at its centre, and then allowed to snap back. The snapping action deposits a straight line of chalk on the surface. The end of the line has a hooked eye that allows it to grip the edge of a surface such as plywood or hook over a nail driven into a structural member.

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

Divider and Trammel Points

Another tool used in connection with layout and metal fabrication is the ***divider***. You can use the divider to scribe circles and ***arcs*** or to locate one ***centre point*** in relation to another. As with the scriber, the hard, slender point must be ground frequently to keep it sharp, but the grinding should be done gently to avoid overheating and softening the metal.

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

Trammel points are attached to a length of scaled material and are used for marking large circles or arcs.

Figure 63 *Trammel point (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Centre Punch

The ***centre punch*** has a tapered bit with a broad, sharp point. Punches are ground to an angle of 90°, which makes them durable tools, but they are also somewhat difficult to position accurately on a smooth work surface such as plate. They are used chiefly for punching small indentations in metal as a guide for starting a drill bit. For this procedure, you first mark the material to be drilled with a scriber or pencil, place the centre punch directly on the mark, and strike the head of the punch with a sharp blow from a hammer. The indentation will prevents the drill tip from slipping or "walking" out of position.

Figure 64 *Centre punch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Prick Punch

The ***prick punch*** has a bit that is tapered to a very narrow, sharp point. The point of a prick punch is ground to an angle of 30°. This gives the prick punch a very thin point that makes it easy to place accurately on the ***workpiece***. Often a prick punch is used to make the first indentation, then a centre punch is used to make a wider, deeper indentation. Although pipe trades workers do not make frequent use of a prick punch, it can be used in connection with drilling to make a small, accurate indentation at the intersection of two layout lines. Once this indentation is accurately located, the centre punch can be used to enlarge the indentation to a size that is suitable for the drill bit.

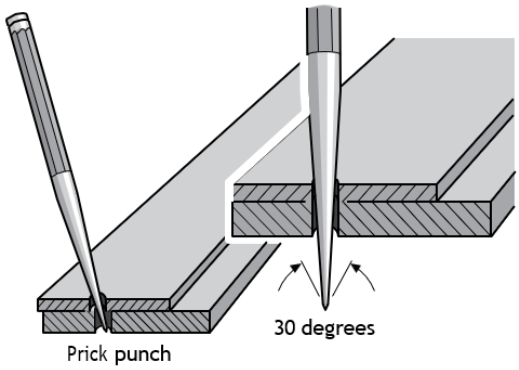

Figure 65 *Prick Punch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The prick punch is occasionally used to align holes in two or more sheets or plates. By inserting the tapered end of the prick punch through the holes drilled into the metal and moving it back and forth, you can accurately line up the holes.

Punches become dull in time, and like scribers, they need to be ground gently on a grinding wheel. As with scribers, you must take care not to overheat punches, as this will remove the ***temper*** from the metal.

Check Your Knowledge: Blades and Measurement Tools

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Hammering and Prying Tools

Hammering tools are used in the pipe trades for striking and shaping materials, driving fasteners, and for hitting objects such as punches and pins. ***Prying*** tools assist the worker in removing unwanted fasteners or objects.

Claw Hammers

The head of a claw hammer is made of ***drop-forged steel***, which is heat-treated to make it strong and long-lasting. Claw hammers come in different weights:

- Light claw hammers, which weigh about 370 grams (13 oz.), are used for finishing.
- Heavy claw hammers, up to about 900 grams (32 oz.) in weight, are used for framing.

The average framing claw hammer weighs between 570 and 680 grams (20–24 oz.).

Claw hammers also come in two claw styles: The *straight (ripping) claw* is used most often for ripping apart wooden members. The curved claw is better suited for pulling nails.

Curved claw

Straight claw
Figure 66 *Claw hammers* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Claw hammer handles are made of wood, fibreglass, or metal. The wood handle, usually fashioned from ***hickory***, absorbs shock better than a metal handle.

The metal or steel handle is either hollow or solid and extends into the hammer head. The end of the handle has either a rubber or leather grip. The advantage of the metal handle is that it almost never breaks; but, as mentioned, it is not a good shock absorber.

The fibreglass handle offers a compromise between the wood and steel types. It stands up to wear better than wood and has superior shock-absorbing qualities.

The head of the claw hammer should be securely fastened to the handle. A head that is loose should be re-tightened with metal wedges.

The most important feature of a hammer is its ***balance***. A hammer should feel comfortable in the hand, not head-heavy. The distribution of weight between the head and the handle, along with the length of the handle, determines the hammer's balance.

The hammer has two parts: the head and the handle. The head is made up of the following parts:

- face
- poll
- neck
- cheek
- claw
- *adze eye*

The face of the claw hammer is slightly curved and can be either smooth or *cross-hatched*. The cross-hatched hammer is usually used for framing because the hatch marks help prevent the hammer face from slipping off the nail. The cross-hatched hammer is not used for finishing because it can leave marks on the material.

Figure 67 *Parts of a hammer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Ball-Peen Hammers

The heads of steel-face hammers, such as ***ball-peen hammers***, are made from high-grade alloy steel, ***drop-forged*** and *heat-treated* to the proper hardness. The ball-peen hammer (Figure 68) generally has a slightly rounded (***convex***) striking surface or face. The end opposite the face is shaped like a full half sphere and is called a ***peen***.

Figure 68 *Ball-peen hammer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The size specification for a ball-peen hammer is determined by the weight of the head. Ball-peen hammers weigh from about 5.6 g to 1.35 kg (2 oz. to 3 lb.).

The ball-peen hammer can be used to set *soft* ***rivets*** or to strike chisels and punches. Small ball-peen hammers can be used to cut *gaskets*.

Sledgehammers

Sledgehammers are used for heavy work requiring significant force. They have longer handles than regular hammers and large rectangular heads. They weigh between 2.2 kg to 9 kg (5–20 lb.). Sledgehammers are also available for special applications, with soft heads or specially shaped heads. Handle length will vary with the weight of the head.

Figure 69 *Sledge hammer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Soft-Face Hammers

Soft-face hammers have a surface that yields (or slightly compresses) when striking an object. Soft-face hammers are preferred when machined surfaces or precision parts are involved or when *marring* (damaging) a finished surface must be avoided. When working with parts that may be damaged by a metal hammer, the *plastic-tip hammers* or *composition plastic hammers* are good alternatives. You can also protect these parts by placing a piece of wood or brass over the surface before striking it with a hammer.

Figure 70 *Soft-face hammer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

A plastic-tip hammer has a soft-face head and usually weighs between 225 g and 850 g (8 oz. to 2 lb.). Head diameters range from 18 mm to 32 mm ($\frac{3}{4}$ in. to 1 $\frac{1}{4}$ in.). Replaceable plastic tips are usually available in different levels of hardness.

Another type of soft-face hammer has a specially compounded *composition plastic tip* rather than a clear plastic tip. Replaceable tips made of extra-tough nylon are also available. This hammer is usually furnished with a fibreglass handle with a rubber handgrip.

A *brass-headed hammer* also has a relatively soft face. It typically weighs between 450 g and 850 g (1–2 lb.). A brass-headed hammer can be used for driving gears or shafts, or for tapping *shaft-mounted rocker arms*.

A *rubber mallet* has a high-grade rubber head moulded onto the handle. The handle may have ridges and grooves to retain the head. Rubber mallet heads are all about the same size, but weights vary from between 450 g and 850 g (1–2 lb.).

Figure 71 *Rubber mallet (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

A rubber mallet should be selected when it is important not to scratch or dent a nearby surface. However, this hammer should not be used on sharp or hardened work. Rubber mallets are often used for ***steam-tracing tubing***.

Lead hammers are used as "***dead-blow***" *hammers* because they don't bounce back when striking. They also don't mar or scratch delicate surfaces. Unfortunately, they tend to release and rub off bits of highly toxic lead dust and are no longer recommended. A safer alternative is a hammer with a hollow head filled with steel shot.

Chipping Hammers

Chipping hammers are a regular part of the pipefitter's or welder's tool set. They are used after every weld deposit to chip ***slag*** from the weld bead. The heads of chipping hammers are made of *forged alloy steel* that has been hardened and tempered for maximum strength. The types available differ only slightly in design, and the most common design is the cone point on one end and a straight chisel edge on the other. They may have either a wire or a hardwood handle. The pointed tip of the slender cone and the thin, tapered chisel edge can reach slag in even the most confined area.

Figure 72 *Chipping hammer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Wrecking Bar

The ***wrecking bar***, also called a *gooseneck*, is from about 300 mm to 915 mm (12 in. to 36 in.) long, with the average length of about 600 mm (24 in.). It is made of heavy octagon-shaped steel with one end flattened and the other formed into a hook and claw for pulling nails. This bar is used for ***demolition***, removing or stripping concrete ***formwork***, and prying materials apart.

Figure 73 *Wrecking bar (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Pry Bar

The ***pry bar*** (also called the *crowbar* or *long bar*) is made in two styles: a *pinch point* and a *wedge point*. A pry bar is typically 1200–1725 mm (5–6 ft.) long and weighs about 15 kg (33 lb.). It measures about 40 mm (1 $\frac{1}{2}$ in.) at the widest point. This bar is used for heavy work such as stripping concrete ***pipe sleeves*** and loosening compacted soil.

Wonder Bar

The ***wonder bar***, which is about 400 mm (16 in.) long and made from flat metal. It is used for light-duty prying and stripping work. There is a claw on either end. One end is bent to 90°, while the other end has a slight bend for leverage when prying. It's flat, wide surface area makes it a useful prying tool for general work.

Figure 74 *Wonder bar (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Nail Claw

The ***nail claw***, also called a *cat's paw*, is a short bar, about 30 cm (12 in.) long. At one end, there is a claw for pulling nails, while the other end has a slightly bent chisel point for prying.

This tool is very useful for wood frame construction when nails have to be pulled from lumber. The small claw is driven

under the nail head, and the tool is used to pull the nail free. Depending on the length, the nail is completely pulled or just started. A wrecking bar can be used to finish pulling larger nails.

Figure 75 *Nail claw (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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Bracing and Clamping Tools

Bracing and clamping tools allow the pipe trades person to secure material while it is being fabricated or manipulated. It is important to know the various types of tools available to make your job safer and less difficult.

Vises

A good-quality ***vise*** is a very rugged piece of equipment. Vises hold material or a part at a bench or stand while work such as assembly, disassembly, welding or filing is being performed.

Bench Vise

The standard metal or bench vise is available in many sizes and variations. Many include a flat anvil surface on the back so that the tradesperson can use this area for forming metal.

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

The size of a vise is usually measured by jaw width, but the maximum jaw opening should also be measured and considered when selecting a vise. Most good vises are available with a variety of jaw widths. Some vises have a set of curved, ***serrated jaws*** just above the winding screw, to hold pipe. The jaws on most styles may be replaceable.

The Machine Vise

This type of vise is used to hold a workpiece for a machining operation. For example, a ***machine vise*** is used to hold a workpiece for drilling with a drill press. The vise can be bolted to the drill press table. Machine vise jaws are replaceable. The jaw face is usually smooth, to prevent the workpiece from becoming marred. The jaws may also have vertical and horizontal machined grooves to provide a gripping surface for round or irregularly shaped objects.

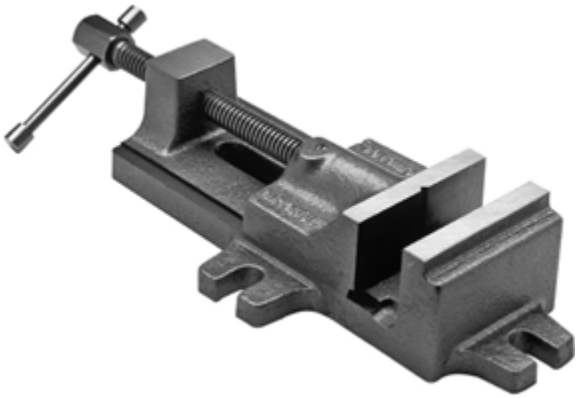

Figure 77 *Machine vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

C-clamps are available in many different sizes (the width they will open to) and throat depths (the distance they can reach over a piece of stock). They come in sizes ranging from 25 mm to 120 cm (1 in. to 24 in.).

C-clamps are used to clamp a work piece to a drill press table when the item is oddly shaped or too large to fit into a vise. They are also often used to hold a workpiece during welding or soldering operations. When welding, you must be careful to protect the screws of the clamp from weld spatter.

It is also important that C-clamps not be over-tightened, as this can damage both the clamp and the work

Figure 78 *C-clamps (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Wood Vises

Wood vises are used to hold a piece of wood while it is being worked on. By using a vise, you can use both hands on the tool, increasing your speed, accuracy and control.

The wood vise has two flat metal jaws that are opened or closed by the action of a screw thread. Wood pads are usually attached to the inner faces of the jaws to prevent marring the work piece held in the vise.

Wood vises are bolted to the front of a workbench to add to their stability. The vise has a small sliding lever near the handle that releases the screw thread and allows for rapid opening or closing of the vise.

Pipe Vises

Pipe vises are holding devices used to hold pipe stationary while you perform operations such as cutting, reaming and threading. Some are attached to portable stands for use at the job site; others are designed to be mounted on a workbench only.

Bench-mounted Pipe Vises

The following pipe vises are permanently mounted to shop benches:

Bench Yoke Vise

The iron yoke and base, and the addition of steel jaws make this yoke vise a sturdy tool; like other bench-mounted vises, it features a pipe rest. The disadvantage of this type of vise is the uneven pressure it distributes by gripping only part of the pipe wall. Too much pressure will result in a damaged or deformed pipe. The typical maximum pipe capacity is 15 cm (6 in.).

Figure 79 *Bench yoke vise (RIDGID/ Emerson Professional Tools). Used with permission.*

Top Screw Bench Chain Vise

The ***top screw chain vise*** is a popular bench-mounted type. Its main advantage lies with the holding chain, which distributes pressure evenly around the pipe. The crank handle is anchored to the base and can be swung freely and quickly in this top-mount position. The toothless jaws (chain) are sometimes specially coated with neoprene to avoid scoring the pipe. Pipe capacity is typically up to 20 cm (8 in.).

Figure 80 *Top screw bench chain vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Bottom Screw Chain Vise

This vise is no longer popular and is usually found in established fabrication shops only. The construction is similar to that of the top screw model, except for the position of the screw, which makes it slower to operate and provides for application of less force. The pipe capacity is usually up to 4 in.

Figure 81 *Bottom screw chain vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Open Side Vise

The ***open side vise*** is used for clamping a long length of pipe, but like the bench yoke vise, pressure is not distributed evenly around the pipe wall. It also maintains the disadvantage of only applying down forces from one side of the material. Pipe capacity is normally up to 10 cm (4 in.).

Portable Pipe Vises

The following pipe vices are portable for use on the job site:

Tri-stand Chain Vise

The ***tri-stand chain vise*** has a large base, hinged legs, and a folding tool tray, making it a complete, portable workbench. The chain type of vise is particularly popular because the chain holds a pipe quickly and securely, with uniform pressure. It is reasonably light and easily manoeuvrable to any area of a work site. To maintain stability it can be fastened with drop-in anchors or other appropriate fasteners to the floor, or it can be secured by the ceiling above with what is called the *ceiling brace screw*. This adjustable device allows the operator to quickly measure and cut a piece of 25 mm (1 in.) pipe to install plumb above the deck of the vise and tighten it against the ceiling for stability. Some models come equipped with a series of tubing benders formed into the deck of the unit. Pipe capacity is normally up to 125 mm (5 in.).

Figure 82 *Tri-stand chain vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Tri-stand Yoke Vise

The ***tri-stand yoke vise*** is similar to the tri-stand chain vise in most ways, except that the holding device is a pair of jaws rather than a chain. This vise is limited to holding pipe sizes up to an including 6 cm ($2\ \frac{1}{2}$ in.). As is with the bench yoke vise, pressure is not distributed evenly around the pipe.

Figure 83 *Tri-stand yoke vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Top Screw Stand Chain Vise

Two pairs of legs connected by a pipe make this vice handy for working on long lengths of pipe that require support. The legs and connecting pipe along the centre are fabricated onsite by the pipe trades worker to suit the height and length required. A ***top screw stand chain vise***, like most chain-style vises, will typically have a maximum pipe capacity of 13 cm (5 in.).

Figure 84 *Top screw stand chain vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Top Screw Post Chain Vise

This is a light but strong vise that fits any shape or kind of post to create an instant work platform. This vise might be

used on a job site where it is inconvenient to set up a tri-stand vise or when working on overhead piping. Pipe capacity is often 13 cm (5 in.) maximum.

Figure 85 *Top screw post chain vise* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Portable Kit Yoke Vise

Similar to the post chain vise in application, the vice clamps to a plank, a workbench, or a flat beam or post up to 10 cm (4 in.) thick. Maximum pipe capacity of this vise is normally up to 6 cm (2 $\frac{1}{2}$ in.).

Figure 86 *Portable kit yoke vise (RIDGID/ Emerson Professional Tools). Used with permission.*

Pipe Vises for Welding

Typically made of malleable iron, welding vises resist strain, heat, and distortion during welding tacking procedures (tack welding for fit-up of pipe). Screws and pins are used to hold the vise chains around the pipe.

Straight Pipe Welding Vise

Used on mains and risers, the straight pipe welding vise holds and aligns pipe to be tacked. Pipe capacity typically ranges from 13 mm to 21 cm ($\frac{1}{2}$ in. to 8 in.).

Figure 87 *Straight pipe welding vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Angle Pipe Welding Vise

The *angle pipe welding vise* is used on headers and branches. It holds a branch line at a right angle to a main or header while layout and cutting work is done. This type of vise can allow the pipe trades worker to work unassisted to fit up the joint. Pipe capacity typically ranges from 13 mm to 30 cm ($\frac{1}{2}$ in. to 12 in.).

Figure 88 *Angle pipe welding vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Elbow Pipe Welding Vise

The *elbow pipe welding vise* is used on horizontal mains, risers and other right angle changes of direction. It permits

lining up and holding of 90° elbows to the pipe until tacking is completed. Pipe capacity is often 6 cm to 21 cm (2 $\frac{1}{2}$ in. to 8 in.).

Figure 89 *Elbow pipe welding vise* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Flange Pipe Welding Vise

The *flange pipe welding vise* lines up the face of a flange at a right angle to the run of the pipe and holds it square for tacking. Pipe capacity is often 6 cm to 21 cm (2 $\frac{1}{2}$ in. to 8 in.).

Figure 90 *Flange pipe welding vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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Wrenches

A wrench is a tool that is used to grip and turn a fastener or fitting. You will need a variety of different wrenches that come in both standard and metric measurements. When selecting a wrench to use, you must first know the size of the nut or bolt head and then find a corresponding wrench. Usually, but not always, each end of the wrench is a different size and is stamped accordingly. Wrenches are available with straight or offset heads.

Different styles include:

- Open-end wrench
- Box-end wrench
- Combination wrench
- Tubing nut (flare nut) wrench
- Adjustable wrench
- Ratchet wrench
- Slug wrench
- Hexagon key wrench (Allen key)
- Socket wrench
- Ratchet ***torque*** wrench
- Pipe wrench

Open-End Wrench

An open-end wrench has an open head on each end. It was designed to fit both square-headed (four corners) and hex-headed (six corners) nuts and bolts. Even though it has the advantage of being easy to position, this style of wrench can wear down corners on the nut or bolt head because it only makes contact at two points.

While the open-end wrench may not provide as good a grip as a box-end wrench, it can be used in situations where you cannot reach all the faces of the nut or bolt head.

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

Box-End Wrench

The box-end wrench is an excellent tool for tightening and loosening nuts and bolts. Unlike the open-end wrench, the box-end wrench is made to grip the nut or bolt head on all sides. This prevents slipping and allows greater leverage.

The wrench must be slipped over the top of the nut or bolt head. The points around the inner circumference of the opening securely grip the bolt head or nut. These wrenches are available in either 6- or 12-point design. The 6-point wrench provides a more secure grip, but the wrench must be rotated further to achieve the next gripping location compared to the 12-point design.

Figure 92 *Box-end wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The two ends of the box-end wrench are usually different sizes. For example, a wrench with a $\frac{5}{8}$ in. opening on one end and an $\frac{11}{16}$ in. opening at the other end would be referred to as a $\frac{5}{8} \times \frac{11}{16}$ in. wrench. A metric wrench would have sizes such as 10 mm × 12 mm. The size of the wrench does not refer to the bolt diameter but rather to the distance across the flat of the nut or bolt head. Like the open-end wrench, the box-end wrench usually has the sizes stamped near the corresponding head.

Combination Wrench

The combination wrench is an open-end wrench and a box-end wrench, with both ends of the same size, combined into one tool. All the features of open-end and box-end wrenches apply also to a combination wrench. The combination wrench is available with 6- or 12-point box-end heads and in a wide selection of sizes and lengths.

Figure 93 *Combination wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Tubing Nut Wrench (Flare Nut Wrench)

The tubing nut or flare nut wrench is specially designed to provide a secure grip on line fittings. These wrenches have a slot through which the line or tube can be passed to allow a grip that is almost equal to a box-end wrench. This grip prevents wearing of the fitting hex nut corners during removal or installation, as might occur with an open-end wrench.

These wrenches are available in both imperial and metric, in a variety of sizes, and in both 6- and 12-point design.

Figure 94 *Flare nut wrench* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Adjustable Wrench

The adjustable wrench, often referred to as crescent wrenches has the provision for adjusting the opening to suit the nut or bolt being turned. The adjustable jaw is moved by a knurled nut. The size of all adjustable wrenches is designated by the wrench length, which varies from 10 cm to 61 cm (4 in. to 24 in.). For example, the 4 in. wrench has $\frac{1}{2}$ in. jaw capacity, while the 12 in. wrench has a $\frac{15}{16}$ in. capacity.

Figure 95 *Adjustable wrench* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Adjustable wrenches are useful but should never be used as a substitute for an open-end or box-end wrench. Adjustable wrenches can be pulled in either direction for light loads but develop their greatest strength when pressure is applied to the side of the wrench with the fixed jaw. Always be sure that the wrench is adjusted as tightly as possible against the nut or bolt head before attempting to turn it. This will act to avoid rounding the corners of fasteners when installing or removing them.

Ratchet Wrench

A ratchet wrench is a tool that is useful in tight places where it is impossible to reposition the wrench after each turn. Instead, you just move the handle back and forth once the box end is positioned over the fastener. It is not recommended for heavy applications.

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

Slug Wrench (Striking Wrench)

A ***slug wrench*** (or striking wrench) is a specialized thick, short, stocky wrench with a block at the end of the handle specifically designed for being struck with a hammer in order to add greater force. Used commonly with large fasteners, slug wrenches also provide shock and high force used to release large or stuck nuts and bolts, and are useful when space does not allow room for a large wrench.

Figure 97 *Slug wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hex Key Wrench (Allen Key)

The hex key or Allen key wrench is typically an L-shaped bar of hexagon-shaped tooled steel. It is made to fit the hexagon shaped hole found in some fasteners. Hex keys are classified by the size of their hexagonal stock measured across the hex flats. They come in either imperial or metric measurements, with the size usually stamped on the wrench. They are also available as a socket wrench, in a folding set, or as a series of T-handled drivers.

Figure 98 *Hex key wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Socket Wrenches

Socket wrenches are designed to be used for turning fasteners that cannot be easily accessed with a standard wrench. Socket wrenches may have 4, 6, 8, or 12 points. The 6- and 12-point sockets are most common. The 6-point socket is stronger and will do less damage to the fastener than a 12-point socket

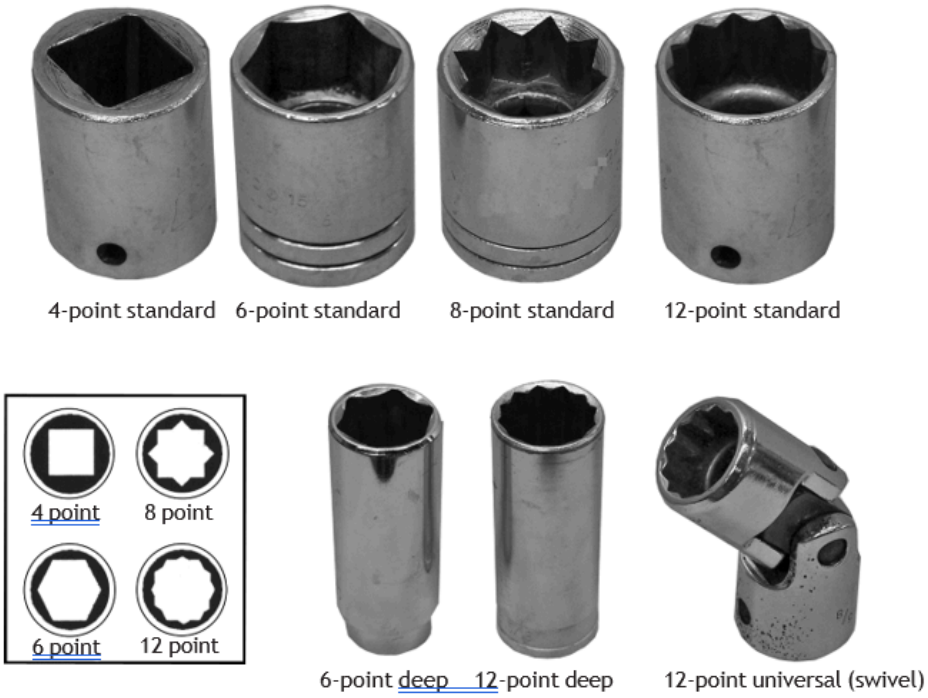


Figure 99 *Various sockets (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

A basic socket wrench set is made up of a handle and several barrel-shaped sockets. Each socket has a square hole on one end that fits directly into the drive lug on the socket wrench handle.

The other end of the socket looks like a box-end wrench and has 6, 8, or 12 points. With the socket firmly attached to the wrench handle, the socket is placed over the nut or bolt head and the handle is moved to loosen or tighten the fastener.

The universal flex or swivel socket permits the socket to be used at various angles by the swivelling action of the socket head. The deep socket allows you to loosen a nut on a stud or bolt that has a large number of threads showing when standard sockets would not be long enough to reach the nut.

Socket sizes are marked on the outside of the socket and indicate the head size of the fastener that they will fit. Other special sockets include those designed for removing and replacing oil pressure and temperature sending units, spark plugs, and sockets designed for use with impact wrenches.

Impact sockets have stronger construction and are not chrome plated, since the chrome would crack and flake off. The thick walls and heavy construction allow them to take the shock of the impact. For this reason, standard sockets should never be used with impact wrenches.

Figure 100 *Socket driver set (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The square drive is the end of the socket that attaches to the socket handle.

The square drives range in size from 6 mm ($\frac{1}{4}$ in.) to 5 cm (2 in.). The 6 mm ($\frac{1}{4}$ in.) through 19 mm ($\frac{3}{4}$ in.) sizes are most common. The drive size is measured in inches on both metric and imperial sockets.

Some socket handles have a small, half-exposed ball bearing centred on one side of the square drive. When the socket is fully pushed onto the socket handle, a machined groove or mating hole aligns with the recessed ball bearing to assist in retaining the socket.

Ratchet Torque Wrenches

Specifically useful for installing no-hub cast iron soil pipe couplings, ***ratchet torque wrenches*** tighten with a quick ratchet action and automatically release when they reach a pre-set amount of torque (twisting force). The $\frac{5}{16}$ in. driver model is common and is pre-set to 60 inch-pounds. The $\frac{3}{8}$ in. model is pre-set to 80 inch-pounds.

The click-type torque release function prevents over-tightening or damaging of gear clamps when installing no-hub couplings.

Figure 101 *Left: T-handle ratchet torque wrench; right: no-hub soil pipe coupling with [latex]\frac{5}{16} [/latex] in. gear clamps (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Pipe Wrenches

A ***pipe wrench*** is used for turning pipe and other round objects. The sharp jaw teeth of the pipe wrench will dig in and mar (damage) the surface. A pipe wrench should not be used to turn bolts or nuts unless the head of the bolt has been damaged and will not accept a straight-faced wrench or socket.

Before using a pipe wrench, remove any grease or dirt from both the part to be turned and the pipe wrench jaws. A small wire brush or scribing tool is adequate. Adjust the movable jaw so that the work is gripped near the centre of the jaws. Pull carefully until the wrench has a good bite on the work. Then exert the force necessary to turn or tighten the work. Pipe wrenches should never be used on hardened surfaces since the jaw teeth may be dulled or chipped.

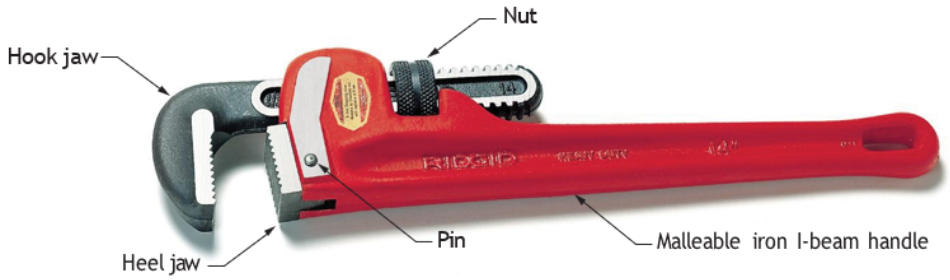


Figure 102 *Parts of a straight pipe wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

A variety of wrenches are used for gripping and turning pipe and fittings. The type of wrench selected for a job depends on pipe size, pipe material, and the amount of working space available.

The following wrenches are most common to the piping trade:

- Straight pattern pipe wrench
- End pattern pipe wrench
- Raprench

- Offset pattern pipe wrench
- Stillson pattern pipe wrenchs
- Vertical pipe wrench
- Rapidgrip wrench
- Spud wrench
- Hexagonal pipe wrench
- Compound leverage pipe wrench
- Chain wrench
- Chain tong
- Strap wrench
- Basin wrench
- Plastic nut basin wrench
- Internal wrench

The jaws of pipe wrenches have teeth for gripping round objects. The heel jaw is attached to the handle, while the hook jaw can be made to move in and out by adjusting the nut on the threaded section of the hook jaw. Both the shank of the hook jaw and the nut are held in position by the wrench housing.

Straight Pattern Pipe Wrench

Available in at least ten models, each is designed for a certain range of pipe sizes. The smallest is typically 150 mm (6 in.) long and has a pipe capacity of $\frac{3}{4}$ in.; the largest is 1500 mm (60 in.) long for use on 8 in. pipe. Pipe wrench sizes are designated by their length, measured from the tip of the handle to the inside of the hook jaw, when fully extended. Like the other standard wrenches shown here, this wrench comes with either an aluminum or cast iron handle.

Figure 103 *Straight pattern pipe wrench* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

End Pattern Pipe Wrench

These wrenches have a 45° opening and can be used when working in tight quarters or next to a wall or a corner.

Produced in about eight different sizes, the end pattern pipe wrench accepts pipe sizes ranging from 19 mm to 13 cm ($\frac{3}{4}$ in. to 5 in.).

Figure 104 *End pattern pipe wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Raprench (Rap-Wrench)

The ***Raprench*** has a pipe diameter scale on the hook jaw for size setting. It is available in several models with different pipe size capacities.

Figure 105 *Raprench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

This wrench has a deeper, broader hook jaw housing with a smooth, flat, hardened surface that is used like a hammer to jar loose pipes and fittings that have seized. The Raprench can usually accept pipe sizes up to 38 mm ($1\frac{1}{2}$ in.).

Offset Pattern Pipe Wrench

This unique pattern has the jaw open parallel to the direction of the handle. It also has a narrower hook jaw head.

These features allow easy entry to tight spots. Several models are marketed, with pipe capacities of 5 cm, 6 cm, and 8 cm (2 in., 2 $\frac{1}{2}$ in., and 3 in.).

Figure 106—*Offset pattern pipe wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Stillson Pattern Pipe Wrench

The forefather of the modern pipe wrench, the ***Stillson pattern pipe wrench***, has a pipe diameter scale on the hook jaw, for size setting. It is available in several models with different pipe size capacities, with the maximum pipe size 6 cm (2 $\frac{1}{2}$ in.).

Figure 107 *Stillson pattern pipe wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Vertical Pipe Wrench

This wrench is manufactured without a long handle and requires the user to insert a handle into the head assembly. It can be used on either vertical or horizontal pipe in closely confined areas and operates in a way similar to that of a basin wrench. It is especially useful for underground valve locations. Pipe capacity is typically 5 cm (2 in.) maximum.

RapidGrip Wrench

The ***rapidgrip wrench*** has a spring-loaded jaw designed for quick ratcheting action. It allows for one-handed operation while the worker uses the other hand to hold a backup wrench. It has a distinctive jaw designed to accept multiple sizes and shapes of material. Maximum jaw capacity is usually 5 cm (2 in.).

Figure 108 *RapidGrip wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Spud Wrench

This tool (also known as a ***monkey wrench***) utilizes smooth, flat, narrow jaws that are ideal for use on square or rectangular stock, such as a flat-edged fitting.

Figure 109—*Spud wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hexagonal Pipe Wrenches

The ***hexagonal wrench*** appears in two designs: straight and offset. Both types give a multi-sided grip, but the main difference between the two is the extra-wide opening of the offset, which is ideal for securing drain nuts on tubs and sinks. Thin, smooth jaws fit into tight spaces easily.

Figure 110 *Hexagonal pipe wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Compound Leverage Pipe Wrench

This wrench has the ability to multiply leverage numerous times. The chain wrench part attaches to the pipe adjacent to the fitting and imparts a holding force opposite in direction to the turning force of the hook jaw, which grasps the fitting. It is ideal for loosening seized joints.

Figure 111 *Compound leverage pipe wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

This wrench works on right- or left-hand threads and comes in several models, with pipe size capacities of 5 cm to 20 cm (2 in. to 8 in.).

Chain Wrenches

Chain wrenches and ***chain tongs*** provide another method of tightening threaded pipe and fittings. They have the advantage of distributing pressure evenly without crushing and work well in tight working areas, since the only clearance needed is sufficient space to wrap the chain around the pipe or fitting.

Figure 112 *Chain wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Chain Tongs

Tongs are manufactured in various sizes that can be used for pipe diameters from 6 mm to 30 cm ($\frac{1}{4}$ in. to 12 in.). When the teeth on one end of the double-ended Tongs jaw have become dull, the head can be unbolted and reversed. Single-ended Tongs (not shown) have a head that is non-reversible.

Figure 113 *Chain tong (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Strap Wrenches

Designed for polished or chrome pipe, the ***strap wrench*** has a woven nylon strap to give a tight grip. The various models have different strap lengths and widths, as well as different handle lengths. The two basic sizes have pipe capacities of 5 cm and 13 cm (2 in. and 5 in.), and handle lengths of 300 mm (11 $\frac{3}{4}$ in.) and 450 mm (18 in.). A powdered Rosin product can be applied to the strap for increased friction.

Figure 114 *Strap wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Basin Wrenches

The spring-loaded jaws of a ***basin wrench*** allow one-hand ratcheting on nuts in hard-to-reach areas. A tension plug holds the tool's head at any angle up to 90°. This wrench is particularly handy behind sinks and lavatories, where it is impossible to use a standard wrench.

The telescoping basin wrench can be adjusted for length. Its maximum capacity is 6 cm (2 $\frac{1}{2}$ in.). The non-telescoping model has a maximum capacity of 32 mm (1 $\frac{1}{4}$ in.).

Figure 115 *Telescoping basin wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Plastic Nut Basin Wrenches

Plastic nut basin wrenches are a type of basin wrench that is designed for turning plastic mounting nuts on faucets, sprayers and ballcocks. They often have a hole through the barrel to allow a screwdriver shaft to fit through and help increase torque.

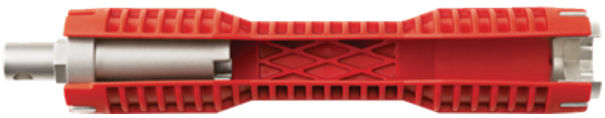


Figure 116 *Plastic nut basin wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Internal Wrench

The ***internal wrench*** is used to hold pipes, nipples, and fixture connections in place from the inside while a nut is tightened down. The knurled head of some types is reversible to accept sizes from 2.5 cm to 5 cm (1 in. to 2 in.).

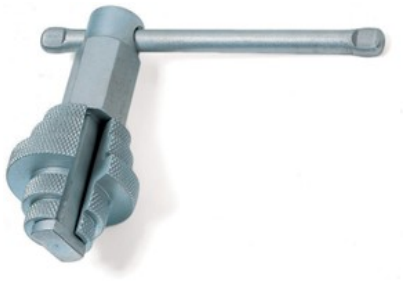


Figure 117—*Internal wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Pliers

Pliers are used to increase gripping power when holding relatively small-diameter objects. Of the many types and designs that are produced, the three pliers illustrated below are the types most commonly used in the piping trades.

Never use pliers for turning nuts or bolts, as the sharp teeth will round off the corners and badly damage the nut or bolt.

Combination Slip-joint Pliers

Combination slip-joint pliers are the most common general-purpose pliers. They can be adjusted to two sizes by means of a sliding pivot that allows the jaws of the pliers to open widely for gripping larger items. The jaws have sharp, hardened cross teeth to grip the object on which you are working.

Figure 118 *Combination slip-joint pliers (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Arc-joint Pliers

Arc-joint pliers are made in various sizes with maximum capacities up to 10 cm (4 in.). The tongue and groove design provides maximum power at all openings. This type of joint design's advantage is that it is less prone to slipping under force due to increased surface area. Most piping trades people will refer to these simply as *Channellock pliers* (that manufacturer being the innovator of this product).

Figure 119 *Arc-joint pliers (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Water Pump Pliers

Water pump pliers have a maximum pipe capacity of 5 cm (2 in.). They are a style of slip-joint plier having multiple positions. The multiple slip-joint setup provides for rapid changes of jaw opening.

Figure 120 *Water pump pliers* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Linesman Pliers

Linesman pliers are non-adjustable, in that they have a fixed pivot point, and are easy to use for a multitude of tasks from bending metal to tying wire. Originally designed for the electrical field, their flat serrated jaws are equipped with cutters for snipping wires.

Figure 121 *Linesman pliers* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Needle-Nose Pliers

Needle-nose pliers come in a variety of sizes and styles, some incorporating a cutting surface. Many needle-nose pliers are useful in bending wire into curves or circles, and for retrieving small parts from equipment and hard to reach places.

Figure 122 *Needle-nose pliers (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Diagonal or Side-Cutting Pliers

Diagonal or side-cutting pliers are made with a diagonally cut head or face and a hard steel cutting edge to cut wire or other metal objects close to the surface. Diagonal cutters are especially useful for removing cotter pins (pins used for securing parts to equipment) and for trimming cotter pins to the desired length after installation.

Figure 123 *Side cutters (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Locking Pliers

Locking pliers are produced by several manufactures in a multitude of styles but are often referred to as *Vise-Grips* due to the popularity of that brand. They have a built-in spring-type mechanism which can be locked into position and released by pulling or squeezing a release lever. Locking pliers come in several sizes and styles and are available either with straight, cutting or curved jaws.

Figure 124 *Locking -pliers (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Wire Strippers/Crimpers

Wire strippers/crimpers are useful when making multiple wiring connections or splices. They include squared and rounded ***crimping*** heads, multi-gauge wire strippers, and a set of wire cutters. Most types also have small holes that enable smooth, quick cutting of small diameter machine bolts.

Figure 125 *Combination wire strippers/crimpers (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Screwdrivers

Screwdrivers are available in a variety of lengths and sizes. The length of a screwdriver is measured from the tip to where

the handle joins the blade. Lengths range from 38 mm to 60 cm (1 $\frac{1}{2}$ in. to 12 in.) or more, with the shorter lengths known as "*stubbies*." Stubbie screwdrivers are used only when space will not permit use of longer screwdrivers.

Some common screwdriver types include:

- Slotted
- Robertson
- Phillips
- Ratchet
- Stubby
- Offset
- Torx
- Clutch drive
- Allen

The parts of a screwdriver are the head, handle, ferrule, shank, blade, and tip. The length of the blade, as mentioned above, indicates the size of a screwdriver. Some screwdrivers may have square shanks that permit turning with a wrench, when required for extra torque.

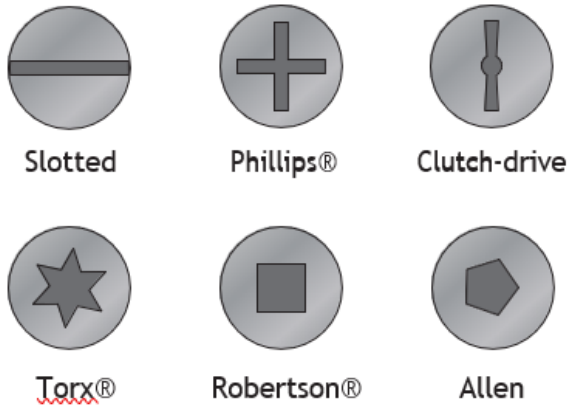


Figure 126 *(BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

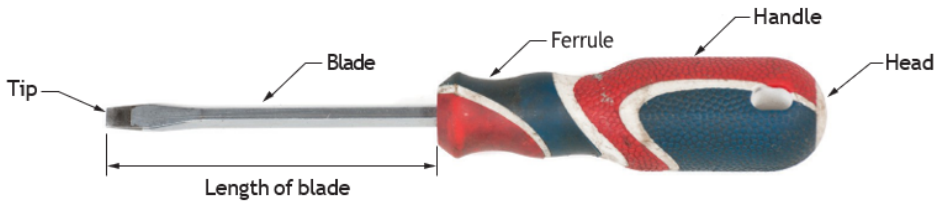


Figure 127 *Parts of a screwdriver (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Slotted Screwdriver

Although almost completely replaced by the Robertson head in modern construction, the slotted screwdriver was at one time the most commonly used screwdriver, and is still sometimes referred to as the "conventional" screwdriver. It comes in many lengths and tip sizes. When you select a screwdriver for slot screws, make sure that the tip is as wide as the diameter of the screw head and that it is as thick as the slot size. The figure below shows the correct fit for slot screwdrivers.

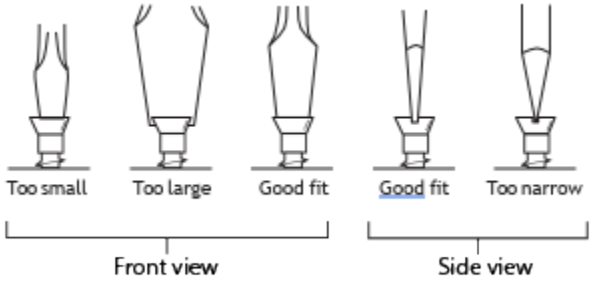


Figure 128 *Fitting for slotted screwdrivers (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

If the tip of the screwdriver becomes worn and rounded, reshape it by filing or grinding, often called dressing. Figure 129 shows correctly and incorrectly ground screwdriver tips.

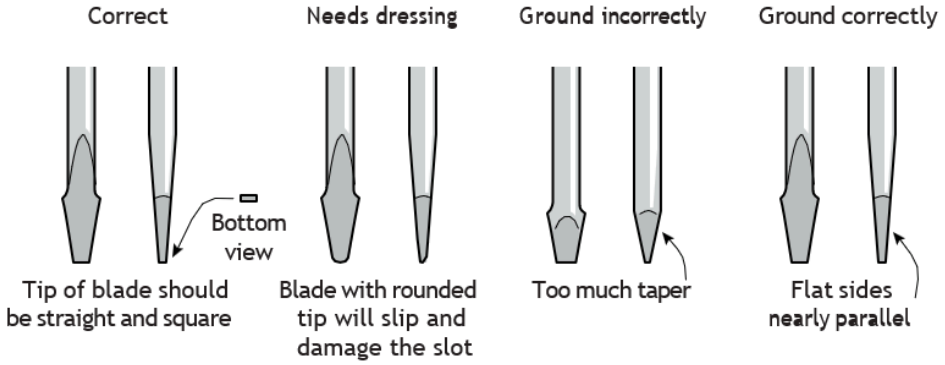


Figure 129 *Grinding slotted screwdriver blades (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Robertson Screwdriver

The advantage of the Robertson-head system is that it has a square-shaped socket in the screw head and a square protrusion on the tool. Both the tool and the socket have a taper, which makes inserting the driver easier and also tends to help keep the screw on the tool tip without the worker needing to hold it there.

Robertson screwdrivers are named after Canadian inventor P.L. Robertson, who invented the system in Milton, Ontario, in 1908.

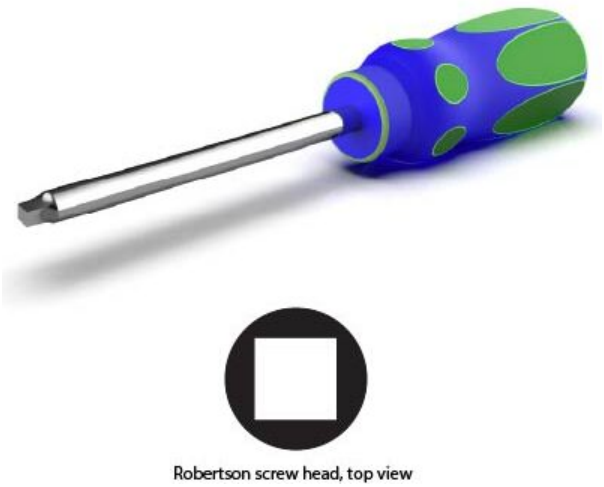


Figure 130 *Robertson screwdriver (Vijesh Panchal/ Pixabay) Pixabay Content License (https://pixabay.com/ service/license-summary/)*

Robertson-head screwdrivers are available in range of tip sizes. Robertson screwdrivers have a unique system of colour coding that are indicated on their handle according to the following colour and sizing system:

Table 1: ***Robertson Screw and Driver Classifications***

Colour	**Tip Size**	**Screw Sizes**
Orange	No. 00	#1 & #2
Yellow	No. 0	#3 & #4
Green	No. 1	#5, #6, #7
Red	No. 2	#8, #9, #10
Black	No. 3	#12 and larger

Phillips Screwdrivers

Phillips screws and drivers were known as “crossheads” when Henry Phillips first developed them in the early 1930s. The importance of the Phillips screw design lies in its self-centring property, useful on automated production lines that use powered screwdrivers. The Phillips screwdriver is available in the following sizes: No. 00, No. 0, No. 1, No. 2, No. 3, and No. 4, with No. 00 being the smallest and No. 4 the largest.

Figure 131 *Phillips screwdriver (kjpargeter/Freepik) Terms of Use (https://www.freepik.com/legal/terms-of-use)*

Ratchet Screwdrivers

The ratchet screwdriver typically has different tips for fitting into slotted, Robertson, and Phillips screws. To speed up a job, the ratchet on the ferrule of the driver can be set to install or remove a screw without the operator having to release the handle to regrip the driver. It can also be set to a locked position to permit the driver to be operated as an ordinary screwdriver.

Figure 132 *Ratchet screwdriver (Pittigrilli/Wikimedia commons) CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/)*

Stubby and Offset Screwdrivers

The stubby screwdriver is available in all sizes of slot, Robertson®, and Phillips® tips. The blade and handle are very short.

Another design is the ***offset screwdriver***, which enables the operator to reach into tight spaces. Most offset designs are Z-shaped, with the face of the tip at one end at right angles to the face of the tip at the other end.

Figure 133 *Stubby (top) and offset (bottom) screwdrivers (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Torx Screwdrivers

Torx is the trademark for a type of screw head characterized by a 6-point star-shaped pattern. By design, ***Torx head screwdrivers*** and screws resist ***cam-out*** (slipping out of the screw head) better than Phillips head or slot head screws. Where Phillips heads were designed to *cause* the driver to cam out, to prevent over-tightening, Torx heads were designed to *prevent* cam-out.

Torx screws are commonly found on automobiles, motorcycles, hard disk drives, and consumer electronics. Initially, they were sometimes used in applications requiring tamper-resistance, since the drive systems and screwdrivers were not initially widely available.

Figure 134 *Torx screwdriver (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Never use an Allen key wrench on a Torx screw. The head of the Torx screw may appear to fit an Allen key wrench, but you will find that as soon as force is applied, the corners of both the wrench and screw may be damaged.

Clutch Drive Screwdriver

The ***clutch drive screwdriver*** is used in the automotive and manufacturing industries. The driver tip must exactly match the size of the head. The head of the screw is held firmly by the driver tip; if a slot or Phillips driver were used with it, the screw might slip out.

Figure 135 *Clutch drive screwdriver (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Allen Head (Hex Head) Screwdrivers

Similar to the Allen key wrench, Allen head screwdrivers have a hexagonal head used to drive screws that have a matching hexagonal socket in the head.

Figure 136 *Allen screwdriver (Ralph/Pixabay) Pixabay Content License (https://pixabay.com/service/license-summary/)*

Check Your Knowledge: Pliers and Screwdrivers

Complete the Complete the interactive knowledge test below.

If you are using a printed copy, you can scan the QR code with your digital device to go directly to the interactive knowledge test.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-29 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-29)

Tubing Benders

An ***annealed*** (softened by heating) copper tube can easily be bent across your knee, but its original circular cross section will be flattened in the process because the lateral forces across the part being bent haven't been contained. The use of ***tubing benders*** enables smooth corners to be formed in tubing while retaining the original profile. Tube benders range in styles from simple spring benders to complex mechanical benders that are used for larger bending operations.

Maximum capacities for tubing benders will be dictated by tubing diameter, wall thickness, style of benders and type and temper of the material.

Spring Tubing Benders

These types of benders form quick changes of direction in small-diameter soft-drawn copper and aluminum tubing.

Capacities range from 6 mm to 22 mm ($\frac{1}{4}$ in. to $\frac{7}{8}$ in.) OD.

Figure 137 *Spring tubing bender (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Compression Hand Lever Benders

This bender is designed for bending stainless steel, steel, copper, and aluminum tubes of several sizes.

It is equipped with a degree dial on the bending wheel allowing the user to easily read any angle of the bend.

Tube size dimensions for this type of bender usually range from 5 mm to 19 mm ($\frac{3}{16}$ in. to $\frac{3}{4}$ in.) OD.

Parts of the Compression Hand Lever Bender:

- **Bending Wheel**: provides the circular form that the tube rotates around during the actual bending process.
- **Placement Link**: has indicators that are used to correspond with measurements that are marked on the tubing.
- **Pull Handle**: assists to draw the tubing around the bending wheel to the desired bend required.
- **Tubing Fastener**: acts to lock the tubing in place during the bending process.
- **Stationary Handle**: supports the bending wheel while the bender is being use.

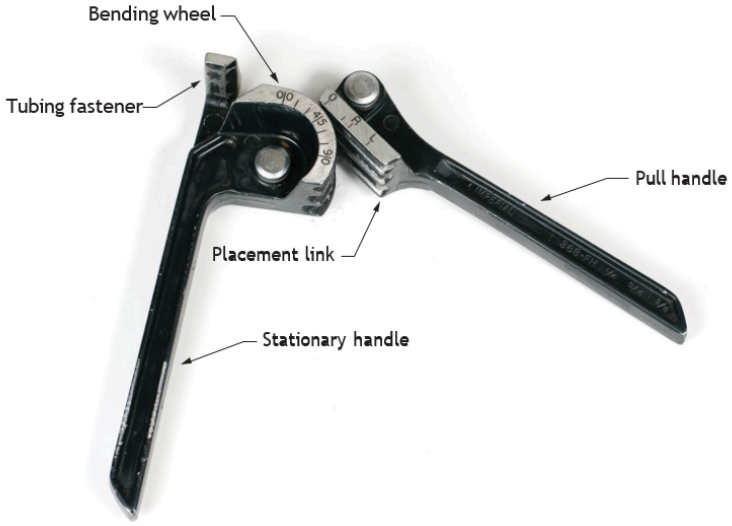


Figure 138 *Parts of the compression hand lever bender (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Swaging Tool

A ***swaging*** tool is sometimes used to join two lengths of tubing together. The tool is driven into the end of an annealed (softened by heat treating) tube. This forms a socket that will accept the end of the other piece of tube perfectly.

Figure 139 *Swaging tools (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Some swaging tools come in sets with a dedicated tool for each tube size, while others may have stepped formations to be used for multiple sizes.

Flaring Tool

Flaring tools are used to provide a mechanical joint in tubing systems. When flaring, the end of the tube is clamped into a flaring block to the correct height. The body of the tool is placed over the flaring block and a screw is turned to drive a steel cone toward the end of the tube. The better versions of flaring tools have the steel cone moving eccentrically, which sweeps the edge of the tube as it lowers forming a 45° flare.

Figure 140 *Flaring Tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

During tube installation, the flare is seated to a fitting with the inside of the flare against the cone-shaped end of the fitting, and the flare nut is screwed onto the fitting, pulling the inside of the flare against the seating surface of the fitting.

PEX Connecting Tools

Cross-linked Polyethylene (**PEX**) has become very popular for use in residential water plumbing because of its flexibility.

PEX tubing has also become the most popular material to transport water in hydronic radiant heating systems. Methods of joining the tubing include crimping, compressing, expanding and stainless steel clamping. It is unable to be welded with solvents.

Crimping Tools

The standard method for connecting PEX pipe to brass or plastic PEX insert fittings uses a copper crimp ring and a crimping tool. The copper crimp ring is placed over the pipe, the fitting is inserted inside the pipe, and the copper ring is crimped over the pipe and fitting using the crimping tool. The compression forces of the tool deform the ring to hold tightly against the tube and fitting, providing a reliable seal.

These tools are available in single size models, multiple size models, and a special style used for crimping in tight locations.

The Stainless Steel Clamp (SSC) method uses special clamps designed for PEX connections. The fittings used here are the same used in the standard connection method above, but in this method the SSC fastens the PEX tube to the fitting. A special SSC crimping tool is used to tighten the clamp around the tube and fitting.

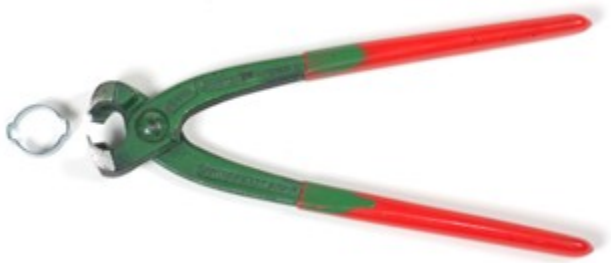


Figure 141 *Stainless steel clamp crimping tool and clamp (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Crimp Ring Removal Tool (Decrimper)

PEX crimp fittings can be reused after removal with the use of this crimp ring removal tool. Its jaws are set to a depth that will bite through the crimp ring and tubing, but won't damage the fitting. Some types will work on multiple sizes of tube, while others are size-specific.

Figure 142 *Crimp ring removal tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

PEX Expander Tools

The expansion method involves using an expander tool to increase the diameter of the PEX tube and a PEX collar, or ring. Special expansion fittings are inserted into the tube once expanded, which shrinks back to shape around the fitting. This method is unique and specific to one manufacturer's product

Figure 143 *PEX expander tool kit (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The shape memory capability of certain types of PEX tubing allows for this distinctive joining capability. Not all types of PEX tubing can be joined through the expansion process. The shape memory capability of PEX-A tubing (which is tubing that is manufactured using the Engel method) allows for this distinctive joining capability. PEX tubing types B and C, which are manufactured differently, must use crimp rings or SSCs.

Hand Threading Tools

The threaded piping used in some plumbing installations for the delivery of gases or fluids under pressure has a threaded section that narrows to create a seal (in contrast to the straight thread pattern commonly found on bolts). This is called ***tapered thread***.

Pipe Thread

The seal provided by a threaded pipe joint depends upon the diminishing seal created by the threads and sometimes on the presence of a sealing coating, such as thread seal tape (Teflon tape), or a liquid or paste applicant such as *pipe dope*. Pipe dopes and tape are applied to male (external) threads to lubricate the mating of the threads, thereby reducing friction and allowing the joint to be properly tightened to specifications without binding.

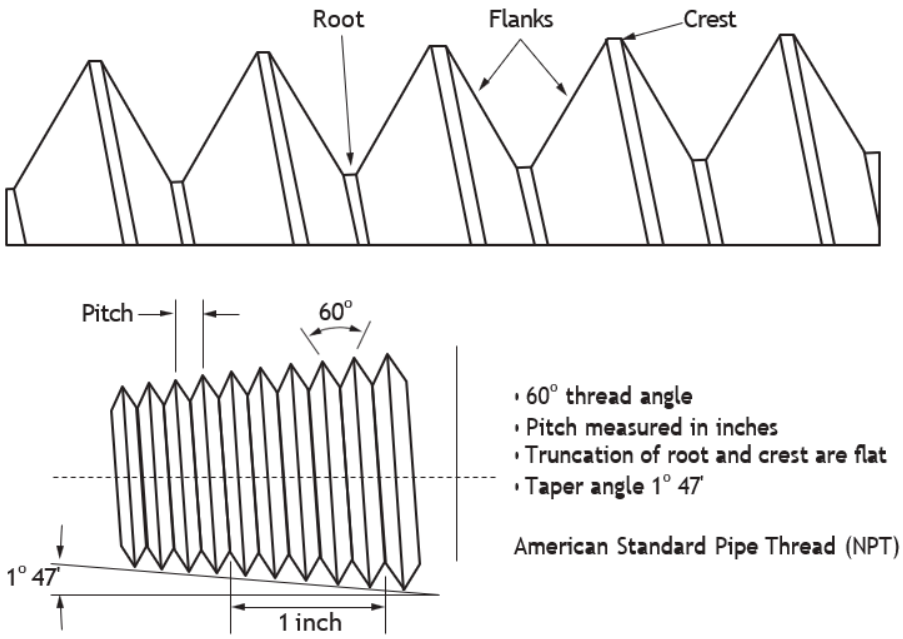


Figure 144 *National pipe thread (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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

The rate of taper for all NPT threads is $\frac{1}{32}$ in. per inch (1° 47′) and the grooves that create the threads are formed at 60° angles.

Commonly used sizes are $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, and 2 inch, appearing on pipes and fittings by most North American suppliers. Sizes smaller than $\frac{1}{8}$ in. are occasionally used for compressed air, while sizes larger than 2 in. are uncommon, due to the use of alternative methods of joining that are more common with these larger sizes.

European standard thread is known as ISO *Thread* or formally British Standard Pipe Thread (BSPT). In this system, there are two types of thread distinguished: *British Standard Pipe Parallel Thread* (BSPPT) which is a "running" thread with no taper—similar to bolt thread—in which the diameter of the threads is constant, and British Standard Pipe Taper Thread (BSPTT) in which the thread diameter increases or decreases along its length. Note that BSPT and NPT are not

interchangeable. BSPT and ISO use threads produced at an angle of 55° and the threads are rounded equally at crests and roots by circular arcs.

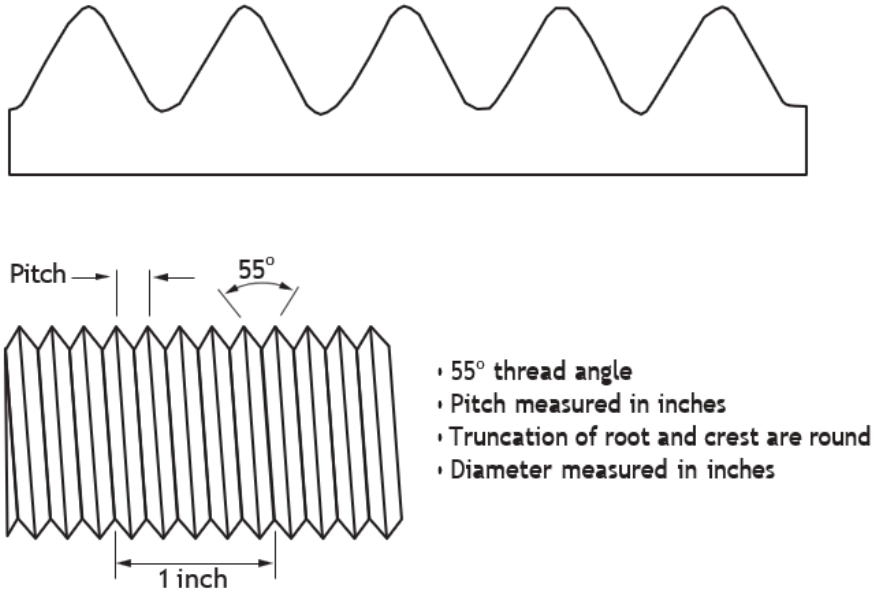


Figure 145 *ISO Thread (British Standard Thread) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Especially precise threads are known as ***dry fit (or dry seal)*** meaning that no sealant is required for a gas-tight seal. Such threads are designed to ANSI/ASME standard B1.20.1 and are needed where a sealant would contaminate or react with the contents inside the piping (i.e., oxygen service).

Tapered threaded fittings are most commonly found in conjunction with carbon steel and other metallic pipe but are also used on plastic piping.

Due to the ***interference fit (wedging effect)*** of the tapered thread, extreme care must be used to avoid over-tightening a plastic joint. The over-stressed female fitting may split days, weeks or even years after initial installation.

Table 3: NPT and ISO Pipe Thread Sizes, Dimensions, and Thread Characteristics

Nominal Size	Threads Per Inch	Pipe OD	Pipe ID	Thread Angle	Pitch
$\frac{1}{8}$ **in.**	NPT **27**/ISO **28**	0.405 in.	0.269 in.	60°/55°	0.037 in./0.036 in.
0.25 in.	NPT **18**/ISO **19**	0.540 in.	0.364 in.	60°/55°	0.0556 in./0.053 in.
$\frac{3}{8}$ **in.**	NPT **18**/ISO **19**	0.675 in.	0.493 in.	60°/55°	0.0556 in./0.053 in.
0.5 in.	NPT **14**/ISO **14**	0.840 in.	0.622 in.	60°/55°	0.0714 in./0.071 in.
$\frac{3}{4}$ **in.**	NPT **14**/ISO **14**	1.050 in.	0.824 in.	60°/55°	0.0714 in./0.071 in.
1 in.	NPT **11.5**/ISO **11**	1.315 in.	1.049 in.	60°/55°	0.087 in./0.091 in.
1 $\frac{1}{4}$ **in.**	NPT **11.5**/ISO **11**	1.660 in.	1.380 in.	60°/55°	0.087 in./0.091 in.
1 $\frac{1}{2}$ **in.**	NPT **11.5**/ISO **11**	1.900 in.	1.610 in.	60°/55°	0.087 in./0.091 in.
2 in.	NPT **11.5**/ISO **11**	2.375 in.	2.067 in.	60°/55°	0.087 in./0.091 in.

Steel Pipe Nominal Dimensions for Standard Weight (Schedule 40) Pipe

Pipe size is specified with two non-dimensional numbers: Nominal Pipe Size (NPS) for diameter (based on inches) and pipe schedule (Sched. or Sch.) for wall thickness. ***Nominal Pipe Size (NPS)*** is loosely related to the inside diameter of

Schedule 40 pipe. NPS is used for referencing pipe sizes from 3 mm ($\frac{1}{8}$ in.) through 30 cm (12 in.), respectively.

Because of the pipe wall thickness, the actual diameter of the threads is larger than the NPS. Other schedules of pipe have different wall thickness, but the OD and thread profile remain the same, so the inside diameter of the pipe is therefore different from the "nominal" diameter.

Most threads are right hand, which means the fitting is screwed on to the threaded pipe in a clockwise motion. Other threads are left hand, in which case the fitting is screwed onto the threaded pipe with a counter-clockwise motion. Unless a thread is designated otherwise, it is assumed to be right hand.

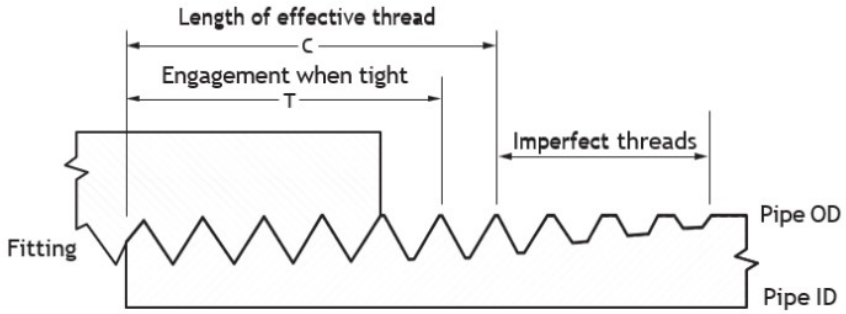


Figure 146 *Thread Engagement (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Considering that 7 to 8 threads are engaged when a pipe is screwed to a fitting (a few more for pipe sizes larger than 32 mm (1 $\frac{1}{4}$ in.), the approximate thread engagement can be measured or calculated for the various sizes of pipe. This will be useful in determining the length of pipe to cut when the centre-to-centre measurement between two fittings is known.

Pipe Taps

Pipe taps are used to cut or repair internal pipe threads. The process is called *tapping* and is usually done by hand, using a special wrench to hold and turn the tap.

Figure 147 *Pipe tap (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The pipe tap cuts standard tapered internal pipe threads. The diameter and pitch are usually stamped on the ***shank (shaft)*** of the tap.

The ***flutes (grooves)*** on a tap provide a space between the cutting edges to catch metal chips. The square end of the tap provides a sturdy grip for the tap wrench. Before attempting to tap new threads in a bare hole, taper the hole (with a taper pipe reamer) to properly shape the hole.

Pipe Dies

Dies are used to cut the *external* threads on pipe and fittings. The process is known simply as *threading*. A die head holds the cutting dies in place. A handle is mounted on the die head, often with a ratchet assembly for convenience and ease of operation and then turned to form the threads.

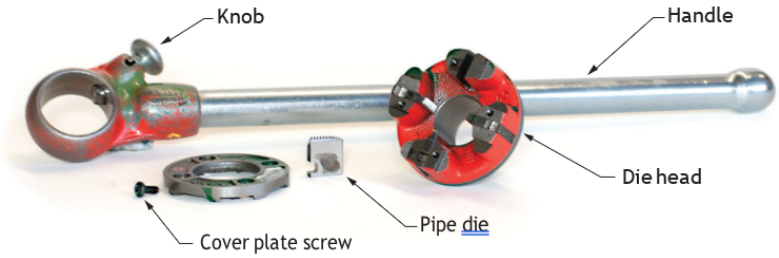


Figure 148 *Drop head threader with ratchet handle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Dies have flutes or spaces between the cutting edges to provide space for metal chips to escape during the threading operation. They also have an angle notched into the front of the die, called the ***lead angle***, which allows the dies to start easily on the work piece.

There are two main types of dies, full width dies and receding

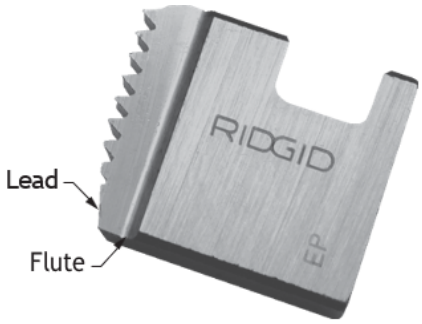


Figure 149 *Full width die (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Full Width Dies

Full width dies are equal to the length of the thread to be cut. The die moves along the pipe as it cuts the thread, and when the outer edge of the die is flush with the end of the pipe, the thread is complete. This applies to taper threads only. Full-width dies are used for threading smaller pipe sizes, where less effort is required.

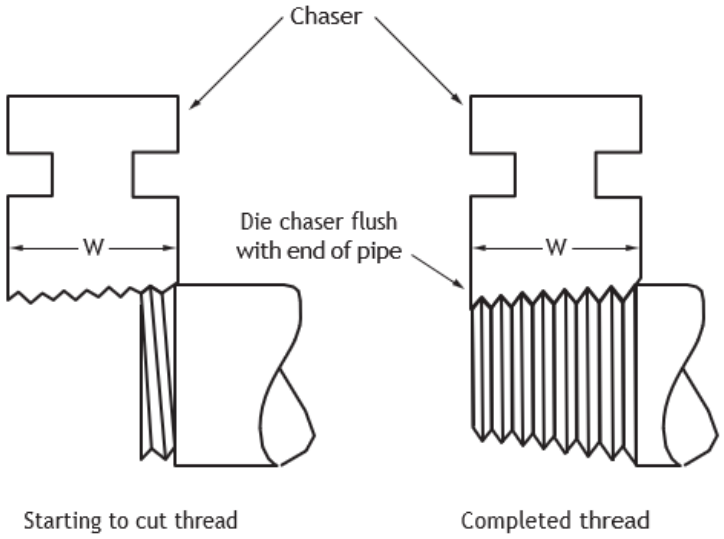


Figure 150 *Full width dies (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Receding Dies

Receding dies have considerably less width than the length of the thread to be cut. The die must travel along the pipe to cut the thread, and as the die moves along the pipe, it must recede from the centreline of the pipe in order to cut a tapered thread.

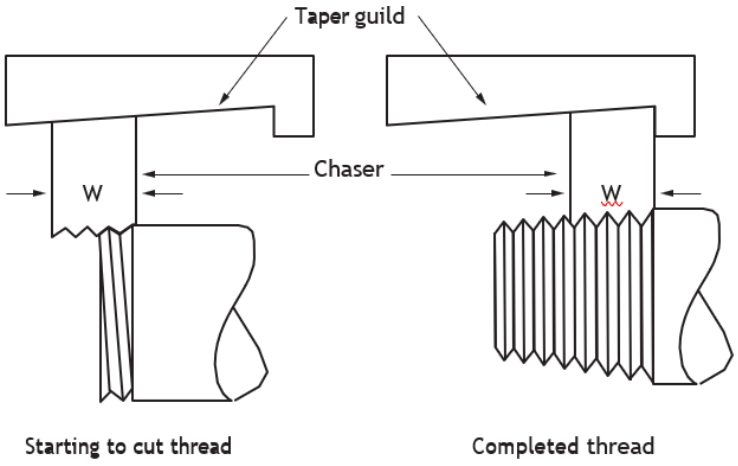


Figure 151 *Receding dies (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Receding dies are usually used to thread larger pipe where there is considerable surface area to cut.

Hand Threaders

The ratchet type of ***threader*** is preferred to other hand methods because the worker's body weight can be used to turn the full width dies while standing to one side of the pipe.

Drop head threaders are quick and easy to use for small jobs or in close quarters. The dies are interchangeable between similar pipe pitches.

Exposed Ratchet Drop Head Threader

The ***exposed ratchet drop head threader*** may be more widely used than the enclosed type. It is designed for pipe sizes ranging from 3 mm to 5 cm ($\frac{1}{8}$ in. to 2 in.). The die head locks into the ratchet and handle assembly and is removed by pulling out the reversible ratchet knob.

Enclosed Ratchet Drop Head Threader

With the enclosed ratchet drop head threader, the die head snaps into the ratchet from either side and is easily removed by pushing it out from the body. The ratchet is enclosed within the head of the ratchet handle. The pipe size capacity of this style is from 3 mm to 32 mm ($\frac{1}{8}$ in. to $1\frac{1}{4}$ in.).

Figure 152 *Exposed (left) versus enclosed (right) ratchet handles and drop head dies* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

In both the exposed and enclosed models, the dies can be reversed when threading in tight locations.

Drop head threaders can also be used with *power vises* (a machine used for turning pipe).

Jam-proof Ratchet Threader

The ***jam-proof ratchet threader*** uses receding dies and is useful for threading pipe between 2.5 cm to 5 cm (1 in. to 2 in.) in size. It uses one set of dies to thread different pipe sizes, and it is "jam-proof" (meaning that it will kick out automatically to prevent damage caused by dies receding past their limit after the thread is completely cut). This hand threader is often used as an attachment on power vises.

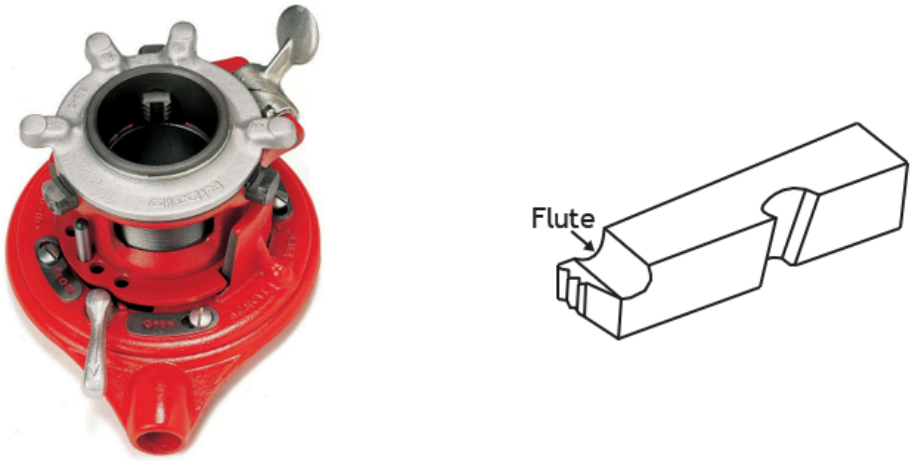


Figure 153 *Jam-proof ratchet threader and receding die* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Geared Pipe Threader

The ***geared pipe threader*** is mainly used with a power vise. It uses one set of high-speed dies for threading several sizes of pipe. A selector plate quickly sets the dies and work holder to the desired pipe size. By making adjustments, the geared threader can cut straight or tapered threads, as well as oversized or undersized threads.

The Model 141 geared threader cuts threads for pipe sizes 6 cm to 10 cm ($2\ \frac{1}{2}$ in. to 4 in.) and the Model 161 threads 10 cm to 15 cm (4 in. to 6 in.) steel pipe.

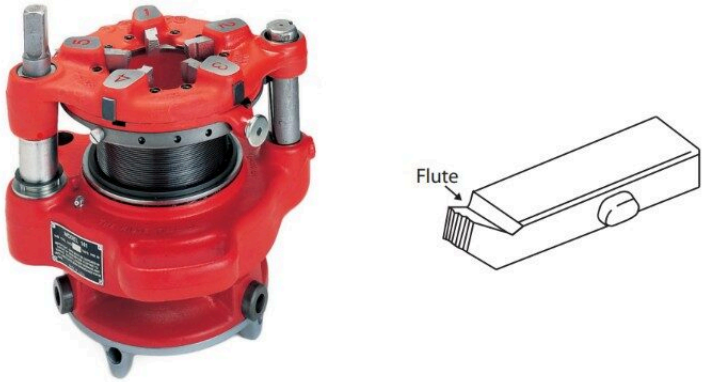


Figure 154 *Geared threader and receding die (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Geared threaders can be driven by hand with a ratchet handle (not recommended), or by power equipment.

Figure 155 *Ratchet handle for geared threader (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

A stationary power drive can be equipped with a drive shaft to power the geared threader, and there is also a hand-held power attachment available.

Thread Cutting Oil

To produce accurate work and smooth cuts, thread cutting oil (mineral oil) is used during a threading operation. The oil covers the pipe and the dies to reduce friction, cool both the chasers and the pipe, and flush away metal chips.

Thread cutting oils are either clear or dark and produce the same result when working with either power-driven or hand tools. The important ingredients include:

- Fatty oil to provide an even covering film on the workpiece
- Sulphur to supply a tough chemical film between the cutting edges and the threaded material
- Anti-foam agent to reduce surface tension and foam build-up
- Germicide to lessen the risk of infection should the operator be injured

Thread cutting oils should not be confused with the oils used to maintain the condition of tools. They are not meant to be used as lubricants for moving parts or machinery.

The hand-powered oiler provides the flow of oil to the workpiece and chasers during the threading operation. It contains a screened sump to receive oil, chips and materials, plus a hand-operated pistol-style pump to supply the oil as needed.

Occasionally the chip tray needs to be emptied of scrap material and the oil level should be maintained as directed by the manufacturer. Deal with the disposal of chips, metal scraps and used oil accordingly. Consult your site supervisor for an approved disposal location.

Figure 156 *Hand oiler (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Roll Groovers

Roll grooving is a piping connection method that continually grows more in popularity. Using pressure on a set of rollers that track the circumference of the pipe, grooves are formed to match strict specifications.

Using matching fittings and shoulder-style couplings with a gasket, grooved joints can be found in fire sprinkler systems, heating and cooling distribution, and water mains.

Figure 157 *Grooved joint (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hand-operated roll groovers are ideal for in-place field applications. Some models require only 89 mm (3 $\frac{1}{2}$ in.) of clearance to travel around a pipe and a minimum of only about 76 mm (3 in.) of exposed pipe for grooving. With the appropriate roll sets, they can form grooves in the walls of many types of metallic pipe up to 30 cm (12 in.) in diameter. A must when performing service work, the hand-operated groover is available in several different styles. Most employ the use of a ratchet handle and can be adapted for use on a power vise as well.

Figure 158 *Hand Operated Roll Groover (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Check Your Knowledge: Tubing Benders and Hand Threading Tools

Complete the Complete the interactive knowledge test below.

If you are using a printed copy, you can scan the QR code with your digital device to go directly to the interactive knowledge test.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-30 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-30)

Electrical Testing Equipment

A technician is only as accurate as the measurement equipment being used. If the equipment is used incorrectly or is faulty, then the measurements will be inaccurate. If the measurements are inaccurate, then the technician will draw the wrong conclusions. To avoid getting inaccurate readings, you need to handle, use, and store meters properly.

The two major types of meters are digital and analog. Although both meters perform the same functions, they look different. As you can see, the difference is in the display unit.

Digital meters are usually simpler to use and are more accurate than analog meters and therefore have become more popular. We will focus on the ***digital multimeter* (DMM)**, as it is the most common type in use, although analog multimeters may still be preferable in some cases, for example when monitoring a rapidly varying value.

Figure 159 *Digital and analog multimeters (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Meter Safety Precautions

The proper care of test equipment and instruments is of utmost importance, whether they are analog or digital. The length of time an instrument retains its original usefulness, and accuracy depends largely on the care it receives in the hands of the user.

Improper connection can cause damage to the circuit or the test instrument and cause personal injury.

Precautions in Handling and Using a Meter

These precautions apply equally to digital and analog meters.

- Do not drop any meter.
- Do not overload any meter. When in doubt, use a high range that you know will not be overloaded. You can always switch to a lower range if necessary.
- Do not tamper with precision instruments. Let a competent instrument repair person service precision instruments.
- Before you connect a meter to a circuit, ensure that the range switch is set to an appropriate position.
- Carefully check circuit connections before applying power to meters.
- Be careful not to touch any other electronic components within the equipment.
- Be careful not to touch the probe tips to each other while connected to anything else.

Digital Multimeters

All ***digital multimeters*** combine the features of an ammeter, a voltmeter, and an ohmmeter. Figure 160 shows a typical DMM, although different models may have a different number of digits in the display unit and the input/output jacks may be in slightly different places. Since a DMM is an important tool, you will want to learn how to use one correctly

Figure 160 *Typical DMM (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The upper portion of the DMM houses the display unit. The middle portion of the DMM houses the function switch, and the bottom portion contains the jacks for test leads.

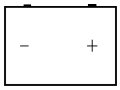
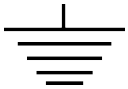
The function dial normally has positions that will allow a technician to measure AC volts, DC volts,

DC amps, and resistance. In addition, some DMMs have function switch positions that will allow a technician to measure AC amps and to test diodes and capacitors. Some DMMs require manual setting of ranges; others have an auto-ranging feature.

All DMMs may be used to measure voltage, current, and resistance. More advanced DMMs may measure frequency, relative power differences, or other important circuit parameters. Each measurement function has similarities and differences that you need to learn about.

Many meters will use symbols on the display, switch, and connections. Table 2 lists some of the common symbols you may see:

Table 2: ***Common DMM symbols***

AC	 Low Battery
DC	Manual range or automatic touch hold
Ohms	Continuity beeper
AC or DC	Diode
Hz Hertz	 Ground
+ Positive	Fuse
– Negative	Double Insulation
µF MicroFarad	Capacitor
m Milli	OL Overload
M Mega	

Mechanical Gauges

Analog Gauges

Gauges used for pressure testing may need to be of a type that can be calibrated—either by using a gauge tester or by comparison to a master gauge. These gauges are generally of the Bourdon tube type. The size of the dial face may be specified in the contract documents for the job. The accuracy of a manual reading increases with the size of the dial face.

The materials from which the gauge is constructed must be compatible with both the test fluid and the surrounding environment.

Bourdon Tube Gauges

The ***Bourdon pressure gauge*** uses the principle that a flattened tube tends to straighten or regain a more circular form in cross-section when pressurized (internally). Although this change in cross-section may be hardly noticeable, the strain of the material of the tube is magnified by forming the tube into a C-shape, so that the entire tube tends to straighten out or uncoil as it is pressurized. Eugene Bourdon patented his gauge in France in 1849, and it was widely adopted because of its superior sensitivity and accuracy.

Figure 161 *Pressure Gauge Measuring Psi and kPa (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Gauge stems (sockets) may be 6 mm or 13 mm ($\frac{1}{4}$ in. or $\frac{1}{2}$ in.) NPT, depending on the pressure range.

Figure 162 *Bourdon Tube Gauge (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Severe vibration or rapid fluctuations in pressure may cause gauges and recorders to give inaccurate readings. Circumstances may require the use of special devices or attachments to protect the gauge. Oil-filled gauges may be used on lines where vibration is not too severe. If pipe vibration is too severe, the gauge may have to be remotely mounted on a board and connected with a tube or hose to the test point.

Figure 163 *Oil-Filled Pressure Gauge (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Pulsation dampeners and snubbers (Figure 164) are devices that can be installed immediately upstream of a gauge to prevent damage due to pressure pulsation or pressure surge.

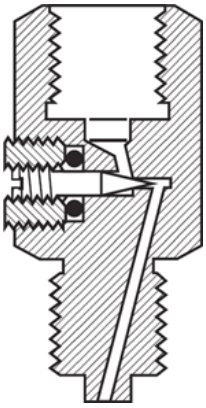


Figure 164 *Gauge Snubber* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Compound Gauges

A ***compound gauge*** indicates pressures above atmospheric (in psi) and vacuum pressures (inHg).

Figure 165 *Oil-Filled Compound Gauge* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Digital Gauges

Most digital gauges have precision within ±0.25% full scale accuracy and often measure positive, negative or differential pressures. The digital displays reduce the potential for errors in readings by eliminating errors commonly experienced with the inaccuracy of analog gages. Most units are powered by 12-24 DC and often have recharging capabilities as well. Keypads allow easy access to features including backlights, peak and valley readings, auto-zero and instant conversion of pressure units. Memory functions enable storage of multiple readings and often a HOLD key freezes the current pressure for situations where readings may fluctuate.

Figure 166 *Digital Pressure Gauge (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Manometers

The ***manometer*** is a measuring tool used to compare two different pressures, most commonly a system pressure and atmospheric pressure. There are two types of manometers, fluid-filled analog and digital. The analog manometer is simple, accurate, and reliable for measuring system fluid pressures. The analog manometer has no moving parts and does not require calibration. However, different fluids used such as mercury enable measurements of higher pressures but require further calculations.

Figure 167 *Fluid-Filled U-Tube Analog Manometer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Typically, an analog manometer is a u-shaped tube partially filled with liquid, such as water or mercury. One end of the tube is open to atmosphere (P^2) while the other end of the tube connects to the system in question (P^1) (Figure 168). When the system pressure acts upon the fluid, this force causes the levels in the manometer to change, as seen in the image below. By measuring the difference in levels, the technician accurately measures the system's gauge pressure. For example, if 'h' was 3.0 inches in length, the system pressure is 3.0 in. of water column. If the fluid were mercury, with a specific gravity of 13.6, this measurement would read 40.8 in. of water column (1.46 psig), or 13.6 times the measurement with water.

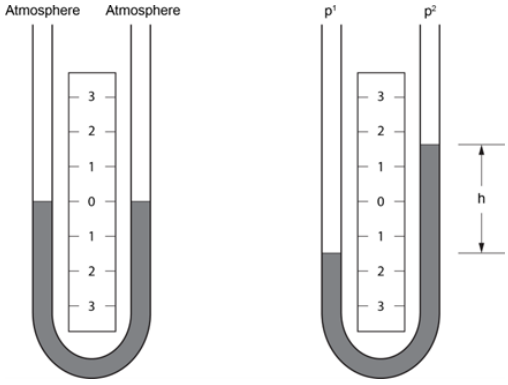


Figure 168 *Manometer basics (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The digital manometer has some advantages over the fluid-filled analog manometer: data storage to record multiple readings; multiple setting for higher pressures; technological compatibility for uploading data.

Supplementary Videos

The following BCcampus playlist includes short demonstrations of hand tools and equipment used in the trades. These videos were created by Camosun College to support the Trades Access Common Core – Tools and Equipment OER and provide practical examples of the tools discussed in this chapter.

Watch the playlist: Tools and Equipment Videos – BCcampus (https://media.bccampus.ca/playlist/details/0_3g8xp22x/categoryId/175673) [Playlist] by Camosun College

Self-Test B-1.1: Describe Hand Tools Used in the Pipe Trades

Complete Self-Test 1.1 and check your answers.

If you are using a printed copy, please find Self-Test B-1.1 and Answer Key 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://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-1 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2725#h5p-1)

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Camosun College. (2015). Trades Access Common Core Competency C-1: Describe Common Hand Tools and Their Uses. Victoria, B.C.: Crown Publications. Download for free from the B.C. Open Textbook Collection (https://open.bccampus.ca/browse-ourcollection/find-open-textbooks/).

Camosun College. (2022). Tools and Equipment Videos [Video playlist]. BCcampushttps://media.bccampus.ca/playlist/details/0_3g8xp22x/categoryId/175673

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All RIDGID tool images are used with permission from Emerson Professional Tools. Some of these images may have been carried forward from SkilledTradesBC learning resources; however, permission has been obtained directly from Emerson Professional Tools for their use here.

- **Figure 2** Compass saw (https://commons.wikimedia.org/wiki/File:Cassells_Carpentry.81-82_compass_n_pad_saws.png) is by Cassells' Carpentry and Joinery on Wikimedia and is in the Public Domain. (https://en.wikipedia.org/wiki/Public_domain)
- **Figure 130** Robertson screwdriver, (https://pixabay.com/photos/tool-screwdriver-manual-repair-7037516/) by Vijesh Panchal on Pixabay is used under the Pixabay Content License. (https://pixabay.com/service/license-summary/)
- **Figure 131** Phillips screwdriver, (https://www.freepik.com/free-photo/screwdriver_922730.htm) by kjpargeter on Freepik is used in alignment with the Freepik Terms of Use. (https://www.freepik.com/legal/terms-of-use)
- **Figure 132** Ratchet screwdriver (https://commons.wikimedia.org/wiki/File:Screwdriver_set_with_great_variety_of_bits_and_ratchet_screwdriver.jpg), by Pittigrilli on Wikimedia commons, is used under a CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/) license.
- **Figure 136** Allen screwdriver, (https://pixabay.com/photos/allen-wrench-tool-allen-key-allen-2134714/) by Ralph on Pixabay is used under the Pixabay Content License. (https://pixabay.com/service/license-summary/)

B-1.2 Use Hand Tools

While reading through the material, pay special attention to the safety precautions required when using hand tools.

Use Cutting Tools

Cutting tools have sharp edges that must be well maintained and handled carefully to avoid injury.

Hacksaws

When you attach a hacksaw blade to the frame, be sure the blade is placed on the pins with the arrow on the blade pointing forward, away from the handle. If the arrow is not visible, ensure that the teeth of the blade face forward because all cutting is done on the forward stroke.

There is no such thing as an all-purpose hacksaw blade. The right blade must be chosen for the specific job. The hardness and thickness of the material will determine the blade you should use.

A good rule to remember in choosing the right blade is to be sure that at least three teeth of the blade are in contact with the material being cut at all times. For materials such as wood, it would be recommended to use a 3-10 pitch blade (low TPI) Materials, such as copper may require an 18-24 pitch saw blade (high TPI).

Proper Use of a Hacksaw

Your technique is important when you use a hacksaw because the teeth are extremely fine, and the blade tends to be brittle.

1. Be sure the material to be cut is held securely in a vise or C-clamp. Secure the workpiece low in the vise. If the material shifts while you are attempting a cut, the blade may break or the material may be damaged. Be sure that the blade is held tightly in the hacksaw frame to prevent any wandering or warping of the blade during the cutting stroke.
2. Never start a cut with the saw held at a sharp angle to the material. This will break or dull the blade's teeth and also doesn't allow for at least two teeth contacting the material at all times.

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

3. Grasp the hacksaw securely, with one hand on the grip or handle and one hand on the front of the frame. In starting the cut, guide the blade back toward you with your thumb guiding the side of the blade until the cutting slot is established (repeat this a few times). However, remember that, like a file, a hacksaw cuts only on the forward stroke—drawing the blade back is only done to accomplish a starting kerf.
4. Use a little downward pressure on the forward stroke but lift the saw slightly on the return stroke so that the teeth barely touch the material being cut.
5. The stroke should be long and steady, employing practically all the teeth on the blade. A lighter pressure should be used on soft metals and thin materials than that used on hard metals and heavier materials. Insufficient pressure on the forward stroke will dull the teeth by rubbing them against the metal without cutting it.
6. To ensure the saw blade moves in a straight line, keep your shoulder, elbow and forearm in line with the saw. This alignment is important to avoid any twisting or wobbling of the blade.
7. Do not rush when using a hacksaw. Most beginners saw too rapidly. Approximately 60 forward strokes per minute is a maximum. An ideal rate is 40 to 60 forward strokes per minute, with even pressure. If you rush the cut, you may damage the material or create injury to yourself or others.

Wood Handsaws

It is important to select the correct saw based on the direction of grain for the wood you intend to cut.

Figure 2 *Wood handsaw (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Using a Crosscut Saw

The following is the procedure for using a crosscut saw:

1. Mark the length of the board to be cut.
2. Square the line across the board, using a square.
3. Hold the saw at 90° to the board and about 45° from the floor.
4. Place the saw on the waste side of the line. Half the line should be left. Cutting on the wrong side will make the piece too short.

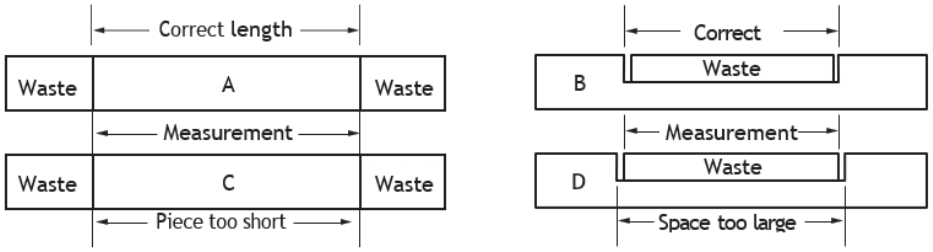


Figure 3 *Cutting on the Waste Side of the Line (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

5. Hold the knuckle of your thumb against the side of the blade. This helps to guide the first few strokes when you start a cut.
6. Start the cut gently and follow the line.
7. As you cut, keep your shoulder, elbow and wrist in line with the back of the saw blade.
8. Do not exert more pressure than you need. If too much is used, the saw may buckle, jump, and cut the operator's hand.
9. Use the full length of the blade to make the cut. Do not force the saw. Make long, smooth cuts.
10. Support the waste stock near the end of the cut. Slow down and shorten the length of the stroke. This prevents splitting the wood.

Using a Ripsaw

Using a ripsaw is similar to using a crosscut saw, except that the larger teeth can cause the saw to buckle more easily. As well, the wood may tend to bind the saw even though the saw has a good set.

The cause lies in the wood itself. When wood is split lengthwise, some of the tensions inside are released, and those remaining in the wood may make the edges want to move toward or away from each other. If the wood binds the saw in a cut, place a wedge at the start of the cut and move it as necessary.

Files

Different kinds of files are used to get the best results with different types of metal. All files are classified in two ways; by shape and by cutting face.

Shapes

The two commonly used shapes of files are the flat file and the half-round file.

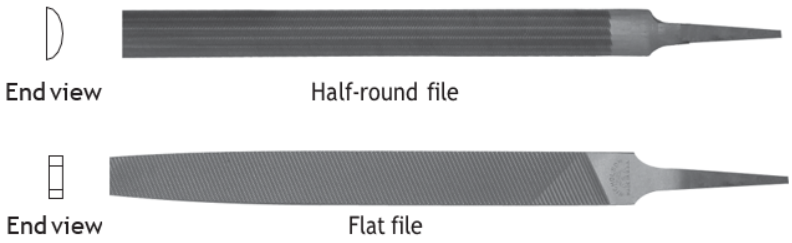


Figure 4 *File types (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The half-round file is used in pipe welding when putting the *landing* on the pipe and for removing slag and burrs. The flat file tapers at the point and generally has teeth on both edges. Flat files are used for general-purpose filing and for ***draw filing***.

Cutting Faces

Remember that ***cutting faces*** are classified according to the design of the cutting and according to the grade of their teeth. There are three designs of cutting face, the single-cut, the double-cut and the curved tooth.

These were covered in detail in Learning Task 1: Files.

File Handles

Files are sold without handles, so the first step in using a file is to fit it with the proper handle. Always select a handle that fits the file, neither too large nor too small for the file tang. File handles should have a strong *ferrule*, or metal collar.

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

There are two excellent reasons for using a file handle on all files. The first and most important is your safety. The tang

of a file is usually pointed. If you meet an obstruction while filing and the file stops suddenly, your hand could be severely punctured. Second, the handle helps guide the file and the work can be done more accurately and more quickly.

Filing Technique

If you are new to working with files, take your time and check your work frequently in order to do the job correctly. Some very common mistakes are:

1. Rocking the file from left to right as the material is being filed. This will create a curved rather than a flat surface.
2. Bearing down too hard in the middle of long cuts, thereby creating a dip in the middle of the material.
3. Filing for too long without checking the material. Frequent checks will help you detect incorrect filing methods and prevent you from removing too much material.
4. Filing with arm movement only. Your body should lean forward slightly during the forward stroke, then return to an upright position during the backward stroke.

Your workpiece should be placed in a bench vise. If it is a soft material such as aluminum, you should protect the workpiece by placing pieces of wood, plastic or soft metal between the vise jaws and the workpiece. Always wear eye protection during filing operations.

When moving the file across any work, hold the file as shown and move it straight ahead or at a slight angle. Hold it so that the handle end fits into the heel of your hand, with your thumb lying along the side of the file. Your forearm and the file should form a straight line.

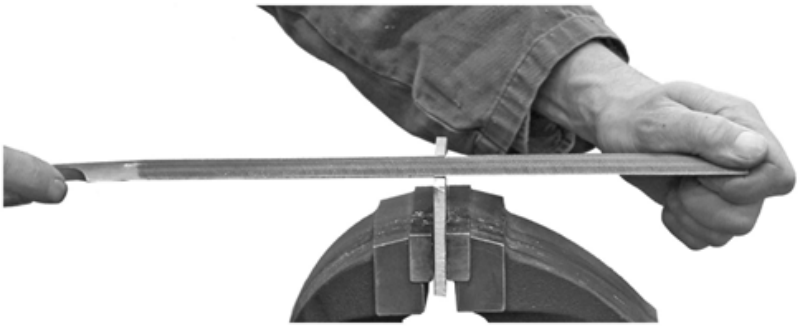


Figure 6 *Proper filing technique* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Hold the point of the file with your thumb and first two fingers of the other hand. For heavy filing strokes, the whole underside of your thumb should press down. On lighter strokes, place your thumb more at a right angle to the file.

When filing a piece of material, frequently stop and check your work for even cutting and squareness. If you are filing incorrectly or at the wrong angle, you will discover the problem before the material has been ruined.

Figure 7 *Checking for square (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

An accurate method of checking your work for even cutting is by using a steel square. Hold the body of the square firmly against one edge of the material and check that no clearance is visible between the bottom of the blade and the top edge of the material. If clearance is visible, your filing methods are incorrect.

Draw Filing

Draw filing is used to finish a smooth surface by removing only small amounts of material at a time. Generally, a single-cut file is used for this operation. When filing pipe however, it may be preferable to use a double-cut file.

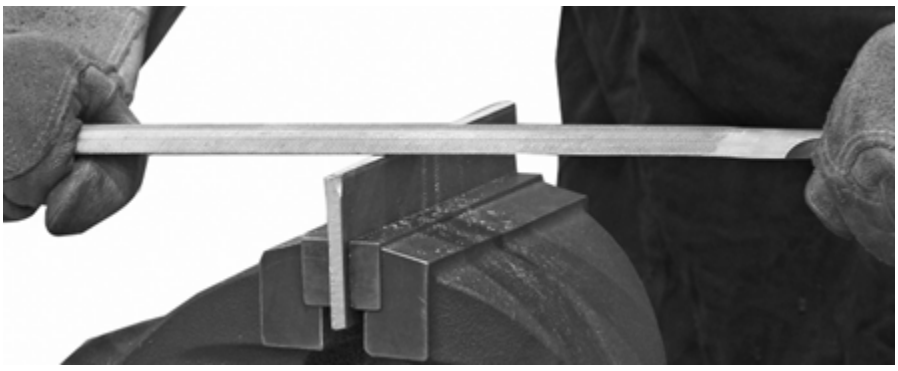


Figure 8 *Draw filing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

To draw file, hold the file in both hands with your thumbs approximately 13 mm to 38 mm ($\frac{1}{2}$ in. to 1 $\frac{1}{2}$ in.) from each side of the material being cut. Then either push or pull the file straight across.

Raise the file slightly on the backstroke, as with ordinary filing. In the case of such soft metals as aluminum, brass, copper or lead, you can apply pressure on the backstroke without damaging the file.

With different grades of files, the angle at which the file is moved across the material will vary slightly, depending on the type of material being cut.

Maintenance of Files

Before starting any filing operation, especially the filing of mild steel or soft non-ferrous metals, coat the file with chalk. The chalk acts as a dry lubricant and prevents metal cuttings from becoming pinned or trapped in the teeth of the file.

Metal particles trapped in the teeth of a file not only reduce the file's ability to remove metal from the workpiece but may also cause damage to the surface of the workpiece.

As soon as you notice a build-up of particles on your file, brush them off with a file card. A file card has wire bristles on one side and fibre bristles on the other.

Figure 9 *File card (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Begin cleaning the file with the fibre bristles. If particles remain, remove them with the wire bristles.

Sometimes after filing soft metals such as aluminum, copper and lead, filings will remain stuck between the teeth even after you have used the file card. If this happens you should use a sharp, pointed piece of hard wood or soft iron to pick the remaining filings from between the teeth.

Never use a piece of hardened steel (such as a pointed punch or chisel) to pick file teeth clean as the tempered steel can damage the teeth.

Storing Files

More files wear out from abuse than from use. To maintain files while they are not being used, keep them separated from each other and from other tools to prevent damage to the file teeth.

A simple method for safely carrying your files in a tool box (or any place for that matter) is to fold a piece of cardboard into an accordion shape. Each fold should be just wide enough to entirely cover the file blade. Place a file in each

fold of the cardboard and fold the accordion together. Use heavy elastics or strips of inner-tubing to secure the file compartment.

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

Once your files have been securely wrapped, always store them in a dry place. Rust will adversely affect the cutting edge of file teeth.

Chisels

Select the appropriate chisel for the material being cut.

Cutting with Wood Chisels

Almost all wood chisels should be driven with a wooden mallet. The exception is the framing chisel, which can be driven with a steel hammer. All work should be held firmly in place, either in a vise or with a bench hook. All cuts should be with the grain of the wood, not against the grain. The blade should be angled for a slicing action instead of cutting square across.

Keep both hands back of the cutting edge. Do not cut toward yourself; always cut away from yourself. Never hold the work in one hand and the chisel with your other hand. Never chisel toward another person. Wear safety glasses when making heavy cuts with a hammer. Keep the chisel sharp at all times.

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

Cutting With Cold Chisels

Cutting with a cold chisel is a quick and efficient method of removing surplus metal on mild steel up to 3 mm ($\frac{1}{8}$ in.)

thick. In this type of cutting the workpiece is held in a vise, and the metal is sheared between the sharpened edge of the chisel and the edge of the stationary jaw of the vise.

It is important that the chisel be held correctly; otherwise, a rough or badly twisted job will result, and both the chisel and vise may be damaged. The bottom face of the chisel should be flat against the jaw of the vise, and the chisel must be angled to achieve a clean shearing action.

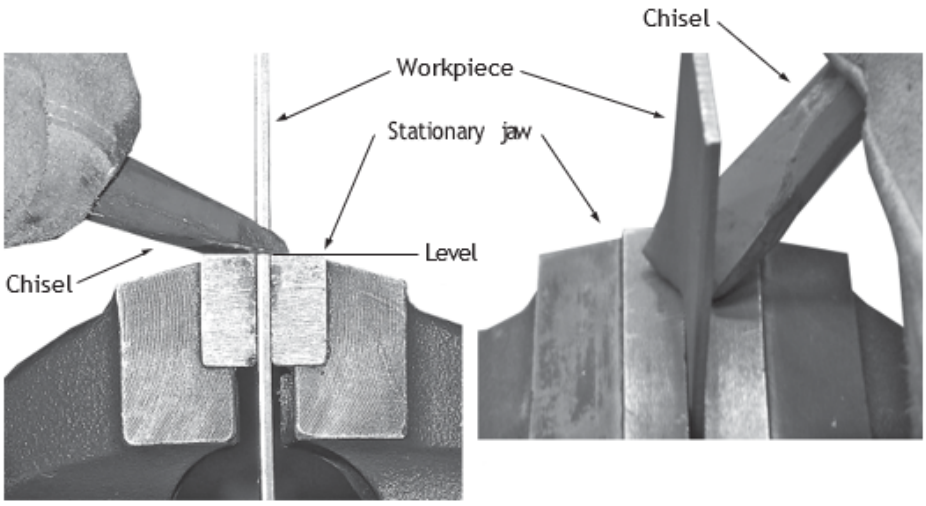


Figure 12 *Correct use of chisel (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Never try to cut from the end of the metal, as illustrated.

Figure 13 *Incorrect use of chisel (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

You can control the depth of the cut by raising or lowering the angle of the chisel. As you approach the end of a cut, strike the chisel lightly because a hard blow could cause the metal to fly off and injure someone nearby.

If you are right-handed, you should hold the chisel in your left hand and use your right hand to swing the hammer, or your left hand, if you are left-handed.

Never grip the chisel too tightly. A poorly aimed blow that misses the chisel could seriously injure your hand.

***A note about* PPE**: Always wear goggles or a face shield when you are using a chisel!

Always select a chisel large enough to do the required job. Chisels are usually struck with a hammer that weighs from 340 g to 900 g (3/4 lb. to 2 lbs.). A large hammer should be used with a large chisel.

Inspection, Maintenance and Storage of Chisels

Regularly inspect chisels for damage. Common conditions are shown here. The head of the damaged chisel, as compared to the undamaged chisel as shown has become mushroomed and the cutting edge has become nicked and dull with prolonged use. When this happens, the chisel must be dressed (cleaned up or repaired) before it can be used again. Mushroomed heads can be extremely hazardous.

Figure 14 *Damaged (left) and undamaged (right) chisel heads – can the right image's description be 'damaged chisel head'? (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Five basic rules for dressing chisels:

1. The tool must be returned to its original shape. Check an undamaged tool to determine the original shape.
2. All cracks and spalls (chipped areas) must be removed. Some cracks cannot be seen with the naked eye. If possible, use a magnifying glass for a closer look.
3. The grinding temperature must be kept low. The material should not turn yellow or a blue/purple colour. If the grinding temperature is not controlled, the hardness of the area that is being ground can be lost, making it hard,

brittle and easily fractured. Generally, chisels are heat-treated (hardened) approximately 38 mm (1 $\frac{1}{2}$ in.) back from the cutting edge. The grinding of the chisel should be kept well within these areas.
4. A medium or fine grit grinding wheel should be used.
5. The wheel rotation should always be away from the cutting edge, toward the body of the tool. This positioning of the tool directs heat away from the cutting edge.

When a tool has been damaged and redressed many times, it loses many of its original qualities and becomes unsafe.

Always store a chisel in a dry tool box or wrapped in a clean, dry rag. Protect the edge from damage; often manufacturers supply a protective cap to keep the chisel's edge, which is ideal.

Pipe Cutters

The following procedures for using different types of pipe cutters are general. In actual practice, you may find it difficult to follow these steps exactly. You should, however, aim to follow them as closely as possible.

Procedure for Cutting Steel Pipe

The following procedure describes cutting steel pipe:

1. Set the piece of pipe to be cut in a vise on a workbench or tri-stand.
2. Ensure the pipe end rests level in the vise. If necessary, use a pipe support stand to keep the pipe level and properly aligned.
3. Measure and mark the pipe to the desired length. (Use pencil, chalk or soapstone.)
4. Secure the pipe in the vise. The jaws of the vise should grip the pipe firmly, but not to the point where the teeth of the jaws dig excessively into the pipe. Too much pressure will result in a deformed, out-of-round pipe.
5. Select the correct type of cutter for the job. Inspect the cutter wheel to make sure it is:
    - Not damaged
    - Sharp
    - Designed both for the cutter and the material to be cut
6. Open the cutter jaws by turning the feed handle. Place the cutter on the pipe so that the rollers are in contact with the pipe.

It is important that the cutter rollers are against the pipe before you begin the cut. This ensures that the cutter will remain steady and square during the cutting operation.

Figure 15 *Position the pipe cutter (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

7. Turn the screw handle until the cutter wheel touches the pipe. Then gently engage the cutter wheel by turning the feed screw one-quarter of a turn.
8. Rotate the cutter a full 360° around the pipe so that the cutter wheel cuts a light groove.

Figure 16 *Lightly tighten and rotate pipe cutter (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

9. Check the groove to see if it *tracks* into the original starting groove. If it tracks, you will have a good cut. If it does not, the result will be a spiral groove on the pipe, not a cut.
10. When a true track is obtained, tighten the feed screw one-quarter of a turn and rotate the cutter around the pipe.

Continue to tighten the feed screw at each turn until the pipe is cut.

As well as steadying the cutter, the rollers "roll down" the burrs that the cutter wheel creates on the outside of the pipe.

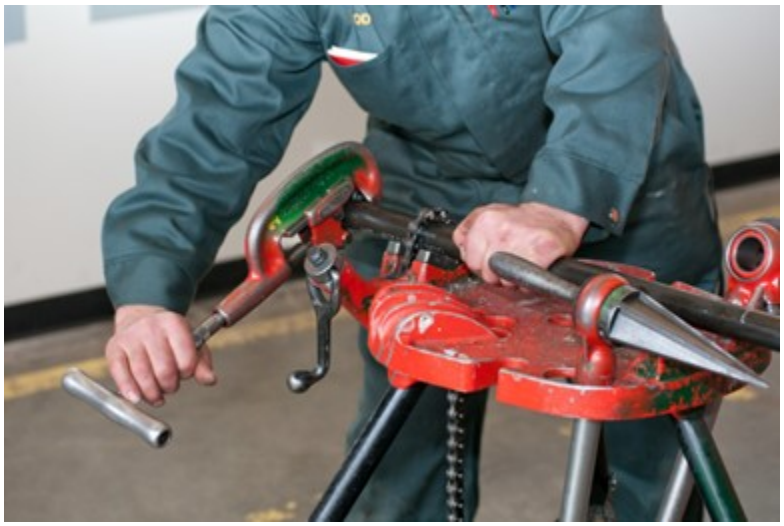


Figure 17 *Continue tightening and rotating (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Procedure for Cutting Copper Tube

The procedure for cutting copper tubing is similar to that of cutting steel pipe. Here are a few of the differences:

1. Some tubing cutters use a screw to anchor the rollers to the body of the cutters. When using these types of cutters, the rotation of the cut must be correct to ensure that the roller screw does not loosen and eventually fall out. Often, it is better to allow the handle of the cutter to *lead* the cut. Check the tension on any adjustable parts regularly.
2. When measuring tubing, it can sometimes be advantageous to quickly score the tubing at the required length with the back of a blade reamer (if the cutter being used is equipped with one), instead of using a marking pen each time. This can save a lot of time when taking multiple measurements.

Figure 18 *Cutting copper tube (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Maintenance of Pipe Cutters

Follow these guidelines to ensure safe operation and a long life for pipe cutters:

- Periodically use a cleaning solution and a wire brush to clean the main parts of the cutter: the feed screw, the slide, the rollers and the cutter wheels.
- Use a suitable lubricating oil to thoroughly lubricate the feed screw, the slide, the rollers, and the cutter wheels. (Do not use thread cutting oil.)
- Inspect the cutter body, the feed screw, and the rollers for damage. Examine the tool for true tracking and sharpness of the cutter wheels. Replace any worn or damaged part of the tool, including the cutter wheels.
- Hang the cutters in a dry, warm place, if possible.

Using a Soil Pipe Cutter (scissor and ratchet)

No vise is required for cutting soil pipe, as cutting is usually done on the ground or on the shop floor.

1. Measure and mark the pipe to the length desired using chalk or soapstone.
2. Position the cutter on the mark.
3. Wrap the cutter's chain around the pipe. Tighten the chain using the hand wheel adjuster (Make sure the cutting chain is at right angles to the pipe.)

Figure 19 *Tighten the chain* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

Figure 20 *Apply quick downward pressure* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

Figure 21 *Pump the ratchet handle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

4. Pump the ratchet handle of the cutter until the pipe separates. If using the squeeze handle (scissor) type, squeeze the handles until the pipe separates.

Procedure for Cutting Glass Pipe (Internal Cutter)

The following procedure describes use of an internal glass pipe cutter:

1. Measure length of pipe required and mark glass with a pencil, grease crayon or felt marker.
2. Insert cutter head into pipe with the cutter wheel facing up.

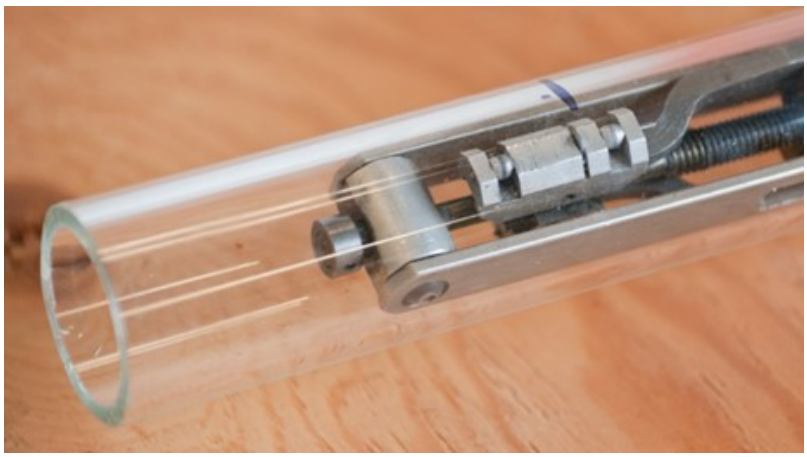


Figure 22 *Positioned in place (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

3. Slide the centring cone into the pipe until it seats against either the cut or beaded end.

4. Slide position collar against cone, align cutter wheel with distance mark on pipe and then lock ring stop using positioning thumb screw.

Figure 23 *Lock the position of the collar (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

5. Turn tension adjustment knob clockwise until cutter wheel contacts glass. Double check alignment of cutter wheel with mark on pipe. Note that the follower wheel does not assist in the scoring of the pipe, but it is required to assist in tensioning the cutter head.
6. Continue to turn tension knob clockwise to give sufficient pressure on cutting wheel to score the glass (a medium to light score is desirable on $1\frac{1}{2}$ in. to 3 in. pipe; use a heavy score on 4 in. pipe and larger).
7. With pipe firmly pressed against centring cone (and cone against position collar), make a test score about 4 mm ($\frac{1}{4}$ in.) long. Make final adjustments to tension knob, if required.

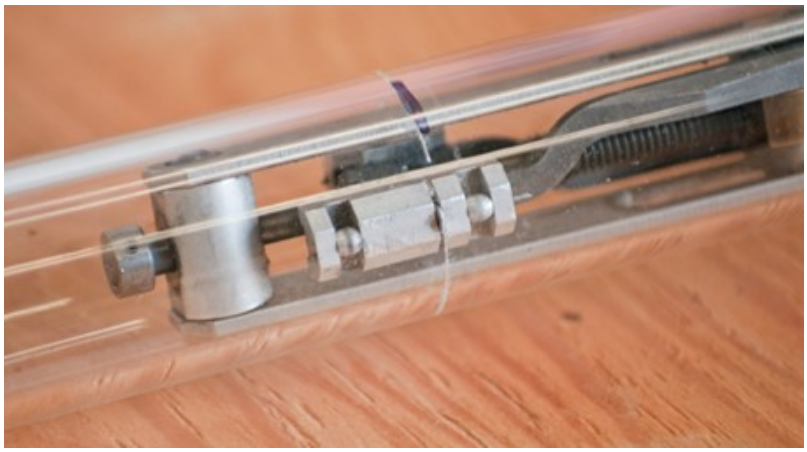


Figure 24 *Scoring the glass (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

8. Complete score around pipe by turning shaft one complete revolution—avoid scoring beyond the closing point of the circle of the cut.

9. Turn the tension knob counter-clockwise to draw the cutter wheel away from the inside wall of the pipe. DO NOT drag the scoring wheel against the pipe when removing the cutter.
10. Apply heat from a torch on score mark. As pipe begins to separate, follow score mark with flame. It may be necessary to tap the piece slightly to assist in separation of the two halves.

Figure 25 *Heat to separate (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

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

11. A plain-end coupling can now be used to transition the cut piece of pipe to a beaded fitting, a factory-beaded pipe, or another plain-cut end of pipe.

Reamers

As you learned in Section B-1.1 (#chapter-b-1-1-describe-hand-tools-used-in-the-pipe-trades), reamers are used for

deburring the inside of cut pipe to allow for full fluid flow. Reamers are made for pipe sizes from 3 mm to 10 cm ($\frac{1}{8}$ in. to 4 in.).

When using a reamer, the burr is only to the full bore of the pipe. Do not make the pipe wall thinner than it was manufactured.

To use either type of reamer as a hand tool, a ratchet handle is inserted onto the unit. To start the operation, centre and rotate the reamer slowly to allow it to align with the pipe's bore. Next, use the ratchet handle to apply pressure to the flutes and to turn the tool clockwise. The feed should be steady and rapid.

Pull back on the handle to remove the reamer. Inspect the interior pipe wall visually to determine if the burr has been removed.

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

Hand reamers can be used in conjunction with power vises, as seen below.

Never use a spiral hand reamer with a power vise, because it bites deep, and can jam.

Figure 28 *Using fluted hand reamer with power vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Maintaining Reamers

Follow these guidelines to ensure safe operation and a long life for the reamer:

- Clean the flutes of the reamer with a cloth or a wire brush.
- Inspect the edges and the grip for damage. If the flutes need regrinding, set the tool aside for professional repair.
- From time to time, feed lubricating oil into the ratchet mechanism in the handle.
- Store the reamer either in a toolbox or by hanging it up so that the flutes will not be damaged.

Chalk Lines

On a flat surface, a line can be marked using powdered chalk on a cotton cord. When the cord is "snapped" on the work surface, a dusting of chalk is left. Coloured or white chalk can be used.

The chalk line is fitted around a reel housed in a case. The powdered chalk is put into the case by removing a cap on the top face of the case. A metal ring with a hook is attached to the end of the line. The hook can be hooked over the end of a board or panel or onto a nail inserted for that purpose.

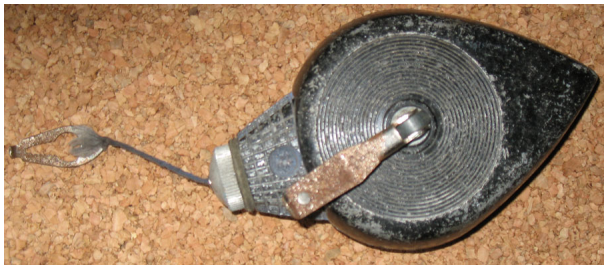


Figure 29 *Chalk Line (B. Askholm (https://commons.wikimedia.org/w/index.php?title=User:B._Askholm&action=edit&redlink=1), Wikipedia) CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0/)*

To use the chalk line, do the following:

1. On the work, mark the two points between which you want the line to be located.
2. Hook the ring over a nail or the end of the work, at the point where you want the line to start.
3. Pull the line horizontally out of the case, but do not allow it to touch the work.
4. Pull the line tight and place the end on the mark or past the point to be snapped.
5. With your other hand, lift the line straight up, about 100 to 150 mm; then allow it to snap down and a chalk mark will be left on the work.

Figure 30 *Lift the line* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

Figure 31 *Chalk Line* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

The following are other pointers on the use of a chalk line:

- If the line to be marked is very long, ask a fellow worker to hold down the line at the centre point, then snap the line on either side.
- When you chalk a line on a vertical surface, the line may sag. If so, use a nail to raise and support the line and ask a fellow worker to sight along the line to make sure it is straight.
- When the chalk line begins to fade, add more chalk powder to the case.

- Too much chalk in the case leaves a fuzzy line.
- Many chalk line tools have a shape that allows them to be suspended by their cord, thereby acting as a plumb bob.
- Some models have locking and quick release mechanisms as well as quick retrieve gear ratios to make them easier and quicker to use.

Wrap-around

When you have determined the length that a pipe is to be cut, a ***wrap-around*** can be used to make a straight, clean line around the pipe's circumference. This is especially beneficial if you aren't using a set of rotary cutters, but rather a high-speed cutting disk or an oxyacetylene cutting torch.

The following is a procedure for using the wrap-around:

1. Remove any varnish from the coating of steel pipe with a wire brush or a grinder equipped with a high-speed wire wheel.
2. Start by looping one end of the wrap-around around the pipe to one side of the mark and line up the edge of the short running end with edge of the longer rolled end.
3. Hold it snuggly between your hands as you slide it toward the mark on the pipe.

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

4. Holding the wrap tightly to the pipe, carefully tuck the short end on to the pipe and wrap the long end at least $1\frac{1}{4}$ times around the pipe in an over-lapping fashion.

Figure 33 *Overlapping (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

5. With the wrap-around tightly in place, draw a line with a sharp piece of soapstone around the pipe, using the boundary of the wrap as a straight edge.

Figure 34 *Mark around the pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hammers

Using a hammer correctly is important for reasons of safety. When using a hammer in conjunction with tools such as a cold chisel, incorrect usage could result in the cold chisel becoming a dangerous projectile.

The correct way to hold and use a hammer is illustrated below. To strike a heavy blow with the least effort, grip the hammer firmly, but not rigidly, near the end of the handle. Gripping the handle near the head reduces the force of the blow. Always strike the object with the centre of the face of the hammer. That way, you will protect the face edge from chipping as the blow is distributed over a larger area. All hammering should be started with light blows, followed by heavy blows, if necessary.

Figure 35 *Correct (left) and incorrect (right) use of a hammer (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

General Rules for Nailing Wood

Nail thinner pieces of wood to thicker pieces of wood. This provides more holding power. Stagger the nails so that they are not in line with the grain of the wood (to prevent splitting).

Do not drive nails too close to the edge of the wood. Keep them back a minimum of 20 mm, or a distance equal to the thickness of the material, whichever is less.

If the wood is very hard, and you encounter difficulty in driving nails, or if the wood is very narrow and tends to split, drill pilot holes that are slightly smaller than the nails being used.

Place the chisel point of the nail across the grain so that it will cut the wood fibres as it is driven in.

When nailing into the end grain of wood, drive the nails at an angle to provide more holding power. Provide solid support for the members. Members without proper support tend to bounce and cause nailing problems.

Do not use a hammer to strike the face of another hammer. This could cause a fragment of hardened steel to fly off and injure the operator or others. Use a small pry bar or nail puller to pull hard-to-remove nails.

Always wear eye protection equipment when using a hammer. Never use a hammer that has a loose head or a damaged handle. Injury can result if the head flies off or if the handle breaks.

Follow these guidelines to ensure safe operation and a long life of hammers:

- Keep your hammer clean at all times. A greasy or dirty hammer can be dangerous.
- Always use a hammer of the correct size and weight for the job.
- Never strike an object with the side of a hammer.
- Never strike hardened steel objects with a hammer, as this may cause chips to fly.
- Use wire brush to clean textured face.
- Regularly inspect handle for damage.

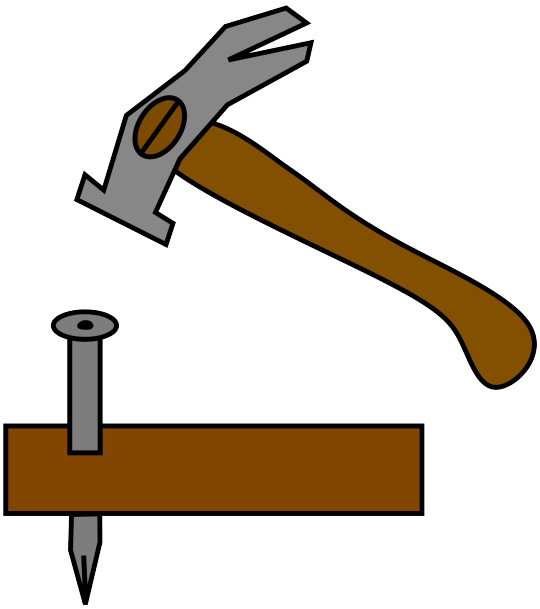


Figure 36 *Image by Bill Shortridge (https://pixabay.com/users/carvit56-9226797/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=7333333) from Pixabay (https://pixabay.com//?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=7333333)*

Vises

To use a vise, simply rotate the handle to the desired opening. Place the work piece in the vise and tighten it just enough to hold it in place. If the part being held is soft or brittle, it may be broken or compressed by too much pressure.

Soft vise jaw-caps are available to protect the workpiece. They come in pairs and slip over the jaw facings. The tabs are bent around the front and back jaws to hold them in place.

Know the type of material being clamped in the vise. Be sure the jaw facings are of the type that will not damage the material. If jaw-caps are not available, use two strips of aluminum, copper, brass or wood to protect the material.

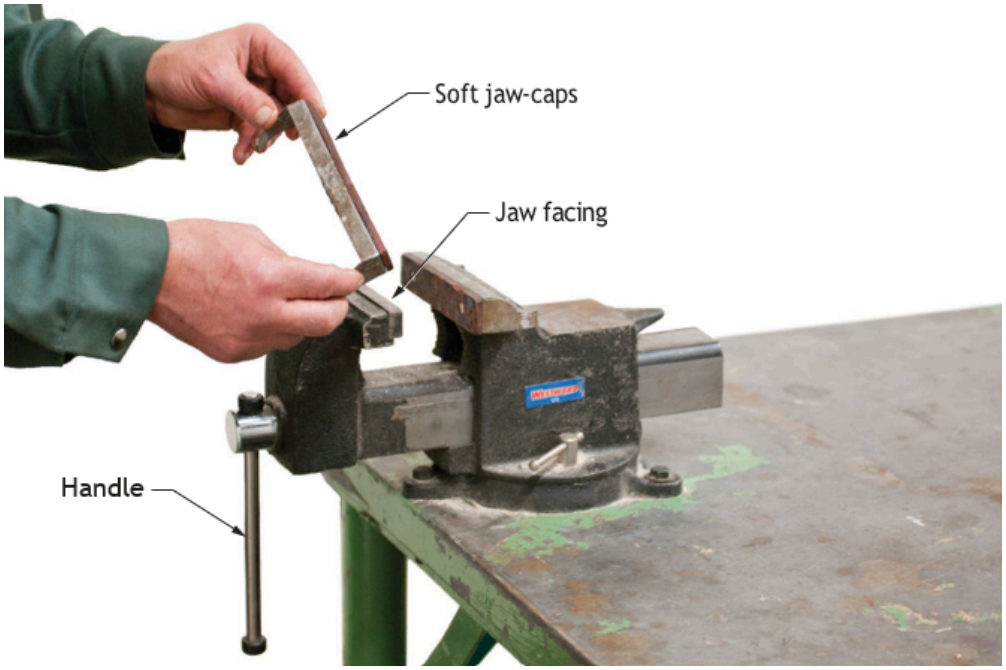


Figure 37 *Bench Vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

For a hard or tough work piece that is to be hammered or chiselled, you must ensure that the vise is tight enough to prevent the workpiece from slipping. You should also place the workpiece in such a position that you will be hammering or chiselling toward the stationary jaw.

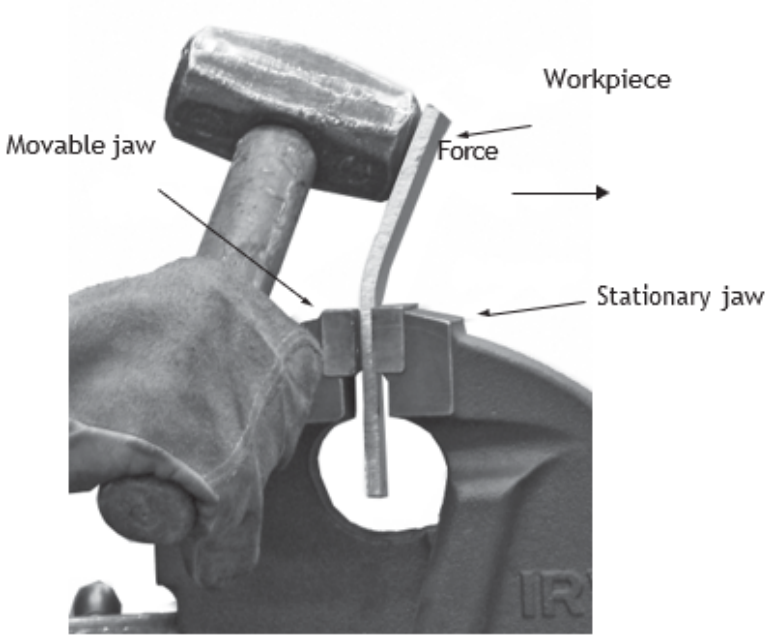


Figure 38 *Correct way to use a vise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Never hammer on the vise unless there is an anvil built on the vise for that purpose. Remove the screw periodically for cleaning and lubrication. When the jaw facings wear out or lose their gripping power, replace them. Never over-tighten the vise handle by using an extension bar over the handle ends or by hammering on the handle.

Follow these guidelines to ensure safe operation and a long life for the vise:

- Clean the housing of the vise with a solvent as the need arises.
- After using the vise, clean the gripping surfaces with a wire brush.
- Use a good grade of lubricating oil to clean and lubricate the screw spindles and any hinged joint.
- Inspect the gripping devices for damage or excessive wear, and replace if necessary.
- Keep the surfaces of the vise and work area free of grease, dirt, and other tools.
- If the vise is portable, hang it up in a clean, dry area when it is not in use.

Wrenches

Keep your wrenches clean. Working with greasy, dirty tools can be dangerous, as your hands can slip, causing injury. The dirt can also damage the component on which you are working. Adjustable wrenches and pipe wrenches should be cleaned and lightly oiled periodically.

Make sure the wrench is the correct size for the job. Loose-fitting wrenches can damage both the workpiece and the jaws of the wrench.

Do not abuse the wrench by driving on it with a hammer or by adding leverage with a piece of pipe. Do not use any wrench as a hammer and do not use socket handles for any purpose other than driving sockets. Do not use a socket wrench as a bushing or seal driver or for any other purpose. Check socket wrenches for chipping and cracking or other damage. Do not use them if they are damaged.

Hex key wrenches can be reconditioned if the end of the key becomes worn and slips in the socket head screw. Grind the end back to a point where the hexagon shape is true. Be careful that you keep the tool cool during the grinding operation to avoid affecting the hardened metal.

Pipe Wrenches

The following procedure describes the use of pipe wrenches:

1. Select the correct wrench type and size for the job. (A loose-fitting wrench will slip and very possibly cause hand injuries.) A pipe wrench is designed for round stock. It should never be used on square or hexagonal material. The following list shows the correct pipe wrench to use for various common pipe sizes:

Table 1: Pipe Wrench Sizes and Their Corresponding Pipe Sizes

Wrench size (inches)	Pipe size (inches)
8	$\frac{1}{8}$ and $\frac{1}{4}$
10	$\frac{3}{8}$ and $\frac{1}{2}$
14	$\frac{3}{4}$ and 1
18	$1\frac{1}{4}$ and $1\frac{1}{2}$
24	2

2. Inspect the wrench for damage. Jaws that are sprung or teeth that are dull, for example, can cause the tool to slip.
3. Mount the pipe wrench correctly on the work piece. Regardless of the size of the wrench, there must be a gap between the shank of the hook jaw and the pipe. This permits the pressure of the two gripping surfaces (the heel jaw and the teeth of the hook jaw) to firmly grip the pipe for full turning force.

Figure 39 *Using a pipe wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

4. With a grip on the pipe, push or pull on the wrench in the direction it is intended to move.
5. To obtain a new grip on the pipe, move the handle in the reverse direction. This will release the workpiece, and the handle can then be moved to its original position and a new grip obtained. Follow this procedure until the workpiece has been given as many turns as required.

- Do not use a wrench to lift or bend pipe.
- Do not use a substitute device or “cheater” to increase the leverage of a wrench.

- Valves, regulators and controls are not designed to withstand the torque across their body that is necessary to tighten or loosen them. Grasp the valve on the same end as the pipe on which you are working.
- Never grasp the open end of a fitting with a wrench. A pipe, nipple or adapter screwed in a few turns will prevent bending the open end of the fitting.

Maintaining the Condition of Pipe Wrenches

Follow these guidelines to ensure safe operation and a long life for the pipe wrenches:

- To prevent rust, apply oil at regular intervals to nuts, springs, jaws and other moving parts.
- Inspect the wrench before and after use for worn or broken parts. Pay particular attention to the heel and hook jaw or clasping device. If the teeth are worn, the wrench can sometimes be restored to usefulness by filing the teeth with a triangular file.
- Store the wrench properly. Use the hole in the handle to hang it up or hang it in a slotted holder designed for tools.

Pliers

When using pliers, observe the following:

- Pliers are not made to withstand any pressure in excess of normal hand squeezing.
- Never attempt to cut large screws or bolts with a pair of cutting pliers.
- Never put excessive side pressure on needle-nose pliers.
- Never expose pliers to a direct flame.
- Do not use pliers on nut or bolt heads.
- Wear safety glasses when cutting wire.
- Cut at right angles.
- Use the right tool for the job.

Figure 40 *Needle nose pliers* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Screwdrivers

Screwdrivers should be kept clean and free of grease, oil and dirt. The handle should be intact and well secured, and the tip should not be worn. When a tip becomes worn, the slot screwdriver can be filed to shape, but other types must be replaced.

Figure 41 *Flat head Screwdriver (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Screwdrivers should never be used as prying tools, punches, hammers or chisels.

Tubing Spring Benders

The following procedure describes using ***tubing spring bender***s:

1. Select bending spring that just fits over the tube to be bent.
2. Slip the centre of the spring over the centre of the area to be bent.
3. Hold bender in both hands, with thumbs supporting the back of the curve and slowly make the bend.
4. Grasp flanged end of the spring and remove from the tubing.

Figure 42 *Bending soft tubing with a spring bender (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Tubing Compression Hand Benders

The following procedure describes using a ***compression hand bender*** to form a 90-degree bend:

1. Measure tubing to the desired length at the centre of the 90° bend. Mark all the way around the tube with a pencil or felt marker. (If more than one bend is required on the tube, measure from the centre of the previously completed bend to the centre of the new bend to be formed.)
2. Place the tubing in the bender with the measured end of the tubing along the stationary handle of the bender. (The critical measurement is to the left of the mark.)
3. Position the measured mark directly in line with either the 90 or L notch on the placement link (manufactures vary in their design). Secure the tubing fastener onto the tube (making sure the 0 notch on the bending wheel and placement link are in line).

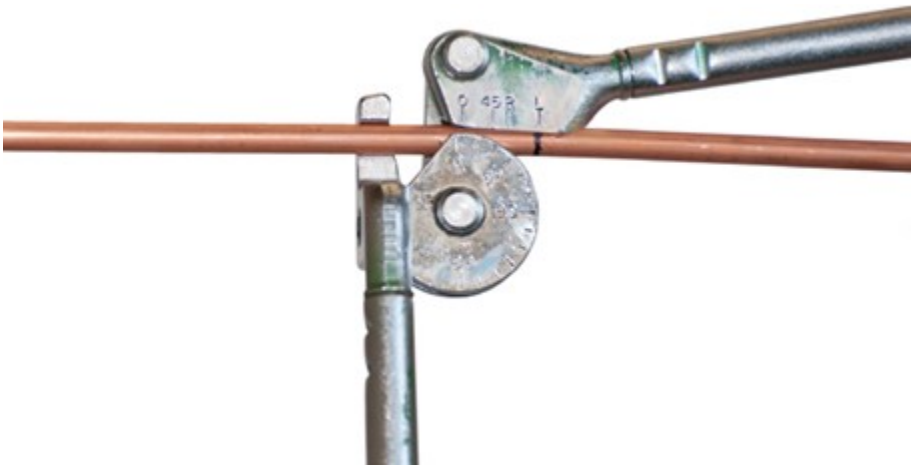
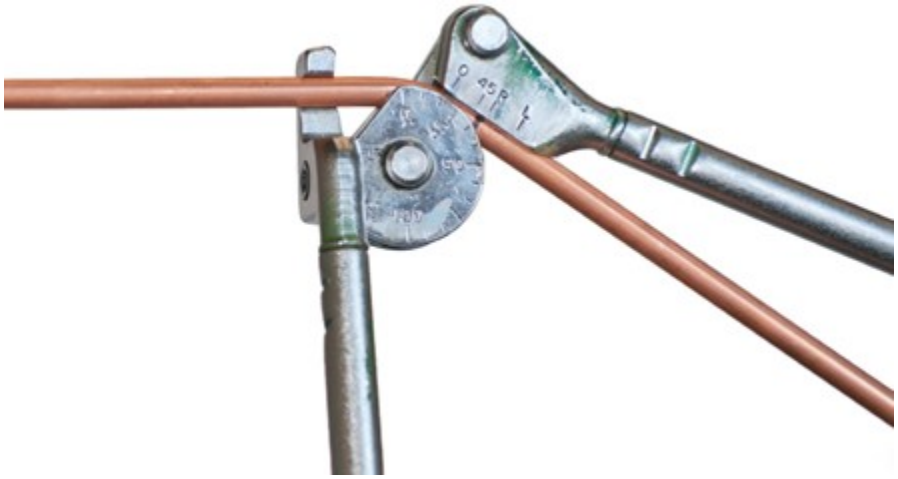


Figure 43 *Position the bender (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

4. While moving the pull handle toward the stationary handle, pull down smoothly and evenly until the 0 notch on the placement link lines up with the 90° mark on the bending wheel.



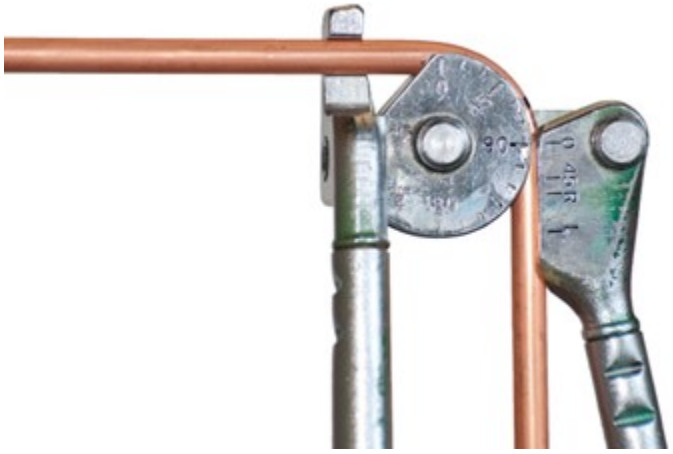


Figure 44 *Bending the tubing* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

90-Degree Reverse-bend

The R indicator notch on the placement link is used when the end of the tube from which the dimension is measured is reversed from what is described above. (In other words, the critical measurement is to the *right* of the bender.)

45-Degree Bend

The following procedure describes using a compression hand bender to form a 90-degree bend:

1. Measure tubing to the desired length at the centre of the 45° bend. Mark all the way around the tube with a pencil or felt marker. (If more than one bend is required on the tube, measure from the centre of the previously completed bend to the centre of the new bend to be formed.)
2. Tubing can be placed in either direction from the bending wheel.
3. Position the measured mark directly in line with the 45 notch on the placement link. Secure the tubing fastener onto the tube (making sure the 0 notch on the bending wheel and placement link are in line).
4. While moving the pull handle toward the stationary handle, pull down smoothly and evenly until the 0 notch on the placement link lines up with the 45° mark on the bending wheel.

Tubing Gain (Bend Length Increase)

When bending tubing, the actual bend made does not follow the absolute profile of a straight line layout. Realistically, the bend made in a tube will short-cut the angle slightly on each bend.

This short-cutting of the corners gives “additional length” to the remaining section of straight tube.

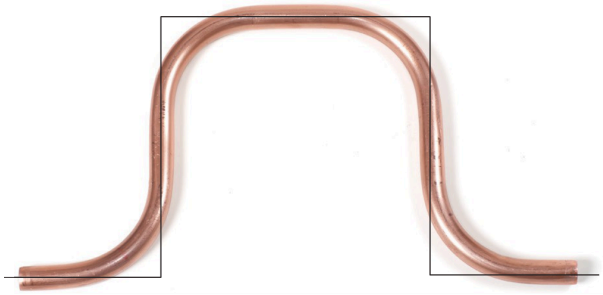


Figure 45 *Tubing gain (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The additional length is commonly referred to as ***gain***.

Gain for 90-degree bends is approximately equal to the OD of the tube being bent. Tables are available that provide the exact gain lengths for various sizes of tube and different bending radii.

If bending is performed correctly by proper positioning of the measurement mark on the placement link (and in multi-bending operations, measuring each bend from the previous bend), the gain will appear correctly on the straight length of the tube opposite the measured length.

Bending in this manner will ensure correct end-to-centre and centre-to-centre measurements when bending tubing.

Flaring Tools

Tube flaring is a method of forming the end of a tube into a funnel shape so it can be held by a threaded fitting. When a flared tube is prepared, a flare nut is slipped onto the tube, and the end of the tube is flared.

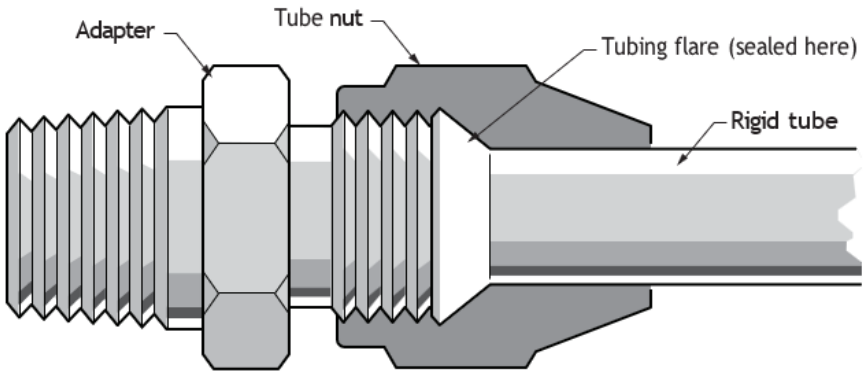


Figure 46 *Flared tubing connection (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

During tube installation, the flare is seated to a fitting with the inside of the flare against the cone- shaped end of the fitting, and the flare nut is screwed onto the fitting, pulling the inside of the flare against the seating surface of the fitting.

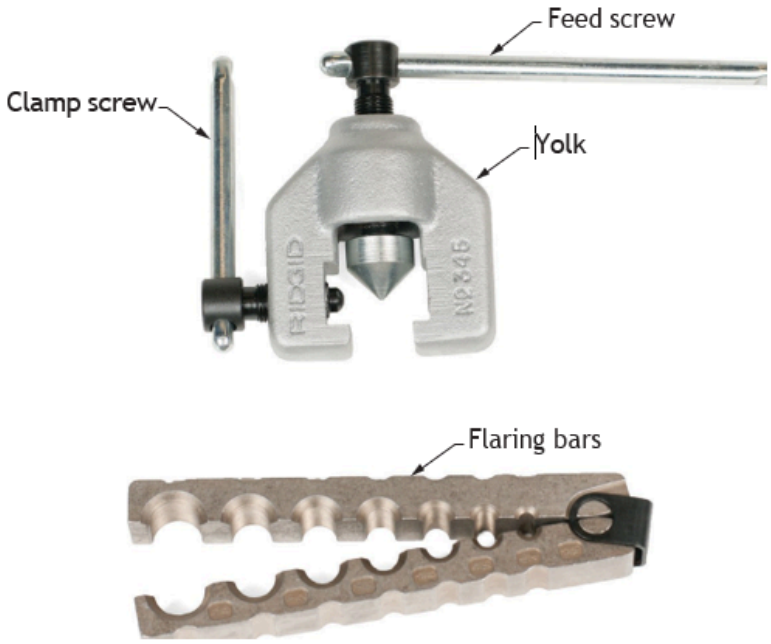


Figure 47 *Parts of a flaring tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The following procedure describes the use of a flaring tool:

1. Cut and ream tubing.
2. Slide flare nut over tubing.
3. Back off feed screw handle and clamp screw to permit flaring bars to slide freely through the yoke. Slide yoke to the hinged end of the flaring bars.
4. Insert tube into proper size opening and close flaring bars. Push tube up from bottom of the tool until it is even with top of flaring bars.
   Note: *Oversize or undersize flares can be made by adjusting tube position slightly above or below the top of the flaring bars.*
5. Slide yoke forward over tube until arrow or indicator on yoke meets line on flaring bars.
6. Turn feed screw handle clockwise until pressure kick-out releases. A few additional turns before backing off will *burnish* (polish) the flare.
7. Back off feed screw handle as far as it will travel. Release clamp screw and slide the yoke back. The completed flare should be slightly visible above the face of the flaring bars.
8. Remove tube. If the tube tends to stick, tighten clamp screw while against tapered end of flaring bars. This action will force the bars open.The flare must be large enough to seat properly against the fitting, but small enough that the threads of the flare nut will slide over it.

Crimpers

PEX fittings are installed in PEX tubing using crimp rings and a crimping tool. The crimping tool compresses the crimp rings over the PEX tubing with a fitting inside of the tubing to create a watertight seal in the joint.

Figure 48 *PEX crimping tool and fittings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The following procedure describes the use of a PEX crimping tool:

1. Square-cut the PEX tubing perpendicular to the length of the tubing. Remove all excess material or burrs that might affect the fitting connection.
2. Slip one crimp ring over the end of the tubing. The ring has to be in place before the fitting is inserted into the tubing.
3. Push a PEX fitting into the tubing. The fitting should be inserted into the tubing as far as is it is designed to travel.

Figure 49 *Insert PEX fitting (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

4. Slide the crimp ring so that it sits 3 mm ($\frac{1}{8}$ in.) from the end of the tubing. Pull the handles of the crimping tool apart to open the jaws of the crimper. Place the open jaws over one crimp ring at a time. Press the crimper handles together to force the jaws together over the crimp ring.

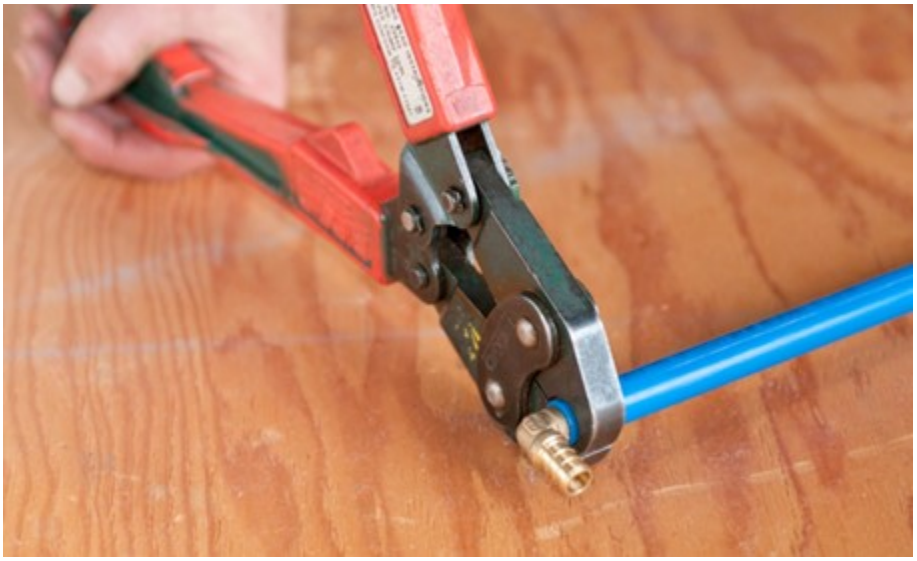


Figure 50 *Compress crimp ring (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

All crimps should be tested with a ***GO/NO-GO gauge***. If the crimp is perfect, the gauge marked GO will slide onto the crimped ring. The gauge marked NO-GO will not slide onto the crimped ring.

Figure 51 *Use the GO/NO-GO gauge (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The GO/NO-GO gauge performs two tests. The crimped ring must pass the GO test and fail the NO- GO test.

If both, gauges slide onto the crimped ring, then the crimp is too tight and the pipe or fitting could be damaged. If both gauges will not slide on, then the ring is not crimped enough and could leak.

Refer to manufacturer's literature for calibration instructions. As well, store your tool with care. It is vital for calibration that the tool be stored with the jaws just touching – the tool should NOT be under tension.

Hand PEX Expander Tool

Expanded PEX fittings make solid, permanent connections without torches, glues or gauges. The unique shape memory of quality PEX-A tubing forms a tight seal around the fitting, creating a strong, reliable connection. Note that fittings used for this system are not interchangeable with other joining methods (i.e., not to be used with crimp rings, or vice versa).

1. Square-cut the PEX tubing perpendicular to the length of the tubing. Remove all excess material or burrs that might affect the fitting connection.
2. Slide the PEX ring over the end of the tubing. Extend the end of the ring over the end of the tubing no more than 1 mm ($\frac{1}{16}$ in.). Manufacturers have added an internal ridge on one end of the ring to ensure proper amount of overhang.
3. When using the hand expander tool, brace the free handle of the tool against your hip or place one hand on each handle. Fully separate the handles and slide the expander head into the tubing until it stops.

Figure 52 *Insert expander tool (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

4. Full expansions are necessary to make a proper connection. Bring the handles together to expand.

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

5. Separate the handles, remove the head from the tubing, and rotate it one-eighth of a turn. Slide the tool head into the tubing in the newly rotated position and expand again. (Some tools have a head with a self-rotating feature.)

Figure 54 *Rotate tubing one-eighth of a turn (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

If the head is not rotated after each expansion, the segments on the tool head may cause deep grooves in the tubing. These grooves can result in potential leak paths.

6. Repeat the expansion process until the tubing and ring are snug against the shoulder on the expander head (usually about 3 or 4 expansions, depending on tubing size).

7. Immediately remove the PEX expander tool. As you slide the tubing over the fitting, you should feel some resistance. If the tubing reaches the shoulder of the fitting without any resistance, the tubing may be over-expanded and may require additional time to fully shrink over the fitting. The tubing and PEX ring should seat against the shoulder of the fitting for a proper connection.

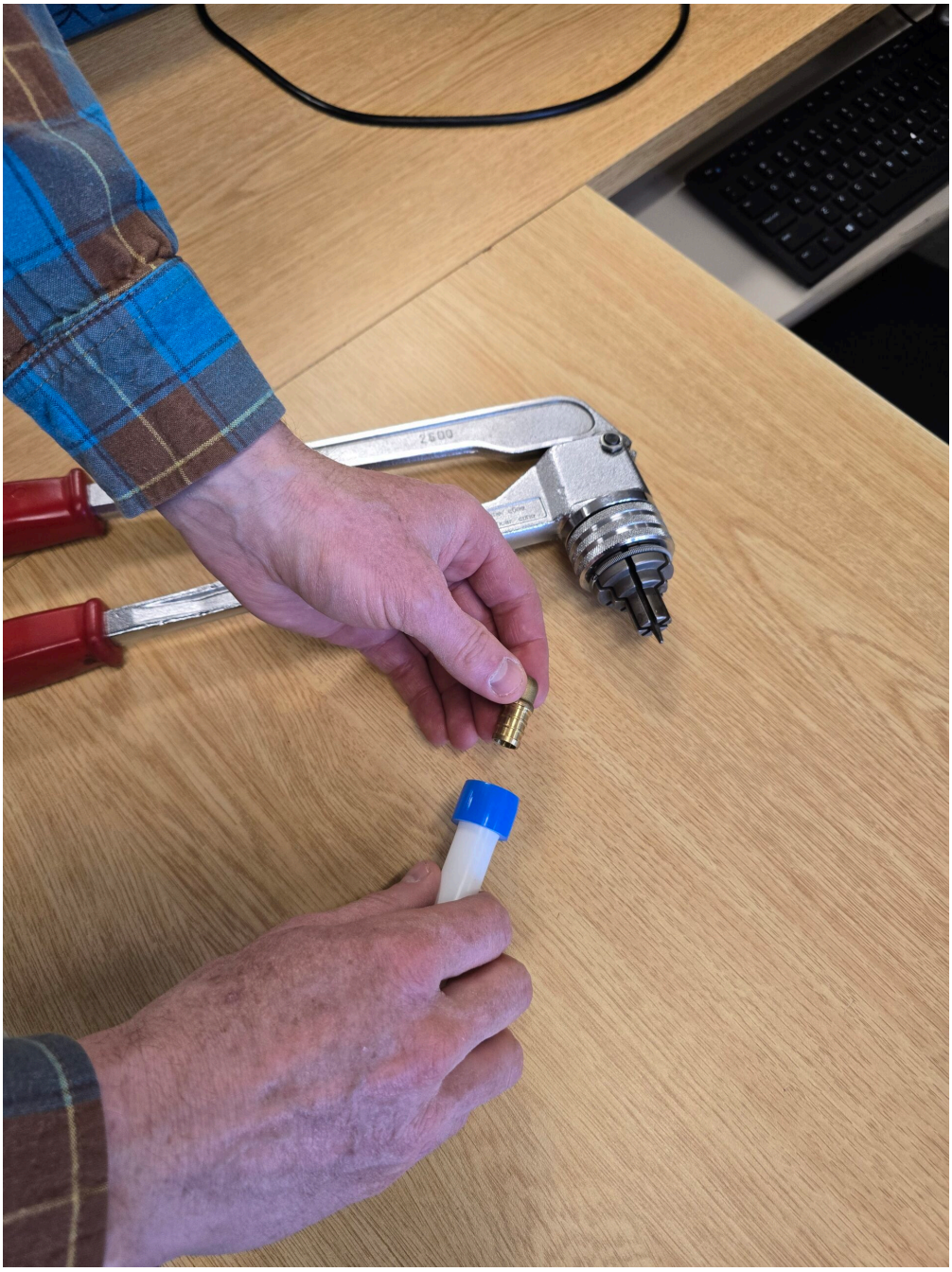


Figure 55 *Insert PEX fitting (Audrey Curran/ TRU Open Press)* CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

Important tips for proper PEX expanded connections:

- If the fitting does not slide into the tubing all the way to the stop, immediately remove it from the tubing and expand the tubing one final time.

Note: To avoid over-expanding the tubing, do not hold the tubing in the expanded position for an extended period of time.

- The manufacturer will recommend the appropriate number of expansions required for each size of tubing. Experience, technique and weather conditions influence the actual number of expansions (PEX becomes less flexible when cold, for example). Greater or fewer expansions may be necessary under certain conditions. The correct number of expansions is the amount necessary for the tubing and the shoulder of the fitting to fit snugly together.
- Good connections result when the PEX ring rests snugly against the stop of the fitting's shoulder. If there is more than 1 mm ($\frac{1}{16}$ in.) between the ring and the shoulder of the fitting, squarely cut the tubing 5 cm (2 in.) away from the fitting, and make another connection using a new PEX ring.

Disconnecting a Brass PEX Fitting from an Expanded Joint

Brass PEX fittings are manufactured connections and can be concealed in walls, ceilings and floors. However, when necessary, brass fittings can be disconnected (plastic fittings cannot be reclaimed or reused).

1. Make sure the system is not pressurized.
2. Use a heat gun to heat one side of the PEX ring. When the ring is a clear colour, use a utility knife to carefully cut through the ring. Take care to cut only the ring and not the tubing. This will protect the fitting from being damaged by the knife. Remove the PEX ring from the tubing with pliers to avoid touching the hot ring. ***Note***: *Do not gouge the fitting when cutting the ProPEX Ring. Nicks and gouges in the fitting may result in leaks. If nicked, discard the fitting.*
3. Remove the PEX ring and apply heat directly around the fitting and tubing connection. Gently work the tubing back and forth while pulling slightly away from the fitting until the tubing separates from the fitting.

Maintenance and Troubleshooting of PEX Expanded Joints

Trouble-free installations begin with a PEX expander tool that is maintained in proper working condition. If the tool or segment fingers are damaged, it is very difficult to make a proper connection.

The following troubleshooting suggestions are designed to assist with problems in the field.

For fittings that will not seal:

- Ensure that the expander head is securely screwed onto the tool (hand-tightened). Make sure the segment fingers are not bent. If the head does not completely close when the tool's handles are open, replace the head.
- Examine the tool for excess grease on the segment fingers. Remove excess grease prior to making ProPEX connections.
- Examine the fitting for any damage. Nicks and gouges on the fitting will cause the fitting to leak.
- Make sure the internal driver cone is not damaged or bent. Make sure the last expansion is not held in the expanded position before the fitting is inserted. The longer the tubing and *ProPEX Ring* are held in the expanded position, the greater the chance for a leak.

- Be sure to rotate the tool one-eighth of a turn after each expansion.

If expansion is difficult:

- Make sure the internal cone is properly greased.

If the expansion head slips out of the tubing when making expansions:

- Ensure the tubing and PEX ring are dry.
- Make sure that grease is not getting into the tubing.
- Examine the segment fingers to make sure that none are bent.

If the PEX ring slides down the tubing during expansion:

***Note*:** this is no longer common since the manufacturers have added an internal ridge to the PEX rings.

- Ensure your hands are clean while handling the tubing. Any sweat or oils on your hands can act as a lubricant. Due to the smooth finish of PEX, any form of lubricant can cause the PEX ring to slide across the tubing during expansion.
- If you anticipate that the PEX ring may possibly slide down, position the ring slightly farther over the end of the tubing and make the first couple of expansions slowly, holding your closed hand tightly under the ring and tube. Once the ring and the tubing begin to expand together, you can continue with the normal number and type of expansions.
- Occasionally, a light amount of abrasion applied to the outer surface of the end of the PEX tube can assist in stopping the ring from sliding.

If more than the recommended number of expansions are needed to make a connection:

- Make sure that the head is hand tightened to the expander tool.
- Examine the segment fingers to make sure that none are bent.
- Be sure to completely cycle the full range of the tool on each expansion.

Cold-weather expansions:

- Temperatures affect the time required for the tubing and ring to shrink onto the fitting. Colder *ambient* (surrounding) temperatures will require longer contraction times.
- Warming fittings and PEX rings reduces contraction time. Put fittings and rings in your pockets prior to installation to keep them warm.
- Make expanded PEX connections at temperatures above –15°C (5°F).
- Fewer expansions are necessary in temperatures below 4°C (40°F).

Hand Threading Tools

There are many different types of hand threading tools. The choice of tool may be based on the size of pipe and/or location as well as ease of use.

Ratchet Drop Head Threader

The following describes the procedure for a ratchet drop head threader:

1. Be sure the end of the pipe has been cleanly and squarely cut.
2. Be sure that the end of the pipe has been thoroughly reamed to remove any burrs from the internal surface.
3. Mount the pipe firmly in a suitable vise. Use a pipe support stand, if necessary, to keep the pipe aligned and level.
4. Select the die head that is appropriate for both the thread form desired and the size of the pipe to be threaded. Make sure the dies are designed for that particular die head.

Figure 56 *Enclosed ratchet drop head threader (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

5. Slip the pipe guide at the rear of the threader over the pipe

Figure 57 *Slide threader on to pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

6. Gently apply pressure to the front of the die head, and move the handle down while holding the die head. This will start the thread.

Figure 58 *Start the thread (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

7. To ensure maximum leverage, keep your weight above the handle. Do not raise the handle above the level of your waist, as this will reduce leverage. Do not let your arms do all of the work. Use the weight of your body.
8. While cutting the thread, generously apply thread cutting oil with a pumping action of the oiler pistol.

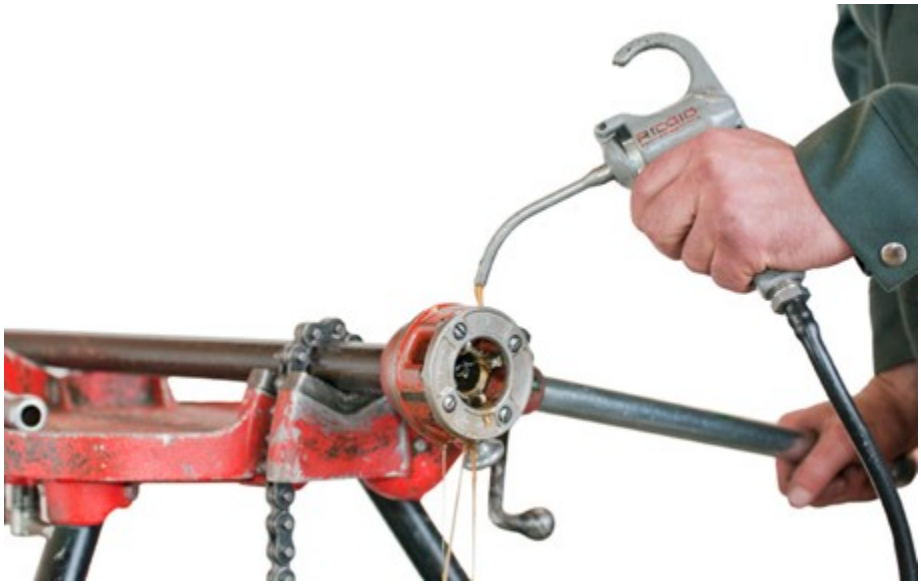


Figure 59 *Oil as you turn (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

9. Stop threading when the outer ends of the dies are flush with the end of the pipe. (You have now made the correct length of thread. To continue threading beyond this point would make a straight or running thread and produce an improper joint.)

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

10. Back off the die head from the completed thread. To do this, reverse the ratchet mechanism and turn the die head in the opposite direction to that used during the threading operation. When the dies are nearly removed from the thread, stop for a moment to be sure that you will have control over the unit when the die head is finally removed from the completed thread. In this way, neither the thread nor the threader will be damaged.

Always check a threaded pipe visually. Do not use your fingers to check a freshly cut thread because the threads are very sharp and will cut skin easily.

Jam-proof Ratchet Threader

The following describes the procedure for using a jam-proof ratchet threader:

Adjusting the Threader for Size

1. Place the threader in the position as shown above.
2. Unscrew the work holder by turning it counter-clockwise until the change plate is clear of the posts.
3. Move the post to the pipe size desired.
4. Screw the work holder clockwise until the change plate slides over the post.
5. For standard thread, set the change plate between the two standard (ST'D) marks. For undersize or deep threads, set the change plate slightly above the standard (ST'D) marks.

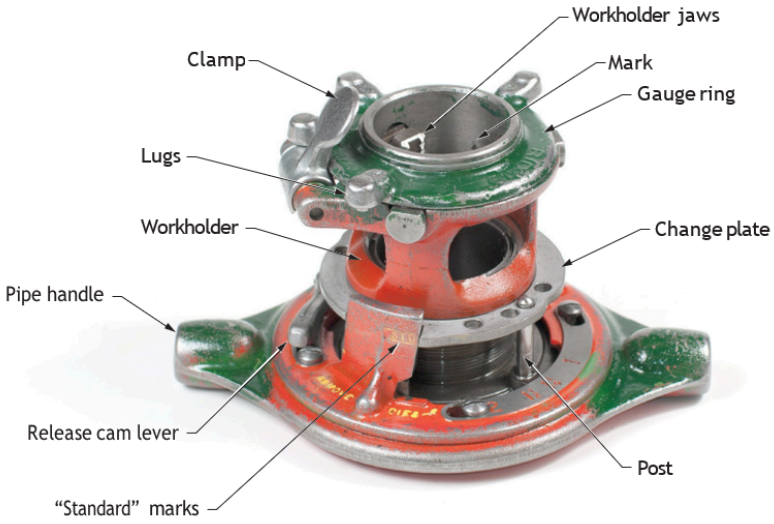


Figure 61 *Parts of the jam-proof ratchet threader* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Setting the Work Holder

Turn the gauge ring until the desired size lines up with the mark on the top of the work holder.

Figure 62 *Jam-proof ratchet threader* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Threading the Pipe

1. Be sure the release cam lever is at the close position for cutting threads.
2. Making sure the pipe is held securely in the vise, slide the threader onto the pipe, work holder end first.

3. Centre the end of the pipe in the dies.
4. Firmly tighten the clamp screw of the work holder.

Figure 63 *Tighten clamp screw (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

5. To thread, pump the threader handle while applying thread cutting oil to the dies.

Figure 64 *Oil as you turn (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

6. The threader automatically releases when the change plate reaches the point shown in the following figure.

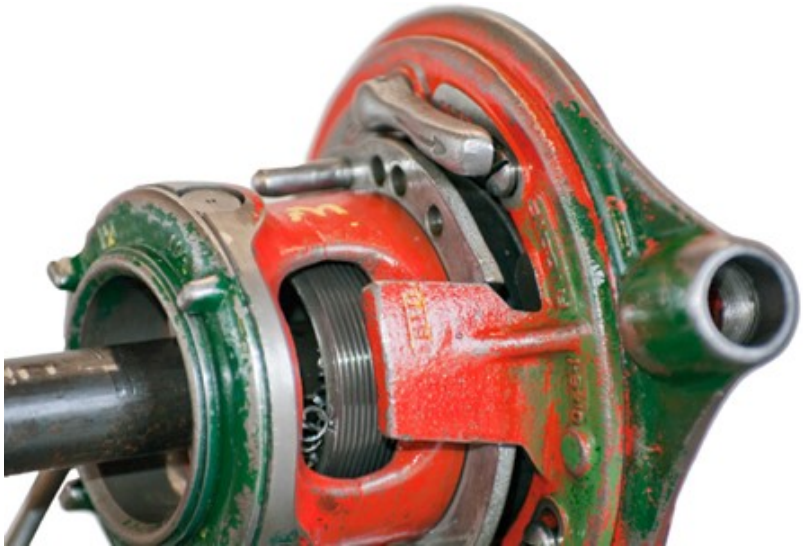


Figure 65 *Threader release point (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Removing the Jam-Proof Ratchet Threader from the Finished Thread

1. Turn the release cam lever to the open position and spin the threader back to the standard position. Loosen the clamp screw and slide the threader off.
   OR
2. Turn the release cam lever to the open position and loosen the clamp screw. Pull the threader straight off the pipe. No spinning off is necessary for this method of removal, but it does help prepare the tool for the next thread.

Figure 66 *Release Cam (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Geared Threader

The geared threader is used for threading pipe larger than 5 cm (2 in.) in diameter. The gears give a mechanical advantage, resulting in the drive shaft turning a number of times for a complete turn of the threader.

Once set up and mounted on the pipe, the geared threader can be turned with a hand ratchet, or any of the power drives using various accessories and hook-up methods.

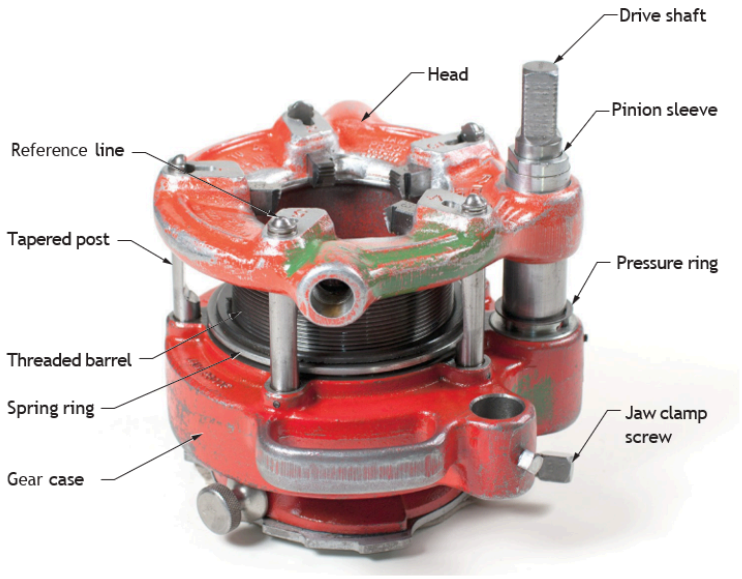


Figure 67 *Geared threader with drive shaft up* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

The jam-proof threader and the geared threader are similar in the fact that they use receding dies. Both have a base that clamps on the pipe with the dies set in to cut threads deepest at the end of the pipe. As threading continues, the die head turns on threads relative to the stationary base, and the dies recede to form tapered threads. Depending on how "open" the dies are at the beginning of threading, oversized and undersized threads can be cut. Other adjustments can be made to make straight (untapered) threads.

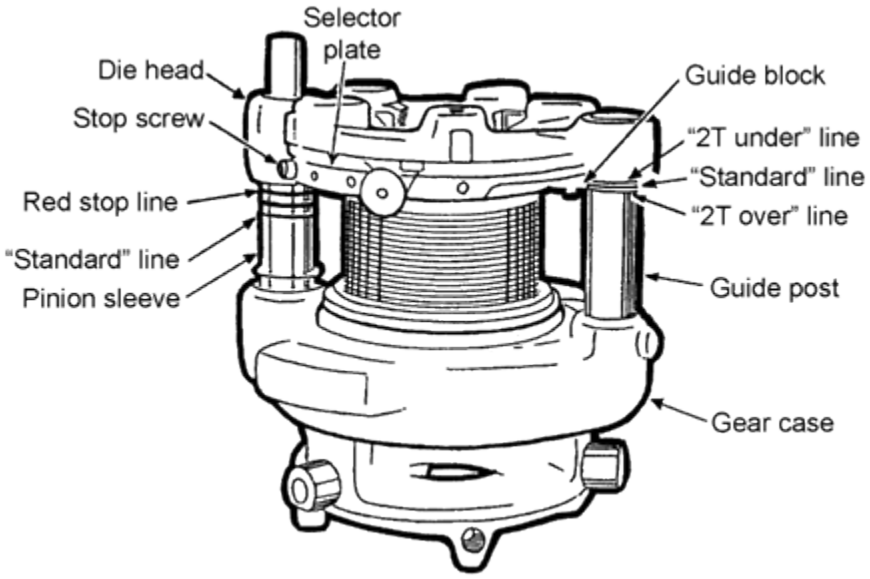


Figure 68 *Geared threader showing pinion sleeve and guide post reference lines (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

To adjust the geared threader for size:

1. Place the threader on the floor or the workbench with the driveshaft up.
2. Pull the knobs of the cam plate, and rotate the cam plate to the desired pipe size marking on top of the die head. Release the knobs when the locating pins drop into the holes of the selector plate. For some types of geared threaders, the size is adjusted by replacing the dies.
3. Grasp the work holder and turn the square end of the driveshaft (or turn the gear case by hand) to the reference line on the guide post.

To set for standard size thread, either one of the following two reference lines may be used depending on the type of geared threader:

- Reference Line 1—Set the bottom surface of the die head at the red "Standard" line on the pinion sleeve.
- Reference Line 2—Set the upper surface of the die head, which houses the guide post, even with the centerline at the top end of the guide post.

Cleaning and Storing Threaders

Follow these guidelines to ensure safe operation and a long life for the pipe threaders:

1. Clean and wipe down threaders at the end of each job.
2. Take the pipe threader apart periodically to ensure through cleaning.
3. Submerge the threader parts in a cleaning solution designed for the purpose and scrub with a wire brush.
4. Because cleaning agents cause tools to become dry, lubricate as necessary after cleaning. Use good quality lubricating oil. **Do not use thread cutting oil** (which is not a lubricant for servicing threaders).

Figure 69 *Exposed ratchet threader and drop head die set (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

5. Inspect dies for damage or wear. First, examine the dies visually. Next, perform a test cut. If you suspect the cutting edges need regrinding, set the die aside for professional repair.
6. Store dies and die heads separately on a rack in a clean, dry area. Careful storage helps prevent damage.

Pipe Taps

Tapered pipe taps can be used for making internal threads into ferrous and non-ferrous materials to connect pipe or fittings. A pipe tap resembles a shortened bolt with a slotted or squared head on one end and threads on the other end, interspersed with sharp fins. Pipe taps come in various sizes and configurations.

Figure 70 *Pipe taps (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The following procedure describes the use of pipe taps:

1. Apply cutting oil to the drill and drill a hole in the material that needs threads. Proper hole size is very important.
2. Clean the hole with a wire brush. Remove any loose chips or pieces of metal that can result from drilling.
3. Apply oil to the pipe tap. Insert the threaded end onto the hole and grasp it with a tap wrench.
4. Turn the pipe tap clockwise one half of a turn, then turn the pipe tape counterclockwise one half of a turn.

Continue this process slowly and carefully until you have advanced approximately ten tap threads into the hole. Check your fitting. If you find that it is too tight, you can run the tap through deeper.

Follow these guidelines to ensure safe operation and a long life for the pipe taps:

- Each time after use, clean off the pipe taps with a file card (a wire brush with short bristles).
- Inspect the cutting edges for wear or damage. If the edges need regrinding, set the tap aside for professional repair. Do not attempt to regrind them yourself.
- Store the pipe tap in its original container, in a toolbox, or on a rack.

Figure 71 *Adjustable tap wrench (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Maintaining and Storing Oilers

Follow these guidelines to ensure proper operation and a long life for the oilers:

- Metal chips and filings should be removed from the chip pan after each job and disposed of in an approved and responsible manner (ex. cleaned/drained, placed in a labelled container, and taken to a metal recycling centre) as to not contaminate soil and water.
- Periodically clean the screen with a cleaning solvent.
- Check to make sure that the level of the oil in the can is above the suction line.
- Remove the oil when the deposit in the can becomes heavy. Clean out the can with a solvent and pour in fresh thread cutting oil, making sure that the oil level is above the suction line.
- Store the full oiler in a safe, dry location away from flammables.

Figure 72 *Hand operated oiler and various threading oils (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Hand Operated Roll Groover

The hand roll groover is designed to groove schedule 10 and 40 steel, aluminum and PVC pipe in 32 mm to 15 cm (1 $\frac{1}{4}$ in. to 6 in.) sizes. It is also designed to groove 32 mm to 150 mm (1 $\frac{1}{4}$ to 6 in.) schedule 10 and 32 mm to 50 mm (1 $\frac{1}{4}$ in. to 2 in.) schedule 40 stainless steel pipe. With a roll set change, it can be used to groove 5 cm to 20 cm (2 in. to 8 in.) Type K, L, M and DWV copper tube.

Table 2: Hand Operated Roll Groovers – Specifications

Material	Schedule/Type	Size Range (mm)	Size Range (inches)	Notes
Steel, Aluminum & PVC	Schedule 10 & 40	32 mm to 150 mm	1¼ in. to 6 in.	–
Stainless Steel	Schedule 10	32 mm to 150 mm	1¼ in. to 6 in.	–
Stainless Steel	Schedule 40	32 mm to 50 mm	1¼ in. to 2 in.	–
Copper	Type K, L, M & DWV	50 mm to 200 mm	2 in. to 8 in.	Requires roll set change

The hand roll groover can be used for in-place applications (pipe that is in place or mounted in a vise) or with a power drive for powered applications on the job site. The hand roll groover is not intended for production type applications.

Figure 73 *Hand operated combination roll groover (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

When grooving in place, make sure that there will be enough space for the hand roll groover to fit and be operated. The roll groover will orbit around the solidly mounted pipe and requires:

- A minimum of 16.5 cm (6 $\frac{1}{2}$ in.) clearance around the pipe to be grooved
- A minimum of 6 cm (2 $\frac{1}{2}$ in.) pipe extending past an obstruction (such as a wall)

Figure 74 *Grooved pipe end (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Note: the use of roll sets (groove roll and driveshaft) on both carbon and stainless steel pipe can lead to contamination of the stainless steel material from carbon steel (ferrous) particles. This contamination could cause corrosion and premature pipe failure. To prevent ferrous contamination of stainless steel pipe, use roll sets dedicated for stainless steel roll grooving only. Alternately, a stainless steel wire brush may be used to thoroughly clean the roll set when switching between materials.

The following procedure describes the preparation for roll grooving:

1. Inspect the pipe to be grooved and confirm that the hand roll groover is the correct tool for the job.

2. If grooving in place on existing piping, make sure that the system has been depressurized and emptied of contents. Know what the contents are and any hazards associated with them.
3. Cut pipe to proper length. Make sure pipe end is cut square and free of burrs. Burrs can catch or cut gloves or fingers during grooving. Large burrs and the method of pipe cutting can affect the quality of the groove made and the tracking of the groove. Do not attempt to groove pipe that has been cut with a torch.
4. All internal/external weld beads or seams must be ground flush at least 5 cm (2 in.) back from the end of the pipe. Do not cut flats into gasket seat area, this could cause leaks.
5. Remove all scale, dirt, rust and other contaminants at least 5 cm (2 in.) back from the end of the pipe. Contaminants can clog the drive *knurls* (ridges) and prevent proper driving and tracking of the pipe while grooving.
6. Make sure that the pipe to be grooved is solidly mounted. The pipe must be able to withstand the weight of the roll groover (approximately 13.6 kg or 30 lbs.), and the force and torque required for grooving without moving.

Always follow grooved coupling manufacturers' specific recommendations for pipe end preparation. Failure to follow the grooved coupling manufacturer's recommendations may lead to an improper connection and cause leaks.

For pipe that is in-place, remove the pipe, if possible, and groove at a pipe vise. In other cases, it may be necessary to add other temporary or permanent pipe supports. When using a pipe vise, make sure that it is secure and will not tip during use. For longer lengths of pipe, use appropriate pipe stands to support the extra length.

Mounting the hand roll groover to the pipe:

1. Confirm that the hand roll groover has been inspected and has the appropriate roll set installed.
2. Make sure that the support arms are tight in the body of the roll groover or remove them completely for better access in tight spaces. Next, install the ratchet into the feedscrew and install the extension into the manual drive square at the back of the roll groover. Make sure both the ratchet and extension are securely installed.
3. Make sure that there is enough space between the groove roll and driveshaft for the pipe wall. If needed, turn the feedscrew counter-clockwise to retract the groove roll.
4. Securely grasp the roll groover. Do not lift with the ratchet. Place the driveshaft into the pipe and make sure that the cover plate is tight to the end of the pipe. Tighten the feedscrew to bring the groove roll into contact with the outside of the pipe. Once the feedscrew is hand tight, use the ratchet to tighten the feedscrew an additional $\frac{1}{4}$ turn. Confirm that the roll groover is securely attached to the pipe and the cover plate is flush to the end of the pipe. If not, repeat the procedure. Always make sure groover is secure when used in place to prevent it from falling.

Figure 75 *Holding the hand roll groover in place while tightening the feedscrew (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Precautions When Grooving Pipe "In Position" (in-place)

- Only drive manually for in-place applications. Do not use powered devices (such as drills or impact tools) to drive the roll groover when used in place. Use of powered devices can damage the groover and increase the risk of injury.
- Do not wear loose clothing when operating the roll groover. Keep sleeves and jackets buttoned. Do not reach across the machine or pipe. Loose clothing can become entangled in rotating parts and cause crushing injuries.
- Keep hands away from grooving rolls. Do not groove pipes shorter than specified. Do not wear loose fitting gloves. Fingers can be crushed between groove rolls or between groove roll and pipe.
- Keep hands away from ends of pipe. Do not reach inside pipe. Burrs and sharp edges can catch and cut. Fingers can be crushed between groove rolls or between groove roll and pipe.
- Always wear eye protection to protect your eyes against dirt and foreign objects. Wear steel toe footwear to protect feet from tipping tools and falling pipe. When working in place, wear a hard hat.

Follow operating instructions to reduce the risk of injury from crushing, tipping, striking and other causes.

Setting/Measuring the Groove Diameter

Note: These instructions are derived specifically from one manufacturer.

1. Confirm that the equipment and pipe are properly set up. Improper pipe preparation can affect the accurate set up of the groove depth gauge. The groove roll should be touching the pipe.
2. Adjust the groove depth gauge so that the correct step of the gauge is under the head of the adjusting screw. The groove depth gauge is designed for use with pipe.
3. Turn the adjusting screw clockwise until the head touches the step of the depth gauge. Turn the groove depth gauge to the grooving position. If gauge is not in the grooving position, it will prevent grooving and may be damaged.
4. Prepare a test groove (follow the steps for *forming the roll groove*, below).
5. Measure the groove diameter. The best method for measuring groove diameter is the use of a pipe tape (diameter tape). Snugly wrap the pipe tape around the pipe in the groove. Make sure that the tape sits flat in the bottom of the groove, and read the groove diameter.

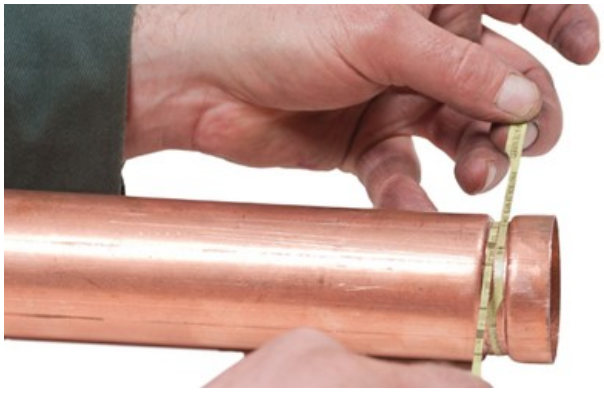


Figure 76 *Using the pipe tape (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

6. Compare the measured groove diameter to the required groove diameter (this may be specified by the groove fitting manufacturer). If the measured groove is outside of the required groove diameter, the adjusting screw must be repositioned to give the correct groove diameter.

    - To increase groove diameter, turn the adjusting screw clockwise.
    - To decrease groove diameter, turn the adjusting screw counter-clockwise.

    - Each $\frac{1}{4}$ turn of the adjusting screw changes the groove diameter approximately 0.5 mm (0.02 in.).

7. Repeat steps 4–6 until the groove diameter is within specifications. If the first groove is too large, the groove can be adjusted and the groove made smaller.
   If the groove is too small, another groove will need to be made. *Proper groove diameter is important to insure connection performance.* Grooves made out of specification could cause joint failure.

Due to differing pipe characteristics, a test groove should always be performed before the first groove of the day, or when changing pipe size, schedule or material. *Groove diameter setting gauges are approximate only and the groove diameter must be measured to confirm proper size.*

Forming the Roll Groove

1. Confirm that the equipment and pipe are properly set up.
2. Assume a proper operating position. Make sure that your footing is good and you are well balanced.
3. Make sure that the feedscrew has been tightened $\frac{1}{4}$ turn.
4. Remove the ratchet from the feedscrew, and securely install in the extension. (In close quarters applications, the extension does not need to be used.)
5. Turn the ratchet clockwise as viewed from the back of the roll groover (this will match the arrows cast into the back of the roll groover). Watch the groover rotate and be sure that the cover plate of the roll groover stays in contact with the end of the pipe.
6. If the roll groover starts to move away from the pipe end, stop rotating the ratchet to prevent the roll groover from spiraling off the pipe end and falling.
7. The roll groover support arms can be pushed on to help bring the cover plate back in contact with the pipe end. If needed, remount the roll groover to the pipe.
8. (See Mounting the Hand Roll Groover to Pipe.) If the pipe end is deformed, it will need to be cut off and a new groove prepared.
9. Continue rotating the ratchet until the roll groover completes at least a full rotation around the pipe.

10. Remove the ratchet from the extension and attach to the feedscrew. Tighten the feedscrew another $\frac{1}{4}$ turn. Remove the ratchet from the feedscrew and securely attach to the extension. Do not tighten the feedscrew more than $\frac{1}{4}$ turn per pipe rotation. Aggressive tightening of the feedscrew can cause excessive groove flare and can cause the roll groover to walk off the pipe. Continue rotating the ratchet to drive the roll groover around the pipe while monitoring the position of the cover plate to the end of the pipe.

Figure 77 *Turn the ratchet handle clockwise (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

11. Continue tightening the feedscrew $\frac{1}{4}$ turn per groove revolution around pipe until the head of the adjusting screw stops against the top of the roll groover. Do not continue tightening the feedscrew after the adjusting screw reaches the top of the roll groover; this can damage the adjusting screw. Rotate the roll groover at least two more full rotations around the pipe after the adjusting screw reaches the top of the roll groover to insure uniform groove depth.
12. Move the ratchet to the feedscrew. Securely grasp the roll groover. Turn the feedscrew counter- clockwise and retract the groove roll so that the roll groover can be removed from the pipe. *Do not drop the roll groover.*
13. Inspect the groove.

- Make sure that the groove is fully formed.
- Check the groove diameter and make sure it is within specification.
- Check any other items required by the fitting manufacturer. If any problems are found, the groove cannot be used.

Changing Groover Roll Sets

When changing roll sets for grooving different types of pipe, refer to and follow manufacturer's instructions carefully. Mismatched parts or rollers will cause improper grooves, which can lead to leaks and possible injury.

Figure 78 *Roll groover gear case* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Hand Roll Groover Maintenance

Follow these guidelines to ensure safe operation and a long life for hand roll groovers:

- Lubricate the hand roll groover with good general purpose grease once a month.
- (Grease fittings are located on the side of the operator's side of the base, the front of the slide block, and the end of the groove roll shaft.)
- Add grease until a small amount is pushed out. Apply a light coat of grease to the feedscrew.

Figure 79 *Location of grease fittings* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

- The gear box of many hand roll groovers has adequate grease for its service life and does not require the addition

of any grease unless the gear box is opened.
- Clean the driveshaft knurls with a wire brush on a daily basis or more often, if needed.

Self-Test B-1.2: Use Hand Tools

Complete Self-Test 1.2 and check your answers.

If you are using a printed copy, please find Self-Test B-1.2 and Answer Key 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://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2732#h5p-2 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2732#h5p-2)

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B-1.3 Use Levelling Equipment

Levels Used to Establish Elevations

Levels are instruments used to project a level line 360° around their axis in order to transfer, measure or set elevations. There are two broad categories of levels: optical and electronic. ***Optical levels***, also known as ***builder's levels***, generally need two people to operate them. One person looks through a telescope and interprets the reading of a sighting from a levelling rod, which is held by the other person. ***Electronic levels*** rotate a light beam and only require one operator, who uses the rod along with a sensor that picks up the light beam.

Optical Level Electronic Level With a Sensor

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

Types of Builder's (optical) levels

Optical levels are high-powered telescopes equipped with crosshairs and centrally mounted on a bearing so that they can rotate *only* horizontally. They are different from ***transits*** or ***theodolite levels***. Transits and theodolites (Figure 2) can measure horizontal *and* vertical angles and are used as surveying tools.

Figure 2 *Surveying level (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Builder's levels are designed for horizontal rotation only and therefore are only used for horizontal leveling. This learning resource will not cover transits or theodolites.

An optical level can be used to perform the following tasks:

1. Find the elevation of selected locations. Given a benchmark location and elevation, you can find the elevations of a series of other given locations.
2. Establish the elevation of an object. Blueprints provide the information needed to do the following:

    - Set the elevation of a slab
    - Set the height of a wall
    - Set the invert (lowest inside point of a pipe's inner surface) elevation and slope of a pipe

Optical levels can be categorized as manual or automatic, according to the way they are set up. There are two types of manual levels: "dumpy" and tilting.

"Dumpy" Levels (also known as 4-pin levels)

Although no one seems to know for certain where the term ***dumpy*** came from, it's widely accepted as the most rudimentary of all the builder's levels. It consists of a short telescope mounted to a table that is adjustable using thumbscrews or "pins." A ***spirit vial*** mounted below the telescope contains an air bubble in a small amount of alcohol, which is used instead of water so that freezing isn't a problem. The vial is similar to those found in ***carpenter***'s or "***torpedo***" levels. Dumpy levels are the least expensive and least sensitive of all the builder's levels and are generally known as being the hardest to correctly set up. They traditionally have four pins, while the others typically have only three.

Figure 3 A *"dumpy" level* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Tilting Levels

A ***tilting level*** (also known as *split-bubble* or *engineer's levels*) is so named because the horizontal plane of the telescope can be raised or lowered very slightly through a limited arc without impairing the accuracy of the reading. This is done to ensure that the reading taken is precisely level.

A fish-eye bubble provides for general levelling, and a bubble tube is usually mounted alongside the telescope and is viewed through a separate eyepiece for fine-tuning. For example, an optical sighting arrangement that brings opposite halves of a bubble image (split bubble) into alignment. Illustrated later in this section.

Tilting levels are generally more compact, more sensitive and more expensive than dumpy levels. They usually have only three pins for levelling the table, which makes them easier to set up than the dumpy, although some are made in a 4-pin configuration.

Figure 4 A *tilting level* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Automatic Levels

Automatic levels (also known as self-levelling levels) have only a fish-eye bubble that needs manual centring. Inside the instrument is a prism, also known as a ***compensator***, suspended by very fine wires. An automatic level, if shaken lightly, will make a slight "jangling" sound from within, evidence of the prism and wires. The prism fine-tunes the levelling, which makes setting up the automatic level very quick and easy. Once the fish-eye bubble is centred, the telescope can be rotated through 360˚ without the need for any further adjustment.

Optical instruments share a number of features:

- ***crosshairs*** and ***stadia*** lines inside the viewfinder
- an eyepiece focus (for the crosshairs)
- field-of-view focus (for the levelling rod)
- a $\frac{5}{8}$„ female thread connection on the footplate (for attachment to the tripod)
- an ***azimuth adjustment*** (for precise sideways movement)

Some varieties may or may not have an azimuth clamp and screw for moving the telescope sideways.

Figure 5 *Automatic level and levelling rod* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Types of Electronic Laser Levels

The use of laser and electronic levels has now become very commonplace on the job site. They are easy to use and have a distinct advantage over optical levels because they require only one operator. One worker using a laser or electronic level can perform the same job as two workers using an optical level. Electronic levels also allow many workers on large jobs to use the same instrument setup at one time with different receivers. They are ideal for setting suspended ceilings, levelling concrete floors, setting drainpipes, grading roads and building lots, and performing other tasks that are usually

done with a standard optical level. It is important to read the manufacturer's instructions before using these levels. Do not exceed the maximum range of the instrument and complete an accuracy check on a regular basis.

Laser levels

The word *laser* is an acronym for "Light Amplification by Stimulated Emission of Radiation." A mixture of helium and neon gases is used to emit a very narrow beam of light that does not grow larger as it moves away from the source, which in this case is the laser level (Figure 6). In low light conditions the laser beam can be seen as bright red. Some manufacturers use a green laser beam, which is easier to see in daylight conditions. In bright sunlight, a sensor or detector is required in order to read the beam.

Never look directly into a laser beam! Looking directly into the beam may be hazardous to your eyes. A quick flash of the beam is not a problem, but avoid prolonged contact with your eyes. The instrument must be positioned either above or below the line of sight of the average worker.

Figure 6 *Laser level (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Electronic Laser Levels

With electronic levels (Figure 7) the beam can be directed to any point, or it can be rotated continuously at various speeds and controlled remotely. A beam detector or sensor must be used to locate this infrared laser beam.

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

Using Electronic Laser Levels

Electronic laser levels depend on an electrical power source such as batteries, a 12-volt source from a truck or car, or a 110 VAC adapter. Set-up is very easy. A bubble level or fish-eye is used to rough- level the instrument. When the bubble is in the ring, the instrument levels itself with its motor- driven levelling system. If, during operation, the instrument is knocked and moved beyond the limits of self-levelling, the beam shuts off.

The instruments can be supported in several ways. The most usual supports are tripods of various heights. They can also be clamped to columns, or have small feet attached so that they can be set into or on drainage pipes. Suspension frames are available to hold the instruments and aim them into pipes.

Sensors or Detectors

Electronic laser levelling instruments can be operated by a single person. When the instrument is set up and running, a level reference plane is created that can be seen by eye or detected with the sensor or detector (Figure 8).

Figure 8 *Beam sensor (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The sensors or detectors operate on batteries and have a narrow window through which the beam can be detected. When the beam is sensed, the detector shows a small, colored light or emits a sound. Sensors or detectors can be attached to the levelling rod or can be used by themselves to locate instrument height on walls or forms.

Targets

Targets (Figure 9) are made of clear plastic with a cross marked on them. They are used to set levels with a laser level for items such as ceiling T-bars, concrete screeds or drainage pipes, using a direct or rotating beam. The object (with target attached) is lowered, raised or moved sideways until the beam is located at the target cross.

Figure 9 *Target (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Checking Laser Level Accuracy

Many laser levels are designed to allow the operator to calibrate the unit. The manufacturer's instructions will include the method. Often it is as simple as setting up 50 meters from a wall, marking the location, and then rotating the instrument 360° and marking again. If the two marks are not within tolerance of each other, then turn the instrument on by pushing two buttons at once and adjust the beam up or down by pushing buttons. Then rotate the instrument 90° and make a third mark. Rotate the instrument another 180° and make a fourth mark. The instrument is turned on by pushing another combination of buttons, and then the beam is adjusted. In this way, both the X and Y axes are recalibrated.

Pipe Laser Levels

Pipe laser levels (Figure 10) are specially designed for installing pipes requiring a constant grade and for setting grades for areas requiring drainage. When laying pipe, the laser is set up at the end of the pipe (either inside or on top) and set to the desired slope of the pipe. The target is located at the end of the pipe and the pipe is moved until the target is centered to the beam. Pipe laying can continue until a change of direction is required or the maximum range of the beam has been reached.

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

Five-Way Laser Levels

A *five-way laser level* is used mainly for laying out 90° corners, for levelling and for plumbing up or down. It can also be used as an electronic chalk line. There are five laser beams (Figure 11); one shoots down, one shoots up, one shoots straight forward. The last two are at 90° on both sides to the forward beam.

Figure 11 *Five-way laser level (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The unit self-levels, and the beams are bright enough that a sensor is not required. Most five-way levels are accurate only up to between 10 and 30 meters, as the laser beam becomes too wide past that point.

Five-way laser levels can be set on the floor, mounted on a tripod or clamped to an object. Follow the manufacturer's instructions; be careful not to exceed the rated distance. As the laser beams are quite bright, extra care should be taken not look into the beams.

Parts of a Tilting Level

Figures 12 to 15 identify the major working parts of a tilting level. Note that a tilting level has some parts that are not found on either a "dumpy" or an automatic level. The functions of these parts and some others are described on the following pages.

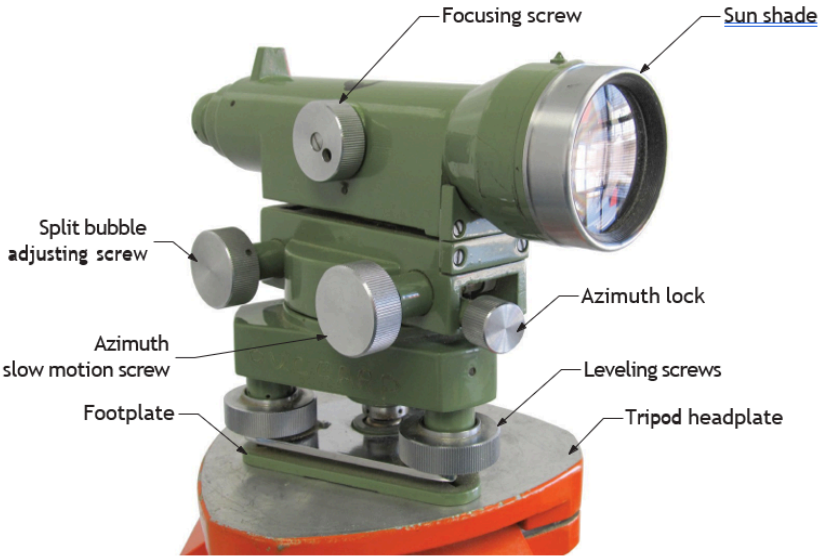


Figure 12 *Tilting level (front view)* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

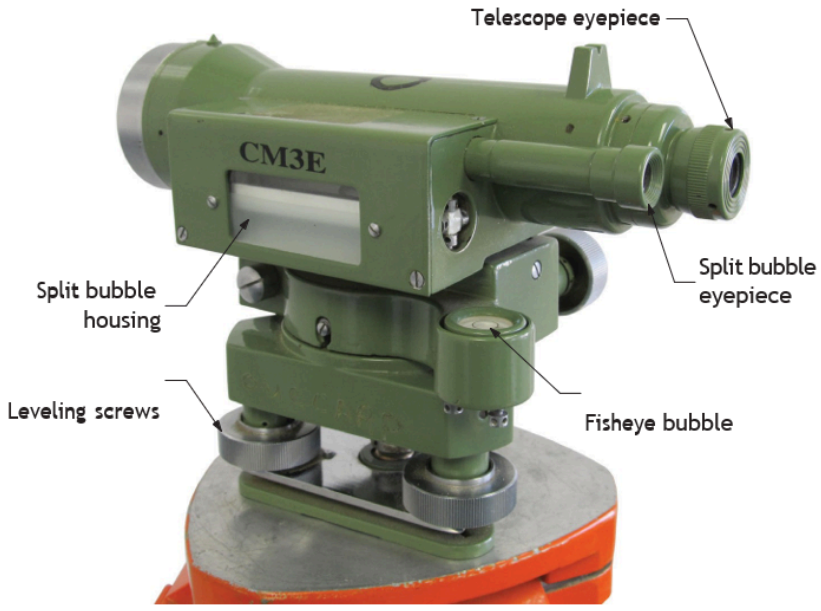


Figure 13 *Tilting level (rear view)* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

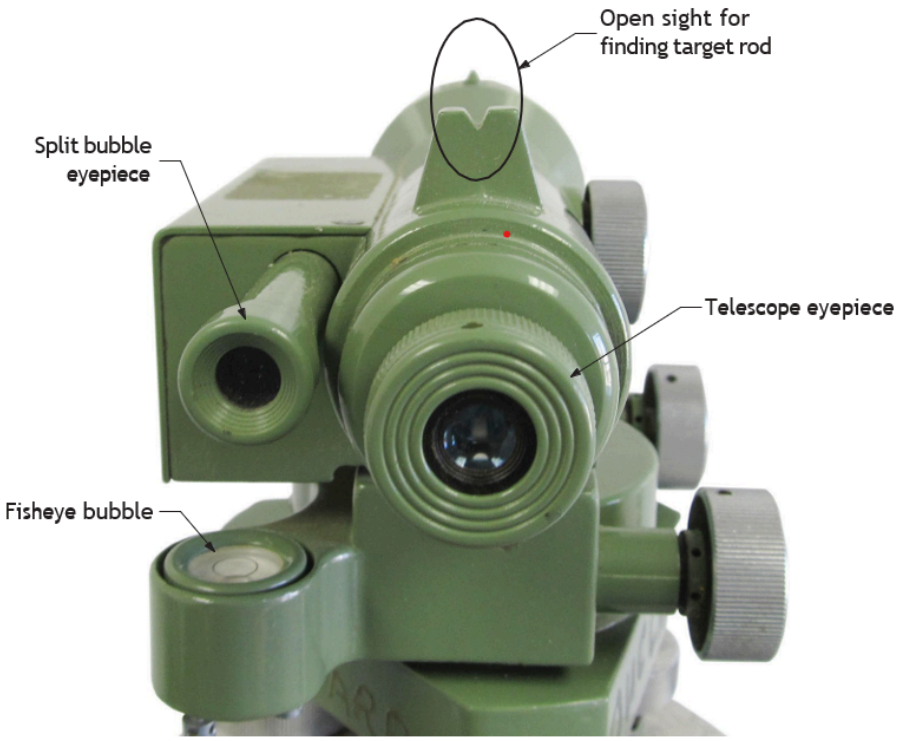


Figure 14 *Tilting level (back view)* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

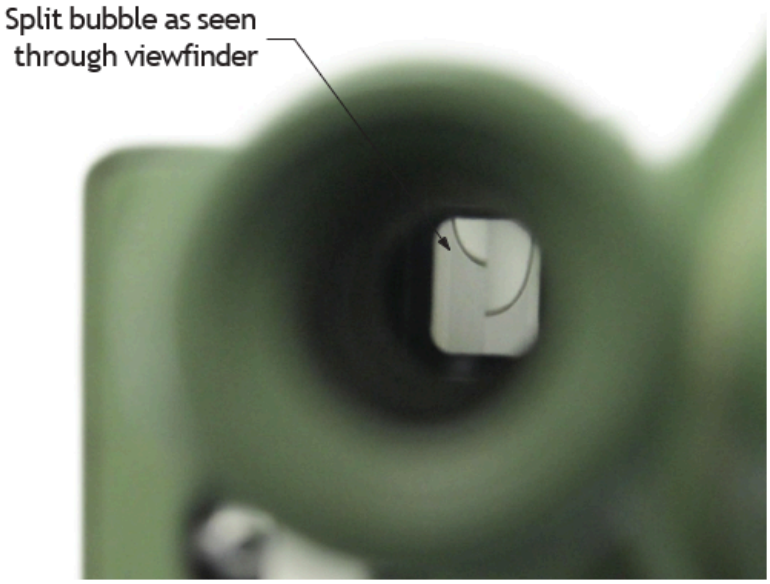


Figure 15 *View of split bubble* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

Telescope Eyepiece

The eye is positioned at the telescopic eyepiece when a reading is being taken. The eyepiece has a knurled adjustment ring for focusing the crosshairs.

Crosshairs/Stadia Hairs

The crosshairs are lines that are etched on a piece of glass, sometimes called the fixed reticle. The crosshairs are a pair of vertical and horizontal lines (Figure 16). Readings are taken at the horizontal crosshair. The rod can be lined up plumb in one direction using the vertical hair. The vertical hair is further divided by lines above and below the horizontal crosshair, called stadia lines, which are used to measure distance.

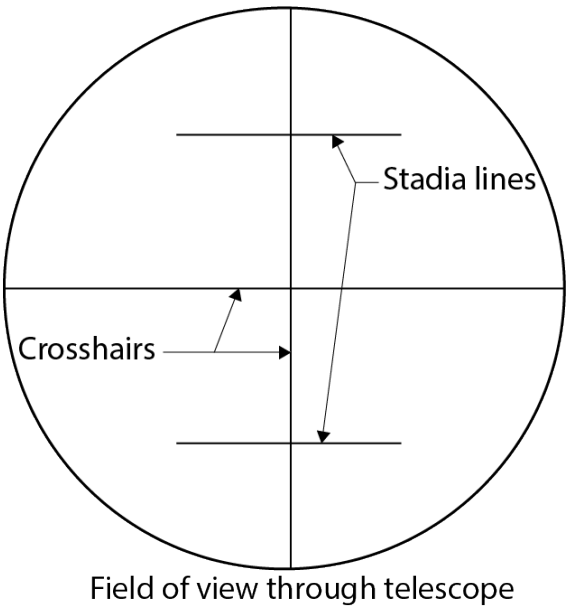


Figure 16 *Field of view through an optical level (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Telescopic Barrel

The telescopic barrel contains the lenses and focusing ratchet mechanism. The lens at the front, or the end opposite the eyepiece, is called the objective lens.

Focusing Screw

The focusing screw brings the object seen through the eyepiece into sharp focus by moving the lenses inside the barrel.

Levelling Split Bubble

The levelling split bubble (Figure 17) can be located above or below the barrel, as on a dumpy level, or alongside it, as on a tilting level. The length of the bubble expands and contracts with changes in temperature.

Figure 17 *Split bubble level as seen through side of instrument (original image) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Fish-Eye Bubble

The fish-eye bubble is used to roughly set to level the line of sight of a tilting level, or to accurately set up an automatic level. It is attached to the levelling head.

Horizontal Tangent Screw

This screw is also referred to as the slow motion or azimuth screw. It is used to slowly rotate and accurately aim the telescope horizontally. Usually it is located just below the objective lens. It will only operate if the horizontal (azimuth) clamp is tightened.

Horizontal Tangent Screw Clamp (Azimuth Lock)

This clamp can be loosened to allow the barrel of the instrument to be freely swung horizontally, and to roughly aim the instrument. Once the instrument is roughly aimed, the clamp is then tightened, and the fine horizontal sighting is done with the slow-motion screw.

Levelling Screw / Tilting Screw

The levelling screw is used to bring the instrument perfectly horizontal, parallel to the line of sight. It is usually located just below the eyepiece and is activated by turning in direction to center the bubble in the level vial. Sometimes it is aided by a coincidence optical mechanism, known as a split bubble. You must line up both halves of the bubble in the mirror to level the instrument (Figure 18).

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

The sunshade is a short tube attached to the objective lens end of the barrel to eliminate sun glare.

Tripod

The footplate of a builder's level is fastened to the headplate of a three-legged stand known as a tripod by a $\frac{5}{8}$" NC bolt fixed to the underside of the tripod's headplate. The tripod has three extendable legs with feet that are pointed and have a horizontal peg that allows for them to be firmly pressed by foot into soft ground (Figure 19).

Figure 19 *Tripod pegs pushed into the ground* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

There are also rubber tips and suction cups available for use on smooth floors. The top pivot pin of each leg can be tightened or loosened to create more or less resistance to opening or closing the legs. When used on fairly rough terrain, a light closing force would be adequate, whereas on smooth, slippery surfaces a more positive force would

be advantageous in order to keep the tripod legs from splaying outward. If the tripod does not have rubber feet or suction cups, a triangle of 1×4 wood can be used, with the tripod feet pushed into the corners (Figure 20). It is of utmost importance to not move the tripod at all once it is set in position; to do so would necessitate a re- setting of the level.

Figure 20 *Tripod on smooth surface (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Levelling Rods

Levelling or *target rods* (Figure 21) also known as *Philadelphia rods*, are used to take readings on sights. They can be either hinged or telescopic and can be made of wood, fibreglass or aluminum alloy. The units of measure (scales) can be metric or imperial.

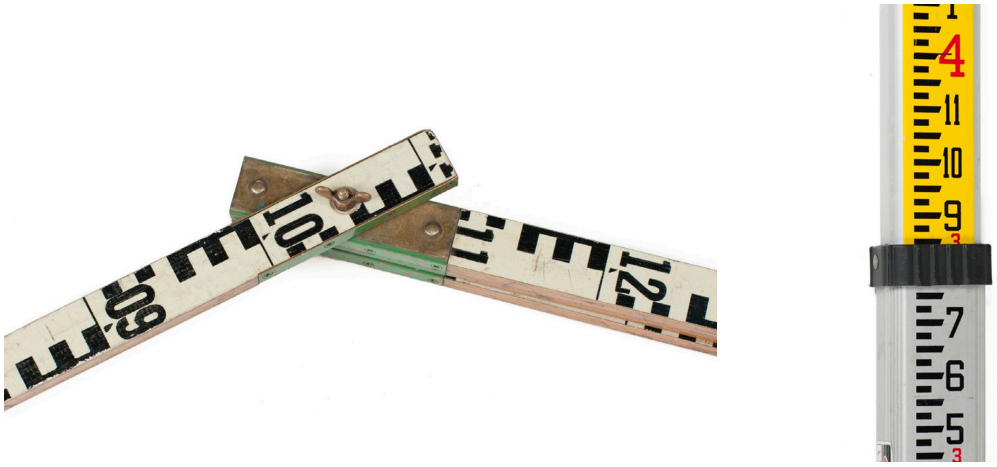


Figure 21 *Levelling rods (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

There are several methods of displaying the scales. The type suited to construction could be the segmented type with a Scotchlite face as they are easily collapsed for use in confined spaces, and a light source can be shone on the scales for easy reading in poor light conditions.

Metric Rods

Scales in the metric system are generally shown in 10-mm (1-cm) divisions (Figure 22). It has been the practice when using metric rods to visually break down the 10-mm divisions. With a bit of practice one should have no difficulty in making rough estimates to the closest millimeter (±1 mm), which is considered an acceptable tolerance. For more accurate readings, a target that has the 1-cm scale divided up into millimeters can be fitted on the rod, or a portion of a metric tape measure can be held with the rod.

Figure 22 *Metric rod (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Imperial Rods

The imperial system of measurement, which uses inches and feet, is used on both the architect's rod and the engineer's rod The architect's rod is broken into feet, inches and fractions of an inch, whereas the engineer's rod is divided into feet and hundredths of a foot. You can quickly tell if it is an architect's or engineer's rod by looking for the 11-inch marking. The engineer's rod does not show the 11-inch mark, while the architectural rod does.

Architect's rod readings (Figure 23) are divided into $\frac{1}{8}$" increments, which are generally considered to be the accepted tolerance for field readings. The marks with the point at the end are at the 0″ mark and the $\frac{1}{2}$" mark.

Engineer's rod readings (Figure 23) are divided into 0.01′ ($\frac{1}{100}$,) increments. The marks with the point at the end are at the 0.1′ ($\frac{1}{10}$, or $\frac{10}{100}$,) mark and the 0.05′ ($\frac{5}{100}$,) mark.

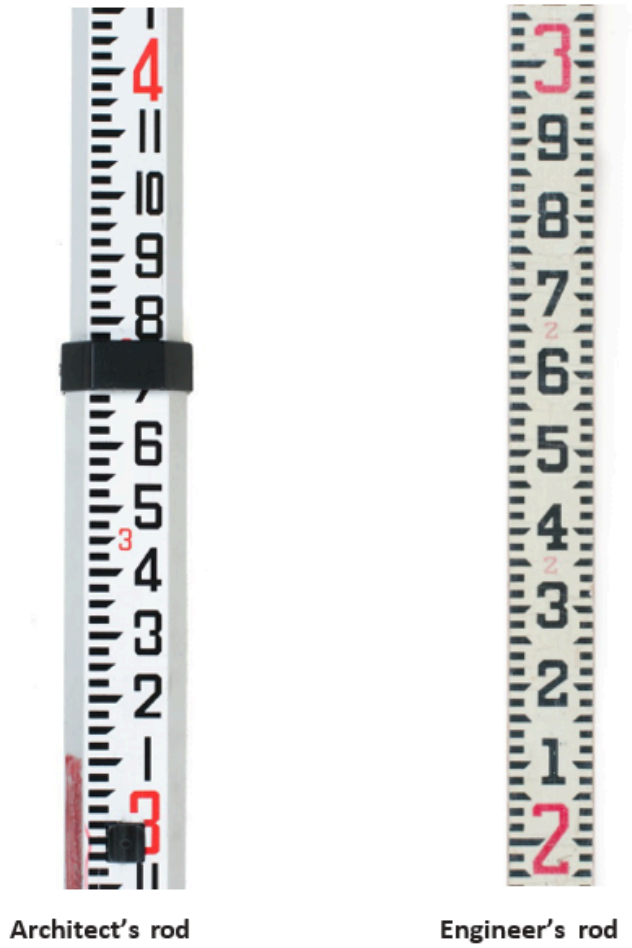


Figure 23 *Imperial target rods (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Care should be taken when reading the engineer's rod: a reading of 0.6′ would be 7.2″ or 7 3/16″ , not 6″!

Note – When geodetic (accurate measurements of the earth) elevations are needed, either the metric or engineer's scales is used.

Stadia Lines

Stadia lines (or hairs) (Figure 24) are used to find the distance from the instrument to the rod.

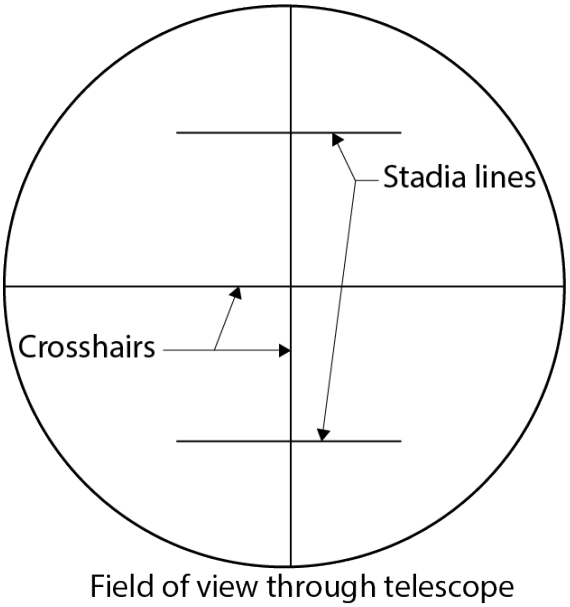


Figure 24 *Stadia lines (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The accuracy of the stadia line distance is totally dependent upon how accurate the rod readings are. For example, if the stadia line reading was accurate to 1 millimeter, then the resulting distance would be accurate to ±100 mm. The stadia line ratio is 1:100, no matter what the rod units are.

To find the distance:

- Take the readings of the top stadia line and of the bottom stadia line.
- Subtract the smaller from the larger.
- Multiply the answer by 100.

The result is the distance from the instrument to the rod. See examples 1 and 2 below. The concept will work with an architect's, engineer's or metric rod.

Example 1

Top stadia line reading = 1.500 m

Bottom stadia line reading = 1.345 m

Difference between readings = 0.155 m

Distance to the rod = 0.155 × 100 = 15.5 m

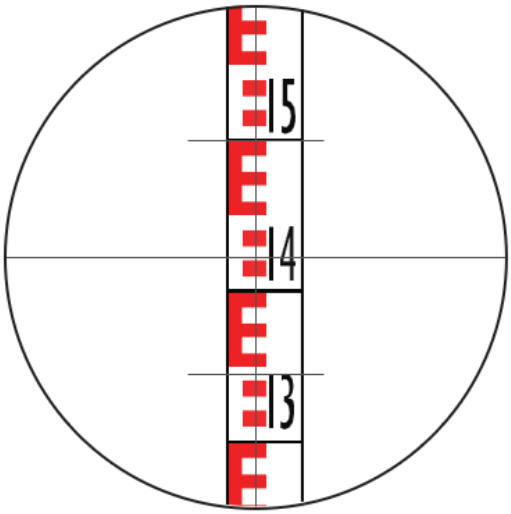


Figure 25 *Illustration for Example 1 (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Example 2

Top stadia line reading = 3.74′

Bottom stadia line reading = 3.51′

Difference between readings = 0.23′

Distance to the rod = 0.23′ × 100 = 23′

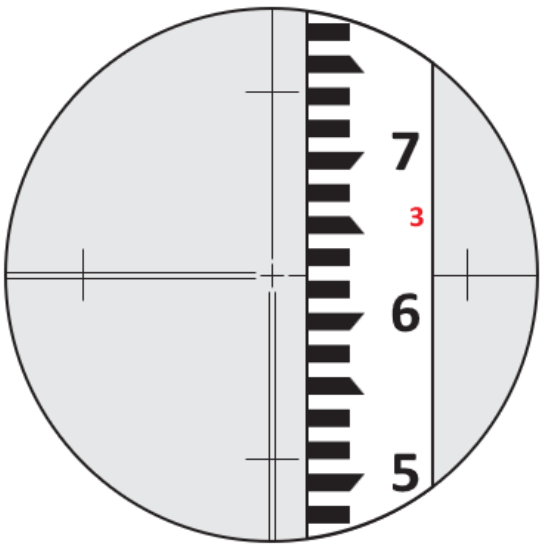


Figure 26 *Illustration for Example 2 (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Using the Level Rod

To ensure that accurate information is obtained, the level rod must be held plumb whenever a reading is taken. The instrument operator can see through the telescope whether the rod is being held plumb in one direction only. To obtain plumb in the other direction, the instrument operator must give a signal to the rod person to slowly move the rod through a small arc forward and backward, so that the lowest reading can be taken if the rod is being held erect, or the lowest reading if the rod is inverted. The illustration in Figure 103 should help in understanding this.

Figure 27 *Moving the rod through a small arc, forward and backward (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The device shown in Figure 28 contains a fish-eye bubble and can be used by the rod person to plumb the rod.

Figure 28 *Fish eye attached to rod (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

A pointed target (like a sharp pencil) is moved up and down on the rod by the rod person as directed by the instrument-person. The rod reading is taken by the rod person and relayed to the instrument person.

Hand Signals

Hand signals should be used for communication between the instrument person and rod person. These are necessary so that the work can be done efficiently, without yelling or shouting to each other. Sometimes the distance between the instrument person and the rod person is too great or it is too noisy for verbal communication.

Figure 29 shows the hand signals that should be used.

Figure 29 *Hand signals (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Set-up and Care of Optical Levels

Tripod Set-Up

If possible, set up midway between the backsight and foresight locations.

Using the leg thumbscrews or cam locks, extend the legs enough so that, when set up, the instrument will be at a comfortable height for readings. A good suggestion is to have all three legs closed and in contact with the ground, and the tripod top plate at chin level. This will put the mounted instrument at a comfortable height. Snug their locking screws up, but do not over tighten the screws. Grasp two of the legs and plant the third out in front of you into the ground. Spread the tripod legs about 900 mm (3 ft.) apart, draw the two legs back and set the feet firmly into the ground (farther apart if windy).

If the ground is sloping, put two legs on the downhill side and the other one uphill. Use a triangular wooden frame if setting up on a floor with a smooth surface such as concrete, where the feet of the tripod cannot dig in. Once the feet are set, adjust the leg lengths so that the top plate of the tripod is level by eye.

Make sure the tripod is secure against any movement by grasping the head and gently trying to move it in a horizontal circle. If there is any movement, then something is loose and all connections should be tightened up before proceeding to mount the instrument. If possible, try to stand between two of the legs when sighting, rather than straddling one of the legs and bumping the instrument. Attach the instrument to the tripod. Tighten the locking screw firmly, but do not over tighten.

Levelling the Instrument

Levelling instruments are used to set, transfer and measure elevations. Levelling the instrument so that the line of sight is in a level position is the most important procedure to obtain accurate levelling work. There are different methods for instruments with four or three levelling screws, and for the quick-set type of instrument. Each will be described separately.

If the instrument goes out of level for any reason, it must be readjusted to a level position before continuing to take readings.

Levelling Instruments with Four Levelling Screws (Pins)

Most instruments with four levelling pins use a tubular level vial. A tubular level vial is a curved glass tube filled with alcohol that has a bubble of air trapped inside. The amount of curve in the vial is very slight, sometimes not even able to be seen by eye. The air bubble will move to the highest point of the curve; if the vial is tipped either left or right, the air bubble will move toward the higher end.

To level the instrument, follow these steps:

1. Make sure all the levelling screws are loose and equally set for height.
2. Position the telescope barrel over a diagonal pair of levelling screws and take up any slack on these screws so the instrument will not wobble horizontally.
3. Turn the levelling screws in opposite directions, using the direction of the left thumb to guide the level bubble roughly to centre. This is referred to as the “rule of the left thumb,” which states that the level bubble will always travel in the same direction as that of the left thumb (Figure 30).
4. Rotate the telescope 90˚ so it is directly over the other two pins, and repeat the process in step 3.

Continue to repeat steps 3 and 4 until the bubble does not move when the telescope is slowly rotated 360 degrees.

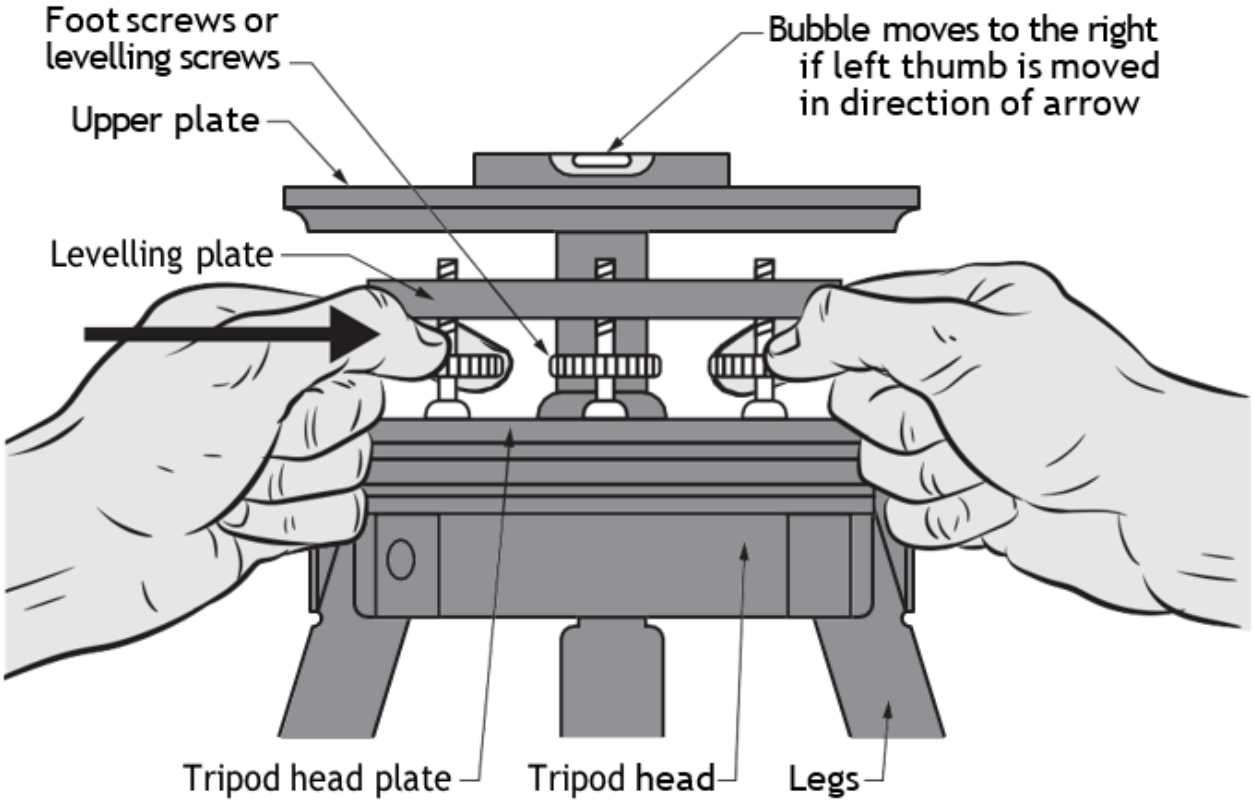


Figure 30 *Bubble moves in the same direction as the left thumb (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Levelling Instruments with Three Levelling Screws (pins)

Instruments with three pins are quite different from those with four pins. The pins on a three-pin instrument always hold the instrument from rocking, so they do not need to be tightened up to take out any slack.

Instruments with three pins usually have two levelling devices: a rough levelling device, which is usually a fish-eye bubble, and a fine levelling device, which could be either a split-bubble or an automatically-adjusting hanging prism.

The foot screws on three-pin levels do not snug up, but it is possible to turn them all the way to the end of their travel, and this will give you the feeling that they are not able to turn any more. To allow full movement of the foot screws, position each of the foot screws halfway in its travel prior to attempting to level the instrument. There is often a mark used to indicate halfway.

Adjusting a Fish-Eye Bubble

Fish-eye bubbles are always used for getting the instrument roughly level. Adjusting a fish-eye bubble can be frustrating because it is possible to "chase" the bubble around and around the vial until the travel of the foot screws is exhausted. To prevent frustration, choose one foot screw and do not adjust it at all during the levelling process.

Refer to Figure 31. First look at the position of the bubble and adjust the foot screw to raise the corner of the instrument that seems to be opposite the bubble's position. Then, when the bubble is halfway across the circle, adjust the foot screw to raise the corner of the instrument that is now opposite the bubble's position. Lastly, adjust the two foot screws to position the bubble. Remember to only adjust two of the three foot screws.

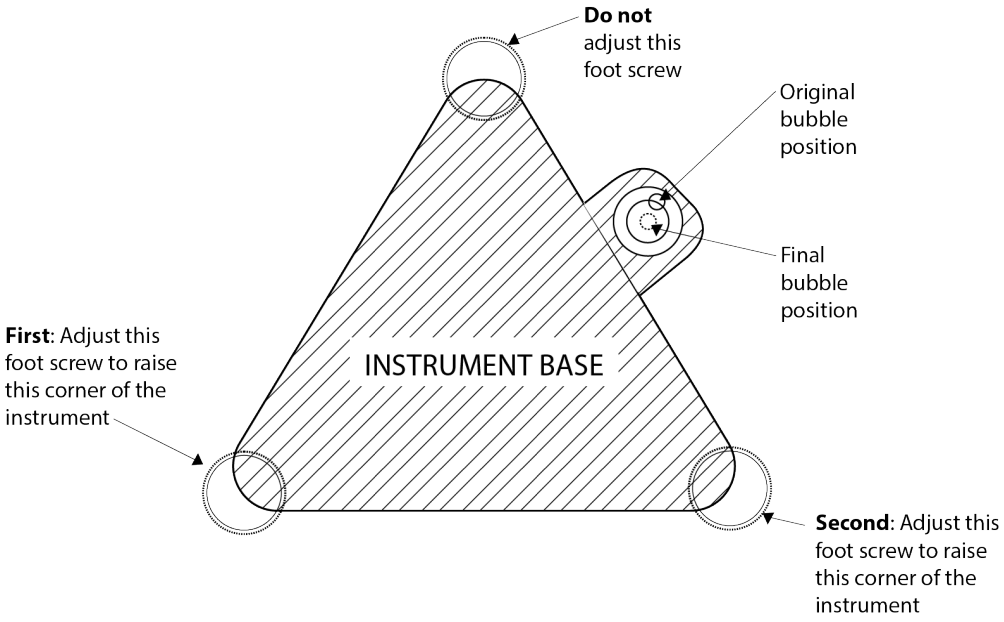


Figure 31 *Adjusting a three-pin instrument (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Adjusting a Tilting Level

Tilting levels use a fish-eye bubble with three-pin levelling to get the instrument head level. They also have a secondary eyepiece that, when viewed through, shows the end of a bubble that is split down the middle. When the instrument is sighted on the levelling rod, the operator looks into the split bubble viewfinder and fine-adjusts the bubble using the split-bubble adjustment screw (knob) so that the two ends line up (Figure 32). The telescope is now exactly level in that position, and this process must be repeated every time the telescope is moved to a new site.

Figure 32 *Split bubble*

Adjusting an Automatic Level

Once the fish-eye bubble in an automatic level is centred, it is rough-levelled, and there are no other adjustments to make. When you look through an automatic level, the light you see passes through a compensator (a prism that is suspended by a number of wires or nylon strands inside a cage). The suspended prism can compensate for the instrument being up to 12° out of level.

The prism completes the fine-tuning for level, and the instrument can be used immediately. If the instrument is lightly shaken before attaching it to the tripod, the prisms and wires will make a faint jangling sound. It is a good idea to check the fish eye from time to time to ensure that the level has not been knocked or bumped out of position, in which case it must be reset. If the automatic level sustains a sharp impact, it may cause the wires or strands to break and the instrument must then be repaired.

Set-up and Operation of Electronic Laser Levels

Select the location for the instrument so that the largest possible area can be covered.

The location should be on solid ground or floor, and out of the way of traffic. Then follow these steps:

1. Set up the tripod and attach the instrument. Level the instrument with the levelling screws until the bubble is in the centre circle.
2. Connect the power supply to the instrument, and turn the power switch on.
3. Using a level rod, establish the height of the instrument from the benchmark.
4. Calculate the vertical distance between the instrument and the elevation point you wish to find.
5. Attach the sensor or detector to the level rod at this mark.
6. If the elevation to be measured is higher than the instrument, hold the rod upside down. If it is lower than the instrument, hold the rod upright.
7. Raise or lower the level rod until the sensor indicates the correct level. Mark the end of the level rod at each location where elevations are required.
8. An alternative method is to mark the location of the beam directly on the wall, concrete form or column. Then measure up or down the required amount to establish the correct elevations.

Typical Levelling errors

There are many errors that can be made while using an optical level. The following is a list of things that can go wrong, resulting in incorrect measurements:

1. Instrument is out of level. The instrument must be level each time a sighting is taken to avoid incorrect rod readings. There are three reasons the instrument could be out of level:
    a. The instrument was not level to begin with.
    b. The instrument was accidentally moved between sightings.
    c. The instrument was set up on an unstable surface, such as soft ground, frozen ground or a wooden floor, and some settlement or movement occurred.
2. The rod is incorrectly read. Whenever you take a sighting, say the reading aloud, and then repeat the reading.

There is no special way to avoid this sort of error, but taking the reading twice will help.

3. The figures on the rod cannot be seen clearly. This can occur if the instrument is set up too far away from the rod. The instrument should be set up about halfway between a benchmark and the location where the reading is to be taken. Equal length backsights and foresights will cancel errors caused by the crosshairs not being in perfect adjustment.
4. The instrument is improperly focussed. Make sure the crosshairs are in sharp focus, and the telescope is properly focussed on the rod. Each person's eyes focus slightly differently, and these adjustments should be made each time you take an instrument out to use it.
5. The instrument was levelled using the stadia lines. There are also two other marks on the vertical crosshair called stadia lines. These are used for distance measurement and are not used in levelling. Be careful not to line your eye up with either of these when taking a reading.
6. The rod is not held plumb. If the rod is not plumb, the result will be a reading that is a higher number on the rod than the correct reading. The way to avoid this is to give the rod person a signal to slowly pivot the rod forward and backward over the centre point while holding it plumb to the vertical crosshair, and then record the lowest reading.
7. The rod person holds the rod at the wrong location or chooses a spot that is not stable. Good communication with the rod person is the best way to avoid this type of error.

Testing the Accuracy of an Optical Level

You should always test optical levelling equipment for accuracy before measuring or setting elevations. Even with all of the levelling devices adjusted correctly, the instrument may still not be able to accurately transfer elevations. The cause of error at this point is the accuracy of the crosshair position. The "reticle" that holds the crosshairs can be adjusted up or down and left or right to correctly position the crosshairs in the image.

When you are using the instrument for the first time, its accuracy is not known to you. If the instrument has been bumped or jarred, its accuracy is in question.

Figure 33 below shows two telescopes set exactly level. The upper telescope has the crosshairs set correctly. The lower telescope has the crosshairs set too high.

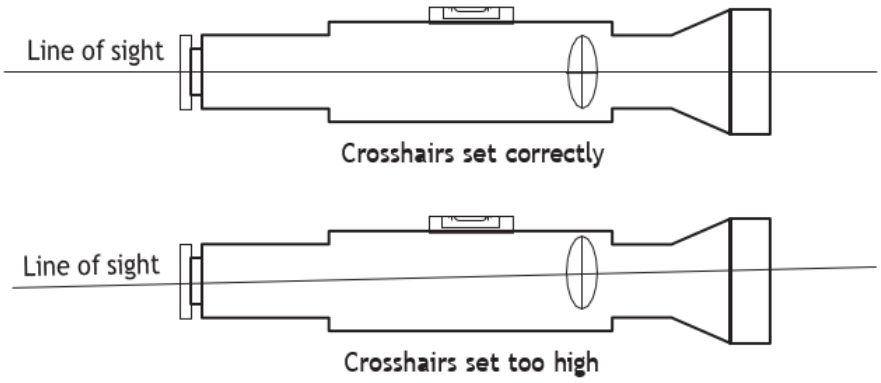


Figure 33 *Correct and incorrect setting of crosshairs (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The only way to check the position of the crosshairs at the job site is to do a peg test on the instrument.

1. Select a location that is reasonably flat alongside a building, or between two buildings, two columns or even two telephone poles. The required distance between locations to use in the test is about 30 m. Figure 34 shows the instrument set-up for checking the level's accuracy.

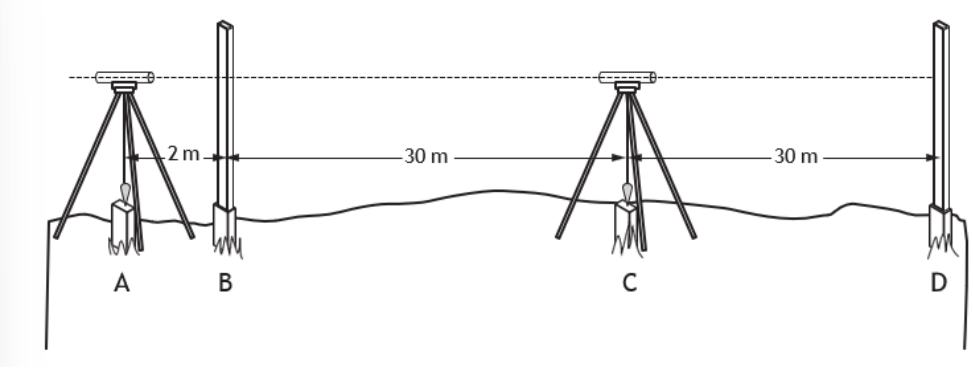


Figure 34 *Checking the accuracy of a level with a peg-test (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

2. Set up at location A and level the instrument.
3. Have the rod person precisely mark a piece of masking tape stuck to object B (the side of a building or column, etc.) exactly at the line of sight. You will guide this by sighting through the telescope and indicating that the rod person raise or lower the pencil, held horizontally, until it is accurately aligned.
4. Have the rod person now move to object D and mark the masking tape located at this point in the same manner as at B.
5. Move the instrument to location C and set up as you did before.
6. Have the rod person accurately mark the new lines of sight on the masking tape at objects B and D.
7. Measure the distance between the marks made on B and D. If they are the same, the instrument is working accurately. If they are not the same, the operation should be repeated. Human nature dictates that errors or inaccuracies are firstly blamed on tools or instruments, so a second check on the readings will eliminate or confirm that as a possibility. If on the second attempt the two differences are not the same, subtract one from the other and divide by 2 to find the error over 30 metres (as the second reading was taken over 60 metres).

Obtaining perfect results is not always practical; a maximum error of 6 mm or $\frac{1}{4}$„ over 30 metres is usually considered to be acceptable on the peg test.

If the inaccuracy is consistent, the instrument can be checked and sent for repair or to be recalibrated. Adjustment of the crosshairs is done by turning the crosshair adjustment screws. These screws are normally located under a cover just behind the eyepiece. Consult the owner's manual before trying to adjust the crosshairs or send the instrument to a survey equipment repair shop for adjustment.

Care and Handling of Levelling Equipment

Survey instruments are constructed to give many years of service in adverse weather conditions, but they can be damaged if they are not handled with proper care. Following these rules will ensure that no damage will occur to your instruments:

- During transportation always store the instrument properly in its case. If there is any chance that it will be subjected to jarring, give it further protection by enclosing it in a Styrofoam container.
- When first selecting an instrument, open the lid and carefully look to see how it is secured in its container. You must return it to its container in the same way each time you use it. When it is not in use, you must always return the instrument to its container for storage.
- When protective lens caps are not in use, leave them in the instrument container. Do the same with the thread protector ring and the cap for the tripod, if the tripod has these.
- Before the instrument is mounted on the tripod, make sure that the tripod is firmly set up and all leg adjusting screws and tripod head screws are properly snugged up.
- The mounting head or top plate should be as level to the horizon as you can get it by adjusting the legs.
- If the legs must be positioned on smooth concrete or any other surface where the points of the tripod legs are not able to dig in, use rubber tips or suction cups, or place the tripod in a triangular frame to prevent slipping (Figure 35).

Figure 35 *Triangular frames for the tripod* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

- While transporting the instrument from the case to the tripod, always grasp the instrument by its base, where it should be held to avoid any damage to any of its parts.
- Thread the instrument onto the tripod securely, but do not over tighten. This avoids stripping the threads or putting undue stress on any part of the instrument. This is no time to become distracted. If the instrument is not properly fastened to the tripod and, as a result, falls to the ground and is damaged, time is lost until it is repaired. A loss in both time and money can be avoided if care is taken each time the instrument is set up.
- Never force the instrument while turning it horizontally or while making any adjustments. Forcing it could result in damage. All adjustable features of any level are designed to be just snugged up but never over tightened or forced.
- When the lenses become dusty or dirty, try to wash with water. When doing this, never rub the lens with anything, as this will probably scratch the lens. The best way to clean lenses is to let them dry completely, then use a camel's hair brush in a circular motion starting at the centre of the lens and working outward. Remember to use the brush

lightly and blow out any particles of dirt as you proceed.

- Levels are built to be used in rain and snow but should not be left out needlessly. When you are finished, bring them inside and lightly dry them off (damp dry them), except for the lenses, which should always be left to dry on their own. Secure them in their container but leave it open so that the machine will completely dry. If you close the container the moisture will remain inside to corrode both the instrument and the case (if it is made of metal). Adding a package of desicant such as silicon will help control any small bits of moisture within the case.
- Avoid sudden extreme changes in temperature. If the instrument is kept in storage at room temperature, then taken directly outside into cold or damp conditions, there is a good chance the inner lenses will become fogged. Nothing can be done with it until the temperatures inside and outside the instrument equalize and the moisture trapped within naturally disperses. This can result in loss of time. To avoid this happening, many contractors keep their instruments in locked storage in the same conditions as those in which they will be used or, if properly protected, in their locked vehicle.
- Extreme heat can expand the air bubble in the level vials, making them very difficult to level. To avoid this, put up an umbrella or some sort of sunshade over the instrument.
- Avoid using the instrument where there is a lot of vibration from soil compactors, piledrivers, etc. This could put the level out of alignment, thus requiring repairs.
- The way in which an instrument is carried when mounted on its tripod is important (Figure 36). Leave the horizontal clamp loose so that the instrument can swing if it should accidentally hit anything. In wide open spaces, always pack it with the tripod legs in front and over one shoulder. This will help to avoid hitting the instrument, and if you should happen to trip, the tripod should contact the ground before the instrument does.
- If the route you must take is full of obstacles, especially doorways, either pack the tripod- mounted instrument in front of you so you can see what it might come into contact with, or dismantle it and put it in its container.

Figure 36 *How to carry a mounted instrument (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

- Never jar the instrument by banging it down when you are about to set it up, or at any other time. At all times, handle the tool as if it were a crate of eggs.
- Never leave the instrument unattended. There are many ways an unattended instrument can be damaged on a busy construction site. Some contractors paint the legs of the tripod in bright colours and attach streamers of

bright surveyor's tape as a precaution against accidents. Also, the instruments could be stolen if left unattended in an occupied area such as a busy downtown street.
- Check all connections for the various parts of the tripod. Looseness at any of the several connecting points could make it unstable and result in incorrect readings. The wood screw connections of wooden tripods that are subjected to wetting and drying tend to loosen.

Use Levelling Equipment to Establish Elevations

Reading the Levelling Rod

In the metric examples in Figure 37, the triangular black "comma" denotes the metres and decimeters area of the rod seen through the telescope. Reading #1 should be interpreted as 1.330 m; #2's reading is 0.850 m; #3 is 2.917 m.; reading #4 is 1.185 m. Rod reading #5 should be close to 2.147 m; #6 is 1.625 m; #7 is 1.540 m and #8 is 1.695 m. With a little practice, you should be able to read a metric rod to the nearest 0.001 m.

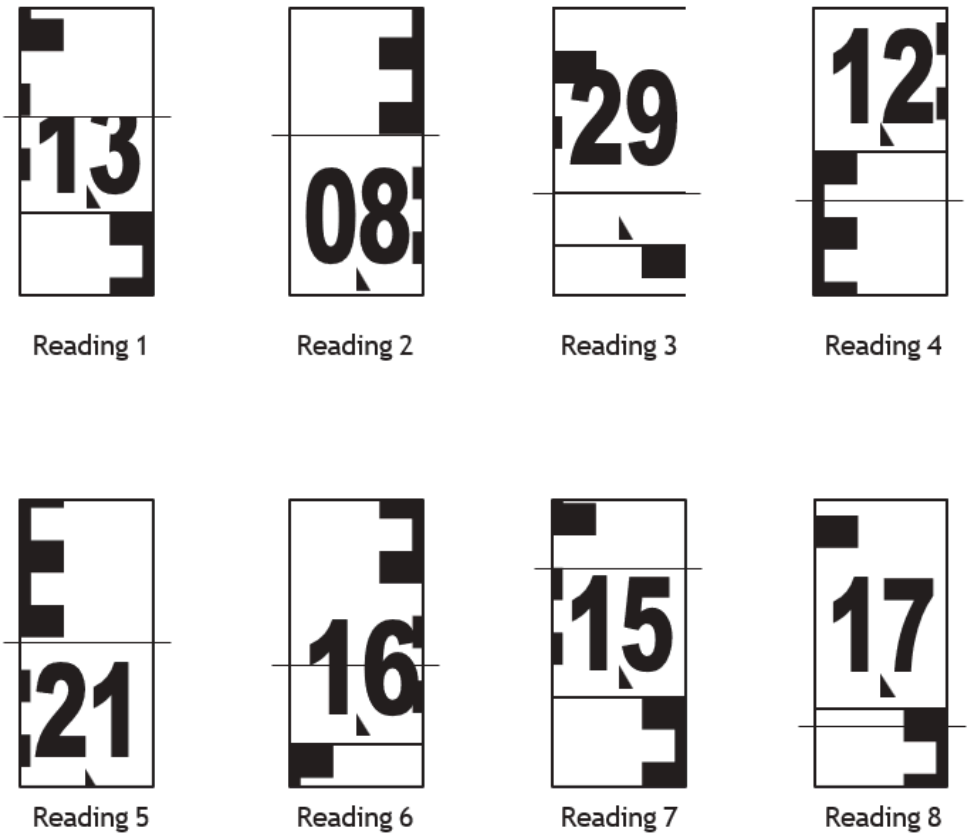


Figure 37 *Readings on a metric rod* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

When reading a rod in imperial measure, first determine whether the rod is in feet and inches or feet and decimals of feet. As mentioned previously, look for the presence or absence of the 11-inch mark.

Figure 38 shows examples of rod readings. The rod is calibrated in feet and hundredths of feet. The footage markings are usually visible in one or two locations between the large numbers representing feet, as shown by the "7" in the lower part of the image.

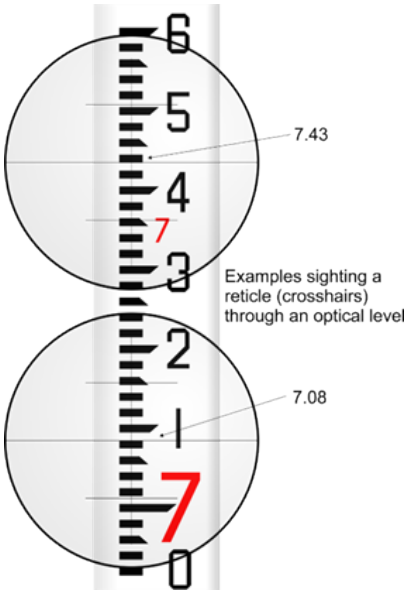


Figure 38 *Examples of engineer's rod readings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The smaller numbers in black along the right side of the rod indicate decimals of feet, and line up with the pointed end of the black graduations. Each point on this scale represents 0.05′, so there are five graduations between points. This is different from the scales that are in feet and inches. On those scales, the pointed graduations occur every $\frac{1}{2}$″ , so there are only four graduations between points. On the imperial rods, you should be able to read to the nearest 0.005′ or $\frac{1}{16}$″ .

Recording the Readings

The measuring and setting of elevations at a construction site must be done accurately and to the exact specifications shown on the construction drawings. Maintaining a record of how the elevations were set and who set them is also of prime importance. Using a surveyor's field book to record all instances where elevations were measured or set allows a permanent record of the results to be kept.

The surveyor's field book is a small, hard-covered book measuring 4 inches by 7 inches. There are many types of field books; the standard field book used for levelling has six columns on each facing page. Some field books have level notes on the left and a grid or graph paper on the right. The grid paper is used to make plan views of horizontal layouts.

Each page in the levelling field book is divided into six columns and 32 rows. The lines on the pages are printed with waterproof ink. When recording instrument readings into the field book, use a pencil, not a pen. The ink from a pen may not be waterproof.

Readings should never be erased once they have been recorded. After a second look, if a reading needs to be changed, cross out the initial reading and put the new reading above it. Leaving the initial reading in the book shows that there was some concern with that reading.

The headings across the top of the pages should always be set up in the same way. Table 1 shows the standard layout of headings.

Table 1: ***Standard Layout of Headings in a Surveyor's Field Book***

STA	BS	HI	IFS	FS	ELEV

Glossary of Levelling Terms

As with any aspect of construction, there are terms, definitions and abbreviations that need to be understood. You should be familiar with the following terms:

Benchmark (BM)

The ***benchmark*** is listed first in this glossary because it is the starting point for all levelling. Before any elevation can be measured or set, a benchmark must be found to refer the elevations to. This should be a relatively permanent point of known elevation. It can be any object not likely to move, such as a lamp standard, rim of a manhole or catch basin or a fire hydrant. It is usually noted on the site plan in a set of working drawings. Nothing that is easily moved or shifted should be considered for a benchmark, as it must be used for the duration of the levelling exercise. Residential benchmarks are assigned arbitrary values such as 100.000 m. All parts of the structure are either above this mark and have a higher value, or below this mark and have a lower value.

If benchmarks are given a value relative to mean sea level on the Earth's surface, they are referred to as ***datum points***. The reason this is the more common way of giving benchmark values is that most structures must tie into existing utilities such as sewer and storm drains, the locations of which are always described with elevations relative to mean sea level. If you have this type of benchmark, it should be very apparent because the altitude of the locality where the structure is to be erected will be known.

Great care must be taken to protect benchmarks from premature demolition or any damage that would spoil their accuracy. Field book records should precisely identify benchmarks so that they can be found again if required when renovations or additions to the structure are made in future.

Backsight (BS)

The first reading of any survey job will be a ***backsight*** onto a fixed point of reference, usually a benchmark. The backsight column is just to the right of the (station) "STA" column in the field book. Backsight ("BS") readings are taken from a levelling rod held plumb on the benchmark or turning point. It is necessary to know the height of the instrument relative to a known elevation, so that work done can be related to that elevation. Therefore, it is a backsight reading that will establish the height of the instrument ("HI").

Datum

A ***datum*** is a clearly defined survey reference marker, from which ground and building levels are measured. This level is referenced to the distance above ***zero datum***, being mean sea level (the average between high and low tide).

Elevations (ELEV)

Elevations are the values assigned to points where elevations have been established relative to the benchmark. These readings are recorded in the "ELEV" column located at the extreme right of the field book.

Foresight (FS)

Foresight readings are taken on points of unknown elevation and are used to determine the elevation of a turning point or the elevation of the final point in a survey. They are essentially the same as intermediate foresights but are listed under their own column so that the math can be more easily checked for errors. FS readings are recorded in the fifth column from the left in the field book.

When determining the unknown elevation, the level rod would be held in a plumb position and the reading from it would be either added to or subtracted from the HI value to obtain the elevation of the turning point relative to the BM.

Height of Instrument (HI)

The ***height of instrument*** is the exact elevation of the line of sight of the instrument in relation to the benchmark (BM) or turning point (TP). It is not possible to find the elevation of any point until the height of the instrument is first established, so that is the first step in any levelling exercise. The "HI" column in the field book is the third from the left.

If the line of sight of the instrument is above the BM, then the level rod reading is added to the value assigned to the BM, thus establishing the HI.

If the line of sight of the instrument is below the benchmark, then the level rod reading is subtracted from the BM value to get the HI elevation.

Intermediate Sight (IS) or Intermediate Foresight (IFS)

Intermediate sights are readings taken on all other points of unknown elevation before the last location, which is the foresight or turning point. There is really no practical difference between the foresight and the intermediate sight, except where it is recorded in the field book and how it is used.

Station (STA)

The ***station*** is the spot where the rod is being held while a reading is being taken. The station is not where the instrument is set up. In the field book, the station column is the first one on the left side, and it is where sightings (or *shots*) are identified and their locations recorded. When setting up an instrument, the name of the benchmark used is recorded in this column, as are the names given to points where elevations are established or where unknown elevations are to be calculated.

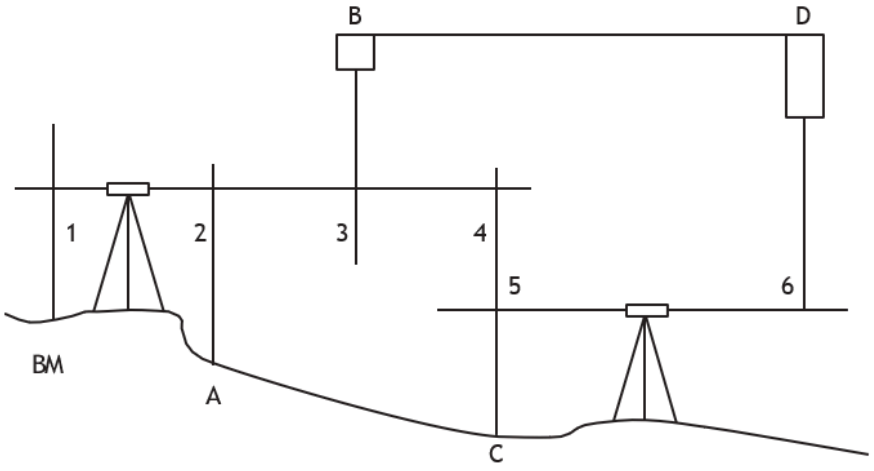
Turning Point (TP)

A ***turning point*** **(TP)** is set when moving the instrument to a new location. It can be either the last station elevation used or one that can be seen from the new instrument location. The point chosen for the TP must have a prominent point for the levelling rod to rest upon. Once the TP is established, the survey rod is held on it, a foresight reading is taken, and the elevation of the TP is calculated.

The instrument is then moved to the new location and levelled, and a backsight reading is taken on the TP. The levelling rod must be held in exactly the same point on a TP for both the foresight and backsight readings to ensure that the transfer of elevation is accurate. The backsight reading is added to the elevation of the TP to obtain the new elevation of the line of sight.

Example:

Using 100.000 m for the benchmark (BM), a backsight was taken on the BM to determine the height of instrument (HI).



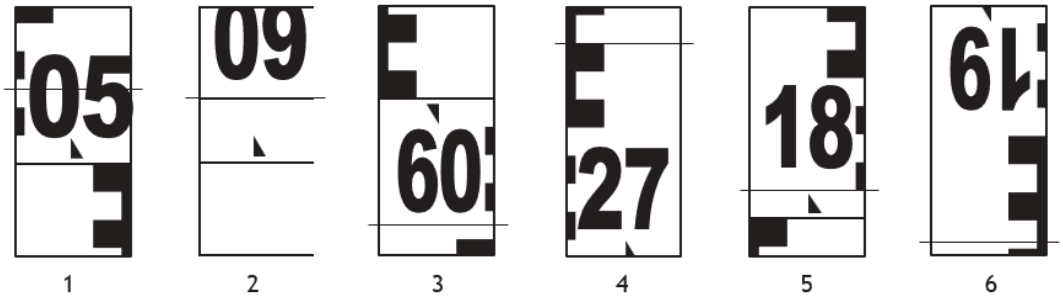


Figure 39 *Locations of level instrument, benchmark and stations and rod readings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Table 2: *Values Entered in Field Book*

STA	BS	HI	IFS	FS	ELEV
BM	0.527	100.527			100.000 m
A		100.527	0.923		99.604
B		100.527	<0.945>		101.472
C		100.527		2.780	97.747
C	1.810	99.557			97.747
D		99.557		<1.988>	101.545

This height of instrument was used for the next three sightings. As station A is lower than the HI, rod reading #2 is subtracted from the HI to get the elevation for A. As B is above the HI, rod reading #3 is added to the HI.

Station C is a turning point. Once its elevation is determined as 97.747, a backsight from the new location can be taken. By adding the backsight to 97.747, the new height of instrument is found. It is then used with rod reading #6 to find the elevation of station D.

To help protect against errors, inverted readings are enclosed in brackets. The degree of accuracy is also important. Entering 9.42 m instead 9.420 m may lead others to think that measurements where only taken to two decimal places. Showing “m” after the benchmark elevation indicates that measurements are in metres, not feet.

Checking the Math

Total the backsight readings and subtract from that the total of all the foresight readings (not any IS readings). The difference should be the same as the difference between the benchmark elevation and the elevation of the last sight taken. If they differ, the math is out and should be rechecked. If you “close the circuit” (finish back at the benchmark), the two totals should be the same.

Using Instrument Readings

Grading Drains

When grading sanitary and storm drains within a building, the structure itself is normally used as the benchmark or reference for measurements. Using a tape measure, you can measure from the underside of the flooring or joists to the centreline of the piping regardless of whether it is being suspended or installed underground. Grade can be set accurately as long as the flooring or joists are themselves set level, which is usually taken for granted as the norm. However, when piping is to be installed underground outdoors, the only way to do this accurately is by using an optical or laser level and datums. In some cases, such as installing piping from the building to the connection at the property line, you must run your piping at a grade that you must establish in order to meet with the connection at the property line, so there are no changes in elevation due to the use of fittings. In some cases, your piping must be covered and compacted as you install it, so your calculations must be very accurate.

The following examples show the calculations that would need to be performed when grading pipe using elevations that are given in feet and decimals or in metric.

Remember that the relationship between grade, length and total fall, as learned in Level 1 of pipe trades training, is constant and can be expressed three ways:

- Grade × length = total fall
- Total fall ÷ length = grade
- Total fall ÷ grade = length

A tool for remembering these relationships can be a learning triangle (Figure 40).

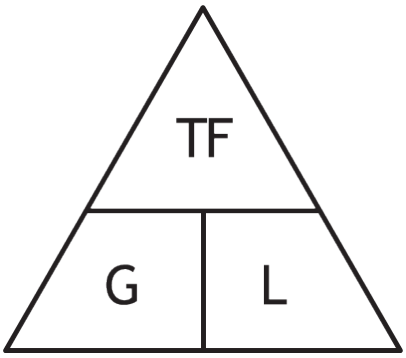


Figure 40 *Learning triangle for grade, length and total fall* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Note: Remember that when grade is in inches per foot, length must be in feet and total fall must be in inches.

Calculating Grade

Example 1: Calculate the grade in inches per foot on the drain in Figure 41.

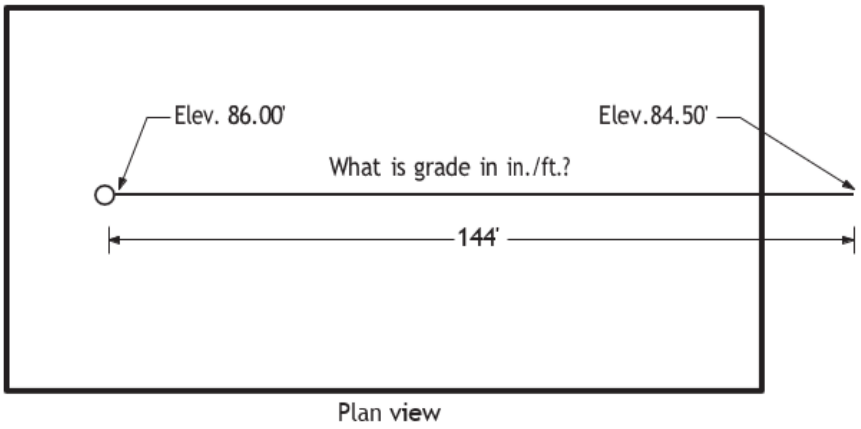


Figure 41 *Image for Example 1* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Formula: Grade = total fall ÷ length

Solution: Grade = (86.00′ − 84.50′) ÷ 144′

Grade = 1.5′ ÷ 144′
Grade = 18″ ÷ 144′
Grade = 0.125″/foot

Grade = $\frac{1}{8}$„ /foot

Calculating Length

Example 2: Calculate the length in feet of the drain shown in Figure 42.

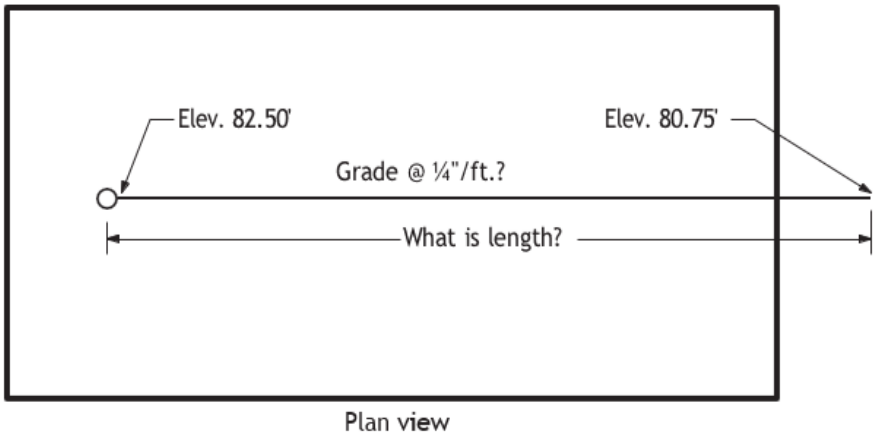


Figure 42 *Illustration for Example 2* (BC *Industry Training Authority*, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Formula: Length = Total fall ÷ grade

Solution: Length = (82.50′ − 80.75′) ÷ $\frac{1''}{4'}$

Length = 1.75′ ÷ $\frac{1''}{4'}$

Length = 21″ × $\frac{4'}{1''}$

Length = 84′

Note: In the above, express the TF as inches. Also, instead of dividing by a fraction, invert the fraction and use it as a multiplier. That way, the inches in the total fall and in the grade cancel each other out, leaving the only unit of measure in the answer as length in feet.

Calculating Total Fall

Example 3: Calculate the total fall on the drain in Figure 43.

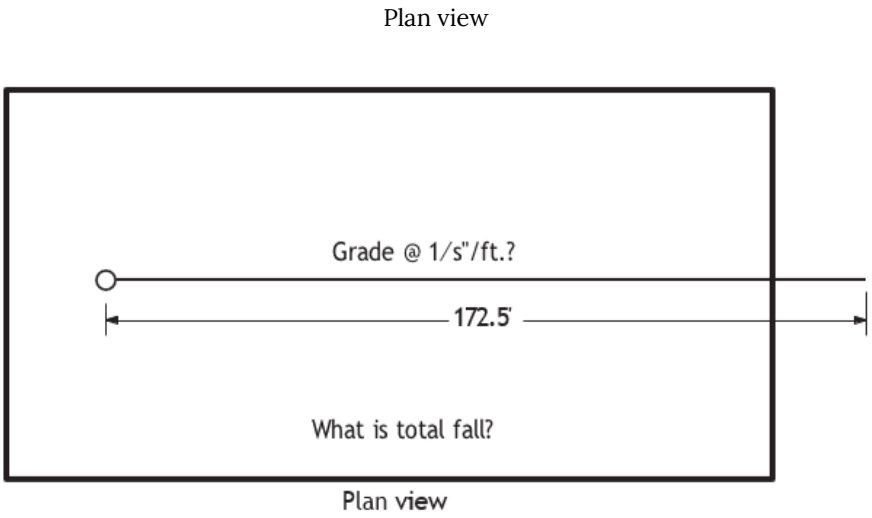


Figure 43 *Illustration for Example 3 (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Formula: Total fall = length × grade

Total fall = 172.5′ × $\frac{1''}{8'}$

Total fall = 21.562″

Total fall = 21 $\frac{9}{16}$″

Note: In the above, the feet unit of measurement in the length and in the grade will cancel each other out, leaving inches as the units in the answer.

Example 4: Calculate the elevations at points A and B in Figure 44.

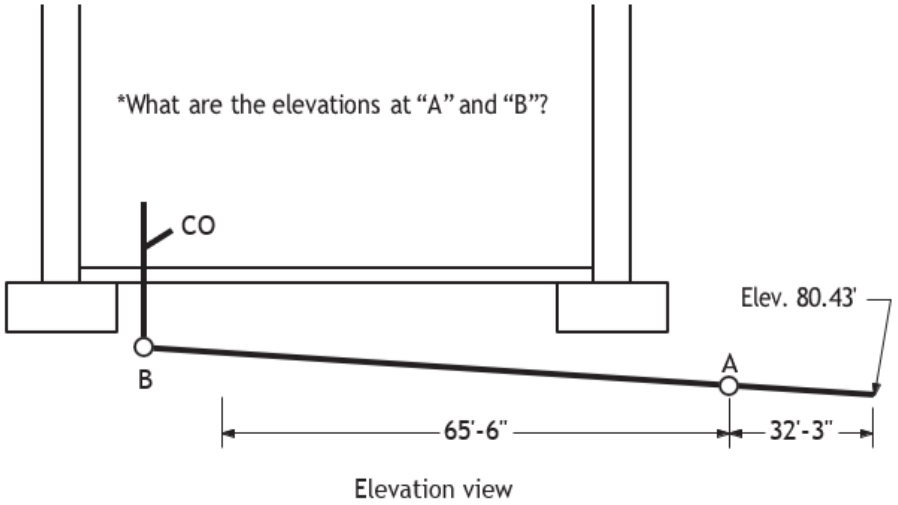


Figure 44 *Illustration for Example 4 (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Formula: Total fall = Length × grade

Solution for elevation at A:

Total fall = 32′-3″ × $\frac{1''}{4'}$

Total fall = 32.25′ × $\frac{1''}{4'}$

Total fall = 8.062″

Note: The foot units in the length and grade cancel out.

Total fall = 8.062 ÷ 12 = 0.67′
Therefore, elevation at A = 80.43′ + 0.67′ = 81.10′

Solution for elevation at B:

Total fall = (65′-6″ + 32′-3″) × $\frac{1''}{4'}$

Total fall = (65.5′ + 32.25′) × $\frac{1''}{4'}$

Total fall = 97.75′ × $\frac{1''}{4'}$

Total fall = 24.437″

Note: The foot units in the length and grade cancel out.

Total fall = 24.437″ ÷ 12 = 2.04′
Therefore, elevation at B = 80.43′ + 2.04′ = 82.47′

Example 5: Calculate the elevations at stacks A and B in Figure 45.

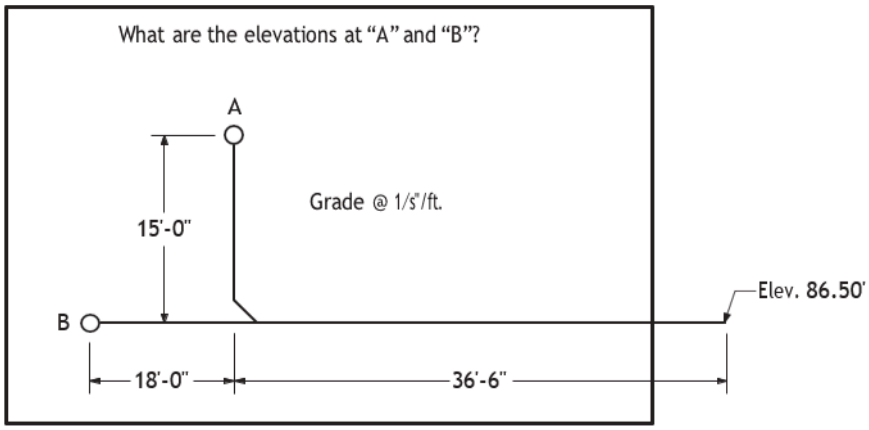


Figure 45 *Illustration for Example 5 (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Plan view

Formula: Total fall = length × grade Solution for elevation at A:

$$\text{Total fall} = (36'\text{-}6'' + 15'\text{-}0'') \times \frac{1''}{8'}$$

$$\text{Total fall} = (36.5' + 15.0') \times \frac{1''}{8'}$$

$$\text{Total fall} = 51.5' \times \frac{1''}{8'}$$

Total fall = 6.4375″

Note: The foot units in the length and grade cancel out.

Total fall = 6.4375 ÷ 12 = 0.54′
Therefore, elevation at A = 86.50′ + 0.54′ = 87.04′

Solution for elevation at B:

$$\text{Total fall} = (36'\text{-}6'' + 18'\text{-}0'') \times \frac{1''}{8'}$$

$$\text{Total fall} = (36.5' + 18.0') \times \frac{1''}{8'}$$

Total fall = 54.5′ × $\frac{1''}{8'}$

Total fall = 6.8125″

Note: The foot units in the length and grade cancel out.

Total fall = 6.8125 ÷ 12 = 0.57′
Therefore, elevation at B = 86.50′ + 0.57′ = 87.07′

Example 6: Calculate the elevation at stacks A and B in Figure 46.

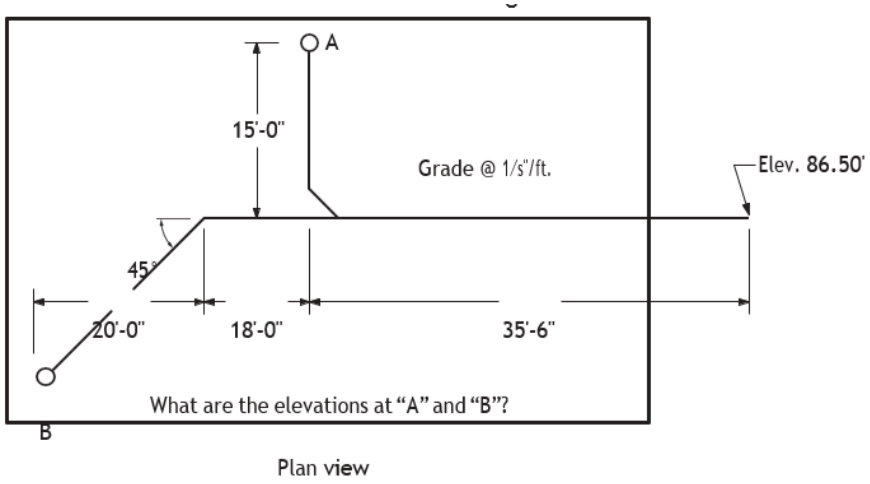


Figure 46 *Illustration for Example 6 (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Note: Because the drain from stack B has a 45˚ turn, it is necessary to use the offset formula for 45˚ to calculate the length of travel for the offset. The formula is:

Travel = offset × 1.414

Also note that the Y & $\frac{1}{8}$ bend on the drain from stack A does not add enough extra length above what a sanitary tee would (which is not allowed on a horizontal drain).

Formula: Total fall = length × grade S

solution for elevation at A.

Total fall = (35′-6″ + 15′-0″) × $\frac{1''}{8'}$

Total fall = (35.5′ + 15.0′) × $\frac{1''}{8'}$

Total fall = 50.5′ × $\frac{1''}{8'}$

Total fall = 6.3125″

Note: The foot units in the length and grade cancel out.

Total fall = 6.3125 ÷ 12 = 0.53′
Therefore, elevation at A = 86.50′ + 0.53′ = 87.03′

Solution for elevation at B: Total fall = (35′-6″ + 18′-0″ + travel) × $\frac{1''}{8'}$

Total fall = (35.5′ + 18.0′ + (20′ × 1.414)) × $\frac{1''}{8'}$

Total fall = (53.5′ + 28.28′) × $\frac{1''}{8'}$ Total fall = 81.78′ × $\frac{1''}{8'}$

Total fall = 10.22″

Note: The foot units in the length and grade cancel out.

Total fall = 10.22″ ÷ 12 = 0.85′
Therefore, elevation at B = 86.50′ + 0.85′ = 87.35′

Example 7: Calculate the following using Figure 47:

- Elevations of points A and B
- Depth of the drain at point B below the given datum of 100.00′ expressed in feet and inches to the nearest $\frac{1}{16}$″

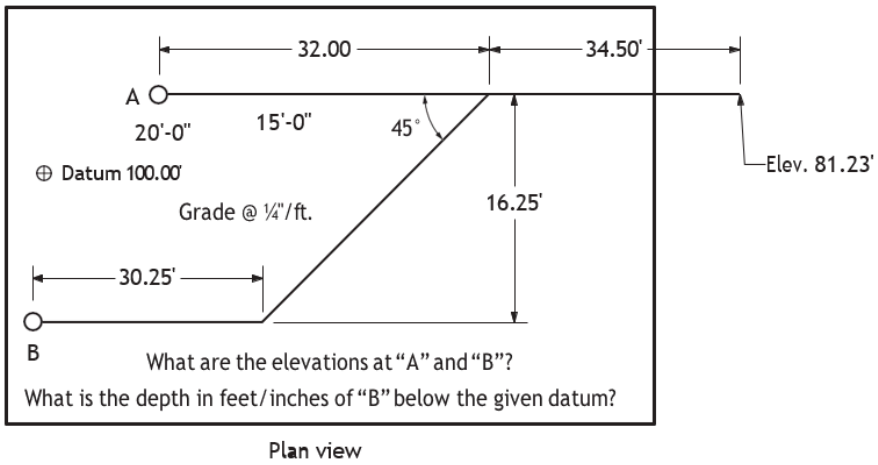


Figure 47 *Illustration for Example 7 (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Formula: Total fall = length × grade

Solution for elevation at A: Total fall = (34.5′ + 32.0′) × $\frac{1''}{4'}$

Total fall = 66.5′ × $\frac{1''}{4'}$

Total fall = 16.625″

Note: The foot units in the length and grade cancel out.

Total fall = 16.625 ÷ 12 =1.39′
Therefore, elevation at A = 81.23′ + 1.39′ = 82.62′

Solution for elevation at B: Total fall = (34.50′ + travel + 30.25′) × $\frac{1''}{4'}$

Total fall = (34.50′ + (16.25′ × 1.414) + 30.25′) × $\frac{1''}{4'}$

Total fall = (34.50′ + 22.98′ + 30.25′) × $\frac{1''}{4'}$

Total fall = 87.73′ × $\frac{1''}{4'}$

Total fall = 21.93″

Note: The foot units in the length and grade cancel out.

Total fall = 21.93″ ÷ 12 = 1.83′
Therefore, elevation at B = 81.23′ + 1.83′ = 83.06′

Solution for depth of pipe at B below given datum of 100.00′: 100.00′ – 83.06′ = 16.94′

0.94′ × 12 = 11.28″

0.28″ × 16 = $\frac{4.48}{16}$ = $\frac{4''}{16'}$ = $\frac{1}{4}$„

Therefore, the depth below B can be expressed as 16′-11 $\frac{1}{4}$„ .

Self-Test B-1.3: Use Levelling Equipment

Complete Self-Test 1.3 and check your answers.

If you are using a printed copy, please find Self-Test A-1.3 and Answer Key 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://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2734#h5p-22 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2734#h5p-22)

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Camosun College. (2015). Trades Access Common Core Competency C-1: Describe Common Hand Tools and Their Uses. Victoria, B.C.: Crown Publications. Download for free from the B.C. Open Textbook Collection (https://open.bccampus.ca/browse-ourcollection/find-open-textbooks/).

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Self-Test B-1.1: Describe Hand Tools Used in the Pipe Trades

Complete Self-Test B-1.1 and check your answers.

1. The numbers 1218 printed on a hacksaw blade indicate:
    a. 18 in. long and 12 teeth per inch
    b. 8 in. long and 121 teeth per inch
    c. 12 in. long and 18 teeth per inch
    d. the date of manufacture—12th month 18th day
2. The teeth of a hacksaw blade always have a small amount of set to allow for:
    a. Ease of starting the cut
    b. Blade clearance through the cut
    c. Protection of the teeth
    d. Ejection of the waste
3. A wrench that has a box end at one end and an open end at the other is known as a(n):
    a. Double-duty wrench
    b. Double-ended wrench
    c. Open-box wrench
    d. Combination wrench
4. The size of an adjustable wrench is designated by its:
    a. Jaw length
    b. Jaw opening
    c. Total weight
    d. Overall length
5. All hand tools should be:
    a. Kept clean
    b. Varnished occasionally
    c. Greased regularly
    d. Soaked in solvent after each use
6. Interlocking slip-joint pliers are also known as:
    a. Vise-Grip pliers
    b. Water pump pliers
    c. Side grip pliers
    d. Oil pump pliers
7. The combination square contains a spirit level in its:
    a. Square head
    b. Bevel head
    c. Protractor head
    d. Fixed head
8. A centre punch has a tip that is ground to an included angle of:
    a. 30°
    b. 45°

c. 60°
d. 90°

9. Which dimension from Figure 1 correctly indicates thread pitch?

a. a
b. b
c. c
d. d

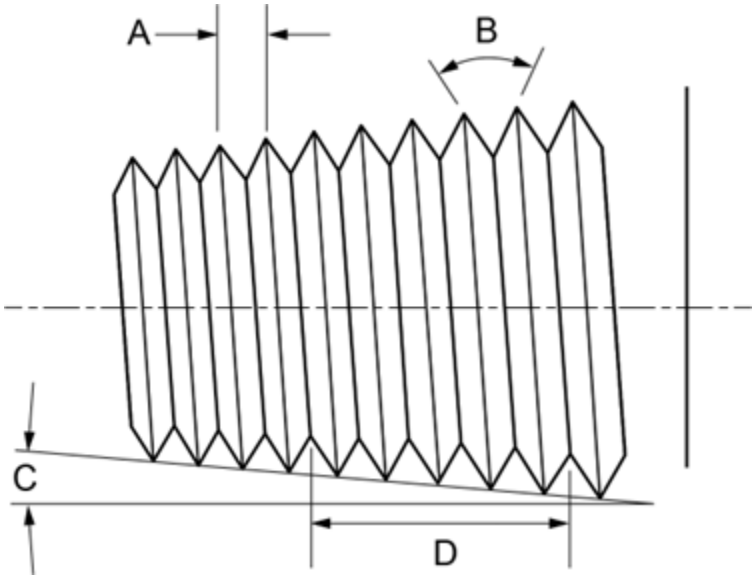


Figure 1 *Image for Question 9.*

10. A torpedo level is used in the piping trades.

a. True
b. False

11. Always file on the forward stroke and raise the file on the backstroke to prevent damage.

a. True
b. False

12. A smoother cut can be obtained from a file that is:

a. Single cut
b. Double cut
c. Round
d. Three square

13. Files that are clogged with waste material can be cleaned with:

a. File comb
b. Hardened steel pick
c. Soap and water
d. File card

14. Name the parts of the screwdriver shown in Figure 2.

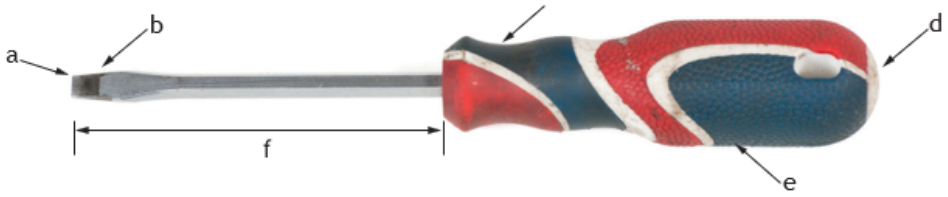


Figure 2 *Image for Question 14.*

a. a
b. b
c. c
d. d
e. e
f. f

15. C-clamps:

a. Exert only a limited amount of pressure
b. Do not require the use of protective padding
c. Are useful for small tight areas
d. Are also known as cabinet clamps

16. To protect your work piece when using a bench vise, you should:

a. Grip it as tightly as possible to prevent movement
b. Use soft vise jaw-caps
c. Grip it very lightly to prevent damage to the piece
d. Grip your work piece by the corners

17. The ball-peen hammer is used to round over bolt threads or rivets.

a. True
b. False

18. A bar that has a hook at one end and is about 750 mm long is called:

a. Wonder bar
b. Wrecking bar
c. Crowbar
d. Lining bar

19. A ball-peen hammer size is classified by the:

a. Length of the handle
b. Length of the head
c. Weight of the head
d. Weight of the entire hammer

20. A cracked hammer handle must be:

a. Replaced
b. Taped up to prevent slivers
c. Used for light hammering only
d. Soaked to close the crack

21. Identify the vises shown below:

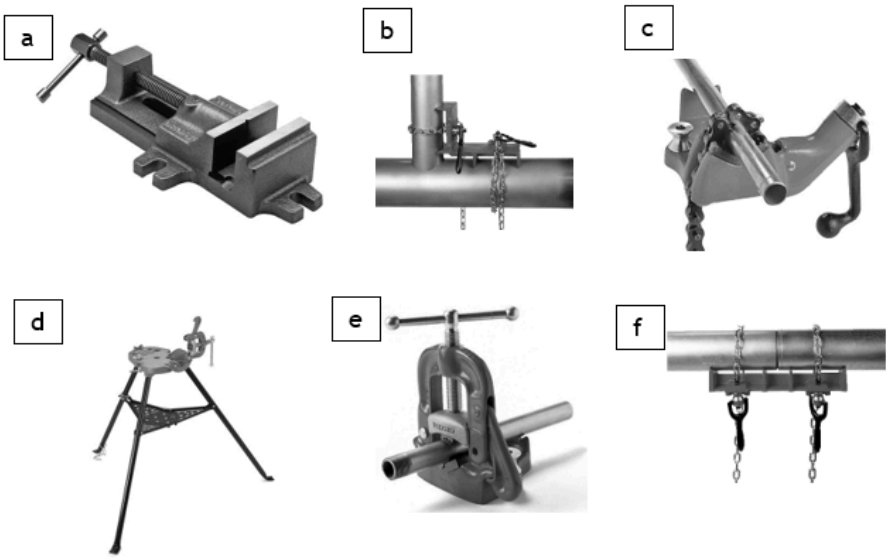


Figure 3 *Image for Question 21.*

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

22. What kind of vise comes with two pairs of legs and uses a connecting pipe?

_____

_____

23. Name the vise that holds and aligns pipe for tacking and is used on mains and risers.

_____

24. Name a principal advantage of the bench-mounted or portable chain vise.

_____

_____

_____

25. Identify the threaders shown below:

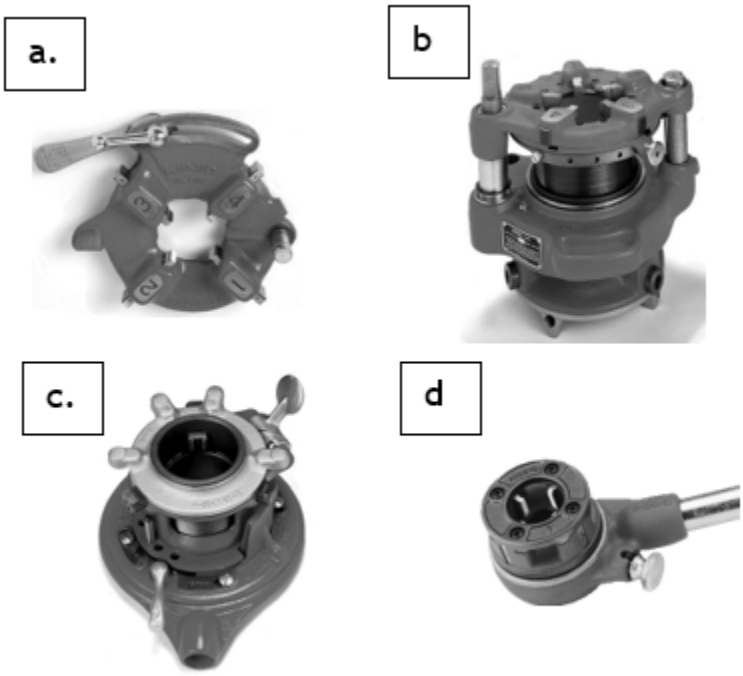


Figure 4 *Image for Question 25.*

a.

b.

c.

d.

26. Identify the cutters shown below

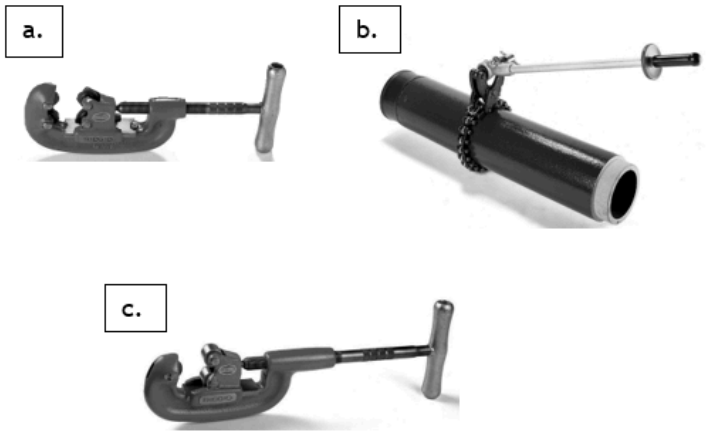


Figure 5 *Image for Question 26.*

a. _____

b. _____

c. _____

27. At what stage of a threading operation is reaming done?

_____

_____

_____

28. What type of reamer would be selected for use with a power vise or threading machine?

_____

29. Name the wrench that multiplies the turning force and is ideal for loosening seized joints.

_____

30. Name the standard wrench that has a jaw opening parallel to the handle and a narrow hook jaw head.

_____

31. Name the wrench especially designed for polished pipe.

_____

32. Describe two features of the basin wrench.

33. Name three uses for thread cutting oil.

34. What are multimeters used to test, in addition to amperage and voltage?
    a. Pressure
    b. Humidity
    c. Resistance
    d. Temperature
35. Analog meters are more popular than digital.
    a. True
    b. False
36. What is the name of the test used when testing a circuit for an open?
    a. Infinity test
    b. Overload test
    c. Continuity test
    d. This test cannot be done
37. Which of the following tools would use a series of prisms and magnifying lenses to accurately measure a liquid's concentration levels?
    a. Hydrometer
    b. Refractometer
    c. Spirit level
    d. Kaleidoscope
38. Which of the following tools is used to measure the relative densities of a liquid?
    a. Hydrometer
    b. Refractometer
    c. Spirit level
    d. Kaleidoscope

Answer Key: Self-Test B-1.1 is on the next page.

Answer Key: Self-Test B-1.1

1. c. 12 in. long and 18 teeth per inch
2. b. Blade clearance through the cut
3. d. Combination wrench
4. d. Overall length
5. a. Kept clean
6. b. Water pump pliers
7. a. Square head
8. d. 90°
9. a. A
10. a. True
11. a. True
12. a. Single cut
13. d. File card
14. a. tip b. blade c. ferrule
    d. head e. handle f. length of the blade
15. c. Are useful for small tight areas
16. b. Use soft vise jaw-caps
17. a. True
18. b. Wrecking bar
19. c. Weight of the head
20. a. Replaced
21. a. Machine vise
    b. Angle pipe welding vise
    c. Top screw bench chain vise
    d. Portable tri-stand yoke vise
    e. Bench yoke vise
    f. Straight pipe welding vise
22. Top screw stand chain vise
23. Straight pipe welding vise
24. Both vises distribute gripping pressure evenly around the pipe wall.
25. a. Quick-opening threader
    b. Jam-proof ratchet threader
    c. Ratchet drop head threader
    d. Geared pipe threader
26. a. Heavy-duty, four-wheel pipe cutter
    b. Soil pipe cutter
    c. Wide roll cutter
27. After cutting or drilling and before threading
28. Straight fluted ratchet reamer
29. Compound leverage wrench
30. Heavy-duty offset pipe wrench
31. Strap wrench
32. The basin wrench has:
    1. Spring-loaded jaws for one-hand ratcheting, and

2. A tension plug that holds the head of the tool at any angle up to 90°.

33. Thread cutting oil is used to:
    1. Lubricate the thread cutter during the threading operation
    2. Cool the tool and the work piece, and
    3. Flush away metal chips.
34. c. Resistance
35. b. False
36. c. Continuity test
37. b. Refractometer
38. a. Hydrometer

Self-Test B-1.2 Use Hand Tools

Complete Self-Test B-1.2 and check your answers.

1. How many hacksaw teeth should be in contact with the material being cut?
    a. 1
    b. 2
    c. 3
    d. 4
2. Which is **not** one of the three designs of a file's cutting face?
    a. Single-cut
    b. Double-cut
    c. Broad tooth
    d. Curved tooth
3. What filing method is best used when attempting to finish a smooth surface by removing only small amounts of material at a time?
    a. Kick
    b. Draw
    c. Rasp
    d. Twist
4. What is the most important consideration in maintaining a cold chisel?
    a. Removing a mushroomed end
    b. Removing a mushroomed end
    c. Sharpening the cutting face
    d. Keeping the shaft painted
    e. Storing it in oil
5. When a true track is obtained, how much should the feed screw be tightened as the cutter is rotated around the pipe?
    a. One-sixteenth of a turn
    b. One-eighth of a turn
    c. One-quarter of a turn
    d. One-half of a turn
6. There are two types of wheels on the cutter arms of the internal glass cutter. One is called the cutter wheel, and the other is called_____ the wheel.
    a. Driver
    b. Draw
    c. Leader
    d. Follower
7. Many chalk lines are manufactured in a shape that allows them to be alternately used as a:
    a. Tape measure
    b. Tubing cutter
    c. Plumb bob
    d. Spirit level
8. What should initially be done to the surface of carbon steel pipe when preparing to mark a cut line while using a

wrap-around?

a. Apply oil to the vicinity
b. Paint the area with lacquer
c. Remove varnish with a wire brush
d. Grind of any certification markings

9. What filing method is best used when attempting to finish a smooth surface by removing only small amounts of material at a time?

a. True
b. False

10. What size pipe wrench is recommended when installing 32 mm and 38 mm (1¼ in. and 1½ in.) threaded pipe?

a. 61 cm (24 in.)
b. 46 cm (18 in.)
c. 36 cm (14 in.)
d. 30 cm (12 in.)

11. When bending tubing, the short-cutting of the corners gives "additional length" to the remaining section of straight tube. What is the length acquired commonly referred to as?

a. Loss
b. Gain
c. Cheat
d. Growth

12. How far should a crimp ring be installed from the end of the tubing?

a. 1 mm (1/32 in.)
b. 1.5 mm (1/16 in.)
c. 3 mm (1/8 in.)
d. 6 mm (¼ in.)

13. Cold weather PEX expansions should take place above what temperature?

a. 0°C
b. 4°C
c. –15°C
d. –40°C

14. Stop threading when the outer ends of the pipe dies are 2.5 cm (1 in.) past the end of the pipe.

a. True
b. False

15. The position of the _____ will determine the correct thread length when using the jam-proof ratchet threader.

a. Change plate
b. Work holder
c. Clamp screw
d. Gauge ring

16. When setting standard size thread using a geared threader, one of two reference lines may be used. One is the upper surface of the die head, and the other is called the _____ line.

a. Typical
b. Regular
c. Average
d. Standard

17. What should be done to carbon steel pipe before grooving the end wall?

a. File out any burrs.
b. Thread each end.
c. Install couplings.
d. Tighten feedscrew.

18. What is the name of the tool used to measure the diameter of a pipe groove (groove depth)?

a. Pipe tape
b. Roll tester
c. Diamometer
d. Groove gauge

19. To maintain a hand roll groover,

a. Clean the driveshaft knurls and lubricate grease fittings daily
b. Clean the driveshaft knurls and lubricate grease fittings monthly
c. Clean the driveshaft knurls monthly and lubricate grease fittings daily
d. Clean the driveshaft knurls daily and lubricate grease fittings monthly

Answer Key: Self-Test B-1.2 is on the next page.

Answer Key: Self-Test B-1.2

1. b. 2
2. c. Broad tooth
3. b. Draw
4. a. Removing a mushroomed end
5. c. One-quarter of a turn
6. d. Follower
7. c. Plumb bob
8. c. Remove varnish with a wire brush
9. a. True
10. b. 18 in.
11. b. Gain
12. c. 1/8 in.
13. c. –15°C
14. b. False
15. a. Change plate
16. d. Standard
17. a. File out any burrs
18. a. Pie tape
19. d. Clean the driveshaft knurls daily and lubricate grease fittings monthly.

Self-Test B-1.3 Use Levelling Equipment

Complete Self-Test B-1.3 and check your answers.

1. What type of operations are laser and optical levels capable of performing?
    a. Vertical levelling only
    b. Horizontal levelling only
    c. Horizontal and vertical levelling
    d. Horizontal, vertical and angle levelling
2. Which instrument, when set to the fish-eye bubble, needs no further adjustment?
    a. Transit level
    b. “Dumpy” level
    c. Automatic level
    d. Engineer’s level
3. Which one of the following is the only level that is considered accurate throughout the full 360˚ circle without needing further adjustment?
    a. Transit level
    b. “Dumpy” level
    c. Engineer’s level
    d. Automatic level
4. What are the two categories of levels?
    a. Optical and laser
    b. Laser and electronic
    c. Fish-eye and bubble
    d. Bubble and streaming
5. What is the major advantage laser and electronic levels have over optical levels?
    a. Optical levels are easier to set up.
    b. Laser levels are less costly than optical levels.
    c. Optical levels can only use metric levelling rods.
    d. Laser levels need only one person to operate them.
6. Which one of the following has a prism or “compensator” in it?
    a. Tilting level
    b. “Dumpy” level
    c. Automatic level
    d. Engineer’s level
7. How many thumbscrews or “pins” do the least expensive levels typically contain?
    a. Two
    b. Three
    c. Four
    d. None
8. What does a tilting level have that the other optical levels do not?
    a. Second eyepiece
    b. Fourth thumbscrew
    c. Eyepiece focus knob

d. Extra fish-eye bubble

9. What type of beam does an electronic level use?
    a. Sonar beam
    b. Light beam
    c. Ultra-red beam
    d. Infrared laser beam
10. What following piece of equipment is shared by the optical instruments?
    a. Crosshairs and stadia lines
    b. Fish-eye bubble
    c. Rotating beam
    d. Sensor

11. Label the numbered parts in Figure 1.

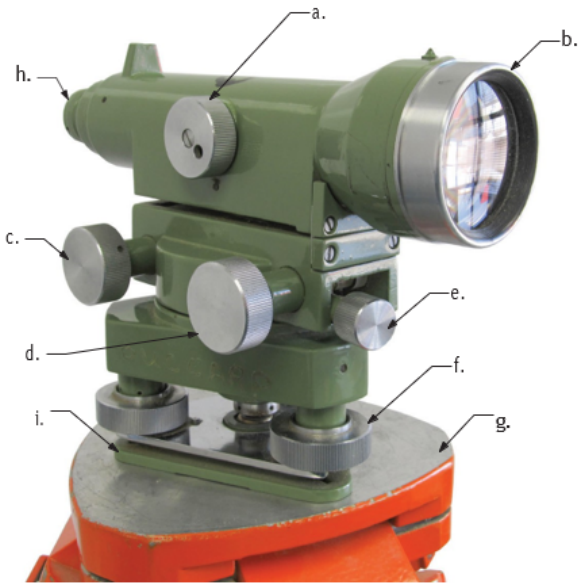


Figure 1 *Image for Question 11.*

a. _____

b. _____

c. _____

d. _____

e. _____

g. _____

h.

h.

i.

12. Where is the knurled knob found that is used to focus the crosshairs on all optical levels?
    a. At the eyepiece
    b. At the levelling head
    c. To the right of the telescope
    d. Just below the objective lens
13. How is focussing the telescope (field of view) accomplished on all optical levels?
    a. Tilting the barrel
    b. Realigning the levelling screws
    c. Turning the horizontal tangent screwturning the focus screw located on the barrel
14. Complete the following statement: "The slow motion screw will only operate when…"
    a. Horizontal clamp is tightened
    b. Horizontal clamp is loosened
    c. Tilt screw is tightened
    d. Tilt screw is loosened
15. How are most instruments secured to the tripod?
    a. Four bolts
    b. Adhesive tape
    c. Tongue-and-groove connection
    d. 5/8″ NC female thread connection
16. What piece of equipment would a tilting level have that is not found on a "dumpy" or an automatic level?
    a. Fish-eye bubble
    b. Split bubble
    c. Spirit vial
    d. Tripod
17. What is another term for the horizontal slow motion screw?
    a. Arbitrary screw
    b. Azimuth screw
    c. Cosine screw
    d. Philips screw
18. What is the purpose of the stadia lines?
    a. Measure mass
    b. Measure height
    c. Measure speed
    d. Measure distance
19. What is another term for a levelling rod?
    a. Tuscon rod
    b. Tallahassee rod

c. Philadelphia rod
d. Tuktoyaktuk rod

20. What are the two types of measuring scales used for levelling rods?

a. Feet and inches
b. Metric and imperial
c. Metres and millimetres
d. Architect's and engineer's

21. What scale would an imperial geodetic elevation be directly read in?

a. Metric
b. Engineer's
c. Architect's
d. Orthographic

22. What would be the distance between the instrument and rod if the upper stadia line reading is 4.357′ and the lower reading is 3.861′?

a. 49.60 inches
b. 4.96 feet
c. 49.60 feet
d. 496 feet

23. What is the smallest scale division on a metric rod?

a. 1 mm
b. 10 mm
c. 100 mm
d. 1000 mm

24. What is the smallest scale division on an architect's rod?

a. 1/8″
b. ¼”
c. 3/8″
d. ½”

25. What is the smallest scale division on an engineer's rod?

a. 1/8″
b. 0.001 ft
c. 0.01 ft
d. 0.1 ft

26. What distinguishing feature is present on the architect's and engineer's scales that helps to interpret rod readings?

a. Pointed graduations
b. Larger numbers
c. Yellow lines
d. Bold letters

27. What would this hand signal indicate?

Figure 2 *Image for Question 27.*

a. Come closer
b. Finished or OK
c. Rod, target or pencil up
d. Mark it there, readings complete

28. Moving the levelling rod forward and backward slowly through a small arc is done for what purpose?

a. Help the instrument person focus
b. Ensure the highest rod reading
c. Ensure that the rod is plumb
d. Keep rain off the rod scales

29. What special parts or device should be used when setting up on a floor with a smooth surface?

a. Triangle made of wood
b. Plumb bob
c. Tripod on rollers
d. Laser level

30. The direction of travel of the bubble will be the same as the movement of what?

a. Left finger
b. Right finger
c. Left thumb
d. Right thumb

31. When taking a sighting, which one of the following levels needs to be set only to the fish-eye bubble?

a. "Dumpy" level
b. Engineer's level
c. Automatic level
d. Builder's level

32. With the legs closed and extended, to what height should the tripod's top plate be adjusted before setting the tripod and mounting the instrument?

a. Top of your knees
b. Centre of your belly button
c. Bottom of your chin
d. Top of your head

33. When setting up a tripod on sloping ground, how should the legs be positioned?

a. One leg uphill
b. Two legs uphill
c. One leg fully extended

d. All legs fully extended

34. How should all the levelling screws be adjusted?

    a. As tight as possible
    b. As loose as possible
    c. Snugged up but not over tight
    d. Tightened snugly but with one screw backed off

35. Complete the following statement: “Once levelled with the fish-eye bubble, an engineer’s level…”

    a. Can be read as is
    b. Will not be very accurate
    c. Needs no further adjustment
    d. Must be fine adjusted to level

36. What does a four-pin instrument use for setting it up level and ready to use?

    a. Tubular level vial
    b. Fish-eye bubble
    c. Laser beam
    d. DC motors

37. When checking the accuracy of an instrument, how far apart should the two “checkpoints” or stakes be?

    a. 10 × 2 = 20 metres
    b. 15 × 2 = 30 metres
    c. 25 × 2 = 50 metres
    d. 30 × 2 = 60 metres

38. What should be the maximum error tolerance of the instrument over the distance in the preceding question?

    a. 3 mm or 1/8″
    b. 6 mm or ¼”
    c. 9 mm or 3/8″
    d. 12 mm or ½”

39. How should an instrument be transported from one job site to another?

    a. Properly stored in its case
    b. Moved with just its protective lens caps
    c. Left for the site superintendent to look after
    d. Left on the floor of a vehicle without its case

40. How should an instrument be placed into its case?

    a. In any way that it fits
    b. With or without its lens cap
    c. Any way, as long as the case is left open
    d. Must be placed back just as it came out

41. How should an optical level be picked up?

    a. Its base
    b. Its eyepiece
    c. Its telescope
    d. Its focus knob

42. How should the lens be cleaned if it has been splattered with mud?

    a. Should be wiped with a wet cloth immediately.
    b. Should be wiped with a dry cloth immediately.
    c. Cleaning should not be done until the lens is dry.

d. Wet it with water and dab the mud off with a camel hair brush.

43. What should be done after using an instrument in the rain?

    a. Put it back in its case as is.
    b. Wipe the whole instrument until it is completely dry.
    c. Damp-dry everything except the lenses and close it up in its case.
    d. Damp-dry everything except the lenses and leave it to dry in an open case.

44. Complete the following statement: "Sudden extreme changes in temperature…"

    a. Have no effect on optical levels
    b. Could cause the interior lens to fog up
    c. Could result in fogging up the horizontal swing mechanism
    d. Will only result in making the instrument too hot or cold to touch

45. How should the instrument/tripod be carried around a wide-open job site with no obstacles?

    a. In any manner that is convenient
    b. With the tripod and instrument held vertically
    c. Over your shoulder with the instrument pointing forward
    d. Over your shoulder with the tripod feet pointing forward

46. Which of the following is the best way to carry the instrument/tripod around a job site with obstacles such as doorways?

    a. In any manner that is convenient
    b. With the tripod and instrument held vertically
    c. Over your shoulder with the instrument pointing forward
    d. Over your shoulder with the tripod feet pointing forward

47. Vibration has a bad effect on optical levels.

    a. True
    b. False

48. Allowing the instrument to become hot could make it difficult to level.

    a. True
    b. False

49. What is a standard residential benchmark?

    a. 0.00′
    b. 50.00′
    c. 100.00′
    d. 1,000.00′

50. What does a backsight determine?

    a. Benchmark elevation
    b. Instrument height
    c. Foresight elevation
    d. Datum

51. Which of the following items should be used as a benchmark at a job site?

    a. Rim of a manhole
    b. Any part of a sidewalk
    c. Concrete block set in the ground
    d. Wooden peg at the corner of the property

52. What is the purpose of "Scotchlite" facing on a levelling rod?

    a. Cut down on glare

b. Make the rod waterproof
c. Bring the numbers into sharper focus
d. Increase visibility of the rod in poor light

53. What is the rod reading shown in Figure 3?

a. 0.272 m
b. 2.800 m
c. 2.892 m
d. 2.792 m

Figure 3
Image for question 53.

54. What is the rod reading shown in Figure 4?

a. 0.978 m
b. 0.988 m
c. 9.088 m
d. 9.078 m

Figure 4
Image for question 54.

55. What is the rod reading shown in Figure 5?

a. 0.241 m
b. 2.401 m
c. 2.410 m
d. 2.450 m

Figure 5
Image for question 55.

56. What is the height of instrument?

a. 99.203 m
b. 101.321 m
c. 102.118 m
d. 103.439 m

57. What is the elevation of station C?

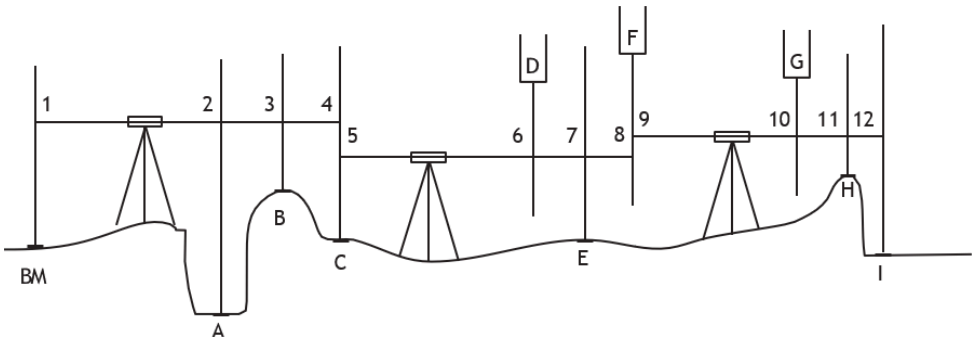
Table for question 57

STA	BS	HI	IFS	FS	ELEV
BM	1.321				100.000
A			2.417		98.904
B			1.998		99.323
C				2.118	

a. 99.203 m
b. 101.321 m
c. 102.118 m
d. 103.439 m

58. Figure 6 shows a schematic diagram and some sample rod readings. Use the information contained in them to fill in the field book page in the following table (include a math check). Note that the numbers on the schematic diagram represent corresponding numbered rod sections, and that BM elevation = 100.000 m.

    a. 99.203 m
    b. 101.321 m
    c. 102.118 m
    d. 103.439 m



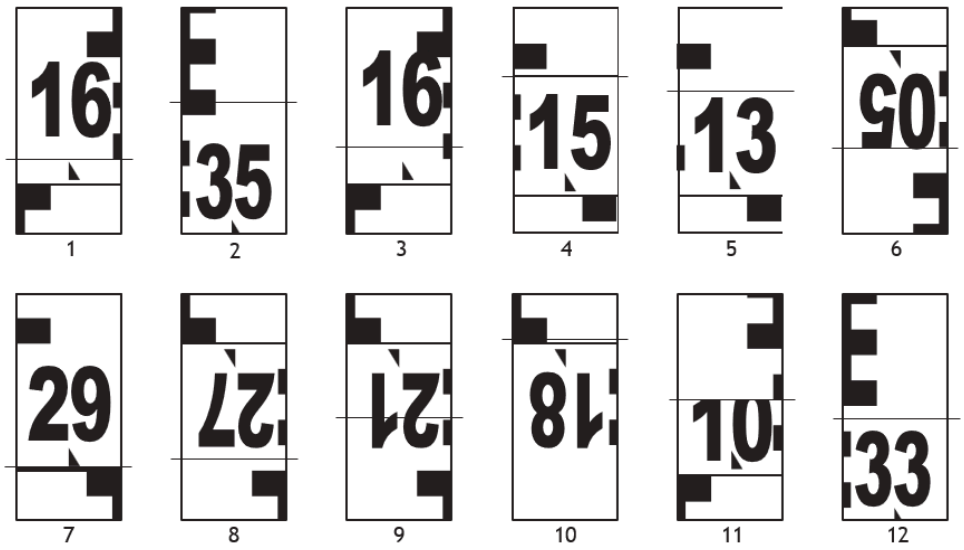


Figure 6 *Sample rod readings.*

Table for question 58

STA	BS	HI	IFS	FS	ELEV
BM					100.000 m

59. Calculate the elevations of A and B in Figure 7. Grade on drain = ¼”/ft.
    a. Elevation of A =
    b. Elevation of B =

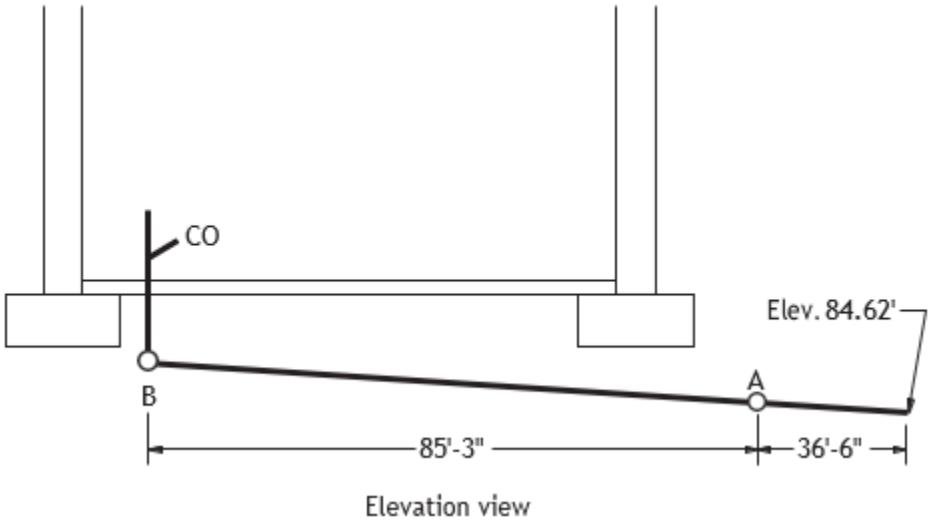


Figure 7 *Image for question 59.*

60. Calculate the elevations of A and B in Figure 8. Grade on drain = 1/8″/ft.
    a. Elevation of A =
    b. Elevation of B =

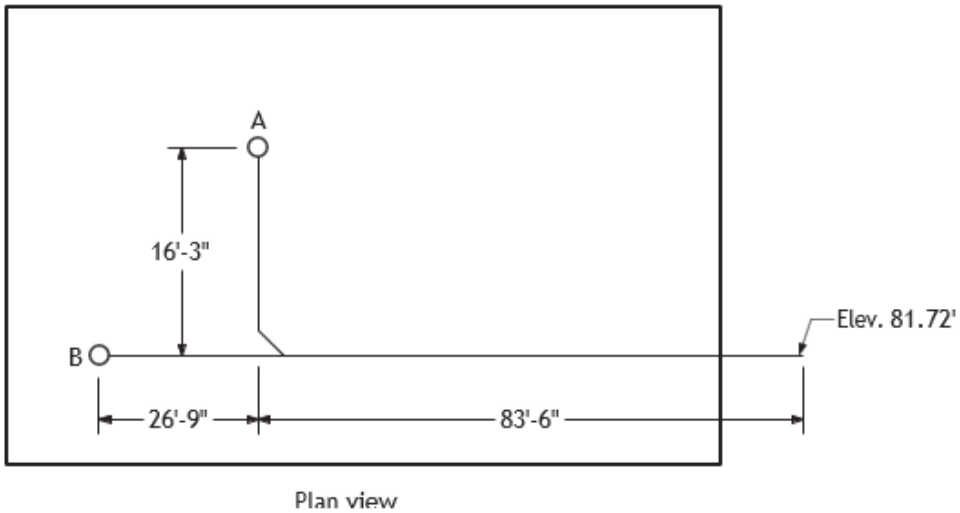


Figure 8 *Image for question 60.*

61. Calculate the elevations of A and B in Figure 9. Grade on drain = 1/8″/ft.

    a. Elevation of A =
    b. Elevation of B =

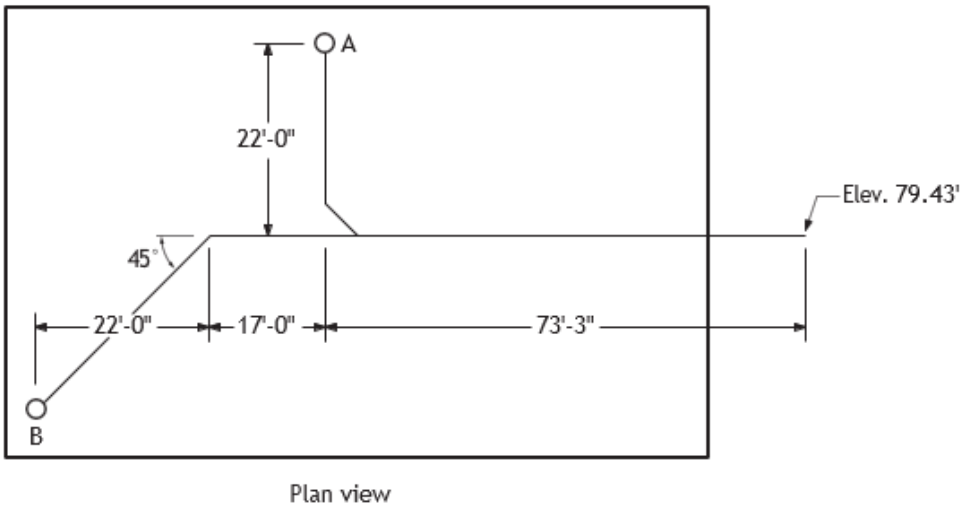


Figure 9 *Image for question 61*

62. Calculate the elevations at A and B in Figure 10. Grade on drain = ¼”/ft.

    a. Elevation of A =
    b. Elevation of B =

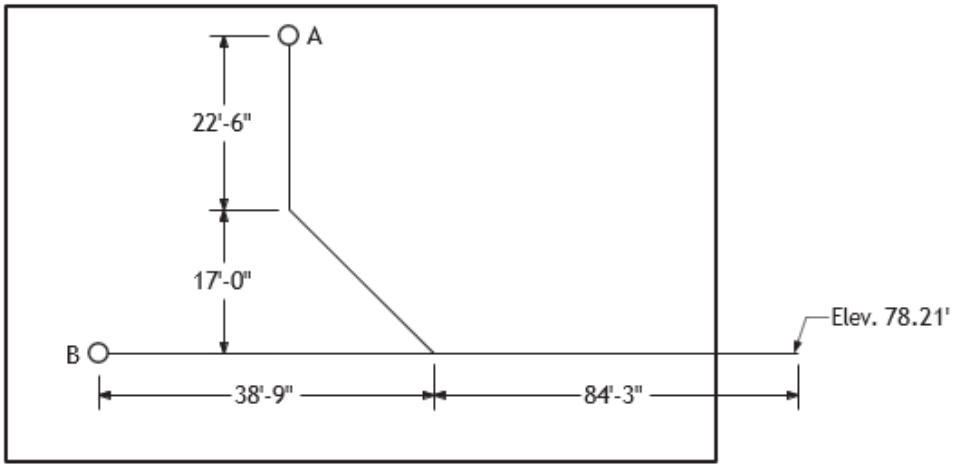


Figure 10 *Image for question 62.*

63. Calculate the following based on Figure 11. Grade on drain = ¼”/ft.
    a. Elevation of A =
    b. Elevation of B =
    c. Depth of drain at B below datum is _____ft _____in.

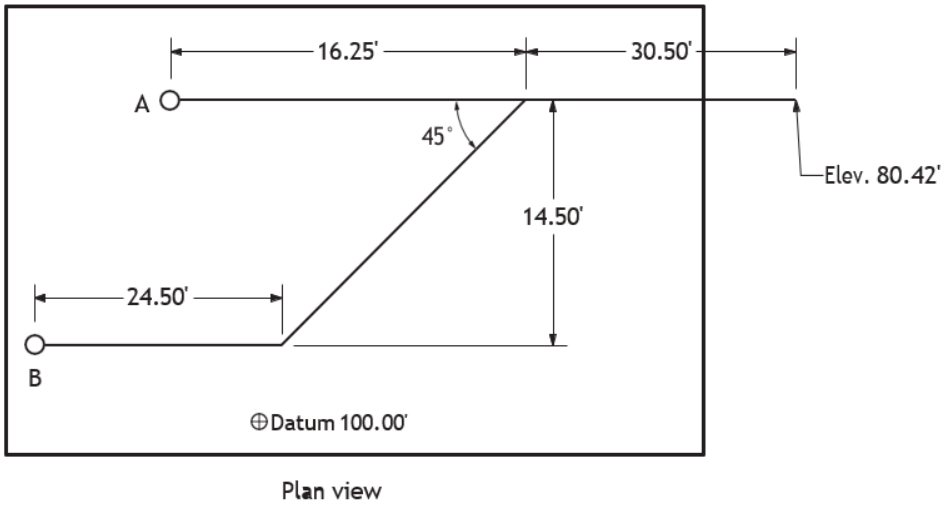


Figure 11 *Image for question 63.*

64. Convert the following readings to feet, inches, and sixteenths.
    a. 105.25′
    b. 116.62′
    c. 145.81′
    d. 174.39′
    e. 186.96′
65. Convert the following readings to feet and decimal feet, to the nearest 1/100.
    a. 8 1/8″
    b. 10 7/8″

c. 1′-3 ½”
d. 1′-7 ¼”
e. 1′-8 ¾”

66. Calculate the grade, expressed as a percentage, if the run of a sewer is 177 feet and the total fall is 3.54 feet.
67. Calculate the total fall, to the nearest 1/100 of a foot, if the run is 64 feet and the grade is 1.5%.
68. Calculate the length of a sewer if the grade is 1% and the total fall is 0.7 feet.
69. Calculate the grade, as a percentage to two decimal places, if the total fall is 18 inches and the run is 115 feet.
70. Change ¼ inch per foot to a percent grade to two decimal places.
71. What is the rod reading called that is taken on a point whose elevation is known?
72. What is the rod reading called that is taken on a point whose elevation is yet to be established?
73. Define the term geodetic datum.

Answer Key: Self-Test B-1.3 is on the next page.

Answer Key: Self-Test B-1.3

1. b. Horizontal levelling only
2. c. An automatic level
3. d. The automatic level
4. a. Optical and laser
5. d. Laser levels need only one person to operate them
6. c. An automatic level
7. c. Four
8. a. A second eyepiece
9. d. An infrared beam
10. a. Crosshairs and stadia lines
11. Focus knob (screw)
    a. Sunshade
    b. Tilting or split-bubble knob (screw)
    c. Horizontal (azimuth) slow motion knob (screw)
    d. Horizontal (azimuth) lock
    e. Levelling thumbscrew (pin)
    f. Tripod headplate
    g. Eyepiece
    h. Footplate
12. a. At the eyepiece
13. d. By turning the focus screw located on the barrel
14. a. The horizontal clamp is tightened
15. d. By a 5/8″ NC female thread connection
16. b. A split bubble
17. b. Azimuth screw
18. d. To measure distance
19. c. A Philadelphia rod
20. b. Metric and imperial
21. b. Engineer's scales are in feet and decimal feet, just like imperial elevations
22. c. 49.60 ft 4.357′ − 3.861′ = 0.496′; 0.496 × 100 = 49.60′
23. b. 10 mm or 1 cm
24. a. Each black mark is 1/8″ in width, as well as the white space between marks
25. c. 0.01 ft
26. a. Pointed graduations (marks)
27. c. Rod, target or pencil up
28. c. To ensure that the rod is plumb. The lowest reading is the one that is desired.
29. a. If soft rubber feet or suction cups aren't available, use a triangle fashioned out of 1×4's
30. c. The direction of the left thumb determines the direction that the bubble will move
31. c. The prism in the automatic level does the fine-tuning
32. c. If the unfolded tripod is set at chin level, the eyepiece will be at a comfortable height
33. a. With one leg uphill, the other two downhill for a more stable base
34. c. Snugged up but not over tightened
35. d. An engineer's (tilting, split bubble) level needs to be fine-levelled for each sight

36. a. A tubular level vial
37. 30 × 2 = 60 metres apart in total
38. b. 6 mm or ¼" over 30 metres or 100 feet
39. a. Taken off the tripod and stored in its case
40. d. Make sure it fits properly and doesn't jam parts when trying to close the lid of the case
41. a. By its base. This is the strongest part of the instrument
42. d. This is the best choice given. Never rub a lens with anything other than a camel hair brush
43. d. Once dry, use a camel hair brush on the dry lens in a circular motion
44. b. Could cause the interior lens to fog up
45. d. This way, if you trip and fall forward, only the tripod feet hit the ground
46. c. This way, the instrument is never out of sight and less likely to be damaged
47. a. True
48. a. True, the tubular level vial expands and the bubble is harder to centre
49. c. 100.00 feet is used, as residential plans are normally in imperial scale
50. b. Backsights determine the height of the instrument
51. a. The rim of a manhole is a stable and long-lasting item, suitable for use as a benchmark
52. d. Scotchlite or reflective facing is easier to see in low light conditions
53. d. 2.792 m
54. a. 0.978 m
55. c. 2.410 m
56. b. Benchmark of 100.000 m + BS reading of 1.321m = 101.321 m
57. a. HI 101.321 – FS reading of 2.118 m = 99.203
58.

Table 1 Solved table for Question 58

STA	BS	HI	IFS	FS	ELEV
BM	1.610	101.610			100.000 m
A		101.610	3.555		98.055
B		101.610	1.615		99.995
C		101.610		1.547	100.063
C	1.341	101.404			100.063
D		101.404	<0.540>		101.944
E		101.404	2.902		98.502
F		101.404			104.149
F	<2.129>	102.020		<2.745>	104.149
G		102.020	1.798>		103.818
H		102.020	1.030		100.990
I		102.020	3.345		98.675
J		102.020	<0.299>		102.319

59. Elevation at A = 85.38′
    Elevation at B = 87.16′
60. Elevation at A = 82.76′
    Elevation at B = 82.87′

61. Elevation at A = 80.42′
    Elevation at B = 80.69′
62. Elevation at A = 80.93′
    Elevation at B = 80.77′
63. Elevation at A = 81.39′
    Elevation at B = 81.99′
    Depth of drain at B below datum is 18′ – 0 1/8″
64.

    a. 105′ 3″
    b. 116′ 77/16″
    c. 145′ 9¾”
    d. 174′ 411/16″
    e. 186′ 11½”

65.
    a. 0.68′
    b. 0.92′
    c. 1.29′
    d. 1.60′
    e. 1.73′
66. 2%
67. 0.96′
68. 70 feet
69. 1.30%
70. 2.08%
71. A backsight
72. A foresight or intermediate sight
73. A geodetic datum is an elevation above mean average sea level.

Version History

This page provides a record of changes made to this learning resource, Plumbing Apprenticeship Level 1, Block B (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/). Each update increases the version number by 0.1. The most recent version is reflected in the exported files for this resource.

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If you identify an error in this resource, please report it using the TRU Open Education Resource Error Form.

Version	Date	Change	Details
1.0	May 2026	Plumbing Apprenticeship Level 1 Block B learning resource from STBC content converted to open and freely accessible digital platform and published at TRU.	

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.