Block B: Tools and Equipment

TRU Open Press

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

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

Symbol Legend

Important Information

Potentially Toxic/ Poisonous Situation

Required or Optional Resources

Potentially Flammable Situation

Complete a Self-Test

Possibly Explosive Situation

Use Protective Equipment

Potential Electric Shock

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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-1: Describe Common Hand Tools and Their Uses (https://collection.bccampus.ca/resource/BzEe9fcq)
- Line C: Tools and Equipment: Competency C-2: Describe Common Power Tools and Their Uses (https://collection.bccampus.ca/resource/zAYtfTec)
- Line C: Tools and Equipment: Competency C-3: Describe Rigging and Hoisting Equipment (https://collection.bccampus.ca/resource/hDUEqpfn)
- Line C: Tools and Equipment: Competency C-4: Describe Ladders and Work Platforms (https://collection.bccampus.ca/resource/7c8Ymhnk)

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The Open Press

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

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- Trades Training BC

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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 V

B-5 USE SOLDERING AND BRAZING AND OXY-FUEL CUTTING EQUIPMENT

Plumber Apprenticeship Program – Level 1

Propane torch soldering copper pipe (https://commons.wikimedia.org/wiki/File:Propane_torch_soldering_copper_pipe.jpg) (Kevin L Neff/Wikimedia Commons) CC BY 2.0 (https://creativecommons.org/licenses/by/2.0)

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

- Describe Oxy-Acetylene Equipment.
- Use Oxy-Acetylene Equipment.
- Describe Soldering and Brazing Equipment.
- Describe Cutting, Brazing and Soldering Techniques.
- Use Soldering and Brazing Equipment.
- Use Oxy-Fuel Equipment.

You will be required to reference publications and videos available online at WorkSafeBC. (https://www.worksafebc.com/en)

Terminology

The following terms will be used throughout this section. A complete list of terms for this section can be found in the **Glossary.**

- **acetylene:** A flammable fuel gas made of carbon and hydrogen that burns at a very high temperature

when mixed with oxygen. It is commonly used for welding, brazing, and cutting metal. (Section B-5.1)

- **backfire:** A small explosion that occurs when the flame burns back into the torch tip during cutting or welding, often making a popping sound. (Section B-5.1)
- **capillary action:** The way a liquid (like melted solder) is pulled into small spaces between two surfaces without being pushed. (Section B-5.2)
- **eutectic alloy:** A special type of metal mixture that melts and hardens at one exact temperature instead of over a range. (Section B-5.2)
- **flashback:** A dangerous condition where the flame travels backward through the torch and hoses toward the regulator, which can lead to fire or explosion. (Section B-5.1)
- **flashback arrestor:** A safety device installed in oxy-fuel equipment that stops flames from travelling backward through hoses or equipment during a flashback. (Section B-5.1)
- **flux:** A substance used in soldering or brazing to clean metal surfaces and help melted metal flow smoothly into a joint. (Section B-5.1)
- **kerf:** The cut or gap left in a material after it has been cut with a tool or torch. (Section B-5.1)
- **neutral flame:** A flame with the right mix of oxygen and fuel so it burns clean and does not damage the metal. (Section B-5.2)
- **oxidizing effect:** The ability of oxygen to make materials burn faster and hotter by increasing the rate of combustion. (Section B-5.1)
- **oxidizing flame:** A flame with too much oxygen that can cause metal to burn or become brittle. (Section B-5.2)
- **oxy-acetylene:** A system that uses a mixture of oxygen and acetylene gas to produce a high-temperature flame for cutting, welding, or heating metal. (Section B-5.3)
- **plastic (pasty) range:** The temperature range where a metal is partly solid and partly liquid, making it soft and easy to shape. (Section B-5.2)
- **purging:** The process of clearing gas from hoses or equipment to remove air or mixed gases before lighting a torch. (Section B-5.3)
- **regulator:** A device that controls the pressure of gas flowing from a cylinder to ensure safe and consistent operation. (Section B-5.3)
- **reverse flow check valve (RFCV):** A device that prevents gases from flowing backward into hoses or cylinders, helping to reduce the risk of fire or explosion. (Section B-5.3)
- **slag:** The leftover melted material that forms during cutting or welding and may stick to the metal or fall away. (Section B-5.1)
- **striker:** A tool used to safely ignite a welding torch by producing a spark. (Section B-5.3)

B-5.1 Describe Oxy-Acetylene Equipment

Fuel Gases

Fuel gases are extensively used in the pipe trades for cutting, welding, brazing, and soldering metals, so it is important that you know the properties of these gases. It is also important that you learn how to handle, store and transport the various components of a welding outfit safely and correctly.

Oxy-Fuel Gases

The process of gas cutting, brazing, or soldering requires two gases and a source of ignition:

- Oxygen
- A fuel gas such as acetylene, MAPP, natural gas, propane

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

Oxygen

Oxygen is the element in our atmosphere that supports ***combustion*** (the process of burning). Second only to nitrogen in its volume, oxygen is the other major component of the air we breathe. It is a colourless, odourless, tasteless gas at ordinary temperatures. By itself, it is slightly heavier than air. One of the hazards of oxygen is that it accelerates combustion rapidly and raises the combustion temperature of fuel gases, which can cause hazards if the oxygen

content is above standard atmospheric percentage (20.8%). Oxygen must be considered potentially dangerous because it combines readily, and in some cases explosively, with many substances.

Under normal conditions, the heavy nitrogen content in air tends to retard combustion and reduce the flame temperature. Combustion with pure oxygen is much faster than combustion in air (which is a mixture of gases), and this increases the flame temperature. In general, materials that burn in air burn much more rapidly in pure oxygen. It is also true that some materials that are not considered combustible in air will burn readily in oxygen-enriched atmospheres. The acceleration of combustion is called the ***oxidizing effect***. Under WHMIS (https://www.canada.ca/en/health-canada/services/environmental-workplace-health/occupational-health-safety/workplace-hazardous-materials-information-system.html) provisions, oxygen must be appropriately labelled, stored, and handled using specific safe work procedures.

Rubber and Oxygen

Rubber will burn in air. The flame is dull red, smoky, and gives off a heavy odour. When rubber burns in oxygen, it burns rapidly, with a white flame, high flame temperature, almost no smoke, and little odour.

The hoses of an ***oxyacetylene*** outfit are made from rubber and cotton and you must exercise caution to keep them from being burned, cut, or ruptured. If either hose on the equipment catches fire while under pressure, the fire cannot be extinguished using a fire extinguisher alone. This is because oxygen is being fed to the flames from inside the hose. A fire extinguisher works on the principle of excluding oxygen from the air and thereby smothering the flame; it can only be used after you stop the flow of oxygen and ***acetylene***. You must turn off the supply of oxygen and fuel gas before attempting to put out the fire using a smothering-type extinguisher. The fire will continue to burn as long as fuel and oxygen is supplied to it from the hoses because the rupture in the hose acts as a torch opening.

Oil or Grease and Oxygen

At normal temperatures, oil or grease is not considered to be highly flammable, but if either one is brought into contact with pure oxygen under slight pressure, a violent explosion can occur.

Keep oxygen equipment away from oil, grease, oil-based cleaning fluids, and gasoline. Never use oil to lubricate regulators or any part of the torch.

Oxygen + Oil = Potential Explosion

Steel and Oxygen

Although steel is not normally considered to be combustible, when it is heated to a red heat and brought into contact with oxygen (as it is during the cutting process), it burns quite rapidly and reduces the reacted metal to iron oxides. An oxyacetylene cutting attachment allows this burning process to be controlled while cutting steel plate. Steel will also combine with oxygen and moisture, causing the steel to oxidize slowly (rust).

Oxygen must always be considered a potential danger because it speeds up the combustion of known flammable materials and combines readily, and often explosively, with materials not generally considered combustible.

Acetylene

Acetylene is a compound formed by uniting two atoms of carbon (C_2) with two atoms of hydrogen (H_2) to form a molecule of acetylene (C_2H_2). Like oxygen, acetylene gas is colourless, but it has a pungent, garlic-like odour. Only 1% of acetylene present in the air is quite noticeable to the average person's sense of smell, making it easy to detect. Acetylene can form combustible mixtures in almost any concentration. It has ***explosive limits*** (allowable concentrations that will support combustion) between 2.5% and 81%, giving it one of the widest available ranges of flammability for any fuel gas.

Acetylene gas generates high heat when burned. When it is proportionately mixed with oxygen, as it is in the oxyacetylene gas welding process, the resulting flame can reach 3300°C (6000°F). This is the highest flame temperature derived from the combustion of any two gases, making the combination of oxygen and acetylene useful for gas welding, metal cutting, and brazing.

Acetylene gas is flammable and highly explosive.

It is important to treat all mixtures of oxygen and acetylene as potentially explosive. Acetylene can quite easily be detected. The moment you smell it, extinguish all open flames immediately and ventilate the room even before turning on a light switch. Then test for leaks in the lines by brushing soapy water on suspected joints or areas. Watch for bubbles. Never test for leaks near an open flame.

Acetylene is an unstable compound. The term "unstable" means that the material is likely to break down (decompose) or undergo a physical change without much provocation or cause. The point at which this happens is said to be its ***critical point***.

The critical point of free acetylene is 28 psi (193 kPa) at a temperature of 70 °F (21 °C), which is the calibration temperature for most acetylene gauges. If this pressure is reached, acetylene breaks down into carbon and hydrogen, and an explosion results. If the temperature is increased, the pressure at which acetylene becomes critical is lowered. To allow for any temperature fluctuations in the work area, acetylene should not be stored or used at pressures over 15 psi (103 kPa).

When acetylene is put in a gas cylinder, the cylinder is packed with a porous filler such as asbestos, charcoal, or balsa wood and then filled with liquid ***acetone*** into which the acetylene is dissolved. This keeps the acetylene from reaching its critical point by not allowing it to be free. Acetylene can then be stored in cylinders at pressures of about 250 psi (1.7 MPa).

Never use copper or red brass for fittings, tubing, etc. with acetylene systems. Acetylene gas reacts with copper to form ***acetylide***, a residue that is even more unstable than acetylene. The slightest shock may cause an explosion and fire. Use only fittings of yellow brass, iron, or steel with acetylene.

Other Fuel Gases

For economic reasons, fuel gases other than acetylene are used for preheating in flame cutting. Three of the more common gases are:

- MAPP gas™ (methylacetylene-propadiene)
- Natural gas (primarily methane)
- Propane gas

These gases are used for flame cutting operations, and in some cases, preferred over acetylene. While acetylene and oxygen produce the highest flame temperature, which permits fast starts when cutting, this combination tends to leave ***slag*** at the bottom of the cut. The other fuel gases, although having lower flame temperatures and therefore slower starts, will produce cleaner cuts with little or no slag clinging to the bottom of the cut.

MAPP Gas

MAPP gas is a trademarked name belonging to Dow Chemical, for a fuel gas based on a stabilized mixture of methyl acetylene and propadiene. The name comes from the original chemical composition: *methylacetylene-propadiene propane*.

MAPP gas is shipped in low-pressure cylinders in liquid form, so it must be used in an upright position. Although it provides less heat than acetylene, it is safer to use and may be safely compressed.

One MAPP cylinder is roughly equal to five acetylene cylinders in terms of equivalent cutting and welding capacity. The flame temperature, 2900°C (5300°F), is lower than acetylene, but the gas is stable and relatively inexpensive when compared to the cost of acetylene.

Natural Gas

Natural gas is preferred in areas where it can be piped in, eliminating the handling of fuel gas cylinders. It is not shipped in a liquid form. The main constituent of natural gas is methane. The flame temperature reaches 1980°C (3600°F), lower than acetylene or MAPP gas. Natural gas requires two volumes of oxygen to one volume of fuel to burn completely. Because of its lower flame temperatures and reduced heating efficiency, either longer preheating or slower cutting speeds are required.

Natural gas is inexpensive compared to acetylene.

Propane Gas

Propane gas is supplied in liquid form in low-pressure cylinders for easy, safe handling. It is widely used because of its

ability to produce clean cuts at a relatively low cost. Propane has a high heat value, but requires 4 $\frac{1}{2}$ volumes of oxygen to one volume of fuel to produce a neutral flame. The flame temperature is 1980°C (3600°F).

Specially designed cutting tips and, in some cases, mixing chambers are necessary with the liquid fuels (MAPP and propane) as the amount of oxygen required for burning it is considerably higher than for acetylene. Of the four fuel gases mentioned, acetylene and propane are the two most common. Table 1 illustrates the key characteristics of these two gases.

Table 1: Key Characteristics of Acetylene and Propane

Acetylene	**Propane**
Hydrocarbon C_2H_2	Hydrocarbon C_3H_8
Burning rate through tip is 100 m/s (300 ft./s) using approximately a 1:1 mixture with oxygen.	Burning rate through tip is 18 m/s (60 ft./s) using approximately a 1:4 mixture with oxygen.
Flame temperature approximately 3000°C (6000°F).	Flame temperature is approximately 2540°C (4600°F).
Principal uses are flame cutting, heating, fusion welding, braze welding and hard- facing.	Principal uses are flame cutting and heating.
Advantages are high flame temperature, reduced preheat time and the capacity to perform a wide variety of tasks. Disadvantage is high cost.	Advantage is low cost. Disadvantage is restricted use due to lower flame temperature.

Gas Cylinders

Oxygen cylinders are forged in one piece from high-grade steel plugs for strength. At the slightest sign of damage, the cylinders are withdrawn from service. Cylinders are not generally sold, but remain the property of the supplier, and are loaned out for a certain period of time. Only full cylinders of gas are distributed. The returned cylinders are drained of any remaining gas in case it is contaminated, and then refilled. Cylinders must be labelled according to WHMIS regulations (https://www.canada.ca/en/health-canada/services/environmental-workplace-health/occupational-health-safety/workplace-hazardous-materials-information-system.html) and the Workers' Compensation Board regulations (https://www.worksafebc.com/en/law-policy/workers-compensation-law/workers-compensation-act-regulations).

Oxygen cylinders are made in various sizes, ranging from 0.5 m^3 to 7 m^3 (20 ft^3 to 244 ft^3) capacity (this may vary slightly with each manufacturer). The oxygen is compressed to 2200 psi (15 MPa) at 21 °C (70 °F). Figure 2 shows a 7 m^3 (244 ft^3) cylinder.

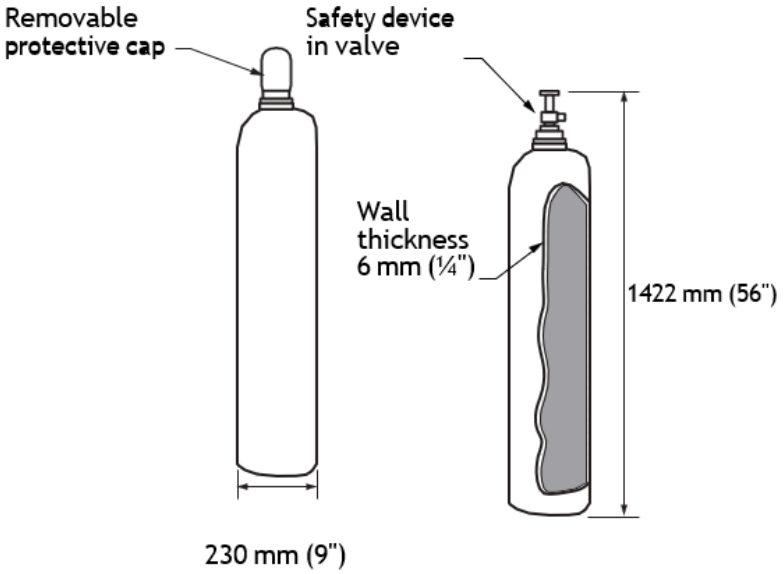

Figure 2 *Oxygen cylinder (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The cylinder valve is protected by a screw-on protective cap. The cylinders and protective caps are usually black, although green and other colours are used occasionally. The caps have right-hand threads (like all oxygen fittings) and come in various sizes to match the cylinders.

Table 2 provides an indication of how temperature change significantly alters the pressure of a full oxygen cylinder:

Table 2: Oxygen Pressure–Temperature Comparison

Temperature		Pressure (approximate)	
Celsius	**Fahrenheit**	**MPa**	**PSI**
49	120	17.3	2500
38	100	16.4	2380
27	80	15.5	2246
21	70	15.2	2200
16	60	14.8	2140
10	50	14.3	2080
4	40	13.9	2020
–1	30	13.5	1960
–7	20	13.1	1900
–12	10	12.7	1840
–18	0	12.3	1780
–23	–10	11.9	1720
–29	–20	11.5	1660

It is important to monitor the amount of oxygen in the cylinder. When the flame is no longer consistent and the working pressure cannot be maintained, remove the cylinder from service. This will prevent poor welds and decrease the possibility of fire or explosion.

Oxygen Cylinder Valves

The ***oxygen cylinder valve*** is designed to operate at high pressures. The double-seal construction prevents leakage of oxygen around the stem when the valve is completely opened. When the valve handle is turned clockwise (closing it), pressure is forced down on seal #1, which shuts off the oxygen supply to the regulator. When the valve is turned counter-clockwise (opening it), pressure is released from seal #1, allowing oxygen to flow into the regulator. The part above seal #1 then threads upward, forcing pressure onto seal #2. This cuts off any oxygen travelling up and around the stem. The outlet fitting for the regulator has a standard external thread to which all standard oxygen pressure regulators may be attached.

Before attaching the regulator, the valve should be “cracked” (briefly opened and re-closed) to remove any dirt that may be lodged in the passage to the regulator.

Never attempt to repair a damaged valve. Tag the cylinder to indicate the fault, move it to an open area, and immediately notify the supplier.

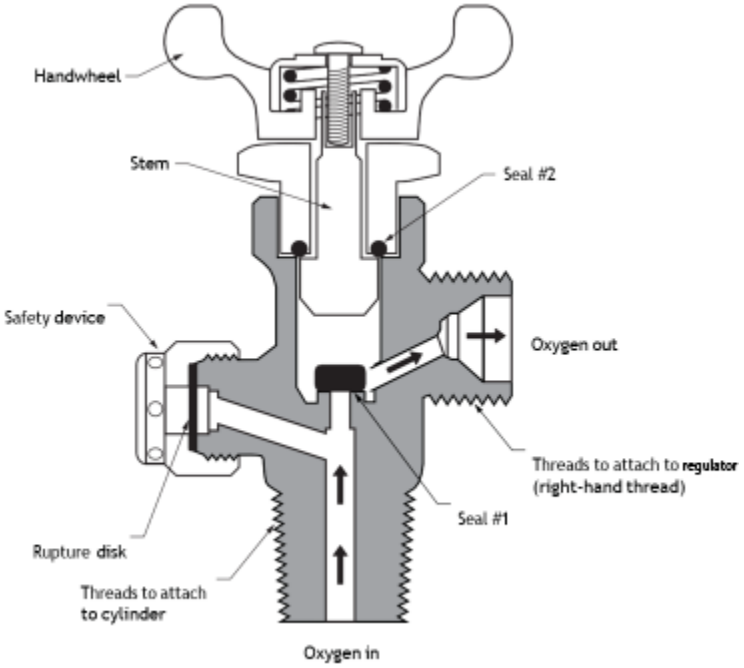

Figure 3 *Oxygen cylinder valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Cylinder Safety Devices

The safety device for the oxygen cylinder is located in the valve. It consists of a pressure or rupture disc, which will burst and release cylinder oxygen into the air when excessive pressure build-up occurs, such as from an increase in temperature.

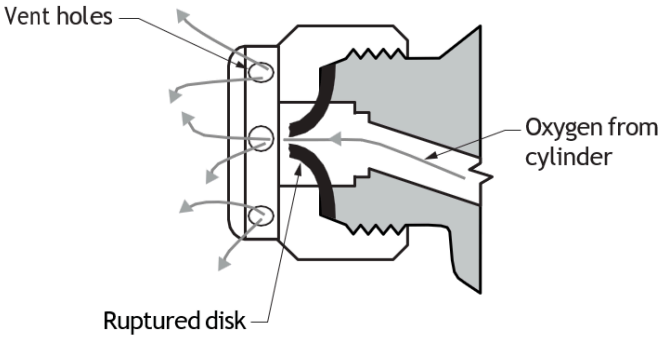

Figure 4 *Safety device on oxygen cylinder (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Acetylene Cylinders

The instability and explosiveness of acetylene requires that the gas be handled with extreme caution at all times, and special considerations are made in construction of the acetylene cylinder.

The acetylene cylinder is a strong, welded-steel container completely filled with a porous material called ***agamassan*** (a porous material such as asbestos, charcoal or diatomaceous earth). This filler material is saturated with acetone, a straw-coloured, stable liquid that is flammable, volatile and strong smelling. Acetone has the ability to absorb acetylene gas and is used in the cylinders to make them safe at high pressures by stabilizing the acetylene. One volume of acetone will absorb 20 volumes of acetylene gas at atmospheric pressure. This ratio increases as pressure is increased.

Because the acetone is in liquid form, acetylene cylinders must be used in an upright position. Otherwise, the acetone may flow into and contaminate the regulator, hose, torch, and flame.

Free acetylene gas is dangerous when stored at pressures above 15 psi (103 kPa), but when porous material and acetone are used, the manufacturer is able to charge the cylinders to an average pressure of approximately 250 psi (1.7 MPa) to 350 psi (2.4 MPa).

It is important to monitor the amount of acetylene in a cylinder. When the flame is inconsistent and the working pressure cannot be maintained, remove the cylinder from service (to prevent acetone from being drawn off into the lines).

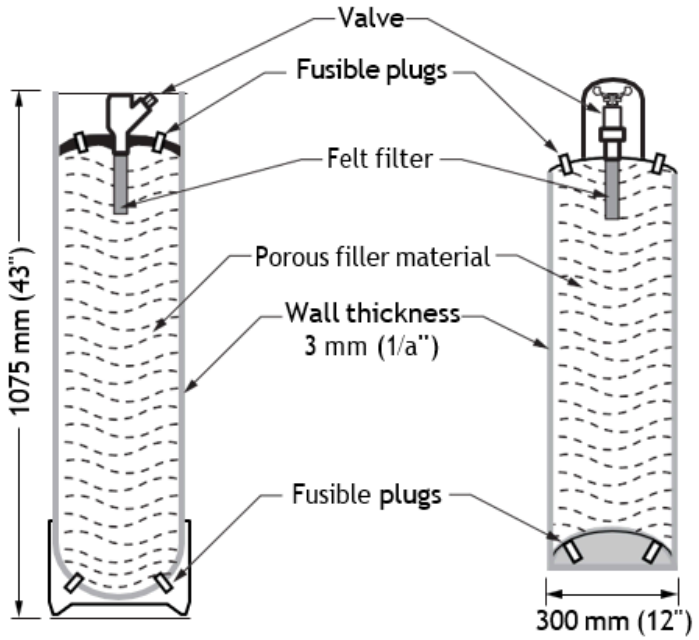

Figure 5 *Two types of acetylene cylinders (BC Industry Training Authority, 2019).*
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Acetylene Cylinder Valves

Unlike the special double-seal design of the high-pressure oxygen cylinder valve, the acetylene cylinder valve has a simple construction to accommodate the relatively low pressure. The valve is opened with a removable wrench or hand wheel. It should be slowly opened $\frac{1}{4}$ to $\frac{1}{2}$ turn. Leave the handle in place in case it must be shut off quickly. When the handle is turned counter-clock-wise (opening it), pressure is released from the seal, allowing acetylene to flow to the regulator.

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

Cylinder Safety Devices

The safety device for the acetylene cylinder consists of fusible (heat-activated) plugs threaded into the top and bottom of the cylinder. Excessive heat causes these alloy plugs to melt, which in turn releases the cylinder contents to avoid an unsafe pressure rise. The average range of melting temperatures for these plugs is 104 °C to 115 °C (220 °F to 240 °F).

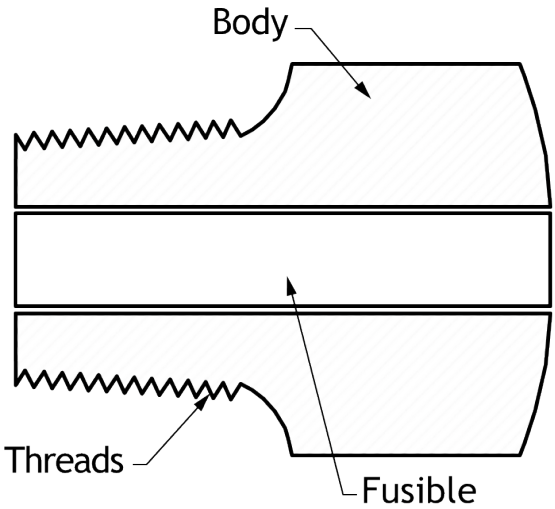

Figure 7 *Safety plug on acetylene valve* (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (*https://creativecommons.org/licenses/by-nc-sa/4.0/*)

Liquid Fuel Cylinders

Fuels such as propane and MAPP gas are liquids when stored in cylinders. When the cylinders are shipped full, there is still a space above the liquid for gas (vapour) to occupy. Gas escapes when the cylinder valve is opened, reducing the pressure on top of the liquid. This allows the liquid to "*boil off*" (evaporate) more gas.

Since the cylinder contains a liquid, it must be operated in an upright (valve up) position to allow only the vapour to be withdrawn. These liquid fuel cylinders contain a greater yield of gas than an acetylene cylinder.

There are also cylinders designed to operate in a horizontal position, such as those used for RVs and forklifts. When intended for this purpose, they are marked as such and must be correctly positioned to function properly.

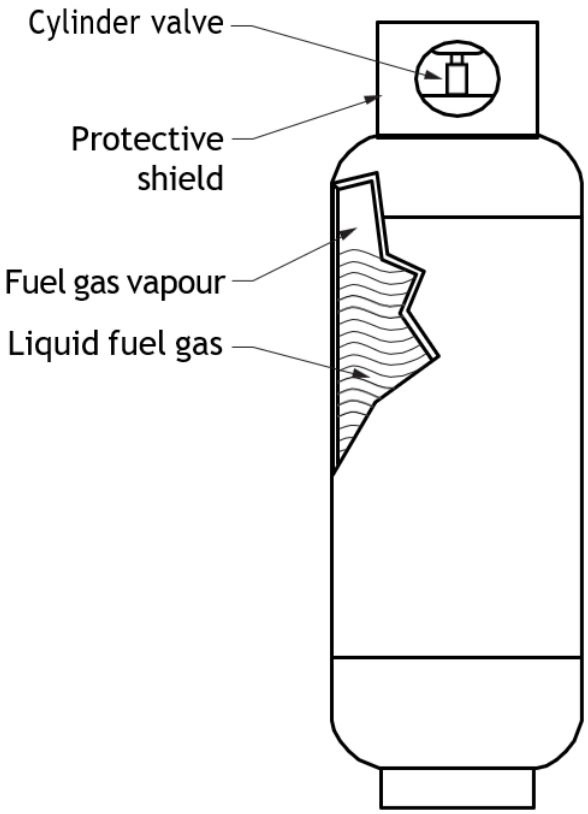

Figure 8 *Liquid fuel cylinder (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The flammable and explosive properties of the gases used in gas cutting, brazing and soldering make safety procedures essential at all times.

Storage

When storing cylinders outdoors, provision should be made for suitable cover from the weather. Full cylinders should be stored separately from empty cylinders; each type of gas should also have its separate storage location.

Cylinders should be stored where they will not be knocked over or damaged by falling objects, passing vehicles, or people. They should not come in contact with salt, corrosive chemicals or fumes. Cylinders (full or empty) should always be secured to a stationary object such as a wall to keep them from falling over.

- Cylinders should not be stored near radiators, stoves, or any other source of heat.
- All storage rooms should be well-ventilated.
- All cylinders should be used and stored in an upright position.
- Once a cylinder is empty, it is to be stored in the appropriate location and marked "MT."

Manifold Systems

In special circumstances, large volumes of acetylene gas may be required to perform a particular job and a single cylinder may not provide enough acetylene at the rate required. When the ***maximum rate of removal (the draw limit)*** is exceeded, liquid acetone will be drawn from the cylinder. To prevent exceeding the draw limit, a series of acetylene cylinders are connected with a ***manifold***. Manifolds are specially designed to connect a number of cylinders together so that the draw limit is increased. The manifold line is filled with stainless steel rod, steel shot, or silica sand to prevent the acetylene from reaching the critical point. The pressure is the same in the manifold as in the cylinders. These systems should be connected and used only by experienced and authorized persons.

Handling

Cylinders must always be handled very carefully. Never drop cylinders or allow them to bump together—they could tip over and explode. When cylinders are being transported, they must be fastened securely.

When your work is finished, close cylinder valves and put protective valve caps on before moving or storing the cylinders. Special cylinder carts should be used for moving cylinders.

Cylinders should be used in the order received from the supplier; when empty, their valves should be closed and the cylinders marked "MT."

Keep cylinders away from electrical wires. Keep oxygen and acetylene cylinders as far away as possible from any area where sparks or flames from welding or cutting work could come in contact with them. Never weld directly over cylinders. If a cylinder valve is clogged with ice or snow, never use a flame or boiling water to loosen it. Use warm water.

To prevent a serious explosive reaction, keep oily and greasy substances away from oxygen cylinders, valves, hoses, fittings, and attachments. Never use oil or grease to lubricate regulators, torches, cylinder valves, or other oxy-fuel gas equipment.

Leaky acetylene cylinders should not be used. When leaks are present, the cylinder should be moved to an area where

good ventilation exists. Warning signs should be displayed to caution people that smoking or using other sources of ignition are not allowed in the area.

The fusible safety plugs on acetylene cylinders should not be tampered with.

Never use a sling, choker, or hook when moving or hoisting cylinders with a crane, derrick, or other lifting equipment. A suitable cradle or box that has been certified and rigged by qualified personnel is the only acceptable method.

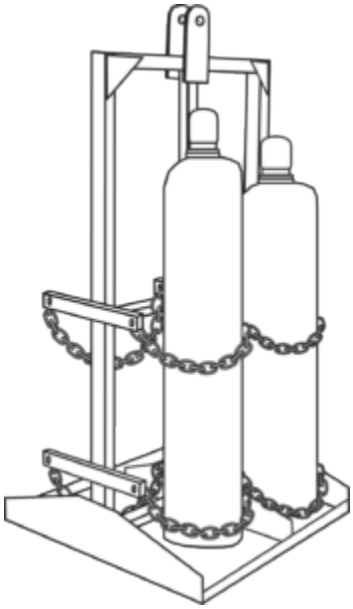

Figure 9 *Oxy-acetylene cart with lifting eye (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Regulators

Oxygen and fuel gases are stored in cylinders at higher pressures than what is required to perform a cutting, brazing, or welding task safely and efficiently. Because of this difference between the stored pressure in the cylinders and the working pressure required to perform welding or cutting operations, it is necessary to install a device on the cylinder that regulates or allows only the amount of pressure needed for a safe and effective operation.

A regulator must not be used for any type of service other than for which it was designed. Repairs to faulty regulators should only be performed by qualified service personnel.

When cylinders of gas come from the supplier, they do not have regulators attached. You must provide the right regulator for the type of fuel gas inside the cylinder.

Most regulators have two calibrated gauges attached. Also included are the permanently attached hex nuts on the regulator cylinder connections. When connected to a cylinder, the gauge with the higher numerical calibrations indicates the pressure inside the cylinder. It is positioned on the same side as the cylinder connection. The gauge with the lower numerical calibrations indicates the working pressure you select. It is on the same side as the hose connection.

Select a safe working pressure by turning the pressure adjusting screw on the regulator. Turning it clockwise increases the working pressure. Turning it counter-clockwise reduces the working pressure.

The oxygen regulator is always equipped with right-hand thread connections, and the acetylene regulator is always equipped with left-hand thread connections. This prevents installing the wrong regulators.

Oxygen Regulators

You can clearly identify an oxygen regulator by the following features:

- Right-hand thread connections
- Cylinder pressure gauge is calibrated from 0–4000 psi (most gauges are available in imperial calibrations only)
- Working pressure gauge is usually calibrated from 0–200 psi, but for heavy welding and cutting, it may read 400 or even 1000 psi
- The word “oxygen” should be printed on the regulator body and on one or both gauges

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

***Note*: Tag and remove any regulator that is found to be defective or damaged.**

Acetylene Regulators

You can clearly identify the acetylene regulator by the following features:

- Left-hand thread connections (and grooved nuts)
- Cylinder pressure gauge is calibrated from 0–400 psi

- Working pressure gauge is calibrated from 0–30 psi
- Working pressure gauge has a red warning line from 15–30 psi
- The word “acetylene” should be printed on the regulator body and on one or both gauges

***Acetylene working pressure must be kept below 15 psi (103 kPa) to prevent the unstable gas from exploding.**

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

All regulators are precision mechanisms. They should be treated with care and never dropped or misused. When they are removed, they should be stored in a box or suitable container to prevent damage. They should be cleaned with a dry, clean rag.

- If regulators are defective or damaged, they should be tagged and removed for service.
- Never use oil, grease, cleaning fluids, gasoline or other petroleum-based chemicals.

Oxy-Fuel Hoses and Fittings

Hoses that carry acetylene and oxygen are specifically designed for oxy-fuel applications. The hose consists of two or three layers of rubber, with a layer of strong fabric between each rubber layer for reinforcement.

The outside layer of rubber may be plain or ribbed.

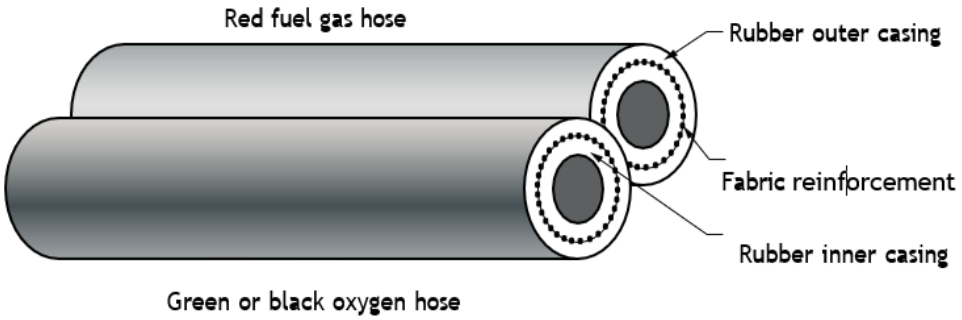

Figure 12 *Double oxy-fuel hose: Colour-coded and attached together (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Most hose used for oxy-fuel application consists of two hoses that have outside layers of rubber fastened together to eliminate entanglements. Since single hose is more prone to kinking and wear, it usually has two layers of reinforcement to make it tougher.

To avoid serious explosions or fires, only use hose in good condition. Faulty or damaged hose should be repaired or replaced immediately with approved products.

Coil, tie, and store hose to avoid kinking. Never expose hose to oil, grease, cleaning solvents, gasoline, paint or contaminants of any kind, and keep hose away from direct sunlight.

Fittings

The same strict manufacturing and handling requirements that apply to oxy-fuel hose also apply to the fittings.

All fittings and connectors used in the hook-up of hose to the regulators and torch body are made of a brass alloy. This prevents sparks if the fittings should accidentally bang against another metal or material. Also, brass alloy fittings will not corrode or produce any dangerous by-products if oxy- fuel gases come in contact with them.

Hose fittings are also right-hand threaded for oxygen, and left-hand threaded for acetylene to prevent switching the hose and possibly causing an explosion. A distinct groove is cut around the outside of the hex nuts on acetylene fittings.

Damaged or faulty oxy-fuel fittings must be replaced immediately. Use only approved fittings.

Oxy-Fuel Torch Assembly and Reverse-Flow Check Valves

The torch assembly is the first point at which mixing of the oxy-fuel gases takes place. It is also the point at which the flow of gases can be adjusted for specific tasks.

Although torch assemblies vary in design, they all have similar characteristics. At one end, the torch handle has gas inlets where the oxygen and fuel gas hoses are attached. At the other end, the mixing barrel has a threaded outlet for the torch attachment. Separate valves control the amount of oxygen and fuel entering the torch handle.

Oxyacetylene flame is used to cut and fuse (weld) metal pieces, but each operation requires a different type of torch assembly. You must select and install the correct attachment to meet a specific job requirement.

Below is a combination torch. The cutting attachment and the welding tip shown can both be interchanged on a single torch handle. When used for cutting purposes, the oxygen valve on the torch handle is opened all the way, and the required amount of oxygen at the torch tip is adjusted by operating the preheat oxygen valve on the cutting attachment.

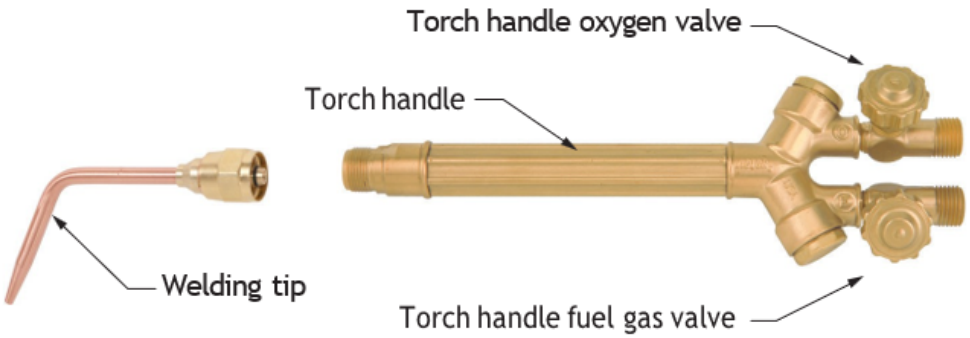

Figure 13 *Combination torch handle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

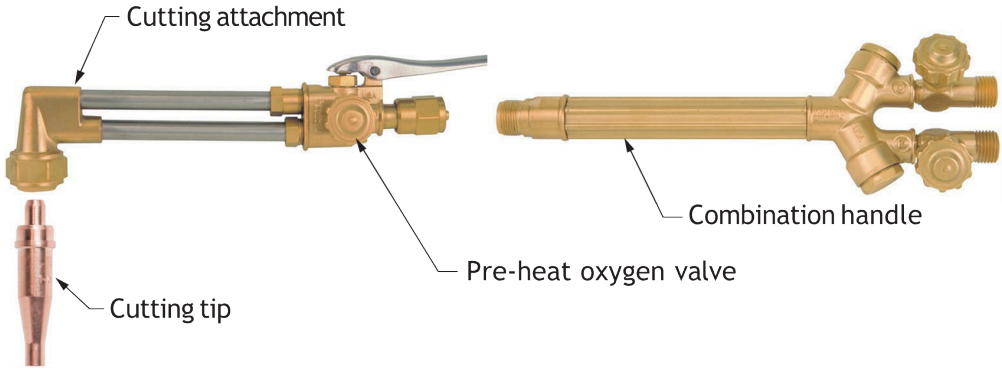

Figure 14 *Cutting torch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Both the oxygen and acetylene valves on the torch handle are used to adjust the amount of gas flow during welding or brazing processes.

When you purchase a combination torch assembly, it includes a cutting attachment, a torch handle and various sizes of

cutting and welding tips. These components are specific to the manufacturer and cannot be used with other brands of torch assemblies.

When brazing with oxyacetylene, a combination torch may be fitted with a multi-port "***rosebud***" tip that is sometimes also used for preheating carbon steel pipe in fabrication work.

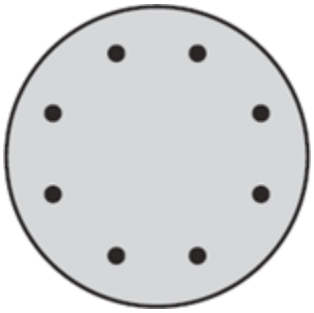

Figure 15 *Rosebud tip (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Torch Line Explosions

When acetylene and oxygen or acetylene and air mix, they form a highly explosive mixture. If this mixture ignites prior to exiting the torch head, it will cause a ***backfire*** or flashback explosion. This is a dangerous and uncontrolled explosion inside the torch equipment that can result in serious injury.

Backfire

During the welding or cutting process, the torch flame may burn back into the welding or cutting tip and make a "popping" sound. This is called a ***backfire*** and is usually the result of the gases pre-igniting inside the tip. The causes of backfire are:

- The obstruction of gas flow at the tip (carbon deposits, hot metal particles)
- A hot tip, from overuse or being too close to the work
- Working pressures too low
- A faulty connection between the torch handle and the welding or cutting attachment

Flashback

A ***flashback*** occurs when the backfire goes beyond the tip and through the hose to the regulator. The torch handle

becomes hot, black smoke and sparks appear from the tip, a squealing or hissing noise is heard, and the fire may eventually burn through the hose. The result of a flashback, aside from fire damage, is a possible explosion.

The causes of a flashback are:

- Incorrect adjustment of torch valves
- Grossly unequal oxygen and acetylene working pressures
- A clogged tip along with excessive oxygen pressure
- Failure to purge the lines before igniting the torch

To help prevent backfire and flashback, make sure the valves on the torch and regulators are functioning properly. The tip should have a clear, undamaged orifice, and ***reverse flow check valves* (RFCV)** should be used to prevent reverse flow in the lines.

A backfire causes the flame outside the tip of the torch to go out and re-ignite instantaneously. If the trouble does not clear up immediately, carefully inspect the equipment, purge the lines, and light the torch.

In the case of a flashback, you must stop the flame IMMEDIATELY before an explosion happens. Assume the worst and shut down the torch valves and cylinder valves as soon as possible. A flashback indicates that something is wrong with the setup. Before you light the torch, check all equipment to see if it is damaged, purge each line separately, and check and adjust working pressures. If a flashback occurs again, remove the equipment from service and have it examined by qualified personnel.

The safe and efficient performance of the torch handle, cutting attachment, and welding tip is dependent on careful use and handling. They are precision tools that can easily be damaged from misuse. Never use a welding torch in place of a hammer or prying tool. When the handle and attachments are removed, they should be placed in a box and stored in a clean, dry area not exposed to oil, grease, solvents, or gasoline.

Reverse Flow Check Valves

The best way to prevent flashbacks and explosions is to keep the gases separated. You should regularly inspect the valves on the torch and cylinders, as well as the gauges on the regulators. Inspection cannot prevent gases flowing in reverse inside the torch or hose. A device called a reverse flow check valve or RFCV (Figure 16) is designed for this purpose (OH&SR Section 12.120 (https://www.bclaws.gov.bc.ca/civix/document/id/loo68/loo68/13_296_97-12#section12.120)). These check valves are compact and are installed between the torch and the hose, or between the hose and the regulators. A stainless steel compression spring holds the valve closed. When the operator opens the regulator and torch valves, the RFCV opens to permit normal gas flow, then snaps shut if the flow reverses.

Different check valves are used for oxygen and fuel gas and sometimes a check valve is built into a cutting attachment. It is important to note that all check valves are marked with an arrow to indicate the direction of gas flow.

Figure 16 *RFCVs between torch and hose (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The WCB recommends that RFCVs be installed on both ends of the hose for safety. Since a torch is subjected to occasional banging or dropping, the RFCVs at that end of the hose may become faulty. Even with RFCVs at both ends of the hose, always check the operation of the valves at regular intervals.

A reverse flow check valve requires much more pressure to close the valve than to keep it open. A reverse flow check valve requires much more pressure to close the valve than to keep it open. For instance, 1.7 kPa (0.25 psi) pressure may open the valve to allow full flow of gases, but 4.3 kPa (1.6 psi) is needed to close the valve. This prevents the usual fluctuations in working pressure from repeatedly closing the valve. An increase in pressure occurs when heat is applied (as in a flashback), and the valve will close.

Reverse flow can be caused by:

- Using plugged or obstructed cutting, welding or brazing tips
- Bleeding the lines by turning off cylinder valves while torch valves are still open
- No pressure from either the oxygen or acetylene cylinders while the torch is in use (empty cylinders)

Flashback Arrestors

Flashback arrestors typically use a combination of methods to stop a flashback. They work just as effectively in any orientation, need very little maintenance, and are often small and light enough to be installed between the torch and hoses. They include:

- A flame trap to cool the flame front. They are designed to allow free flow of gas through them but they take the heat out of the flame front to get it below the ignition temperature of the burning gas mixture. The most common types are:
    - ***Sintered*** metal or ceramic
    - Layers of mesh
    - Ceramic beads
- **Temperature-triggered valves to stop the gas flow completely.** Because it relies on extracting heat from the flashback to stop it continuing, most arrestors have a temperature- controlled valve that will cut off the gas flow when the unit reaches around 90 °C (195 °F), until either the unit cools (if the unit is automatic) or a reset button is pressed (if the unit is manual).

Self-Test B-5.1: Describe Oxy-Acetylene Equipment

Complete Self-Test 5.1 and check your answers.

If you are using a printed copy, please find Self-Test A-5.1 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=2973#h5p-15 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2973#h5p-15)

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- Plumber: Competency B-5 Use Soldering and Brazing Equipment
- Plumber: Competency B-6 Use Oxy-Fuel Cutting Equipment
- Sprinkler Fitter: Competency B-4 Use Soldering and Brazing Equipment
- Steamfitter: Competency B-6 Use Soldering and Brazing Equipment
- Steamfitter: Competency B-7 Use Oxy-Fuel Equipment

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B-5.2 Describe Cutting, Brazing, and Soldering Techniques

The Oxyacetylene Cutting Process

When metal is heated to a red-hot temperature by the preheat flame, it combines easily with oxygen and forms oxides. The jet of oxygen from the central orifice causes the metal to burn and disintegrate rapidly, leaving a ***kerf*** (cut path). The rate of cutting depends on the oxygen pressure, the size of the tip, and the thickness of the metal.

Figure 1 *Oxygen valve controls oxygen to cutting lever and preheat valve (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Since the pressurized oxygen continues to flow as a narrow, penetrating stream some distance from the tip, it allows you to accurately control the cut simply by aiming the torch in the direction where you want the cut. The burnt metal (slag) is either blown away as red-hot particles or it may adhere to the underside of the cut surface. You will immediately notice the difference in appearance between the base plate metal and slag.

Figure 2 *Oxy-fuel gas cutting process (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

With the variety of oxyacetylene cutting torches available, sheet metal as thin as 0.8 mm ($\frac{1}{32}$ in.) and plate steel as thick as 600 mm (24 in.) can be accurately cut. The majority of cutting is done on plate ranging from 2 to 50 mm ($\frac{1}{8}$ in. to 2 in.) thick.

Not all metals can be successfully cut by this process. Metals that contain iron, such as low carbon steel and wrought iron, can be cut without difficulty. Metals that contain no iron (*non-ferrous alloys*), such as aluminum, copper or brass, cannot be cut with the oxyacetylene process.

Setting Pressures

1. Make sure the cylinder valves are open and the regulator pressure-adjusting screws are turned out all the way before setting working pressures.
2. Select and install the appropriate cutting tip. The tip may already be installed, but make a note of the cutting tip size. Remember, the thickness of the metal to be cut has a direct bearing on tip size, and tip size has a direct bearing on working pressure. Refer to the manufacturer's chart for correct settings.
3. Before setting working pressures, make sure the preheat oxygen valve on the cutting attachment is closed. Then open the oxygen valve on the torch handle all the way.
4. Open the acetylene torch valve no more than $\frac{1}{2}$ turn, and then turn in the pressure adjusting screw on the acetylene regulator until the gauge reads the selected working pressure. After adjusting, close the acetylene torch valve.
5. Open the preheat oxygen valve $\frac{1}{2}$ turn, then turn in the pressure adjusting screw on the oxygen regulator until

the gauge reads the selected working pressures. After adjusting, close the preheat oxygen valve.

Lighting and Adjusting the Flame

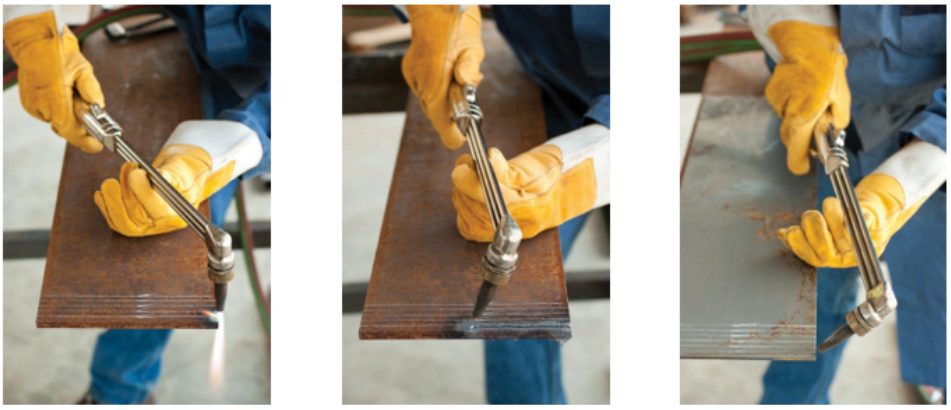
1. Equip yourself with appropriate personal protective equipment (PPE), including coveralls, heavy leather gloves, boots, shaded safety goggles, and a welding cap. Be careful where you point a lit torch and where you let slag deposit once you begin to cut.
2. Before lighting the torch, ensure that there is adequate ventilation, particularly if the metal to be cut is coated with primer or other treatment.
3. To light the torch, open the acetylene valve on the torch handle no more than $\frac{1}{2}$ turn and ignite the gas at the tip using a striker. The flame will be long and yellow. Adjust the valve until most of the smoke clears from the flame. Never attempt to light a flame with any other form of ignition other than a striker (e.g., matches or lighters).
4. Slowly open the pre-heat oxygen valve. You will immediately notice the flames change in colour from yellow to blue.
5. Adjust the preheat oxygen valve to a ***neutral flame***. The torch is now adjusted and ready to use for cutting.

Extinguishing the Flame

1. To extinguish the flame, first close the acetylene torch valve. The flame will go out but oxygen gas will continue to flow from the tip.
2. Close the preheat oxygen valve on the cutting attachment to temporarily stop the flow of oxygen. The torch can be left for a short time (10 minutes or less) in this state. Whenever work is stopped for a longer period, bleed the system completely.

Torch Position and Motion

If the plate is 13 mm ($\frac{1}{2}$ in.) thick or greater (Figure 3a), the cutting tip should be held vertically to the plate at a 90° angle. For plate 6 to 13 mm ($\frac{1}{4}$ in.) to $\frac{1}{2}$ in.) thick (Figure 3b), the cutting tip should be angled 60° to 70° back in the direction opposite the cut. This allows an increase in the cutting speed and helps prevent a buildup of slag underneath the plate. For plate less than 6 mm ($\frac{1}{4}$ in.) thick (Figure 3c), angle the tip 15° to 20°.



a. b. c.

Figure 3 *Angle of torch depends on thickness of metal (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Before lighting the torch, practise the cutting motion to become familiar with the required body and hand positions. Note the placement of the hoses. They should not lie where sparks or slag from the cutting operation could land on and burn them. Keep them well out of the way, preferably behind you, and away from sharp edges or heat sources. Do not use your body or arms to support them. Take any twist out of the hose.

With goggles and gloves on, hold the torch in your right hand*, with your thumb on the cutting lever. Rest the outside edge of your left hand about 150 mm (6 in.) from the line to be cut and support the torch with your thumb and index finger.

(Note that the positions suggested here are for right-handed operators.)*

Ensure that you are not positioned directly above the plume of the cutting torch. Placing your head to one side of the cutting line will reduce the amount of exposure to the metal fumes being produced and will allow you to better see the tip of the torch. Ensure that the ventilation takeout fitting is positioned opposite the material from you so as not to draw the fumes toward your breathing zone.

Figure 4 *One hand guides the torch, the other acts as a pivot (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Guide the torch with your right hand, and support it with your left. With the left hand acting as a pivot, swing the torch from one side of the plate to the other. The torch should always be moved away from you, rather than toward you. You will notice that the cutting tip moves in a wide arc. To make a straight cut, you must perfect the technique of sliding your left hand and the torch in such a way that the cutting nozzle stays on a straight line. On a dry run (without the torch lit), hold the torch so that the tip is pointing straight down, midway between the two ends of the cut line.

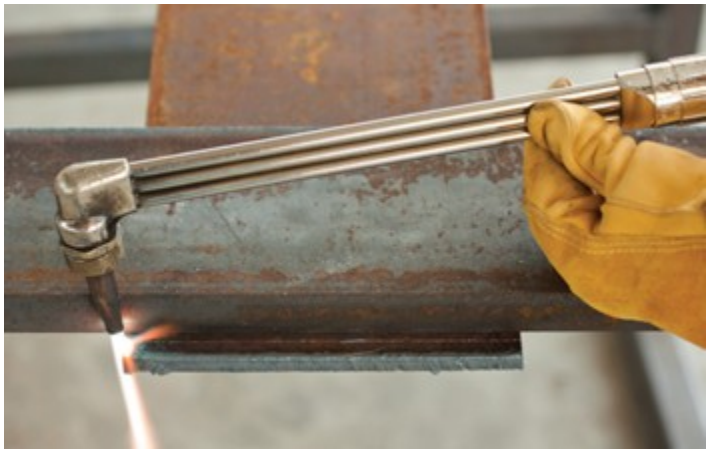


Figure 5 Technique for starting a straight cut (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)

Roll your left hand forward and to your right, to bring the tip directly over the starting point of the cut.

Steadily roll your left hand, from right to left and use your right to guide the tip along the cut line. Continue to roll and guide the torch until you reach the end of the line (Figure 6). The tip should remain approximately 10 mm ($\frac{3}{8}$ in.) above the surface of the plate at all times.

This roll may seem a little awkward and unnatural at first, but with practice, it will become easy. It is important to be comfortable and have full control of the torch. The same motion is used when making very long cuts, but it may be necessary to stop cutting and reposition yourself several times. Keep in mind that the angle of the tip should change according to the thickness of the metal.

Starting Methods

Several methods can be used to start a cut at the edge of a work piece. The most common is to place the tip halfway over the edge of the plate, steadily holding the ends of the preheat flames about 3 mm ($\frac{1}{8}$ in.) above the plate surface. When the edge reaches a cherry-red colour, slowly depress the cutting oxygen lever to start the cutting process.

Figure 6 *One method of starting the cut (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Another method is to put the entire tip over the edge of the material to be cut, then move it back and forth a short distance along the line of the cut until the material is cherry red in colour. Move the tip back from the edge, depress the cutting lever, and then slowly move toward the material to begin the cut. This method has the advantage of producing sharper corners at the beginning of the cut and reducing slag buildup on the underside.

Once the cut has been started (the cut is all the way through), move the torch along the line of cut with a smooth, steady motion. Maintain a constant tip-to-work distance as closely as possible. Move the torch at a speed which produces a light ripping sound and a smooth spark stream.

Cutting Results

Examine the surface on the edge of a cut plate to determine the quality of the cut and the performance of the torch. The following examples show possible cutting results as they appear on the plate edge. Use these as a reference when cutting plate.

Correctly Made Cut

On a good cut, drag lines (lines created by the cutting action on metal) are vertical and not too pronounced. The top edge should be square, and any slag is easily removed. The bottom edge should be sharp.

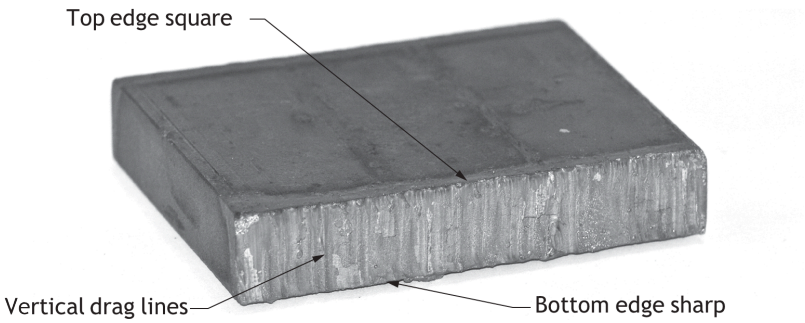


Figure 7 *Correctly made cut (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Cutting Speed Too Slow

On a cut made too slowly, the drag line will be irregular, the bottom edge will be uneven, and the top edge will be rounded. Too much cutting oxygen for the cutting speed is the cause, possibly from an oversized tip, incorrect pressure setting, or poor technique.

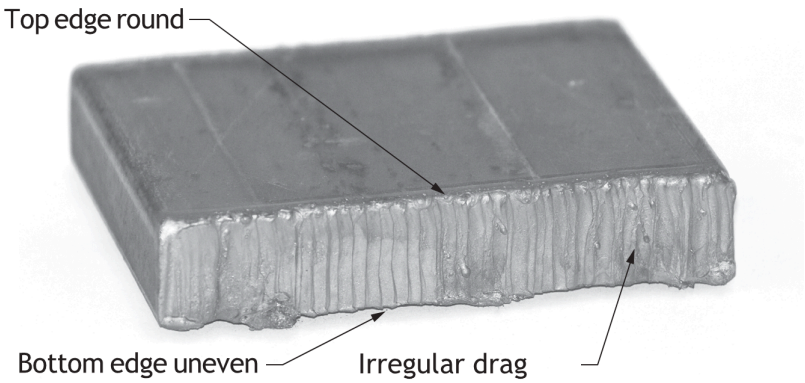


Figure 8 *Cutting speed too slow (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Cutting Speed Too Fast

On a cut made too quickly, the drag lines are curved, slag adheres to the bottom edge, the top edge is sharp, and the cut face is smooth. When not enough heating is used to complete the cut, slag will collect.

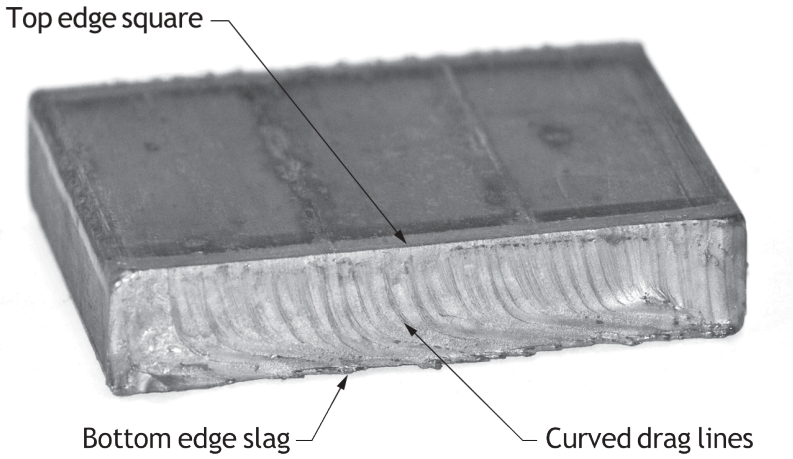


Figure 9 *Cutting speed too fast (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Dirty Tip Used

On a cut made with a dirty tip, drag lines are irregular, the cut face is rough, ***slag*** is excessive and control is poor while cutting. These problems are caused by dirt or slag in the tip deflecting the oxygen jet and reducing cutting efficiency.

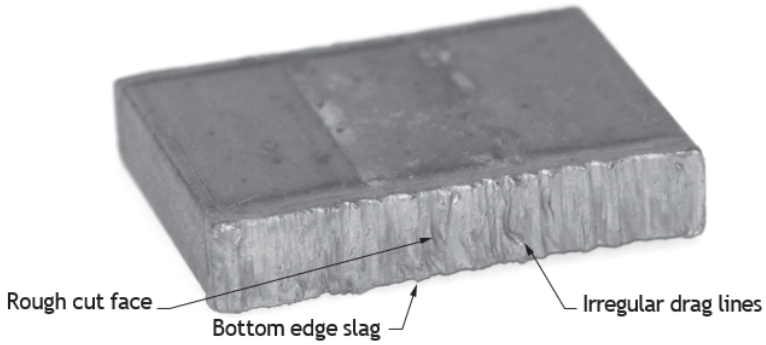


Figure 10 *Dirty tip used (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Factors that are important in achieving a quality cut are:

- Working pressure settings
- Amount of preheat flames
- Angle of torch tip relative to metal
- Tip size
- Speed of cutting torch across metal
- Control of torch by operator

After making a few cuts, see your instructor for an evaluation of the cuts. The instructor may suggest adjusting the torch

or the pressures, or perhaps altering your grip or the motion of the torch. Your instructor can provide helpful hints to aid you in achieving quality results.

Precautions with Containers

A common task is the potentially dangerous cutting and welding of tanks and containers. Combustible gases and solid residues make containers potential bombs unless they are carefully prepared before cutting or welding. Work involving flame or sparks should never be done on barrels, drums, tanks or other containers until they have been thoroughly cleaned to ensure that no flammable solids, liquids, or vapours remain and the container has been verified safe.

Fuel must combine with oxygen and have a form of ignition for a fire or explosion to occur. Most liquids and solids do not explode until they have been heated and vaporized into gases. Even a gasoline tank that contains no liquid gasoline can have enough vapour present to cause an explosion if ignited.

The importance of using correct procedures and precautionary measures to ensure that fires or explosions do not occur cannot be over-emphasized. The various methods used for cleaning containers, such as steaming, boiling or purging, should be done only by qualified individuals using specialized equipment.

If you are asked to cut or weld a container that you suspect may have contained a combustible substance, do not assume that the proper procedures for preparing the container have been completed. Do not proceed to cut or weld unless you are absolutely sure all necessary precautions have been taken.

Note: Do not attempt to weld or cut, smoke near, or bring a light into any tank or enclosure that contained gasoline or any other flammable material unless the space has been thoroughly purged and inspected.

Precautions with Oxyacetylene Equipment

When using oxy-acetylene equipment it is important to observe the following safety precautions:

- Never use cutting or welding torches where sparks or an open flame of any kind would be a hazard. If possible, take the workpiece to a location where there is no possibility of setting fires. If the workpiece cannot be moved, remove any flammable material, including matches from your pocket. When necessary, use sheet metal guards or flame-resistant curtains to contain sparks.
- Butane lighters are potentially explosive and should never be in your possession when welding or cutting.
- Keep sleeves and collars buttoned at all times. Avoid pants with cuffs and shirts with rolled- up sleeves or open pockets into which sparks may fly. Avoid greasy or oily clothing.
- Be sure to keep a clear space between the cylinders and the work. This is important in case the regulators need to be reached quickly.
- Always test an outfit for leaks before use.
- Never cut or weld any material on concrete, as concrete may explode when heated.

Soldering and Brazing

The basic principles behind soldering and brazing are adhesion, cohesion, state change, and ***capillary action***. Properly cleaning the tube and fittings and applying ***flux*** prepares the copper for the filler *alloy* to adhere to the surface of the copper. As the alloy is heated, it changes state from a solid to a liquid. The flux wets the alloy and reduces its surface tension, allowing it to flow readily into the joint. Capillary action draws this free-flowing liquid alloy into the annular space between tube and fitting. The filler alloy, once cooled, has strong cohesive properties to create a physical bond able to withstand the pressure of the system and resist physical damage.

Copper tube and fittings may be joined in a number of ways, depending on the purpose of the system. Soldering and brazing with capillary fittings are the methods used most.

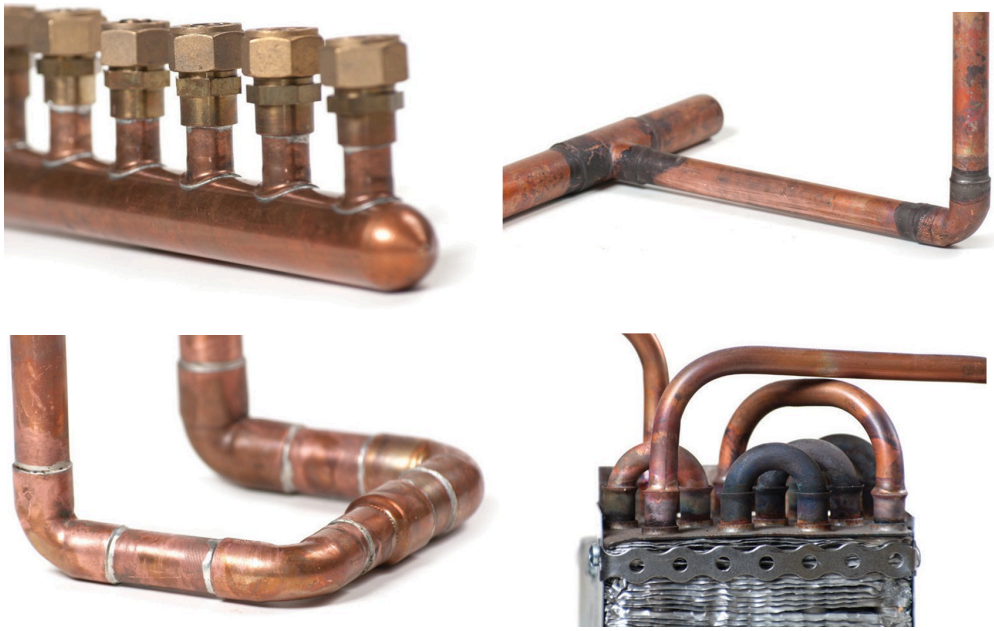


Figure 11 *Soldered and brazed fittings* (*BC Industry Training Authority*, 2019). *CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

The American Welding Society (AWS) defines soldering as a joining process that takes place below 449 °C (840 °F) and brazing as a similar process that occurs above 449 °C (840 °F) but below the melting point of the base metals. In actual practice for copper systems, most soldering is done at temperatures from about 177 °C (350 °F) to 288 °C (550 °F), while most brazing is done at temperatures ranging from 593 °C (1100 °F) to 816 °C (1500 °F).

Potable water systems are often soldered as are hydronic heating and compressed air. Medical gas systems, fuel gas systems, and refrigeration systems are all brazed. As well, potable water underground must be brazed.

Definitions

alloy: A homogeneous metal composed of two or more elements.

capillary action: When liquid solder is drawn into the *annular space* between the inside fitting wall and the tubing's

outside wall because there is a stronger attraction (*adhesion*) between the copper and the liquid solder molecules than between the solder molecules themselves (*cohesion*).

solidus: The temperature at which 100% of the alloy is in a solid, crystalline form.

liquidus: The temperature at which 100% of the alloy is in a fluid, non-crystalline form.

plastic range: Also called the *pasty* range, the plastic range is the temperature range between the solidus and liquidus of an alloy; some portion of the alloy is solid, but the majority is liquid. This is due to the alloy's components solidifying at different temperatures.

eutectic alloy: Alloys are eutectic when the solidus and liquidus points are the same. The opposite of having a plastic melting range, eutectic alloys solidify at a single, sharp temperature.

Abbreviations

S*n*—tin
Pb—lead
A*g*—silver
N*i*—nickel
Cu—copper
S*b*—antimony
C*d*—cadmium
Z*n*—zinc

Soldering and Brazing Uses

- Potable water systems—residential, commercial and industrial
- Refrigeration tubing (silver brazing only)
- Fire sprinkler systems
- Extracted tee joints
- Drainage, waste and venting systems
- Medical gas systems (silver brazing only)

Solder Filler Metals

Soft soldering filler metals are a group of filler metals with melting temperatures below 800OF.

They are available in $\frac{3}{64}$ in., $\frac{1}{16}$ in., $\frac{3}{32}$ in. and $\frac{1}{8}$ in. diameter, 1 lb. spools. Other diameters and spool sizes are available from manufacturers on request.

50/50, 40/60, 60/40 Tin/Lead

With some exceptions, the tin/lead (i.e., **60/40** = 60% tin and 40% lead) solders can be used to solder copper and most copper alloys, lead, nickel alloys and steel.

Tin-lead solders are not recommended in high stress or vibration joints in the cooling industry due to lack of sufficient elongation properties. It is illegal to use lead alloys in connection with potable water systems. (Refer to lead-free solder information). 40/60, 60/40, and 50/50 solders are also available with rosin or acid cores.

95/5 Tin/Antimony

The 95/5 tin/antimony lead-free solder is useful for applications where moderately elevated temperature is a factor. With a higher electrical conductivity and high fluidity, 95/5 is recommended for lead-free installation of small-diameter, tight-fitting connections. The tin/ antimony solders are not recommended for use on brass.

Lead-Free Solders

Lead-free solders were developed to conform to regulations banning the use of lead-based solders with over 0.2% lead in potable water systems. This non-toxic solder alloy typically exceeds the physical advantages of lead-tin solders. Lead-free solders may contain all of or parts of the following metals: specific amounts of silver (Ag), antimony (Sb), copper (Cu), nickel (Ni) and or tin (Sn). The strength of a lead-free solder joint will normally exceed the pressure point at which copper tubing will burst.

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

Brazing Filler Metals (Hard Solders)

Brazing alloys have two general categories:

1. **BAg** containing primarily copper and varying amounts of silver with some other minor elements.
2. **BCuP** comprised mostly of copper, with added phosphorus to act as a flux. Some BCuP alloys may contain small amounts of silver for added strength.

Copper tube and solder-type pressure fittings are accurately made for each other, and the tolerances permitted for each assure the capillary space will be within the limits necessary for a joint of satisfactory strength, regardless of whether you are soldering or brazing.

Brazing Copper Silver Alloys (BAg)

[B = Brazing/Ag = Silver] Used for high-temperature applications, loose tolerance situations and for dissimilar metals. Many contain cadmium (a highly toxic element) so treat these alloys with caution and wear proper Personal Protective Equipment. BAg is not used as commonly in the pipe trades as BCuP.

Brazing Copper Phosphorous Alloys (BCuP)

[B = Brazing/Cu = Copper/P = Phosphorus] Copper/phosphorous and copper/silver/phosphorous alloys are used to braze copper to copper and copper to brass. The phosphorus content in these alloys makes them ***self-fluxing*** on copper. When brazing brass or copper to brass, a brazing flux must be applied. BCuP alloys are not recommended for brazing steel or other ferrous metals.

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

Fluxes

Soldering fluxes are classified as corrosive, intermediate, or non-corrosive. The choice may depend on the metals being joined and the melting range of the alloy. Fluxes can be either petroleum based or water based.

Although brazed joints may not always require the application of a flux, soft solder joints will always require a flux to be applied to the metal surfaces prior to heating, primarily to remove any minor surface impurities. As the material is heated, fluxes prevent the formation of oxides, which may contaminate the joint. They also assist the flow of alloy into the capillary spaces of the cup and tube.

Different fluxes perform these duties in various ways and at different temperatures.

Soft Solder Flux (Petroleum Based)

Petroleum-based paste fluxes are basically made up of organic chlorides, zinc, bromides, fluorides and ammonium chlorides mixed in a petroleum-grease base. Because of their corrosive properties, it is necessary to properly limit the amount of flux entering the joint and to thoroughly clean the exterior after soldering to avoid further oxidation and visible discolouration.

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

Soft Solder Flux (Water Based)

Water-based fluxes are a newer development in fluxes in response to a need for materials that have less environmental impact. Many of these new fluxes are more sensitive to being heated within the temperature ranges in which petroleum-based fluxes are used. Care must be taken to avoiding charring the flux, as it has less tolerance to overheating than petroleum flux.

The active temperature range for these soft solder fluxes is between 200°F (93°C) and 600°F (315°C).

Composition:

- Chlorides

Precautions

- Fumes and gases can be hazardous to your health. Burns eyes and skin on contact.
- Can be fatal if swallowed.
- Before use, read and understand the manufacturer's instructions, the Material Safety Data Sheet (MSDS), and your employer's safety practices.
- Keep your head out of fumes.
- Use enough ventilation, exhaust at the flame, or both, to keep fumes and gases from your breathing zone and the general area.
- Avoid contact of flux with eyes and skin. Wear safety glasses and gloves.
- Do not take internally.

First Aid

- If contact with eyes, flush immediately with water for 15 minutes.
- If swallowed, induce vomiting.
- Never give anything by mouth to an unconscious person. Call a physician.

Brazing Flux

White brazing paste flux is an effective and efficient flux for use in silver brazing most ferrous and non-ferrous metals except aluminum, magnesium and titanium. Recommended filler metals for use with white brazing flux include those of BAg and BCuP classification.

The shelf life of these types of fluxes is approximately 1 year from the time of manufacture.

The active temperature range for brazing flux is between 566°C to 871°C (1050° to 1600°F).

Composition:

- Water
- Boric acid
- Potassium fluorides

Precautions

- Contains fluorides.
- Fumes and gases can be hazardous to your health. Burns eyes and skin on contact.
- Can be fatal if swallowed.
- Before use, read and understand the manufacturer's instructions, Material Safety Data Sheet (MSDS), and your employer's safety practices.
- Keep your head out of fumes.
- Use enough ventilation, exhaust at the flame, or both to keep fumes and gases from your breathing zone and the general area.
- Avoid contact of flux with eyes and skin.
- Do not take internally.
- Keep children away when using.

First Aid

- If contact with eyes, flush immediately with water for 15 minutes.
- If swallowed, induce vomiting.
- Never give anything by mouth to an unconscious person. Call a physician.

Soldering and Brazing Using Air-Acetylene

Size B Acetylene Tank Specifics

- Holds 40 cubic feet of pure acetylene gas (the smaller tank, size "MC" holds 10 cubic feet). Note: These capacities represent the volume of fuel available at standard atmospheric pressure (14.73 psia) and temperature (70°F). The B

tanks' true internal volume is actually 0.61 ft^3.

- Tank is normally supplied with a protective plastic cap or shield over the outlet to prevent the entry of debris before the regulator and hose are connected.
- Tank has *fusible* (liquefiable), temperature-sensitive plugs, which release excessive pressures when activated.
- Requires no oxygen cylinder; the oxygen required to support combustion is supplied from the air surrounding the torch tip.
- Produces a flame with temperature of about 4000°F—hotter than gases such as Butane, Propane and Natural Gas.
- Tank is packed with a porous material called *agamassan* (a porous material such as asbestos, charcoal or diatomaceous earth) that is saturated with acetone (acetone has the ability to dissolve many times its own volume of acetylene), so that there is no free unstable gas in the tank. It is therefore gas dissolved in liquid—but when pressure is released in the cylinder, the acetylene boils off.
- The pressure inside a fully charged tank at 70°F is approximately 250 psi. At higher temperatures the pressure will be also be higher; at lower temperatures, it will be lower, but these pressure variations have no effect on the quantity of gas in the tank. However, the amount of pressure change caused by a change in temperature varies according to the amount of acetylene in the tank.
- The newer versions of the tank have a regular wheel handle shut-off valve at the top. Older versions only have a square valve stem that needs a valve key to open and close the valve. Or the square hole in a tubing cutter reamer can be used.
- Never use pliers to open the tank valve; the valve stem will be damaged.
- Use the tank in the upright position.
- If acetone appears from the tip (purple, hazy flame), it is typically due to the tank having been laid on its side. Allow the bottle to sit upright for 24 hours before attempting to re-light. Contact the supplier if problems persist.

Figure 15 *B-tank outfit complete with regulator, handle, hose and torch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

B and MC Tank Equipment

- Tips come in a variety of sizes. Tips are selected based on the required amount of heat for the job. A larger tip provides more heat than a smaller tip. For most brazing jobs, acetylene-air or B tanks will suffice. Always refer to the manufacturer's literature for correct tip size selection.
- The tank hose is typically $\frac{3}{16}$ in. in diameter and is available in 6, 12 and 25 ft lengths.
- Torch handle has a control valve for on/off command.
- The pressure regulator is equipped with a pressure regulating adjustment that allows a variable delivery pressure of up to 13 psi.
- A gauge displays the gas content (volume) at all times.
- A gauge to display working pressure (delivery pressure) is sometimes present, or can be added.
- A metal filter, located in the inlet of the regulator, prevents dirt or foreign particles from entering the regulator from the tank.

Setting Up the B Tank

1. Secure the tank.
2. Have fire protection equipment ready, including fire shields to protect nearby surfaces.
3. Remove the protective shield on the tank outlet, and open the tank valve briefly to clear any debris that may be lodged in the tank outlet.
4. Install the regulator, hoses, handle and tip. Excessive force must not be used on connecting nuts. Care must be taken not to damage the pressure regulator.
5. Make sure that the pressure regulator connecting nut and all hose and handle coupling nuts are secure. Do not allow the hose to come in contact with flame, sharp objects, oil or grease.
6. Open tank valve on half turn and test connections with soap and water to make sure there are no leaks.
7. Select the right size tip.
8. Turn the control all the way on at the pressure regulator.
9. Open the needle valve on the torch handle slightly and light it with a flint lighter.
10. Adjust flame to the required amount at the tank regulator with the torch handle control valve fully open.
11. If the flame should blow out, re-light the torch and adjust the regulator accordingly (clockwise for more flow).
12. If you smell acetylene gas at any time, check for leaks immediately.

Soldering and Brazing Procedures

The following instructions and techniques will aid in producing quality, leak-free soldered or brazed joints when connecting copper tube and fittings.

The procedures for soft soldering are similar to those for brazing. Above all, cleanliness is most important to avoid joint contamination and possible failures. Fluxes used for either process must be compatible with the temperatures involved, and flux may not be required under some circumstances (for example, copper-to-copper joints using BCuP alloy).

1. **Safety Precautions**

Always observe the following safety procedures when using soldering and brazing equipment:

- Wear eye protection and hand protection.
- Work in a well-ventilated area when possible.
- If the joints to be sweated (soldered) are near combustible materials, such as a wall or floor of a building, use a shield such as a fireproof board between the joints and the combustible material. Use care to avoid causing a fire with the torch.
- Always have a charged and appropriate fire extinguisher on hand. Have a hot-work permit, if required.
- Avoid contact with molten solder.

2. **Measurement**
   Measure and mark the tube with a pencil or marker. Remember to allow for the length of tube that fits into the fitting cup. Dry-fitting the tube and fittings before soldering will ensure that the fittings are square and the runs straight.
3. **Cutting**
   The tube is best prepared when cut with a rotary tubing cutter. Care must be taken that the tube is not deformed while being cut. If you are installing soft temper tube (annealed tube), you must be especially careful to not deform the tube end by applying too much pressure when cutting. Regardless of the method, the cut must be square to the run of the tube so that the tube will seat properly in the fitting cup.

4. **Reaming**
   Ream all cut tube ends to the full inside diameter of the tube to remove the small burrs created by cutting. If the rough inside edge is not removed by reaming, erosion corrosion may occur due to local turbulence and increased local flow velocity in the tube. A properly reamed piece of tube provides a smooth surface for better water flow. Also remove any burrs on the outside of the tube end created by the cutting to ensure proper entrance of the tube into the fitting cup. Tools that can be used to ream the tube end include the reaming blade on some tubing cutters, half-round or round files, a pocketknife or a suitable de-burring tool.
5. **Cleaning**
   The removal of all oxides and surface oils from the tube end and fitting cup is crucial to encourage proper flow of solder metal into the joint. Failure to remove them can interfere with capillary action and may lessen the strength of the joint. There are two methods of cleaning:

- **Mechanical cleaning** of surfaces can be accomplished by filing, brushing or scouring. Scouring the tubing and larger fittings with a product like *sand cloth* is the most common way to mechanically clean copper, brass and other soft metals. Smaller fittings, typically 1 in. and under, are often cleaned internally by a stainless steel *fitting brush*. Never use steel wool as it often contains contaminants.
- **Chemical cleaning** uses solvents or alkali substances for the removal of oils or grease. Carbon tetrachloride, trichloroethylene or methyl chloroform may be used. Chemically *pickling* uses an acid-bath for the removal of rust, scale and oxides from pipe and fittings. Acids such as hydrochloric, nitric and sulphuric acids are sometimes used. ***Note*: Strong chemical cleaning is highly corrosive to copper and brass and must be neutralized to protect the piping system. It is not the common method and is prohibited for use by modern plumbing codes.**

  Lightly clean the tube end and fitting socket using open-mesh sand cloth or emery cloth for a distance slightly more than the depth of the fitting cup. The capillary space (annular space) between the tube and fitting is approximately 0.004 in. Solder metal is drawn into this gap by capillary action. This spacing is critical for the solder metal to flow into the gap and form a strong joint. Copper is a relatively soft metal. If too much material is removed from the tube end or fitting cup, a loose fit may result in a poor joint

5. **Inert Gas Purge**
   Some systems, such as medical gas and refrigeration systems, require the brazing process to be conducted under an oxygen-purged condition. This is accomplished by pumping an inert gas such as nitrogen or argon through the piping during the brazing process, purging any oxygen and thereby eliminating the potential for oxidation. This condition occurs when materials are heated with oxygen available and oxides are created. These impurities, such as copper oxide, collecting on the surface of the tube, both inside and out. If this flaky by-product is permitted to be created inside the system, it could then damage components or in the case of medical gas, result in a life-threatening contamination.
6. **Applying Flux**
   Use a flux that will dissolve and remove traces of oxide (which is usually blackish or greenish in colour) from the cleaned surfaces. This will protect the cleaned surfaces from re-oxidation during heating and promote wetting of the surfaces for the solder metal. It is important to use fluxes that conform to the ASTM B 813 standard so that any flux residue left inside the system will flush out with water. Apply a thin, even coat of flux with a brush to both the tube and fitting immediately after cleaning.

   ***Note*: Do not apply the flux with your fingers.**

   Chemicals in the flux can be harmful if they come into contact with the eyes, mouth or open cuts. Careless workmanship can cause problems long after the system has been installed. If excessive amounts of flux are used, the flux residue can cause corrosion. In extreme cases, such flux corrosion could perforate the wall of the tube, the fitting or both.
7. **Assembly and Support**
   Insert the tube end into the fitting cup, making sure the tube is seated against the base of the fitting cup. A slight twisting motion ensures even coverage by the flux. Remove excess flux from the exterior of the joint with a cotton rag. Align, square and support the tube and fitting assembly to ensure a uniform capillary space around the entire circumference of the joint. Uniformity of capillary space will ensure good capillary flow of the molten solder metal. Excessive joint clearance can lead to solder metal cracking under conditions of stress or vibration. The joint is now ready for soldering. Joints prepared and ready for soldering must be completed as soon as possible (preferably the same day) and should not be left unfinished overnight.
8. **Heating**
   Begin heating with the flame perpendicular to the tube. The copper tube conducts the initial heat into the fitting cup for even distribution of heat in the joint area. The extent of this preheating depends on the size of the joint. Preheating of the assembly should include the entire circumference of the tube in order to bring it up to a suitable temperature. Next, move the flame onto the fitting cup. Sweep the flame alternately between the fitting cup and the tube a distance equal to the depth of the fitting cup. Practice and experience will indicate the amount of heat and time needed. Observe the reaction of the flux as the heat is applied. The reaction of the flux will give some indication of the temperature when you arrive at the temperature to apply the filler metal. Soft solder fluxes look and react differently than silver brazing flux. Petroleum-based fluxes will show smoke, indicating that the joint is near a temperature that is adequate to attempt to introduce filler alloy. Be careful not to overheat the flux at this point. Touch the solder to the joint where the tube meets the hub of the fitting. If the solder does not melt, remove it and continue heating. Do not attempt to melt the solder with the torch flame. The alloy must be introduced to the joint by the heat of the fitting and tube itself. Avoid overheating the joint or directing the flame into the face of the fitting cup. Overheating could burn the flux, which will destroy its effectiveness. Also, the solder will not properly enter the joint. When the solder melts, apply heat to the base of the cup to aid capillary action in drawing the molten solder into the cup toward the heat source. Once the entire joint is heated to the point where the solder alloy flows smoothly, remove the flame from the joint in stages in order to maintain the desired amount of heat without continuing to increase the joint's temperature. Cap the entire circumference of the joint to make certain that no voids exist. Control of temperature can be a key to filling trouble spots. You may need to cool and

re-clean an area that is difficult to fill.

9. **Cooling and Post-Cleaning**
   Allow the completed joint to cool naturally to below its ***plastic (pasty) range***, as shock-cooling with water may stress the joint. As soon as the joint is cool, to be sure to clean off remaining flux residue with a damp rag. When soft soldering, excess solder may be visible outside the joint. Part of your duty as a tradesperson requires that you take great pride in your ability and the appearance of your work. While the joint is still molten, use the end of the solder metal to sweep the excess solder off, or carefully wipe the joint with a clean, dry rag. However, be careful not to bump or disturb the joint while the solder filler metal is still molten. Moving the joint before the solder has cooled to below its pasty range can cause internal stresses that weaken the joint. These added stresses may show up some time down the road as hairline cracks that will cause the joint to "weep."

Self-Test B-5.2: Describe Cutting, Brazing and Soldering Techniques

Complete Self-Test 5.2 and check your answers.

If you are using a printed copy, please find Self-Test A-5.2 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=2977#h5p-16 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2977#h5p-16)

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B-5.3 Use Oxy-Acetylene Equipment

You must understand the correct procedures and safety precautions to use when assembling, testing, lighting, adjusting, shutting down, and disassembling a portable ***oxy-acetylene*** outfit.

Always follow general fire safety procedures. Work in a well-ventilated area. Have a charged and appropriate extinguisher nearby and a ***hot-work permit***, if required. Remove all combustible materials from work area.

Assembly, Light-Up, Shutdown, and Disassembly of a Portable Oxy-Acetylene Setup

To avoid accidents, you must follow an organized procedure for assembling an oxy-acetylene unit.

1. Secure the cylinders in an upright position. A safety chain is commonly used to secure cylinders to a portable cart so they do not tip over or get jarred (Figure 1). The cylinder cart is designed to roll easily when tilted back on the wheels, yet be stable and secure when stationary.

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

2. Remove the caps covering the cylinder valves once the cylinders are secured. The caps match the size and colour

of the cylinders. Oxygen cylinder caps will typically be red or green, and ***acetylene*** caps are typically black. Cylinder caps should always be in place when transporting or storing cylinders.

3. Before attaching the regulators, "crack" the valves by opening them slightly, then quickly closing them. This clears any dust or foreign particles from the valve outlets. Stand to the side of the valve outlets and make sure they are not pointed toward you or another person. Any particles inside the valves will be ejected with tremendous force.
4. Match the regulator connections to the cylinder valve connections. Start turning the nut by hand (it should turn easily), then tighten it with an appropriate cylinder wrench. Do not force the nut to start. If it is cross-threaded, it will not turn easily, and the threads will be damaged. Never over- tighten fittings. Remember, oxygen fittings have right-hand threads. Note that the oxygen cylinder valve is externally threaded on the regulator connection, while the acetylene valve is internally threaded.

Never lubricate fittings. Oil or grease combined with pressurized oxygen will ignite and cause an explosion. Machined fittings need no lubrication.

5. Turn the pressure-adjusting screws out (counter-clockwise) on both regulators. This closes off the regulators so that working pressure gauges are not permanently damaged when high-pressure cylinder gases are allowed to flow through the valves.
6. Install reverse flow check valves (RFCVs) or flashback arrestors to regulator connections and tighten them. Make sure to use RFCVs with correct arrow markings for the direction of gas flow. RFCVs have left-hand or right-hand threads to match with corresponding connections.
7. Connect the hoses to the correct RFCV or flashback arrestors. The oxygen hose must be connected to the right-hand threaded RFCV or flashback arrestor, and the acetylene hose to the left-hand threaded RFCV or flashback arrestor. Avoid over-tightening the fittings.
8. Turn the oxygen cylinder valve wheel counter-clockwise very slowly to prevent damaging the regulator. Watch the cylinder gauge. When maximum pressure is reached (the gauge needle will stop), turn the valve all the way open until it stops.
9. Turn the acetylene cylinder valve wheel or wrench counter-clockwise very slowly, watching the cylinder gauge at the same time. When the pressure reaches maximum pressure (when the gauge needle stops moving), turn the valve $\frac{1}{4}$ to $\frac{1}{2}$ turn more (this may vary slightly) to maintain that pressure. The small amount of turning provides for a quick closure of the valve should an emergency situation occur. If a cylinder wrench is used on the acetylene cylinder valve, leave it on the valve. Note that when adjusting the cylinder valves, working pressure gauges remain at zero. ***Note*: Always stand to the side of regulator and gauge faces in case the regulator fails.**
10. Attach the RFCVs to the torch handle (remember to match the arrows to the direction of the gas flow). Connect the hose to the RFCVs. Most workplace regulations advise using RFCVs at both the torch handle and regulator hose connections.

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

Since RFCVs are sensitive and may become plugged, it is recommended that they be tested once a week.

11. Place the welding tip on the torch handle and hand-tighten the nut. Never use a wrench or pliers to tighten the connection, as this can damage seals inside the tip.
12. Adjust the acetylene to the correct working pressure first. Open the acetylene torch valve no more than one turn. Turn the acetylene pressure-adjusting screw clockwise for higher pressure until the working pressure gauge reads 3 psi. This setting may vary, as different tip sizes and torch designs require different pressures. Refer to the manufacturer's specifications for correct settings. Next, close the torch valve gently, to prevent damage to the torch valve seat.
13. Follow the same procedure to adjust the oxygen to the correct working pressure. The working pressure gauge should read 5 psi (again, this may vary).

The torch is ready to use, except there is always the possibility that one or more of the oxygen or acetylene fittings may be leaking.

Testing For Leaks

Step 12 in the previous procedure has left the cylinder valves open, the working pressure gauge is set at 5 psi for oxygen and 3 psi for acetylene and the torch valves are closed. The system is considered to be pressurized from the cylinders to the torch valves and will remain so, if there are no leaks.

Before you start to use the torch, you should always check the line for leaks, whether the equipment is being assembled for the first time or the setup is used repeatedly. The line should also be tested after any new cylinders or parts have been installed.

Larger leaks can be quickly detected by closing the cylinder valves after correctly setting the working pressures. If a cylinder gauge shows a pressure drop, there is a leak. Smaller leaks may be detected the same way, but it will take longer for the pressure drop to show on the gauge.

To quickly determine if a small leak is present, increase working pressures to 10 psi after opening the cylinder valves. After adjusting the working pressure, close both cylinder valves again and watch the cylinder pressure gauges for pressure drop. Make sure the torch valves are closed.

If a gauge indicates a leak, use the following methods to pinpoint it:

1. Listen, smell and touch around connections, hoses and fittings for a leak.
2. If the leak cannot be found by those methods, apply a soapsud solution to possible leak areas. Bubbles will appear where there is a leak.

Figure 3 *Apply a soapy solution to locate leaks (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

Note: Never use oil or flame near equipment when looking for leaks.

3. Repair the leak, if possible, then test the system again. When cylinder pressure readings remain constant, the system is okay. Be sure to adjust back to recommended working pressures after testing is done.

The equipment is ready for adjusting and lighting the torch.

Light-Up

Equip yourself with shaded safety goggles, heavy leather gloves, coveralls, boots and a welding cap.

1. Take a few minutes to familiarize yourself with the feel of the torch and striker while wearing gloves. Practise using the striker, holding it about 25 mm (1 in.) from the end of the welding tip.

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

2. As a safety precaution, always purge the torch and hose before igniting the flame, especially if the equipment was shut down. Flammable or explosive gas mixtures may have collected inside the torch and hose. Open each torch valve (one at a time) for 5 to 10 seconds, and then close them.

3. Open the acetylene torch valve no more than a $\frac{1}{2}$ turn, and light the gas coming out of the tip with a striker.

4. Set the striker aside and adjust the acetylene valve until the flame becomes turbulent and stops giving off black smoke (Figure 5). Another method is to slowly adjust the valve until there is a gap between the tip and the flame. The flame should be yellow-orange.

Note: Never use matches, a lit torch or burning paper to light a torch—use only a striker. Never place butane lighters near hot work.

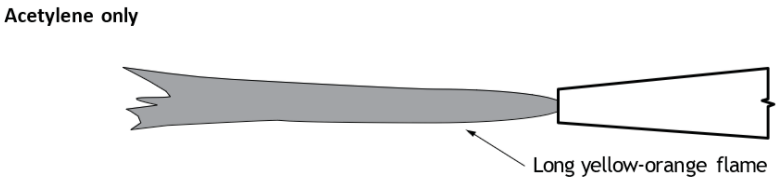

Figure 5 *– Acetylene only flame (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

5. Gradually open the oxygen torch valve and adjust it to a neutral flame. As oxygen is fed into the flame, the colour changes from yellow-orange to blue and a small, light green inner cone starts to form.

The inner cone is a fuzzy, irregular shape. As more oxygen is added, the cone becomes white, rounder and smoother. This is a neutral flame, in which acetylene and oxygen mix in the right proportion to release only heat and harmless gases. If the inner cone is pointed and the flame hisses, too much oxygen has been added. This is an oxidizing flame in which the metal being heated will burn or oxidize. A carburizing flame has too much acetylene and results in adding carbon to the metal. The flame is blue with a dark-blue, feathered inner cone. Each type of flame is used for specific applications, so it is very important to know how to produce all three flames.

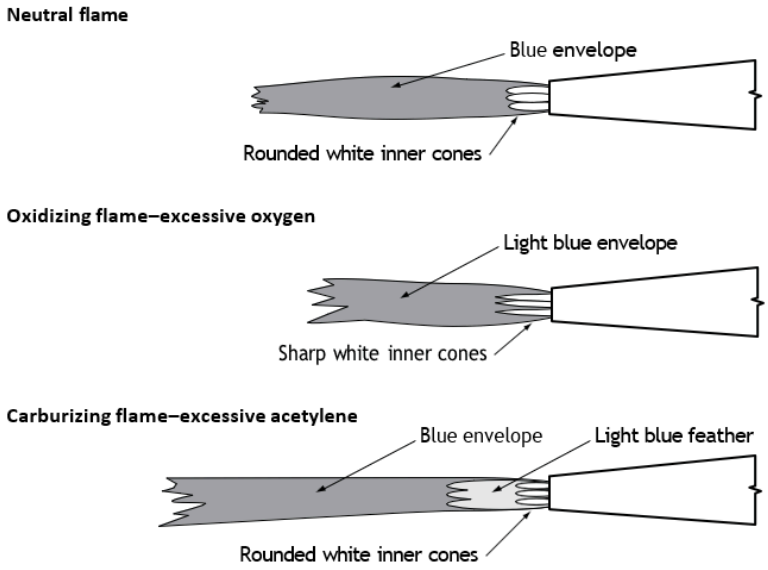

Figure 6 *Types of flame (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (https://creativecommons.org/licenses/by-nc-sa/4.0/)*

A ***neutral flame*** is the ideal flame for fusion welding and preheating steel for cutting. Temperatures range from 3075°C (5600°F) to 3237°C (5900°F) at the hottest part of the flame (the tip of the inner cone). With a neutral flame, melted steel flows easily, and the welds are clean.

A ***carburizing flame*** is used for welding white metal (i.e., aluminum) and for brazing and other applications where oxidizing the metal would cause poor welds or where lower flame temperature is required.

An ***oxidizing flame*** produces a slightly higher flame temperature than a neutral flame and is used to braze with bronze rod. If used on steel, it will burn and cause foaming and sparking of the metal.

Shutting Down

It is very important to know how to correctly shut down an oxy-acetylene outfit once the welding is completed or when you leave the work area for more than ten minutes. A mistake could result in injury to yourself and others, so follow the shutdown procedure exactly as described.

1. Close the acetylene torch valve. The flame will immediately extinguish, and only the oxygen gas will flow from the tip.
2. Close the oxygen torch valve. Gas is no longer leaving the welding tip, but the system is still pressurized. In this state, the torch can be left for a short period of time (10 minutes or less). When work is stopped for a longer period, such as during lunch or overnight, the pressurized oxygen and acetylene must be bled from the torch, hose and regulators.
3. Bleeding the lines refers to the releasing of the gas pressure still in the system. To bleed lines, tightly close the acetylene cylinder valve first, then the oxygen cylinder valve.
4. Open the acetylene torch valve. The pressure readings on both acetylene gauges will drop to “0” and you will hear what is left of the acetylene gas in the line being released from the welding tip. Never bleed the acetylene near hot metal, sparks or open flames.

5. Turn the acetylene-pressure-adjusting screw all the way out (counter-clockwise) to close the regulator.
6. Close the acetylene torch valve gently.
7. Open the oxygen torch valve. The pressure readings on both oxygen gauges will drop to 0 and you will hear the oxygen gas being released from the welding tip.
8. Turn the oxygen pressure adjusting screw all the way out (counter-clockwise) to close the regulator.
9. Close the oxygen torch valve gently.
10. Store the hose and torch off the floor and away from objects that might damage them. Make sure the hose is not kinked, as this could cause damage and problems with gas flow.

You are handling precision equipment that is potentially dangerous. Follow the shutdown procedure as carefully as you would follow the assembly procedure. Both operations can be hazardous unless you do them correctly.

Disassembling the Oxy-Acetylene Setup

When cylinders are empty and must be replaced, or the outfit is to be transported a long distance or stored, the oxy-acetylene outfit should be disassembled.

Never disassemble the equipment if the gauges do not read 0, the lines have not been bled, or the cylinder valves are not tightly closed.

1. Disconnect the welding tip attachment from the torch handle and store the two pieces in a container free from oil or grease. Attach a fitting to the torch handle to protect the threads and seat.

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

2. Disconnect the hose from RFCVs on the torch handle. RFCVs may remain on the torch handle unless they need service or replacement. Store the handle and RFCVs in their proper container.
3. Disconnect the hose from RFCVs on the regulators. Again, RFCVs may remain on the regulators. Coil the hose and store it in a place free from dust, oil, grease and direct heat.
4. Disconnect the regulators from the cylinder valves. Carefully place each regulator with the attached RFCV in separate containers. Regulators are precision instruments and can be damaged from rough handling.
5. Place protective cylinder caps over the cylinder valves and hand tighten. Even if the cylinder is empty, install the cylinder caps. Empty cylinders should be marked with the letters MT and stored separately from full cylinders.

Although an instructor will demonstrate the procedures for assembling, testing, lighting, adjusting, shutting down and disassembling the oxy-acetylene setup, carefully read and understand the sequences before you attend the demonstration. After the instructor's demonstration, be prepared to answer questions and perform the steps as

described. Do not take shortcuts, and never take safety for granted. Oxy-acetylene equipment is very dangerous if used improperly.

Self-Test B-5.3: Use Oxy-Acetylene Equipment

Complete Self-Test 5.3 and check your answers.

If you are using a printed copy, please find Self-Test A-5.3 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=2985#h5p-17 (https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2985#h5p-17)

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Self-Test B-5.1: Describe Oxy-Acetylene Equipment

Complete Self-Test B-5.1 and check your answers.

1. _____ is not a fuel gas.
   a. Natural gas
   b. MAPP gas
   c. Oxygen gas
   d. Acetylene gas

2. Which gas has the highest flame temperature?
   a. Acetylene gas
   b. Propane gas
   c. MAPP gas
   d. Natural gas

3. What is the first step in putting out a fire in the hoses of an oxyacetylene outfit?
   a. Use a fire extinguisher on the hoses.
   b. Close only the acetylene cylinder valve.
   c. Close only the oxygen cylinder valve.
   d. Close both the oxygen and acetylene cylinder valves.

4. The critical point of free acetylene is_____psi (_____kPa) pressure at 21°C (70°F); if the temperature is increased, the pressure becomes critical at a_____pressure.
5. The safety devices on an acetylene cylinder are _____activated.
6. Oxygen cylinder valves are opened _____, acetylene cylinder valves are opened _____.
7. Liquid fuel cylinders are designed to allow the liquid to _____when the cylinder valve is opened and gas escapes.
8. When cylinders are too low on gas to be used, they should be marked _____.
9. Cylinder valves should always be _____open momentarily before the regulator is attached, and_____ _when your work is finished.
10. To increase the working pressure, the pressure-adjusting screw is turned _____.
11. A grooved hex nut indicates a(n)_____regulator.
12. The gauge with the higher numerical calibrations indicates_____pressure.
13. The gauge with the lower numerical calibrations indicates_____pressure.
14. The colour of an oxygen hose is usually _____.
15. The colour of the fuel gas hose is usually _____.
16. An RFCV placed between the torch and hose has the arrow pointing toward the _____; between the hose and regulator, it is pointing toward the_____.
17. When you are using the combination torch for the cutting process, the_____valve is used to adjust the amount of oxygen mixed with acetylene for preheating.
18. If a flashback occurs, the_____and_____valves must be shut down as soon as possible.

Answer Key: Self-Test B-5.1 is on the next page.

Answer Key: Self-Test B-5.1

1. c. Oxygen gas
2. a. Acetylene gas
3. d. Close both the oxygen and acetylene cylinder valves
4. 28, 193; lower
5. Heat
6. All the way; ¼ to ½ turn
7. Boil off or evaporate
8. MT
9. Cracked; closed
10. Clockwise
11. Acetylene
12. Cylinder
13. Working
14. Green or black
15. Red
16. Torch; hose
17. Preheat oxygen
18. Torch; cylinder

Self-Test B-5.2: Describe Cutting, Brazing and Soldering Techniques

Complete Self-Test B-5.2 and check your answers.

1. If cutting 13 mm (½ in.) plate or thicker, hold the cutting tip _____ to the plate.
2. The cutting oxygen lever should be depressed when the metal has been preheated to a _____ colour.
3. The vertical lines created on the cut edge by the cutting action on metal are called _____.
4. Name four factors that can affect the quality of an oxyacetylene cut:

   _____

   _____

   _____

   _____

5. What is required prior to welding on closed containers, or on any structure where flammables or other explosive substances are likely to be present?
   a. tests for combustibility must be performed.
   b. area must be flushed with hot water and detergent to remove chemicals.
   c. fire safety watch should be posted, and the area should be protected from sparks and flames.
   d. Tests for combustibility must be performed by a qualified person and posted for review.
6. Never cut or weld on _____, as it explodes when heated.
7. List three reasons why flux is used in preparing a joint for soft soldering:

   _____

   _____

   _____

8. The active range for soft solder fluxes is between _____°C and _____°C (or _____°F and _____ °F).
9. According to the American Welding Society, brazing, also known as hard soldering or silver brazing, is a process that is performed above _____°C (or _____°F).
10. According to the American Welding Society, soldering, also known as tinning or sweating, is a process that takes place below _____°C (or _____°F).
11. A "B" size acetylene tank holds the equivalent of _____ft^3 of gas (@ 14.73 psia).
12. Acetylene is unstable when stored at pressures exceeding 15 psig. To ensure its safe storage, a porous material is contained within an acetylene cylinder and the gas is dissolved in a liquid such as _____.

Answer Key: Self-Test B-5.2 is on the next page.

Answer Key: Self-Test B-5.2

1. Perpendicular or vertical (at 90°)
2. Cherry-red
3. Drag lines

    - Working pressure settings
    - Amount of preheat flames
    - Angle of torch tip relative to metal
    - Tip size
    - Speed of cutting torch across metal
    - Control of torch by operator

4. d. Tests for combustibility must be performed by a qualified person and posted for review.
5. Concrete

    - Remove minor surface impurities
    - Prevents formation of oxides
    - Aids in capillary action

6. 93 °C to 316°C (200 °F to 600 °F)
7. 449 °C (840 °F)
8. 449 °C (840 °F)
9. 40 ft^3
10. Acetone

Self-Test B-5.3: Use Oxy-Acetylene Equipment

Complete Self-Test B-5.3 and check your answers.

1. When you turn the pressure-adjusting screw on the regulator all the way out, it the _____regulator.
2. The lines are said to be _____ when the cylinder valves are open, working pressures are set, and the torch valves are closed.
3. An acetylene cylinder valve outlet for the regulator is left-hand threaded and _____threaded as an extra precaution against improper setup.
4. An oxygen cylinder valve outlet for the regulator is right-hand threaded and _____ threaded as an extra precaution against improper setup.
5. Before you light a torch, you should always check for _____in the lines.
6. The only thing that should be used to create a spark for lighting a torch is a _____
7. A flame that has an excessive amount of acetylene compared to a neutral flame is called _____ flame.
8. When oxygen is added to the acetylene flame, the flame changes colour from _____ to _____ .
9. Name the three types of oxyacetylene flame that can be produced.

   _____

   _____

   _____

10. When shutting down the flame, first close the _____ torch valve.

Answer Key: Self-Test B-5.3 is on the next page.

Answer Key: Self-Test B-5.3

1. Closes
2. Pressurized
3. Internally (female)
4. Externally (male)
5. Leaks
6. Striker
7. A carburizing or reducing flame
8. Yellow-red; blue
9.
    - Neutral flame
    - Carburizing (reducing) flame
    - Oxidizing flame
10. Acetylene

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.