The Business of AIRQuality

SECTION 5.9

CUTTING AND WELDING

SECTION 5.9 CUTTING AND WELDING

This section outlines best practice guidelines for cutting and welding activities or equipment used by small to medium sized industrial businesses.

Section 5.9 Cutting and welding is divided into three components:

5.9.1 Background.
5.9.2 Potential impacts on air quality.
5.9.3 Best practice guidelines.

5.9.1 Background

The industry

Metal fabrication includes many activities such as cutting and welding. During the fabrication process welding is the most commonly used method of joining workpieces together. There are several types of welding and cutting methods that vary according to the type of industry undertaking the activity.

Welding and cutting are used in a range of fabrication activities such as welding boat hulls, cutting sheets of metal for burglar alarm cases, repairing holes in trailers, assembling car bodies and pipe welding.

The process of welding and cutting metal to form a workpiece has been used for thousands of years.

Businesses conducting cutting and welding activities range from one-person shop operations to automated production lines and industries from boat builders and smash repairers to joineries and businesses that solely conduct welding activities.

The welding process

Welding is the process of joining metals by applying heat, sometimes with pressure and sometimes using a filler metal. The process generally involves melting and cooling metals with this thermal cycle, producing a distortion of the metal being welded. During the process the metal to be welded can be moulded to a particular shape by having residual stress applied.

Inside a welding workshop – frequently welding can be a difficult process due to the size and shape of the object to be welded.

Commonly welded metals include:

- **Mild steel** which may contain iron, carbon, manganese, silicon, aluminium and occasionally nickel, chromium, molybedenum, niobium, vanadium and boron.
- **Stainless steel** which may contain iron, chromium and nickel and occasionally molybedenum, manganese, titanium and other elements.
- **Aluminium** which may contain aluminium, silicon, iron, copper, manganese, chromium, zinc, titanium and occasionally gallium, vanadium or boron in wrought alloys and tin or lead in cast alloys.
- **Copper, bronze and brass alloys** which may contain copper, zinc, nickel, aluminium, tin, lead, silicon, iron and occasionally manganese, tellurium, sulphur, chromium, cadmium, beryllium, silver, cobalt.

There are a variety of welding techniques which use different equipment and materials. However, there are some common elements such as electrodes, powders and chemical aids such as coolant. These are commonly referred to as consumables. Electrodes can come in a variety of different forms, depending on the welding process used. They are commonly a wire or rod made from metal, carbon or graphite which can be bare, or coated through which a current is conducted between the electrode holder and the arc. Coated electrodes have had a flux applied externally. Upon burning the coating produces a gas which envelops the arc. The electrode is held in an electrode holder which is a device that mechanically holds the electrode and conducts current into it. An electrode can also be the part or parts of a resistance welding machine through which the welding current and the pressure are applied directly to the metal to be welded.

Another term commonly referred to in welding is flux. Flux is the substance which aids, induces or actively participates in the fusing or flowing of a substance applied to a surface to allow the flow of solder and prevent the formation of oxides. The most commonly used fluxes are inorganic corrosive general purpose ones which contain zinc chloride and ammonium chloride with a hydrochloric acid activator. However other halide salts and acids such as fluorides are found in some fluxes. Organic fluxes cover a wide variety of organic acids, which decompose at higher temperatures and are applied via a vehicle such as water or various organic carriers or wetting agents.

There are seven main welding techniques:

- **Arc welding**. Arc welding is a method of joining two pieces of metal into one solid piece. To do this, the heat of an electric arc is concentrated on the edges of two pieces of metal to be joined. The metal melts while the edges are still molten and additional melted metal is added. This molten mass then cools and solidifies into one solid piece. An arc is formed between the workpiece and the electrode (a stick or wire) that is manually or mechanically guided along the joint. The electrode can either be a rod that carries the current between the tip and the workpiece or it may be a specially prepared rod or wire that not only conducts the current but also melts and supplies filler metal to the joint. Most welding in the manufacture of steel products uses the second type of electrode. In arc welding a basic circuit is established with a power source fitted with controls. This power source is connected by a work cable to an electrode holder which makes electrical contact with the welding electrode. An arc is created across the gap when the energised circuit and electrode tip touches the workpiece and is then withdrawn yet stays within close contact.

  The arc produces extremely high temperatures at the tip. This heat melts both the base metal and the electrode, producing a pool of molten metal (known as a crater). The crater solidifies behind the electrode as it is moved along the joint. The result is fusion. Arc welding covers a variety of different welding techniques including:
  - **Carbon arc welding** produces a fusing of metals by creating heat with an arc. The arc exists between a carbon electrode and the metal being welded. Pressure and filler material may or may not be used. Filler metal is metal which is added to make the weld.
  - **Shielded metal arc welding** is a development of the carbon arc welding process. It produces a fusing of metals by heating them with an arc between a covered metal electrode and the metal being welded. Shielding is obtained from decomposition of the electrode covering which protects the molten metal from reacting chemically with elements in the air. Shielding is a shield of gas that covers the crater and the arc and prevents the formation of oxides and nitride which can destroy the strength and toughness of the weld joint. Filler metal is obtained from the electrode.
  - **Submerged arc welding** produces a fusing of metals by heating them with an electric arc. The arc exists between a bare metal electrode (an electrode with no coating) and the metal to be welded. Pressure is not used and filler metal is obtained from the electrode and sometimes from a supplementary welding rod. A welding rod is filler metal in wire or rod form used in gas welding, brazing processes and arc welding processes where the electrode does not provide the filler metal.
  - **Gas tungsten arc welding** produces a fusing of metals by heating them with an arc between a tungsten electrode and the metal being welded.
  - **Plasma arc welding** produces a fusing of metals by heating them with a constricted arc between an electrode and the metal to be welded. Shielding is obtained from the

hot ionised gas that is produced. This can sometimes be supplemented by an auxiliary source of shielding gas.

  - **Gas metal arc welding** was developed for the welding of aluminium. It produces a fusing of metals by heating them with an arc between a continuous filler metal electrode and the metal to be welded. Shielding is obtained from an externally supplied gas or gas mixture. This process has many variations depending on the type of shielding gas, the type of electrode and type of metal being welded.
  - **Stud arc welding** produces a fusing of metals by heating them with an arc between a metal stud or similar part and the metal to be welded. When the surfaces are heated they are bought together under pressure.

- **Brazing.** Brazing is a group of welding processes which produce a fusing of metals by heating them to a suitable temperature and adding filler metals to make the weld. The filler metal is distributed between the surfaces of the joint. A braze is a different form of weld because the metal welded is not melted. The main differences between different types of braze welding comes from the different sources of heat used. Forms of braze welding include diffusion, dip, furnace, induction, infrared, resistance and torch brazing.
- **Oxyfuel gas welding.** Oxyfuel gas welding is a group of welding processes that produce a fusing of metals by heating them with an oxy fuel gas flame or flames. It can be used with or without the application of pressure and with or without the use of a filler material. There are three distinct processes within this group:
  - **Oxyacetylene and oxyhydrogen welding** which are welding processes that are classified according to the type of gas used as fuel. In these processes the heat of the flame is created by the chemical reaction or burning of the gases.
  - **Acetylene welding** which uses acetylene gas instead of oxygen.
  - **Pressure gas welding** which uses pressure and heat from the burning gases to weld metals.
- **Resistance welding.** Resistance welding is a group of welding processes that produce a fusing of metals using heat. The heat is generated from an electrical current resistance produced by an electrical circuit which includes the metal to be welded. Resistance welding is assisted by the application of pressure to the workpiece. Differences between resistance welding processes are in the weld design and type of machine used to produce the weld. Resistance welding is an automatic group of welding processes (weld machines incorporate both electrical and mechanical functions). Resistance welding includes flash, high frequency resistance, percussion, projection, resistance-seam and resistance-spot welding.
- **Solid state welding.** Solid state welding is a group of welding processes which produces a fusing of metals at temperatures which are below the melting point of the metals being welded. Pressure may or may not be used to assist the process. The oldest of all welding processes is forge welding. Others include cold, explosion, friction, hot pressure and ultrasonic welding. These processes are all different and utilise different forms of energy for making welds.
- **Soldering welding.** Soldering welding is a group of welding processes which produce a fusing of metals by heating the metals to a suitable temperature and using a filler material which has a melting point of 450 degrees centigrade or below that of the metal being welded. The filler material is distributed between the surfaces of the joint. Soldering includes dip, furnace, induction, infrared, iron, resistance, torch and wave soldering.
- **Other welding processes** less commonly used include electron beam, electroslag, induction, laser beam and thermit.

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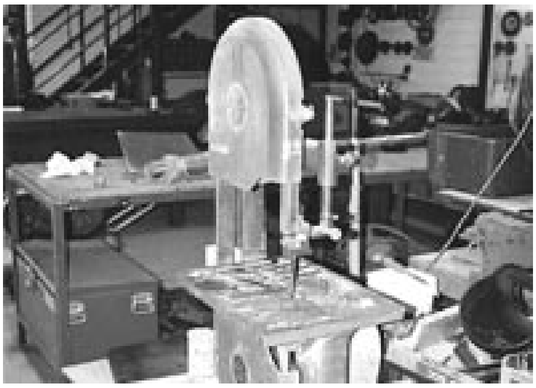
The cutting process



The cutting process can be undertaken with a sharp edged instrument such as a cutting saw.

Cutting is the process of separating a metal sheet or workpiece into parts usually with a sharp edged instrument. Cutting undertaken with a sharp edged instrument often involves the use of a cutting oil or some form of lubricant. However other cutting techniques such as oxygen, thermal and arc cutting are also used. Some commonly used cutting process include:

- **Arc cutting.** Arc cutting is a common cutting process accomplished by melting the metal with the heat of an arc created between the electrode and the metal being cut. This process can cut all metals that conduct electricity and usually uses a gas or compressed air supply.
- **Arc oxygen cutting** is slightly different to arc cutting. It uses high temperature and the chemical reaction between oxygen and the metal to be cut to sever the metal.
- **Air carbon arc cutting.** Air carbon arc cutting is a process where metals are melted by the heat of an arc using a carbon electrode. Molten metal is forced away from the cut by a blast of air from a compressed air supply.
- **Oxygen thermal and oxyacetylene cutting.** Oxygen thermal and oxyacetylene cutting operates in a similar manner to oxy fuel gas welding. They are an oxygen cutting process in which the necessary cutting temperature is maintained by flame obtained from the combustion of acetylene with oxygen creating heat which cuts the base metal.
- **Oxygen Cutting.** A process of cutting metals containing iron (ferrous metals) through chemical action of oxygen on elements in the metal at elevated temperatures. There are a variety of different oxygen cutting techniques including:
  - **Oxy-hydrogen cutting** in which the necessary cutting temperature is maintained by flames obtained from the combustion of hydrogen with oxygen.
  - **Oxy-natural gas cutting** in which the cutting temperature is maintained by flames obtained by the combustion of natural gas with oxygen.
  - **Oxy-propane cutting** in which the necessary cutting temperature is maintained by flames obtained from the combustion of propane with oxygen.

5.9.2 Potential impacts on air quality

Pollutants produced

The main pollutants produced from welding and cutting are particulate and dust emissions, fumes and smoke. Welding processes may generate many different fumes and other toxic emissions depending on composition of metals being welded and the type of welding rods or filler used.

Substances emitted from welding include:

- **Carbon monoxide and carbon dioxide** mainly derived from the carbon dioxide shielding atmosphere created by reduction of shielding gas and to a much lesser extent in all welding of steel through partial oxidation of carbon (in the consumables).
- **Phosgene** produced when welding is carried out in the presence of VOCs escaping from nearby activities or when solvent is left behind on the metal to be welded after degreasing. Chlorinated hydrocarbons like trichlorethane, perchloroethylene, acetone and freons are commonly used as degreasing products. Chlorinated hydrocarbons and freons under certain conditions can decompose to form phosgene, which is highly toxic. Surfaces should be dried prior to welding.
- **Phosphine** produced when steel coated with a rust proofing compound is welded.

- **Particulates** including metal and metal oxides, lead from paint and inorganic fluxes which produce halide salts.

Consumables can also contain various elements with the potential to pollute. Aggressive soldering fluxes contain inorganic salts, often with hydrochloric acid as well as fluorides and fluoroborates, orthophosphoric acid and glycerin. Less aggressive solder fluxes contain organic compounds that decompose at soldering temperatures, including lactic and glutamic acids and hydrochloric acid.

Metals can be coated with plastics, polyurethane, epoxy materials, paint or other metals. Common examples include primers with rust preventatives, galvanised steel and chrome plating. Particular care must be taken for cadmium coatings which are highly toxic. Common coatings include:

- **Metallic coatings** including galvanising (zinc), sprayed coatings such as aluminium and zinc, electroplating such as copper and nickel, cadmium zinc and tin.
- **Paints** which give off a complex mixture of emissions. They can include lead, chromium, cadmium and other materials which come from the pigments and resins contained within the paint.
- **Plastics** which commonly give off a complex mixture of emissions. This can include emissions of ammonia, hydrochloric acid, carbon dioxide and cyanides.

Sources

Pollutants in the welding process are produced from the materials present in the fumes. These fumes may come from the following sources:

- The consumable.
- The surface coatings or preparation such as paint or degreasers.
- The gases which are added such as carbon dioxide in carbon arc welding.
- The gases formed by the electrical arcs in the welding process such as ozone and oxides of nitrogen.
- The metal being welded.

The main sources of pollutants include:

- Poor handling of various products and spilling of oils and solvents leading to pollution of the atmosphere through the release of VOCs.
- Heat treatments such as emissions from the combustion of products leading to atmospheric pollution with VOCs, particulates and other hazardous air emissions.
- All activities emitting fumes and gases leading to atmospheric pollution with metals, gases and particulate and dust emissions.
- Poorly maintained equipment or equipment malfunction and failure.
- Poor housekeeping practices such as irregular sweeping, vacuuming and poor disposal of spent metal scraps and shavings in the bin with no closed lid.
- Technical ability of personnel involved in welding and cutting activities.
- Inefficient drying of metals after degreasing (usually with some form of solvent or pickling acid) prior to welding or cutting. This can create hazardous emissions of gases and particulates.
- Coolant which becomes contaminated by the cutting and welding processes with foreign materials which can cause it to lose its effectiveness and develop foul odours.
- Cutting oils can give off atmospheric pollutants with gases and particulates if not stored and handed correctly.

Particular issues of concern

Certain metals have toxic properties including stainless steel which contains nickel and chromium, mild and carbon steel which contains manganese and galvanised metal or paint which can contain zinc. These are all commonly used metals in cutting and welding activities and adequate precautions should be taken.

Another issue of concern are the coatings and residue left on metals prior to welding and cutting activities taking place. This can include lead and cadmium, commonly used in paint and fillers. These coatings and residues should be fully removed from the metal prior to welding and cutting operations being carried out.

Commonly metals are degreased prior to cutting and welding. This usually involves the use of a solvent (degreaser). Welding through or near chlorinated solvents in particular can produce poisonous phosgene gas which can have harmful effects on personnel and the environment.

Lastly when carbon dioxide is used in the welding process carbon monoxide can be emitted. Carbon monoxide can also be emitted by oxyacetylene welding. In this case the welding arc can also form nitrous oxides and ozone.

5.9.3 Best practice guidelines

All activities should follow the best practice guidelines in **Section 5.1 General background guidelines** and **Sector 5.2 General activity guidelines**.

For best practice guidelines on activities commonly undertaken by metalworkers such as spray painting, abrasive blasting and powdercoating refer to **Section 5.3 Spray painting**, **Section 5.4 Abrasive blasting** and **Section 5.6 Powdercoating**.

There are four main areas where best practice should be used to prevent environmental harm. These include:

- Air extraction, ventilation and filtration systems.
- Materials handling and preparation.
- Cutting and welding.
- Gas cylinders.

Air extraction, ventilation and filtration systems

- Efficient local and general air extraction and ventilation should be present when conducting welding and cutting activities. This will usually require the installation of an air extraction and ventilation system with an exhaust fan. The most effective control is local exhaust extraction and ventilation where an exhaust hood is placed near the welding arc or flame, and the contaminants are drawn away from the metal to be welded or cut and through a ventilation system exhausting through a stack on the roof.

Local exhaust ventilation should be used to remove fumes and dust produced by the welding process.

- A system of moveable exhaust hoods, flexible and stationary ducts, a powered fan and fume or dust collector should be used. This should exhaust through a stack on top of the building roof. See **Section 5.2.1 General activity guidelines ventilation and exhausting of emissions** for best practice guidelines on exhausting emissions.
- The Welding Manufacturer's Association of Australia recommends that the level of fume in the welder's breathing zone should be less than five milligrams per cubic metre. The respiratory standard *AS/NZS 1715 Selection, use and maintenance of respiratory protective devices* states that every effort should be made to prevent the release of airborne particles into the working environment. 'At source' extraction is the preferred method of control. This requirement should also be employed for environmental purposes.
- Fumes and smoke should pass through a filtration system prior to exhausting if they are potentially harmful to personnel and the environment.
- Filtration systems can be fitted locally at the source or at the end stage within a stack, filtering gases as they are exhausted.

- If gas and smoke emissions cause complaints or a demonstrable environmental nuisance a filtration system capable of absorbing gases and smoke such as an activated carbon filtration system or charcoal filtration system should be used. See **Appendix 2 Filtration systems** for further information on the types of filtration system detailed.

Materials handling and preparation

- All paints and solvents should be removed from metals prior to welding or cutting. If a degreaser containing solvent is used the metal should be completely dry prior to welding or cutting.
- Businesses should identify the potential for flux fumes to be generated during the welding process and ensure familiarity with the MSDS.
- Businesses should limit types of coolant used. Most metal working facilities require no more than two coolants, one for machining and one for grinding. Using a large number of coolants requires extra storage space, adds to inventory and maintenance needs and increases the chance of using the wrong coolant, cross contamination and requires more training for personnel.

Cutting and welding

- Welding and cutting activities should be conducted on a paved, covered surface so that metal scraps can be vacuumed or swept up.

Activities such as drilling, cutting and sawing metals can produce particulate dust which should be vacuumed or swept up into a sealed container or bag and then placed in the bin.

- The use of oxyacetylene gas for cutting should be limited. A good substitute for oxyacetylene gas cutting can be a cut-off saw.
- The safest welding method for the job should be used. A welding process that creates or is assisted by shielding generally emits fewer emissions than a welding process not using shielding.
- The electrode or welding rod used should produce a low fume. Up to 90 per cent of fumes can be produced by the electrode or welding rod used.
- Low fume welding processes that should preferably be used include:
  - Submerged arc welding.
  - Electrolag welding.
  - Water jet cutting.
  - Resistance welding.
  - High frequency induction welding.
  - Friction welding.
  - Ultrasonic welding.
  - Semi automatic stud welding.

A guillotine used for cutting sheets of metal prior to welding activities are conducted can produce particulate and dust emissions that can be harmful to the health of personnel and the environment.

Gas cylinders

- Oxyacetylene gas should be used away from possible ignition sources.
- Gas cylinders should be secured in an upright position. The cylinder labelling should be able to be clearly read and contents of the cylinder readily recognisable. The cylinder should be checked for no mechanical damage and the storage area and cylinder clean and dry as identified in series *AS 2030 The verification, filling, inspection, testing and maintenance of cylinders for storage and transport of compressed gases*.

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- The cylinder valve should be regularly inspected for damage. If the valve is damaged it should not be opened as it may not be able to be turned off again as identified in *AS 2473 Valves for compressed gas cylinders (threaded outlet).*
- The type, rating and condition of the regulator should be checked. When regulators are fitted to cylinders they should not be contaminated with oil or grease as identified in *AS 4267 Pressure regulators for use with industrial compressed gas cylinders*.
- Flash back arrestors should be fitted at both the regulator and blowpipe ends of the hose the most current inspection should be noticed on an inspection tag or sticker as identified in *AS 4603 Flashback arrestors-Safety devices for use with fuel gases and oxygen or compressed air*.
- The hoses, oxygen (blue), acetylene (red) and LPG (orange) should be regularly checked to ensure they are fitted correctly. The hoses should also be checked for damage particularly at the junctions to fittings where fatigue damage may occur. The manufacturers recommendations for length and diameter and fitting of hoses should be adhered to in accordance with *AS 1335 Hose and hose assemblies for welding, cutting and allied processes*, *AS/NZS 1869 Hose and hose assemblies for liquefied petroleum gas, natural gas and town gas* and *AS 4839 The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes*.
- The regulator pressure should be set to suit the tip and plate thickness in accordance with the manufacturer's specifications and *AS 4839 The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes*.
- For purging and pressurising the manufacturer's specifications should be followed. Businesses should have a copy of these specifications on the premise and be able to demonstrate the correct techniques as identified in the manufacturer's specifications.
- A pressure test should be undertaken in accordance with the manufacturer's instructions and *AS 4839 The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes*. Generally to conduct a pressure test on a gas cylinder supply the following tasks are performed:
  - With the system purged and pressurised and blowpipe valves closed, the cylinder valves are be closed. The regulator valve is observed for one minute and any anti-clockwise movement of the cylinder pressure or regulated pressure gauges noted.
  - The cylinder valve is then opened and any clockwise movement of the cylinder pressure or regulated pressure gauges noted. A change in the cylinder pressure gauge usually indicates a leak between the cylinder valve and the regulator diaphragm. A change in the regulated pressure gauge usually indicates a leak downstream of the regulator.
  - All leaks are found and eliminated. Use soapy water is commonly used to find leaks.
- Lighting up should be conducted in accordance with the manufacturer's specifications and in accordance with *AS 4839 The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes*. In lighting up an approved lighting flint should be used (not matches or cigarette lighter) and fuel gas lit with a medium flow.
- Shutting down should be conducted in accordance with the manufacturer's specifications and in accordance with *AS 4839 The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes*. The fuel feed blowpipe valve and then the oxy feed blowpipe valve should be shut down. The cylinders valves can then be closed.
- In storage different gas types should be kept separate and empty and full cylinders segregated. Gas cylinders should be stored in accordance with *AS 4332 The storage and handling of gases in cylinders* and *AS 4839 The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes*.

- Gas cylinders should be regularly inspected in accordance with the manufacturer's specifications. The cylinder should have a current inspection tag fitted.
- All fittings should be clean and dry before assembly and use. Oils, greases and other organic compounds may become highly flammable or explosive in the presence of pressurised oxygen.
- Water soluble cutting fluids should be used in place of oil based fluids.
- Gas cylinders should also adhere to the best practice guidelines in **Section 5.2.6 General activity guidelines gas cylinders**.

Gas cylinders should be stored away from potential hazards such as ignition sources and chained to a wall or post to prevent cylinders from tipping or falling over.