Oxyfuel Equipment

Rationale

Why is it important for you to learn this skill?

The use of oxyfuel processes for heating, welding, brazing and cutting is an important part of your work experience. In order to work safely and with competence, you must have a thorough knowledge of oxyfuel equipment safety, operating procedures and gases used.

Outcome

When you have completed this module, you will be able to:

Assemble oxyfuel equipment.

Objectives

Describe the characteristics and handling procedures for oxygen and fuel gases.
Describe the functions of oxyfuel equipment components.
Demonstrate the use, care and maintenance of oxyfuel equipment components.
Explain the recommended procedures for placement, set-up and shutdown of oxyfuel equipment.
Identify causes and preventive measures for backfires, flashbacks and burnbacks.
Describe pressure and flame adjustments.

Introduction

In order for you to assemble and safely use oxyfuel equipment, you need information on the following topics, which are covered in this module:

- gases used,
- equipment components,
- set-up procedures,
- using the equipment,
- shut down procedures and
- flame types and their uses.

Objective One

When you have completed this objective, you will be able to:

Describe the characteristics and handling procedures for oxygen and fuel gases.

Oxygen

Oxygen (chemical symbol O_2) is a colourless, odourless, tasteless gas and is the element in air that supports life and combustion (see **Error! Reference source not found.**). Oxygen is not flammable by itself but it combines readily, sometimes violently with other materials. Some materials not considered combustible in air burn in the presence of O_2. Oxygen for welding and cutting has been produced by chemical processes, water electrolysis and air liquefaction. The air liquefaction process is used almost exclusively today.

Hazards Associated with Pure Oxygen

When rubber burns in air, the flame is dull red, smoky and gives off a heavy odour. Rubber in the presence of oxygen burns rapidly with a white flame, practically no smoke and little odour. Flame temperature is high.

The hose on an oxyfuel outfit is made from either, rubber and cotton, or neoprene and nylon. Unless the operator is careful, hoses are easily burned, cut or ruptured. Keep the hose clear of hot slag, falling metal, pushcarts and anything that could damage it. When a hose is ruptured, cut or burned while under pressure and catches fire, the fuel gas and the hose combine with oxygen from the air and pure oxygen from the cylinder. Such a fire cannot be extinguished with conventional fire-fighting equipment because oxygen from the oxygen hose is supporting combustion from within the flame. In this case, you must first stop the flow of oxygen, then the fuel gas and then extinguish the fire.

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

DANGER
Keep oxyfuel equipment away from oil or grease, petroleum-based cleaning fluids, gasoline and other flammables. **Never oil regulators or torch parts**. **Oxygen + oil = explosion or fire**.

Acetylene

The chemical symbol for acetylene (C_2H_2) shows that it is a compound formed by uniting two atoms of carbon with two atoms of hydrogen to form a molecule of acetylene. Acetylene gas is colourless, but has a strong and irritating odour. As little as 1% acetylene in air is quite noticeable to the average person's sense of smell. It acts as an anaesthetic and in its pure form has been used for this purpose.

Acetylene is an Unstable Compound

The term unstable as it applies to acetylene means that it can break down or undergo a physical change once it reaches a certain pressure. When this change takes place, it is said to have reached its *critical point*.

The critical point of acetylene is 193 kPa (28 psi) pressure at 21°C (70°F). At this point, acetylene breaks down, releasing heat and this usually results in spontaneous ignition if air is present. The temperature of the gas affects the critical pressure. If the temperature is higher than 21°C (70°F), the pressure at which acetylene becomes critical will be lower than 193 kPa (28 psi).

DANGER
De-stabilized acetylene is not safe when compressed beyond 103 kPa (15 psi), especially in larger volumes, such as cylinders, pipelines, generators, etc. Therefore, **the maximum safe working pressure (MSWP) of acetylene gas is 103 kPa (15 psi).**

Objective Two

When you have completed this objective, you will be able to:

Describe the functions of oxyfuel equipment components.

Oxygen Storage and Use

Oxygen may be obtained from suppliers in liquid or gaseous form. Specially designed equipment is required to handle and store liquid and gaseous oxygen. These are usually in the form of:

- liquid oxygen tanks and
- oxygen cylinders.

Liquid Oxygen Tanks

Oxygen obtained in liquid form is stored in *cryogenic* (very low temperature service) containers. They are constructed very much like a thermos bottle (Figure 1) and use an outer and inner vessel arrangement. Often referred to as a *mini-bulk* container, the internal pressure of a liquid oxygen vessel is seldom greater than 1655 kPa (240 psi). The evaporation of some of the liquid oxygen keeps the temperature of the remaining liquid at approximately –183°C (–297°F).

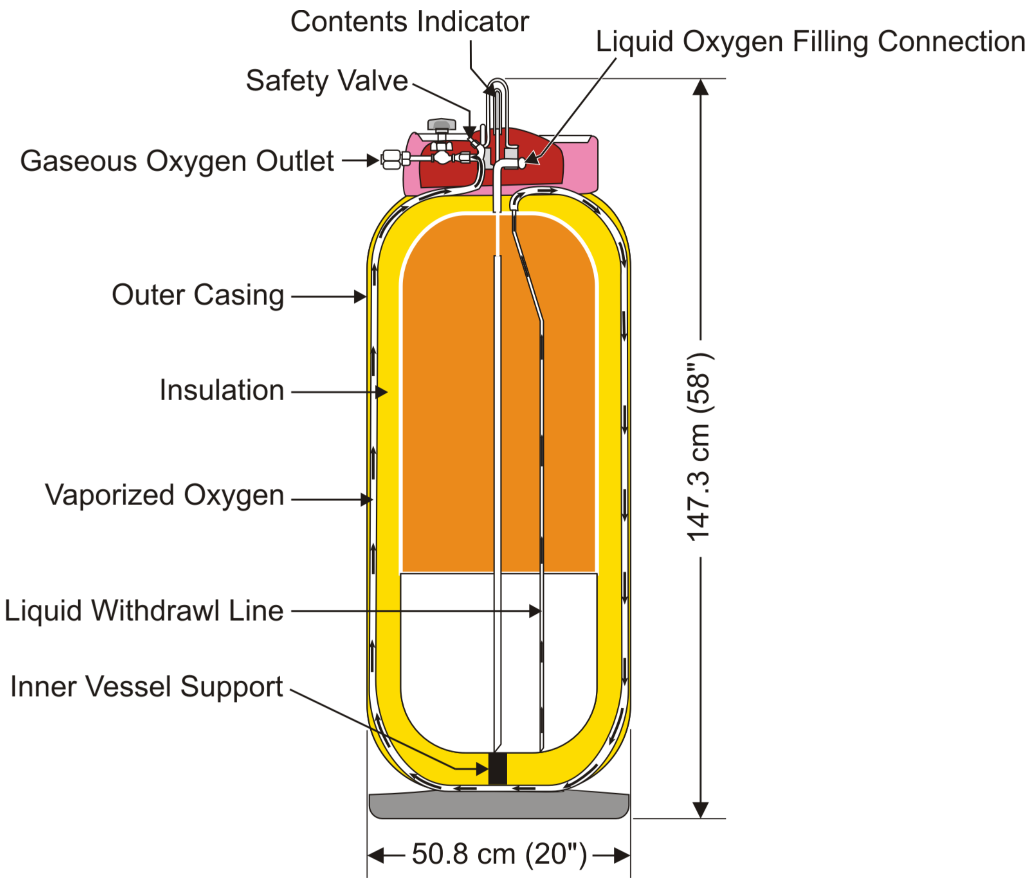

Figure 1 - Liquid oxygen vessel. (Courtesy ESAB Welding and Cutting Products)

Acetylene Cylinders

Unlike the seamless hot drawn vessels used for oxygen containment, acetylene cylinders are of welded construction. This is because acetylene cylinders operate at much lower working pressures and therefore their design and construction need not be to the standards demanded for that of oxygen cylinders.

Older acetylene cylinders are usually filled with a mixture of shredded asbestos, infusorial earth, charcoal, Portland cement or balsa wood. This aggregate mixture is approximately 75 to 80% porous, is very heavy and tends to crush on impact, leaving a void in the cylinder (Figure 2).

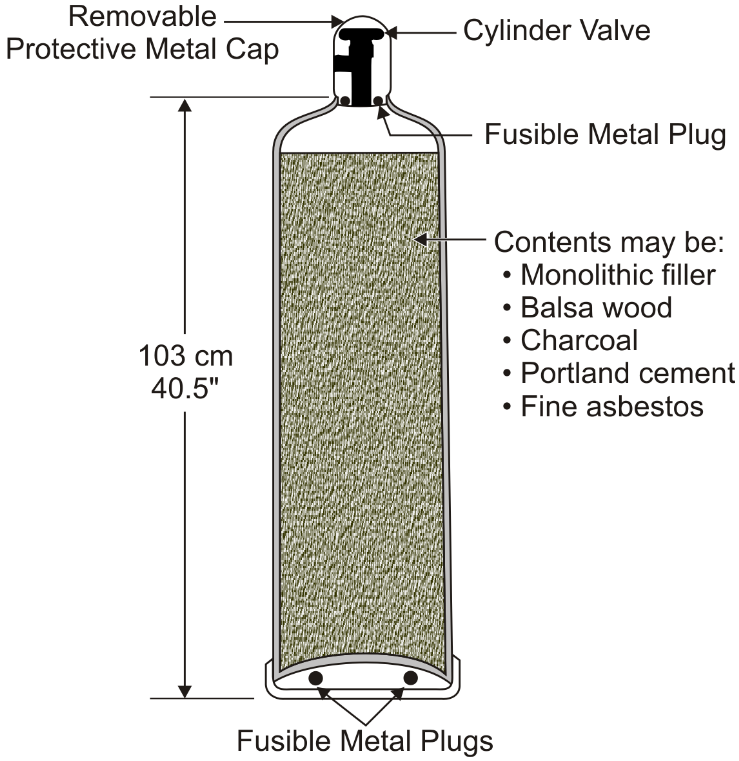

Figure 2 - Acetylene cylinder.

Fusible Metal Plugs

The main safety feature built into an acetylene cylinder is a set of fusible metal plugs (Figure 3). The melting temperature of the fusible plugs is approximately 100°C (212°F). The purpose of the fusible plug is to melt out in case of fire, thus allowing a controlled escape of gas rather than a violent explosion.

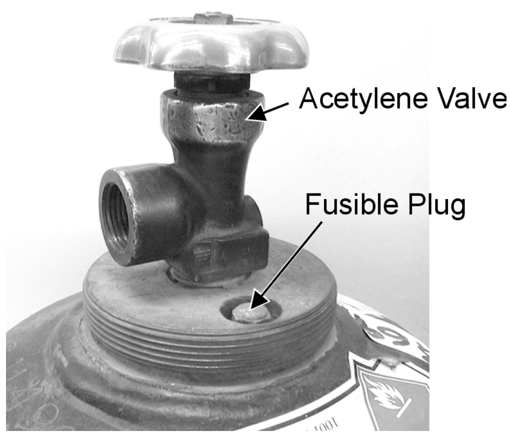

Figure 3 - Acetylene cylinder fusible plug.

Rules for Handling Compressed Gas Cylinders

For safety reasons, it is very important that you adhere to the following guidelines.

- Store cylinders in a cool, dry, well ventilated location.
- Store oxygen and fuel gas cylinders separately (a minimum of 6 metres (20 ft) apart).
- Store and use cylinders in the vertical position.
- Do not attempt to transfer acetylene from one cylinder to another.
- Do not drop, bump or pound on cylinders of either type.
- Do not use cylinders as rollers, dollies or supports.
- Do not attempt to interchange equipment (such as regulators, hose etc.) from one type of gas to another type.
- Call the gases by their proper names. Do not refer to acetylene as **gas** or oxygen as **air**.
- Operate cylinder valves according to instructions.
- Keep oxyfuel equipment away from oil or grease.
- Do not use oxygen for dusting purposes or for blowing out passages. Use compressed air.
- Keep oxyfuel equipment clear of electric arc welding equipment. An accidental arc strike against the cylinder could cause a fire or serious explosion.
- Do not attempt to use oxygen or fuel gas directly from the cylinder at cylinder pressures. Always use a proper pressure regulator.
- When returning empty cylinders to the supplier, always close cylinder valves snugly and place protective caps on the cylinders to protect the valves. Cylinder valves left open during shipping are always an explosive hazard, since a change in temperature could cause the release of gas from within the cylinder.
- When lifting cylinders with a crane, use a properly designed cradle.

Identification of Gases in Cylinders

Identification of the gas content of compressed gas cylinders is established by means of a chemical or trade name of the gas marked on the cylinder.

It is important that users identify gas content of cylinders by reading the cylinder markings (Figure 4). **Do not be influenced by cylinder colour**.

Figure 4 - ANSI compressed gas cylinder identification.

Workplace Hazardous Materials Information System (WHMIS)

In addition to the ANSI identification system, the WHMIS system has been instituted nation-wide for purposes of providing information on hazardous materials used in the workplace. The WHMIS system contains three key elements, which are:

- labels on hazardous material containers,
- material safety data sheets and
- worker education.

Consequently, all compressed gas cylinders must have a WHMIS label. In most cases, the suppliers of compressed cylinder gases must affix a label that contains seven categories of information, which are:

- product identifier,
- supplier identifier,
- a statement regarding the availability of a material safety date sheet (MSDS),
- hazard symbol,
- risk phrases,
- precautionary measures and
- first aid measures.

The Oxyacetylene Outfit

The combination oxyacetylene outfit consists of the following items, which are labelled in Figure 5.

1. one oxygen and one acetylene regulator,
2. a torch handle complete with torch valves,
3. cutting tips,
4. a cutting attachment,
5. welding tips with individual gas mixers,
6. an accessory package (includes hose, goggles, spark lighter and tip cleaners) and
7. one set of check valves and/or flashback arrestors.

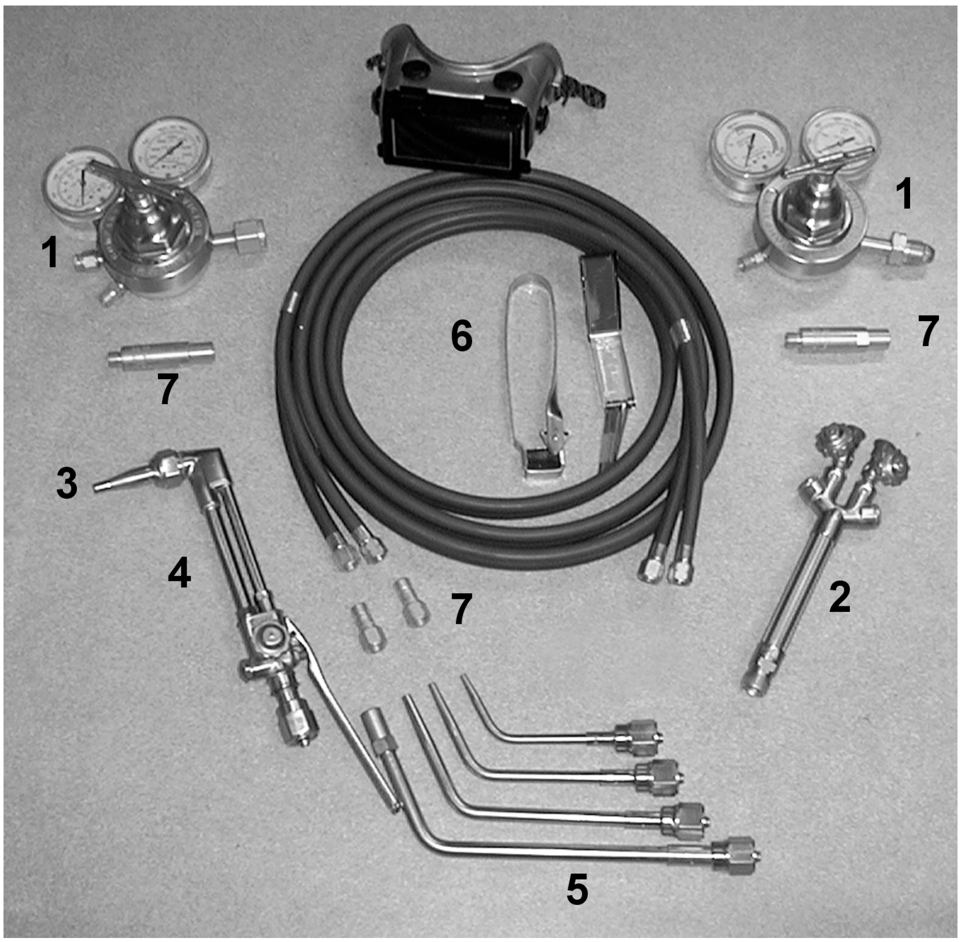

Figure 5 - Oxyacetylene outfit.

Welding Tips

Welding tips are generally of two classes.

- Swedge tips (Figure 6) produce a long, thin, pointed inner cone.

Figure 6 - Swedge tip.

Figure 7 - Tip Cleaners.

Objective Three

When you have completed this objective, you will be able to:

Explain the recommended procedures for placement, set-up and shutdown of oxyfuel equipment.

Setting up the Oxyacetylene Outfit

The following procedure should be used when setting up an oxyfuel welding or cutting outfit (Figure 8). In this procedure, the equipment is being treated as though it were completely dismantled. Not all of these steps are necessary if you are just changing cylinders or mounting an assembled outfit to cylinders or a manifold system.

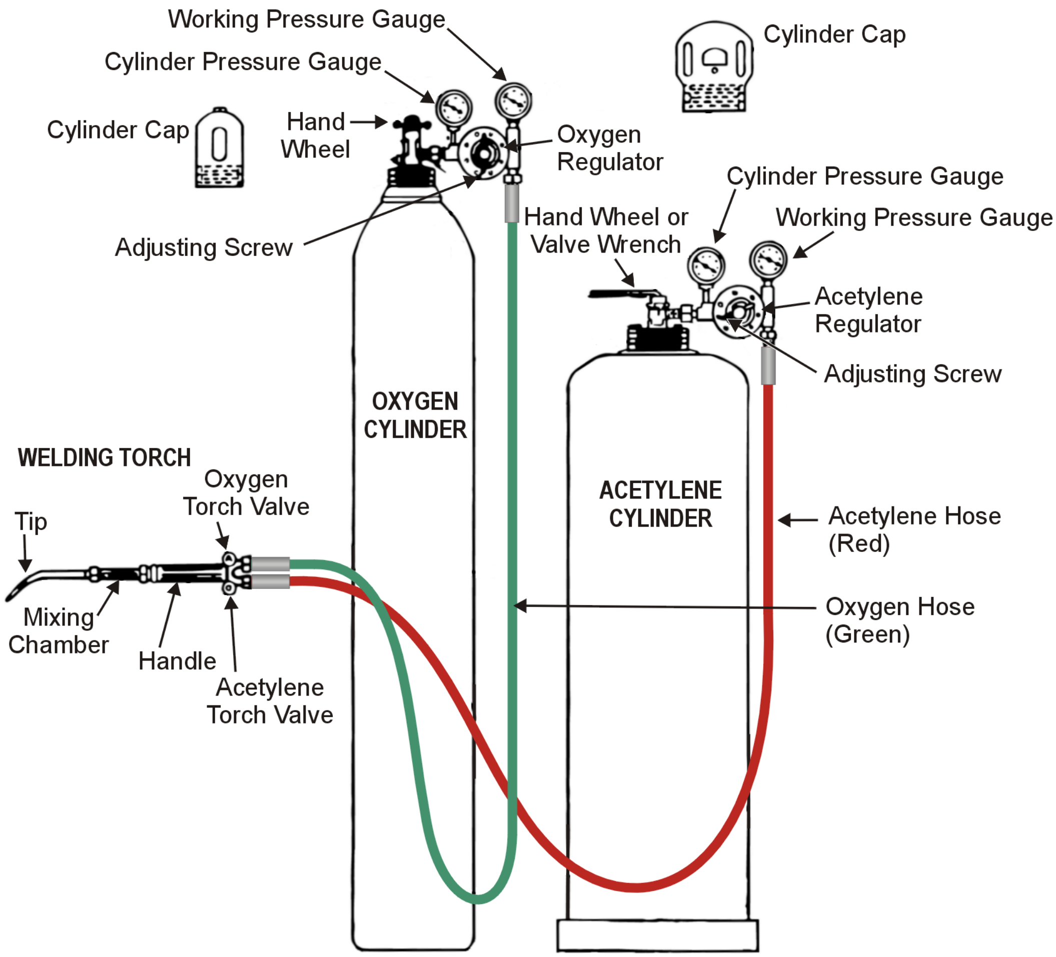

Figure 8 - Oxyfuel outfit.

Objective Four

When you have completed this objective, you will be able to:

Identify causes and preventive measures for backfires, flashbacks and burnbacks.

Backfires, Burnbacks and Flashbacks

As mentioned previously, acetylene and oxygen or acetylene and air form a highly explosive mixture. Failure to follow recommended operating procedures with oxyfuel equipment may lead to disastrous results. Three basic types of malfunctions that you can experience with oxyfuel equipment are:

- backfires,
- burnbacks and
- flashbacks.

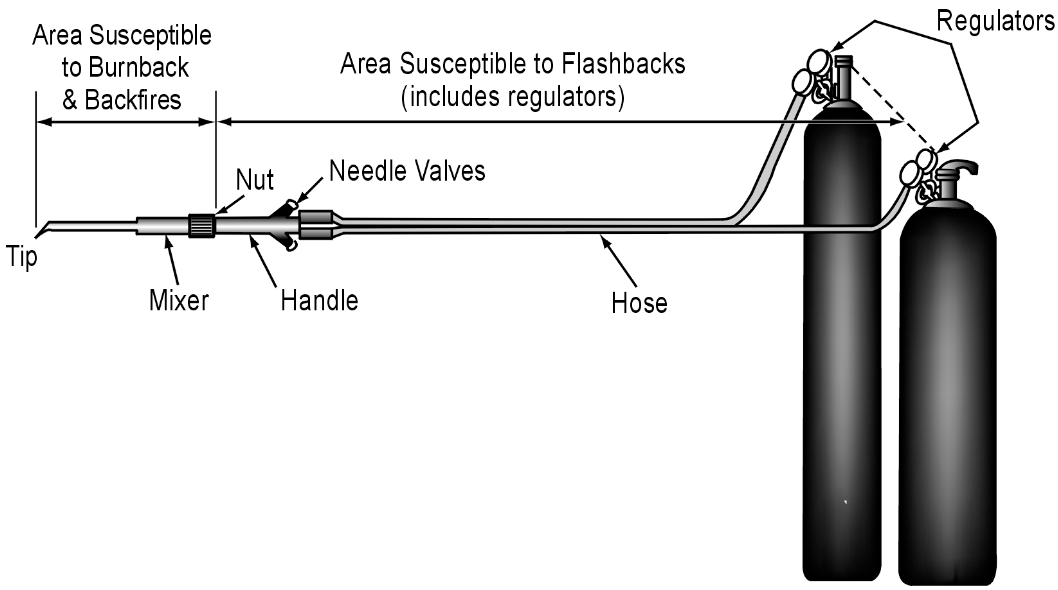

Figure 9 - Areas susceptible to backfires, burnbacks and flashbacks.

Objective Five

When you have completed this objective, you will be able to:

Describe pressure and flame adjustments.

Checking and Balancing of Pressures for Welding Tips

Since regulators can vary by as much as 30 kPa (5 psi) on working pressure accuracy, it is necessary to check and balance the working pressures of both regulators.

Industrial quality regulators are made to withstand moderate abuse and designed to give a rough estimate of pressures as read on the working pressure gauge. This is accurate enough for most cutting operations. However in welding, maximum control of flame settings is a must and the balancing of pressures is necessary for good flame control and safe operation.

Procedure for Balancing Pressures

The following general procedure is typical of many welding torch types and brands. Check with your torch's manufacturer for recommended alternative flame setting procedures.

Follow these steps to balance the pressures in the two lines.

1. Having purged both lines, open the acetylene torch valve about $^1/_2$ turn and light the torch.
2. You now want to establish the maximum amount of acetylene that can be burned satisfactorily for the tip in use. To do this, open the acetylene torch valve fully or at least beyond the point where the flame ceases to increase in size.
3. Now adjust the acetylene pressure at the regulator so that the flame blows away from the tip, but not violently so. For example, using an Air Liquid #3 tip, the flame should blow away about 10 mm ($^3/_8$") to 13mm ($^1/_2$") from the tip without becoming too harsh in sound. Smaller tips would require less *blow-away*. Some welders use a rule of thumb: 3 mm ($^1/_8$") of blow-away per tip size. So, for a #3 tip use 10mm ($^3/_8$") blow-away and for a #7 tip use 21mm ($^7/_8$") blow-away. You have now established maximum acetylene pressure and flow for the tip.
4. If oxygen is introduced to the flame while the acetylene torch valve is at maximum, the flame will blow out. For this reason you must bring the flame back to the tip before adding oxygen. This is done by partially closing the acetylene torch valve. You will notice that the flame is now smoky and smoke on the acetylene flame indicates too little gas flow and would cause backfires if you proceeded to use this amount of flame for welding. Now increase the acetylene flow until the smoke disappears yet the flame is still burning at the tip.
5. Now add oxygen to the flame by slowly opening the oxygen torch valve until a cone is formed. Alternating between valves, keep opening first the acetylene and then the oxygen torch valves until the maximum acetylene flow is reached.
6. With the oxygen torch valve open to full flow, adjust the oxygen pressure at the regulator so that a neutral flame is formed, while both torch valves are fully open.

NOTE
Your original oxygen working pressure setting may have been too high. In this case, an oxidizing flame will be formed before you have the oxygen torch valve opened to full flow. You must reduce the oxygen pressure at the regulator until you can open the oxygen torch valve to full flow and have a feather showing on the flame. Then with both torch valves fully open, slowly increase oxygen pressure at the regulator until the feather just disappears. You now have established a neutral flame.

7. With both torch valves fully open, you have established maximum flame for this tip. Any attempt to increase pressures and gas flow from this point will produce a harsh flame which tends to agitate the puddle, allowing air to come in contact with the molten metal and resulting in burned deposits. By setting the flame to neutral, with both needle valves at full flow, you are balancing to equal pressures, since an equal amount of oxygen and acetylene are required from the cylinders to form a neutral flame.
8. Finally, reduce the flame size to proportions suitable for the work at hand. This is done by partly closing both torch valves, thus reducing the flow of gases.

CAUTION
The flame must not be reduced to a point where the acetylene flame by itself is smoky. Working in the smoke range (low gas speed) will result in backfires. You are advised wherever possible to use the mid-range of the tip. If you need enough heat so that it is necessary to operate a tip at maximum, you would get far better results by using a larger size tip at mid-range.

Types of Flame

There are three types of flames possible with a standard oxyacetylene welding or cutting torch.

- *The carbonizing flame* (also known as *carburizing* flame or *reducing* flame) is a flame that is rich in acetylene. The flame temperature of a carbonizing flame is lower than a neutral flame and varies according to the amount of oxygen present.
- *The neutral flame* is a flame that has no excess of acetylene or oxygen. It is a perfectly balanced flame. The combustion of acetylene is complete and no oxygen is left over. Flame temperature is 3090°C (5600°F).
- *The oxidizing flame* is a flame that is rich in oxygen. After the acetylene burns completely, some oxygen is left over. Flame temperature can reach 3470°C (6300°F).

Neutral Flame

A neutral flame occurs at a point where the feather just disappears (and no more) (Figure 10). It may also be described as the largest clean-nosed cone available with the amount of acetylene being used remaining constant.

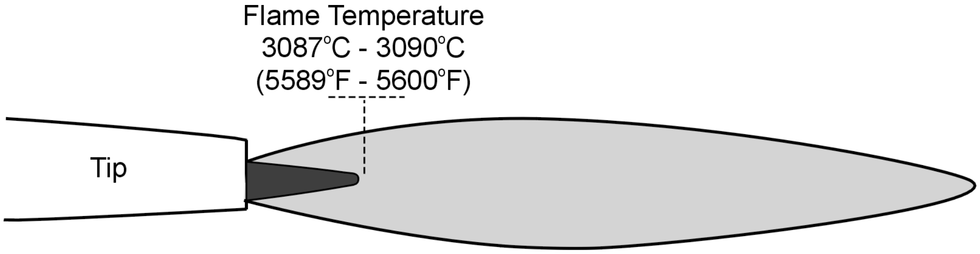

Figure 10 - Neutral flame.

Reactions Visible in the Puddle

With a neutral flame the puddle is clear, calm, quiet and mirror-like (Figure 11). Puddle definition (outline) is clear-cut and distinct. During welding there should be little or no marginal glow. Sparking will not be excessive if material is clean and the application of heat and filler rod is correct.

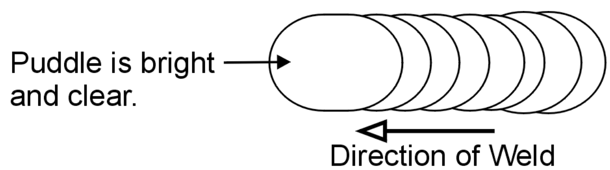

Figure 11 - Neutral flame reactions.

Uses of Neutral Flame

A neutral flame is used for:

- fusion welding of mild steels,
- fusion welding of cast iron,
- braze welding of steels,
- brazing of copper and its alloys,
- flame cutting and
- heating.

Self-Test

1Explain why oxygen is dangerous.

___

___

___

2. For efficient welding and cutting operations, oxygen must have a minimum purity of:
   a) 80%.
   b) 93%.
   c) 98.6%.
   d) 99.5%.

3.Oil or grease in contact with pure oxygen can ___

___.

4Fill in the blanks with the correct numbers associated with acetylene.

a) The critical pressure is ___ kPa (___ psi).

b) The maximum safe working pressure is ___ kPa (___ psi).

5State the location and purpose of fusible metal plugs on the Acetylene tanks.

___

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___

6.State two safety precautions used to prevent acetone loss.

a) ___

b) ___

7.What should be done before the cylinder valve protective caps are removed?
   a) Cylinders should be pressure-tested.
   b) Cylinders should be secured.
   c) Cylinder valves should be cracked.
   d) Equipment should be lubricated and ready for installation.

8.Why are the cylinder valves **cracked** before the regulators are attached?

___

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9. How should you check for leaks on oxyfuel equipment?

a) Use an open flame.
b) Use a spark lighter.
c) Spray with anti-spatter solution.
d) Apply a suitable leak detection fluid.

10. When shutting down an oxyfuel outfit you should:

a) close the cylinder valves and bleed the system.
b) close the torch valves and bleed the system.
c) back off the regulator screws and bleed the system.
d) roll up the hoses and remove the welding tip.

11. Regarding shutting down an oxyfuel outfit, answer true or false to the following.

e) Hoses are rolled up.
f) Torch valves are closed.
g) Regulator adjusting screws are disengaged.
h) Cylinder valves are closed.
i) Shutdown is done at the end of each work shift.

12. Why are regulators used for oxyfuel welding and cutting operations?

____

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13. The oxygen hose is usually coloured ________________________.

14. Which hose fittings have a left-hand thread?

____