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SAFETY

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Foreword

THIS BOOKLET was produced by the New Zealand Department of Labour as part of its continuing drive to reduce the incidence and severity of industrial accidents.

It is not a technical guide or a recommendation to use particular brands of clothing or equipment.

It is a guide to safe work methods and practices wherever welding and gas-cutting are performed in the industrial environment. It should be closely studied by employers and workers, tradespeople, apprentices, and anyone who has to use welding or gas-cutting equipment in a factory or workshop, on a building site, or in any other workplace.

It is the responsibility of employers to ensure that all operators are adequately trained, and that they know, understand and use the correct operating techniques.

Equally, it is the responsibility of every operator to use only the correct operating techniques.

Information in this booklet conforms with NZS 4781:1973 *Code of practice for safety in welding and cutting*. As this booklet is a general guide, the code of practice should be referred to when more specific information is required on any point.

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Fig. 1 A typical portable gas plant, with the cylinders securely mounted on a robust, rubber-tyred trolley for easy movement. A flashback arrestor is fitted to each regulator. The welder is wearing suitable goggles, overalls and safety shoes. The cylinder key is left fitted to the oxygen cylinder.

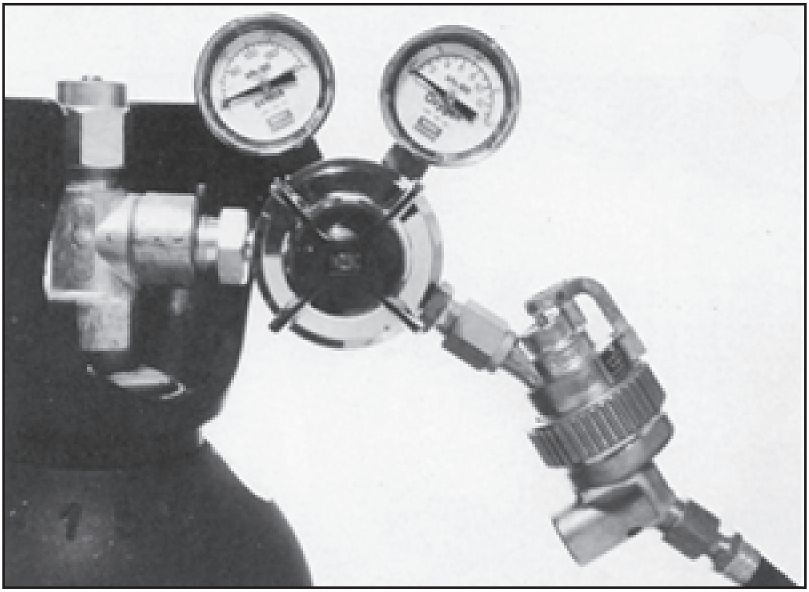

Fig.2 A typical set-up showing oxygen cylinder, cylinder valve, regulator with gauges and a flashback arrestor.

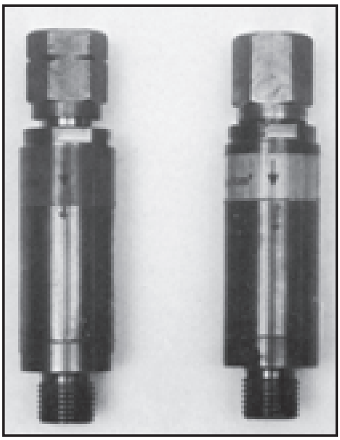

Fig.3 Outlet valves, showing left-hand and right-hand threads.

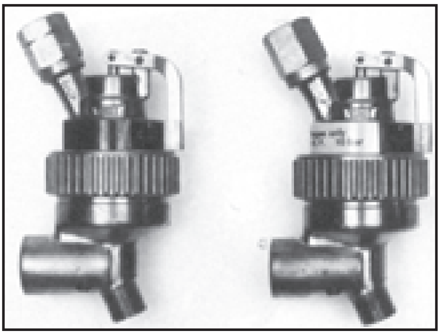

Fig.4 A suitable flashback arrestor for use with portable trolley-mounted gas plants or individual pipeline outlets. There are also other suitable models and types to protect branch lines, ring mains, manifold and storage cylinders. Some include a temperature cut-off valve which is activated by an external fire. Reputable equipment suppliers will be able to recommend particular models for particular situations

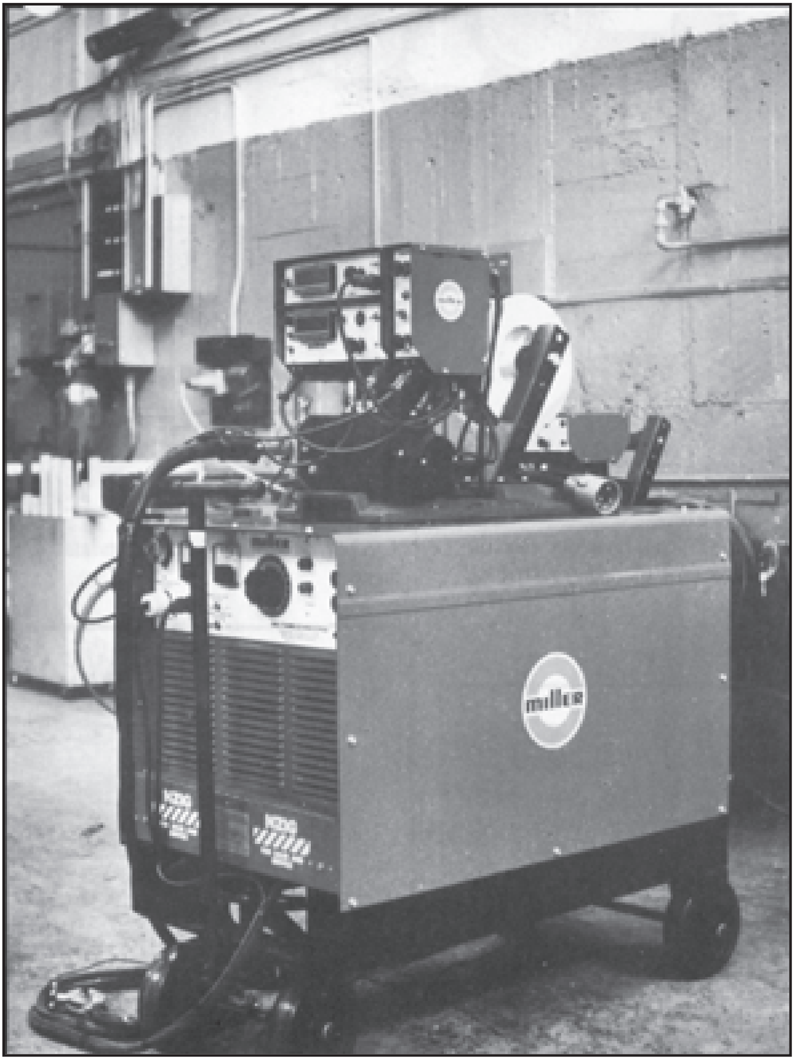

Fig. 5 A MIG (Metal Inert Gas) welding plant. The gas cylinder is not shown, but stands behind the wire feed unit. The complexity of the unit can be seen, and it is suitable for use only by experienced workers.

Storage and handling of cylinders

CYLINDERS CONTAINING compressed oxygen or fuel gases are labelled with their contents on the shoulder of the cylinder.

Although the cylinders are also colour coded, the label is the primary identification of the contents. Do not use an unlabelled cylinder— return it to the supplier.

Here are the general rules for the safe storage and handling of cylinders:

(a) Store cylinders safely and securely to prevent them from falling. Do not store them near elevators, stairs or gangways, or in unventilated enclosures such as cupboards.

(b) Handle cylinders one at a time and use rope slings only for lifting — not chains or magnetic lifts.

(c) Always close the valves of empty cylinders, and store them separately from full ones.

(d) Keep all cylinders away from electrical apparatus, heat and other sources of ignition.

(e) Store oxygen cylinders separately from fuel gas cylinders.

(f) Keep all oxygen cylinders and fittings in a place where they cannot be contaminated by oil or grease. These substances can ignite violently in the presence of oxygen, and if the oxygen is under pressure an explosion may result.

(g) Always store and use acetylene cylinders in the upright position. They contain liquid acetone to keep the acetylene stable. If the valve is opened when the cylinder has been on its side, liquid acetone will be will be withdrawn with the gas. If the cylinder has been on its side, stand it upright for at least an hour before use.

Gases used in welding and cutting

OXYGEN (0_2) makes up about 20 percent of the air around us. It is not a flammable gas, but usually nothing can burn unless oxygen is present.

If the amount of oxygen in the air is increased, even slightly, the air itself becomes dangerous. Sparks will readily ignite into fires, fires will burn much more fiercely, and flames will spread more quickly. If clothes catch fire in an oxygen-enriched atmosphere they will burn as if soaked in petrol.

Never allow the air to become enriched with oxygen through leaks or misuse. For example, do not use oxygen to "sweeten the air" in a confined space or to blow dust off clothes.

Do not use oxygen to power tools which run on compressed air as any oil or grease in the tool may burst into flames or explode.

ACETYLENE (C_2H_2) burns quietly and smokily with a white flame. Mixed with oxygen, it produces the blue, very hot flame used in welding and cutting.

Acetylene cylinders are filled with a porous material containing acetone into which the acetylene is dissolved. Acetylene is an unstable gas and dangerously so at pressures over 100 kPa (14.5 lbs/in^2). Never set the cylinder outlet gauge at a higher pressure than this.

Acetylene forms an explosive mixture with oxygen at concentrations from 2 percent up to 82 percent. This can easily happen if there is a leak, especially in a confined space. Acetylene smells like garlic or onions, which helps in detecting this hazard.

Copper, or any material containing 70 percent or more of copper, forms an explosive compound (copper acetylide) with acetylene which is likely to explode on impact. For this reason, never join acetylene hoses with copper tube or copper wire — always use the proper fittings.

LIQUEFIED PETROLEUM GAS (lpg) is used in oxy-lpg cutting and in air-lpg heating torches. It is heavier than air and will collect in low-lying places.

Lpg in New Zealand is approximately 60 percent propane and 40 percent butane. Because it is heavier than air, do not use lpg in trenches, holes, or anywhere it can spill down to a lower level. As with acetylene, the cylinder must be kept upright. This is because propane is a liquid, and is likely to seep through the valve.

Lpg forms an explosive mixture with oxygen at concentrations of between 2 percent and 10 percent.

Assembly of equipment

THE OUTLET valves on oxygen cylinders and other, inert, gases are threaded right-hand. The valves on acetylene, lpg and all other fuel gases are threaded left-hand.

This safeguard of using right-hand threads for oxygen and left-hand threads for fuel gases applies also to the associated equipment.

However, this does not mean that all equipment with right-hand threads may be used for any inert gas, or that equipment with left-hand threads may be used for any fuel gas. Only equipment labelled for use with the particular gas may be used.

The proper sequence for assembling equipment is as follows:

(a) Make sure that the cylinder valve threads are free from oil, grease and other foreign matter.

(b) Open each cylinder valve briefly to blow out any dust or moisture inside the thread.

(c) Fit the regulators to the cylinders.

(d) Make sure the regulator pressure adjusting screws are released, by turning them anti-clockwise until they are slack.

(e) Open each cylinder valve slowly. When the high-pressure gauge needle has stopped moving, screw in the pressure adjusting screw until a steady flow of gas issues from the regulator outlet. This purges the regulator of any dirt or dust. Allow the gas to flow for a few seconds only then release the pressure adjusting screw to stop the flow of gas.

(f) Fit the hoses to the regulators.

(g) Purge each hose to remove dust or dirt by the same procedure used when purging the regulators.

(h) Fit the torch to the hoses.

(i) Fit the correct tip or cutting nozzle to the torch.

(j) Always check that all unions are correctly tightened and that there are no leaks before lighting up. (Use a mixture of detergent and water.) If you do this every time the equipment is assembled, it will become automatic.

NOTE: The cylinder valve key should be left fitted to the oxygen cylinder. This is to enable any person to turn the cylinders off in case of an incident.

Flashbacks: the causes and cure

FLASHBACKS are the unintentional and uncontrolled burning back of gas through the blowpipe mixer. They result from the presence of oxygen and a fuel gas in the same supply line. Any flashback will damage the equipment to some extent. A serious flashback — or several minor ones — will make the equipment unsafe for further use, unless it is properly overhauled.

Many flashbacks go unrecognised. Sometimes the only sign is a loud crack, followed by a puff of carbon from the welding tip when relighting. This carbon, which is produced by the decomposition of the fuel gas, is proof that a flashback has occurred.

The least damage a flashback can do is to deposit carbon in the torch valves, which can affect their operation and lead to more serious flashbacks. If, as is likely, the flame travels some distance along the hoses, the bore will suffer damage and be weakened. Small particles may break loose and lodge in the valve or mixer.

Serious flashbacks can cause substantial and expensive damage to the regulator and may even pass right through it and into the cylinder, causing a cylinder fire.

The most common causes of flashbacks are:

- Excessive or incorrect pressures set by the operator, resulting in the gas flow rate exceeding the capacity of the cutting nozzle or welding tip. The gas at the higher pressure then flows into the lower pressure line. This can occur either if incorrect pressures are used, or if incompatible items of equipment are connected together.
- A leak from the regulator, hose, or connections results in a drop of the gas pressure in the line, and gas from the higher pressure line backfeeds into it.
- Leaking valves allow gas to seep through and mix by diffusion when the equipment is not in use, such as during tea breaks, meal breaks and overnight.
- Lighting up with both torch control valves open, but one cylinder closed.
- When an oxygen cylinder becomes empty the fuel gas may backfeed into the oxygen line, regulator and cylinder. If the regulator is then placed on a new oxygen cylinder, and the

Flashbacks cont'd

cylinder valve is opened too rapidly, the pressure can increase the temperature of the mixed gas enough to ignite it.

The use of flashback arrestors can virtually eliminate this cause of fires. A suitable fully integrated flashback arrestor is shown in fig. 4 on page 7. Fitting an arrestor is recommended especially in situations where the operator is not working close to the cylinder control valves. Possible consequences of not arresting a flashback range from a burst hose to the bomb effect of a cylinder exploding.

The functions of flashback arrestors are to:

- Protect against sudden or slow reverse flow of gas, by means of a non-return valve.
- Arrest a flashback and extinguish the flame.
- Protect against leakage and ignition of unburnt gases after a flashback by automatically shutting off the gas supply.
- Show when the arrestor has operated by means of an indicator.
- Vent off excess pressure in hoses via a safety valve.
- Shut off the gas supply if the arrestor inlet pressure falls below the outlet pressure due to a leak in any of the supply equipment.

For total protection, fit an arrestor to each gas line, one adjacent to the regulator outlet and one at the handpiece. The arrestor will not have to be fitted if the handpiece has a built-in arrestor. Consult the manufacturer or supplier to make sure the correct model, for the particular gas and for the particular equipment, is used.

NOTE: Should a flashback occur, first turn off the blowpipe oxygen and then the acetylene. Inspect the hoses for possible damage and replace if necessary. Purge the hose before lighting up, but never in a confined space.

Sequence for lighting up

MOST FLASHBACKS are preventable if the correct lighting up and shut down procedures are carried out. This is the sequence to follow:

(a) Open both cylinder valves (using only the key supplied by the manufacturer).

(b) Check that there is ample gas in both cylinders.

(c) Set the fuel gas regulator pressure in this sequence:

   (i) Open the fuel gas valve on the blowpipe;

   (ii) Adjust the pressure regulating screw until the gauge reads correctly;

   (iii) Close the blowpipe fuel gas valve.

(d) Set the oxygen regulator pressure, using the same sequence.

(e) Open the fuel gas valve on the blowpipe. Allow the gas to flow for a few seconds to purge the hose of air or any mixture of gases. Then close the valve.

   NOTE: Never purge the hose in a confined space.

(f) Open the oxygen valve on the blowpipe and purge the oxygen hose of air or any mixture of gases.

(g) Make sure that the torch is not pointed at any other person or at the cylinders. Then light the fuel gas and adjust the valve (until the flame stops smoking, if acetylene is being used). Use a friction lighter or an electric lighter. Never use a cigarette lighter or matches.

(h) Open the oxygen valve(s) on the blowpipe, gradually, and adjust to the desired flame.

   NOTE: Purging the hoses should become an automatic procedure before lighting up after any shutdown such as a tea break.

Sequence for shutting down

ON COMPLETION of the welding work, these are the correct procedures for shutting down:

(a) Close the fuel gas valve on the blowpipe.

(b) Close the oxygen valve(s) on the blowpipe.

(c) Close both cylinder valves.

(d) Open oxygen valve(s) to release the pressure in the hose and regulator. When both gauge needles have fallen to zero, close the oxygen valve(s).

(e) Wind back the regulator pressure adjusting screw to release the pressure on the regulator diaphragm.

(f) Repeat steps (d) and (e) with the fuel gas valve and regulator.

General safety rules

SOME ADDITIONAL safety hints are given below. If you are unsure about any safety matter, always ask an experienced person.

(a) Many booklets and pamphlets suggest you should make periodic checks for leaks by using soapy water. However there are oils or fats in soap which are not compatible with high-pressure oxygen. Instead, use a 5 percent solution of Teepol or a similar detergent in water.

(b) Never fill an oxygen cylinder with compressed air from an oil-lubricated compressor. This is because residual oil in the air will be deposited in the cylinder. If the cylinder then goes back into the pool, and is refilled with oxygen, an explosion will occur. Any oxygen bottle, regulator or hose that has been used with compressed air must be downgraded and not used for oxygen again.

(c) Leave the key spanners in position on the cylinders when in use so they can be closed quickly in an emergency.

(d) Keep hoses and other equipment from obstructing passageways, ladders and stairways. Where hoses are required to go over passageways, they should be protected from scuffing.

(e) Never wrap hoses around cylinders or regulators, as a leak or flashback could cause even more damage.

Hazards and how to avoid them

HERE ARE the main hazards encountered in gas welding and cutting and how you can avoid them.

Injuries from burns during and after welding

Wear protective clothing. Never point a torch towards any other person. Chalk a warning onto hot metal so that others will not touch it or stand on it.

Injuries from backfires of blowpipes and explosions in hoses and equipment

Only use equipment in good condition. Light up only as set out on p.14 of this booklet. Fit flashback arrestors to equipment.

Explosion of gas-air mixtures in workshops

These generally result from leaking hoses or from connections not being gas-tight. If there is a smell of gas in the workshop, do not light up until the cause has been found and rectified and the area has been well ventilated to clear away any residual gases.

Fires in the work area and vicinity

Good housekeeping is essential. There should be no flammable liquids (including solvents or liquefiable solids) waste or flammable materials in the area, or piles of rubbish in which sparks may smoulder. Do not leave a lighted torch unattended, or hung over the gas bottles or regulators.

Oxygen-enriched atmosphere

A small increase in oxygen content of the air will cause fierce burning of flames and sparks. Avoid allowing the air to become oxygen-enriched as described on p. 10.

Fumes and gases

These are not a problem in a well-ventilated workshop. But, in confined spaces, carbon monoxide can be a hazard. It comes from the incomplete combustion of acetylene, and from the welding or cutting of metal covered with paints, varnish, resins, or carbonaceous materials such as bitumen.

Carbon monoxide has no smell to warn of its build-up. Early symptoms may be a headache or sleepiness. At carbon monoxide levels near the threshold limit of 50 ppm (parts per million) the symptoms are a lack of concentration and co-ordination, and then unconsciousness.

Hazards cont'd

Fumes of all descriptions should be disposed of promptly, especially those from zinc and lead oxides. These are given off when flame is applied to metals primed with zinc and lead paints. No one should be exposed to fumes from zinc, lead, brass, bronze, copper, nickel, arsenic, cadmium, manganese, phosphorus, selenium, silicon, beryllium, mercury, fluorine, or stainless steels.

Good workshop ventilation, coupled with mechanical extraction devices or breathing apparatus, is necessary.

Eye injuries

Suitable eye protection must be provided by employers and worn by workers. There are types available, with either tinted or clear lenses, to suit all types of work.

If in doubt, ask for advice from the manufacturer and/or supplier. Use only the correct type of eye protection for the job.

Repair of petrol tanks etc.

SEVERE EXPLOSIONS and fires, many resulting in fatalities, have been caused by welding, cutting, brazing, soldering, or other applications of heat to pipes, tanks, drums, and similar vessels which have contained flammable materials and have not been made safe for this work.

Containers which have previously held petrol or white spirit and other such volatile liquids are highly dangerous to work on. A pin-point of heat can be enough to set off an explosion or fire.

Equally dangerous are pipes or containers which have carried or held such diverse contents as linseed oil, soap, diesel oil, any acid that reacts with metals to produce hydrogen, or any combustible solids which may have left a residue of dust.

It is essential to remove all residues during cleaning. The preferred method is to steam clean and then either to fill with an inert gas such as carbon dioxide or nitrogen, or to fill with water, leaving a very small vented space at the point where the repair is to be made. (Allow for the expansion of liquid in small-bore pipes.)

Never wash the container out with cold or hot water, or blow the container out with air, to remove flammable material. Both methods are ineffective.

The use of carbon tetrachloride is not recommended because:

- It is highly toxic.
- It can form phosgene gas when heated.
- It may react with the metal of the containers.
- It has been found to be ineffective on a number of occasions in cleaning containers and explosions have followed.

Cleaning with trichloroethylene must be carried out with care since:

- It is toxic.
- It decomposes on heating and may form phosgene gas.

Welders are recommended to study the booklet *Hot Work on Drums and Tanks* (obtainable at any Department of Labour office) before carrying out such repairs.

ELECTRIC WELDING PLANT AND EQUIPMENT

Fig. 6 A MIG (Metal Inert Gas) welding plant. The complexity of this equipment makes it suitable for use only by experienced workers.

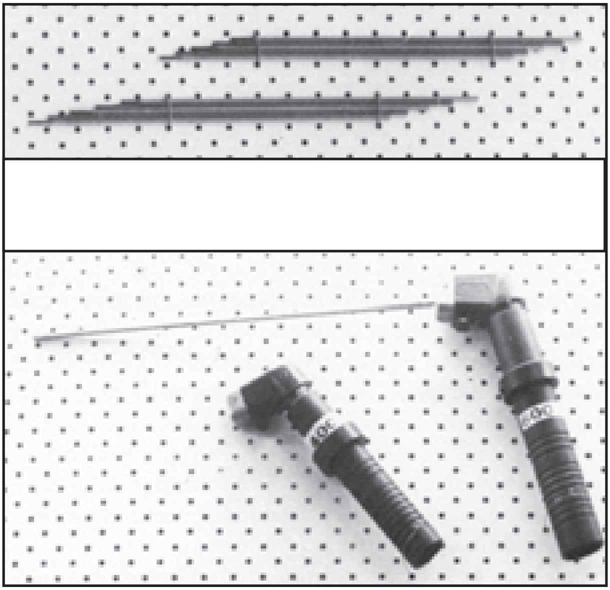

Fig. 7 Well-insulated modern electrode holders of the screw type.

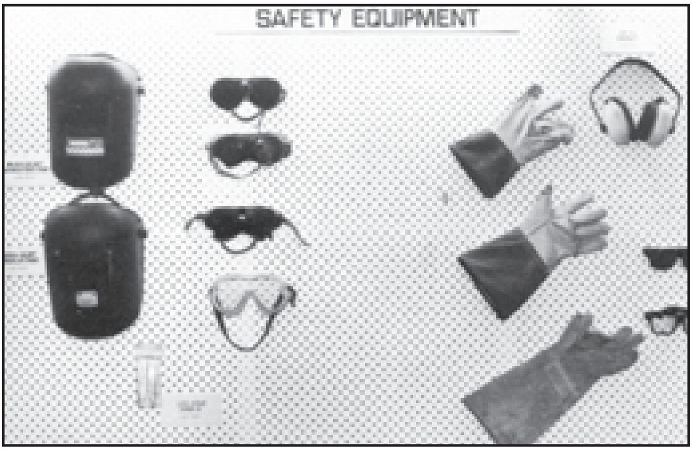

Fig. 8 Typical safety equipment for the protection of eyes, ears, and hands. These are suitable for various tasks, but it is important to select the correct equipment for the work undertaken.

Arc welding machines

BOTH AC and DC welding generators and AC/DC transformer rectifier welding machines operate on relatively high voltages that can seriously injure or kill.

Under normal operating conditions, it is not possible to get a shock from the outer casing or the frame of an electric welder. Should anybody receive one, stop the engine of an engine-driven generator or switch off the power supply and remove the connection plug from the mains supply. Do not restart the machine until it has been cleared by a registered electrician.

Do not use any welding machine that has been tampered with by an unauthorised person. Only a registered electrician may make alterations or repairs to the electrical supply, or to the internal electrical connections of any welding machine.

Before using any welding machine, check the location of the power disconnect switch. In an emergency, there may not be a chance to pull the plug out.

Follow all printed rules and operating instructions supplied by the manufacturer.

Equipment checklist for operators

MODERN ELECTRIC welding equipment is well designed and easy to adjust, but should be checked over before use. This is the suggested checklist for operators:

(a) If the machine has become wet, disconnect the primary power and dry it before use.

(b) Spread out the coiled welding cable and check the insulation for damage.

(c) Reject all welding lead spliced within 3 metres of the holder.

(d) If a metal inert gas (MIG) or tungsten inert gas (TIG) welding process is used, check the gas hoses and fittings for leaks.

(e) Check electrode holders for loose or exposed connections to reduce the shock hazard.

(f) Check that the welding machine frame is earthed, with special attention to earth connections.

(g) Do not earth to pipelines carrying gas or flammable liquids, or to conduits carrying electric wires.

(h) If it is unavoidable for AC welding to be performed under wet conditions, a reliable automatic control should be fitted to reduce the no-load voltage. This is to prevent shock. Refer to a registered electrician or to the manufacturer for advice.

General safety rules

SOME ADDITIONAL safety rules for operators are given below:

(a) Always treat all electrical equipment as "live". Do not take chances. Keep water and other liquids away and keep yourself dry.

(b) Keep leads and cables clear from obstructing passageways, ladders and stairways.

(c) Use only cables of a sufficient capacity to carry the current used. Do not overload.

(d) Use only a proper earthing clamp or bolted terminal.

(e) Use only standard cable connectors.

(f) Use only an insulated hook or other suitable device to hold the electrode holder when you are not actually using it.

(g) If you are using a welding generator driven by an internal combustion engine inside a building or confined area, the engine exhaust must be conducted to the outside air.

(h) Input cables and extension leads should be kept as short as practicable.

(i) Take particular care in earthing portable welding machines driven by an internal combustion engine. Where an earthing connection is provided, it must be used in accordance with the manufacturer's instructions. (This is also very important when using ancillary power supply for drills, grinders and other equipment).

Hazards and how to avoid them

ELECTRIC WELDING has its own set of hazards. Here are the main ones and how to avoid them:

Electric shock

Check the insulation of all cables regularly. Do not work in wet conditions unless suitable precautions have been taken. Electrical work should be carried out only by a registered electrician.

Burns

Wear suitable protective clothing. Cool down or clearly mark hot objects.

Eye hazards

Use only a suitable helmet or handshield which is in good condition. Always wear approved safety spectacles with side shields, goggles or a visor when chipping or grinding. Ensure that adequate welding screens are erected where practicable.

Fumes, vapours, dust, and gases

Make sure the work area is well ventilated. There are health risks from the toxic substances in fluxes, filler rods, coatings, and cleaning agents, and the by-products of heat and ultraviolet radiation from the arc.

Dangerous substances

Some dangerous substances to note are:

BERYLLIUM. Used mainly as an alloy with other metals, beryllium is deadly and extreme precautions must be taken. This metal must be welded in inert atmospheres, inside airtight enclosures, with the welder outside.

CADMIUM. Used in electroplating and as an alloy with metals, cadmium is also an ingredient in some paints. A single exposure to cadmium oxide fumes can cause a severe lung irritation that may be fatal.

CHROMIUM. The oxidation of chromium alloys can produce chromium trioxide fumes, often referred to as chromic acid. These fumes may produce skin irritation as well as bronchitis and other problems.

Hazards cont'd

LEAD. Poisoning generally results from inhalation of fumes, although the swallowing of dust is also a cause. Lead-based paints are a source of lead fumes, especially when old steel structures are cut or welded. Signs and symptoms of lead poisoning may include abdominal pains, constipation, headaches, weakness, muscular aches or cramps, loss of appetite, nausea, vomiting, weight loss, and anaemia. In severe cases it can be fatal.

MAGNESIUM. The oxide fumes from magnesium can produce metal fume fever, which is characterised by influenza-like symptoms.

MANGANESE. Fumes from manganese are highly toxic and can produce total disablement after a few months of exposure to high fume concentrations.

MERCURY. Mercury vapour can be produced by welding or cutting metals coated with protective materials containing mercury compounds, such as the antifouling paints used on ship bottoms. Nowadays less toxic substitutes are used in place of mercury, but there will still be some vessels in service which are protected with mercury-containing antifouling compounds. Exposure to mercury vapour may result in abdominal pain, vomiting, diarrhoea, and other serious problems which, collectively, can result in death.

NICKEL. Often used as an undercoating on chrome-plated parts, nickel and its compounds are generally considered to have low toxicity.

TITANIUM. Dust may irritate the respiratory tract in high concentrations.

VANADIUM. Dust and vanadium pentoxide fumes may cause severe eye, throat, and respiratory tract irritation and pain.

ZINC. Welding, brazing, or flame cutting of galvanised steel causes zinc oxide fumes. Inhalation of these may result in metal fume fever.

FLUORIDES. These and other toxic compounds of fluorine may be found in some welding and brazing fluxes, electrode coverings and submerged arc fluxes. Containers are labelled to warn of the presence of fluorides. The fumes will cause chills, fever, painful breathing, and coughs if inhaled. Over a long period, fluoride can build up in the bones, causing them to lose calcium and become brittle.

NITROGEN DIOXIDE. Formed in the welding arc directly from the air, nitrogen dioxide is very irritating to the eyes and mucous membranes of the lungs and throat. Exposure to concentrations between 200 ppm and

Hazards cont'd

700 ppm (parts per million) can be fatal. Lower concentrations may produce only mild bronchial irritation, but will be followed several hours later by acute pulmonary oedema (fluid in the lungs).

PHOSGENE. This gas is produced when residues of chlorinated hydrocarbon degreasers such as trichloroethylene and perchloroethylene are left on metal being welded or flame-cut. The heat and the ultraviolet radiation cause the degreaser to decay into phosgene gas, which was used as a poisonous gas in the First World War. Freon gas, which is used in many refrigeration plants and as a propellant in aerosol cans, will also decompose to form phosgene when exposed to ultraviolet rays. Phosgene will produce skin inflammation. Inhalation of high concentrations will cause pulmonary oedema. Death may result through respiratory or heart failure.

PHOSPHINE. When steel which has been coated with a phosphate rust-proofing is welded, phosphine gas is generated. High concentrations will irritate the eyes, nose, and skin. Very high concentrations can result in severe damage to kidneys and other organs and perhaps death.

OZONE. A gas produced by the ultraviolet radiation in the air in the vicinity of arc welding and cutting operations, ozone is very irritating to all mucous membranes. Excessive exposure produces pulmonary oedema. Other effects of exposure include headache, chest pain, and dryness of the respiratory tract.

Training of gas/electric welders

THE CARDINAL rule is do not use welding equipment unless you are adequately trained and familiar with its safe use.

The Factories and Commercial Premises Act 1981 contains specific provisions about training of personnel using dangerous equipment. Never operate equipment which you do not understand. If you notice untrained personnel using dangerous equipment, or anyone using dangerous methods, report the matter to your supervisor immediately.

If your supervisor does not act to stop the offence, inform your trade union representative or the Department of Labour.

Overalls and protective clothing

SPATTER FROM the welding arc, ultraviolet radiation, and slag from chipping can all cause burns or health problems. Always wear industrial overalls and appropriate eye protection when you are engaged in welding and cutting operations. Keep overalls fastened up to the neck, with the sleeves down and fastened about the wrist.

Wear gloves or gauntlets for arc welding, as protection against shock, burns and radiation burns. Various jobs may require additional protective clothing to be worn such as aprons, leggings, skull caps, and shoulder covers. Safety footwear, preferably boots, should also be worn, especially when heavy materials are handled.

The employer has a duty to provide these items where needed, and the worker must wear them. All such items must be made of suitable flame-resistant materials.

Protective equipment

NEVER USE a helmet or shield which has cracks, splits, or pinholes in it. Similarly, do not use, even for the smallest job, a cracked or broken filter glass. It is an offence for an employer to provide unsatisfactory equipment, and no worker should knowingly use it.

Safety spectacles with side shields must always be worn for chipping or grinding, or when in an eye danger area.

You have a specific duty to protect others from the ultraviolet radiation given off by electric arc welding. Unless you are welding in a room or a booth which prevents other people from being affected, you must place suitable screens around the work.

There are several types of portable, flame-resistant screens and translucent curtains available. If a screen is damaged it must not be used again until properly repaired. It may sometimes be necessary to use suitable signs in addition to the screens.

Noise is not usually a problem associated with gas welding and cutting, but some operations involving fabrication of steel plate can generate high noise levels. If so, or if there are noisy processes nearby, discuss the matter of personal hearing protection with your supervisor.

If fumes given off from the work are highly toxic, such as those from cadmium, chromium, or beryllium, then some form of respiratory protection, such as an air-supplied helmet, is still necessary even though the work is done outside.

Fire protection and extinguishers

FIRES ARE an ever-present danger around welding and cutting work. No welding or cutting work should be started unless all the requirements in this checklist have been met:

(a) All operators who are to use the equipment must be fully trained.

(b) All equipment must be in good working order and correctly assembled.

(c) Cylinders must be secured against falling or being knocked over.

(d) Sufficient and suitable fire extinguishing equipment must be available in the immediate vicinity of the work.

(e) All workers should know how to operate the fire extinguishing equipment.

(f) Fire watchers must be appointed in locations where any major fire may develop.

It is recommended that "Hot-Work Permits" (as shown in the examples overleaf) be issued by the supervisor but only when the supervisor is satisfied that it is safe to proceed.

The chart on page 33 of this booklet should be helpful in dealing with small fires. Always notify the Fire Service even if you put the fire out. They may wish to examine the scene for your benefit.

Fires from gas welding operations tend to occur while work is in progress, while those caused by arc welding often occur some time after work has ceased. This is because hot slag and spatters of molten metal will bounce into awkward places, where they are not noticed, and smoulder for some time before igniting.

Be careful when wetting down the work area, especially where there is electrical equipment. It is advisable to check the area an hour or so later. A fire watcher, equipped with sufficient and suitable fire fighting equipment, must remain behind until all danger of fire has passed. This will be not less than 30 minutes after hot work has been completed.

HOT WORK PERMIT

TO BE DISPLAYED ON THE WELDING OR CUTTING APPARATUS AND RETURNED TO THE RESPONSIBLE OFFICER ON COMPLETION OF THE WORK.

Permission Granted to

[ ]

To Use (Type of Equipment)

[ ]

In (Location)

[ ]

On (Date) [ ]

From (Time) [ ]

To (Time) [ ]

1. All combustible materials removed or made safe ☐

2. No flammable liquids, vapours, gases or dusts present ☐

3. Extinguishers/hoses provided on site ☐

4. Operator knows how to use fire equipment ☐

5. Operator knows location of telephone/ fire alarm ☐

6. Site inspected after completion of work ☐

Permit issued by (Responsible Officer)

[ ]

HOT WORK PERMITS
Left: Example of a hot work permit which can be printed on a card and attached to a welding trolley. (Published by the Australian Fire Protection Association Ltd.)
Below: Example of NZS 4781

HOT WORK PERMIT

........................is hereby authorised to carry out: cutting, burning, welding
(Name) (cross out where not applicable)
other work on..........................as from..........................
(Plant or equipment) (Date: time)
Signed..........................
Factory manager
I have inspected the work. The permit is withdrawn as from..........................
(Date:time)
Signed..........................
Factory manager or nominee

CLASS OF FIRE	APPROVED TYPE OF EXTINGUISHER				
	Water	Foam	Vapourising Liquid	Dry Chemical	CO_2 Gas
	Bucket Pump Water/Gas expelled. Soda Acid. type.	9l Mixed Chemical type 9l Stored Pressure	B.C.F.	Ordinary Dry Powder Multi-purpose	Gas under ptressure
A CLASS “A” FIRES Ordinary Combustibles Paper, wood, cloth, etc. COOLING ACTION	YES	YES	Small fires only	Small surface fires only	Small surface fires only
B CLASS “B” FIRES Burning Liquids Petrol, oil, paint, fats, etc. SMOTHERING ACTION	NO	YES	YES	YES	YES
C CLASS “C” FIRES Gases or liquefied Gases DILUTE or disperse gas SMOTHER liquid	Cautious use as spray to dilute gas only	YES	YES	YES	YES
HOW TO USE	Direct jet at heart of fire and saturate. Fine spray to dilute or disperse gas.	Allow foam to fall lightly on burning surface to form a smoth-ering blanket.	Direct jet to front edge of fire first, sweeping from side to side to cover burning area.	Direct discharge to front edge of fire first, sweeping from side to cover burning area.	Direct discharge to front edge of fire first, sweeping from side to side to cover burning area. Note: Rising heat may drive CO_2 away.

ELECTRICAL FIRES

It is not now considered that electrical fires constitute a class, since any fire involving or started by electrical equipment must, in fact, be a fire of Class A, B or C. The normal procedure is to cut off the electricity and use an extinguishing method appropriate to what is burning. It is, however, advisable to use extinguishing agents which are non-conductors of electricity; these include: B.C.F., Dry Powder, Carbon Dioxide.

Work in confined spaces

IT IS ALWAYS dangerous to work with welding or cutting equipment in a confined space.

Here are the safety procedures to follow:

(a) Never enter any confined space unless you are satisfied it is adequately ventilated with fresh air. If in doubt, wear suitable respiratory protection.

(b) Do not attempt to weld or cut if the presence of explosive vapours or dusts is suspected. Test the atmosphere with a suitable gas detector.

(c) All workers should wear a safety belt or lifeline as appropriate, so that they may be easily removed from the confined space without the need for anyone else to enter it.

(d) Keep welding plant outside and run leads only to the work site.

(e) Do not work in a confined space unless you are closely watched by someone outside. This person must understand the welding plant and must be able to shut it down properly and quickly in an emergency.

(f) Remove the gas torch and hoses from the space every time that work stops-even for tea breaks. A small leak, for ten minutes or so, could result in an explosion when work re-starts.

NOTE: A correct safety procedure should be adopted for work in confined spaces. An “entry permit” system should be used, and completed by an experienced person. A copy of the completed entry permit should be posted at the work site. As well as declaring the confined space safe to be worked in, it should also ensure that all machinery (prime movers, connecting pipes and electrical equipment) has been isolated by blanking, disconnecting or valving. Valves should be secured to prevent accidental operation.

Ventilation systems

FUMES CAN be a serious problem in welding and cutting. They are released from the coatings on welding rods and from the action of heat or ultraviolet rays from the process reacting with solvents or coatings on the metals being welded.

Some fumes are merely objectionable, but others are toxic and can damage your health. Unless the work is being done in the open air, mechanical ventilation is necessary to move the fumes away from the worker and to produce a current of fresh air in the work area.

Always pay particular attention to ventilation when working in a confined space, such as inside a boiler, tank or compartment of a ship. Where gas-shielded arc welding is performed take care to guard against creating an oxygen-deficient atmosphere. Air-supplied respirators, small enough to fit beneath a welding helmet, are available and should be used where satisfactory fresh air ventilation cannot be guaranteed.

There are two main types of mechanical ventilation:

General ventilation

Dilution of fumes by introducing or exhausting quantities of air from the work room can be sufficient for many welding and cutting activities if the workroom is large enough, if there are not too many welders working within the area, and if there are no specially hazardous chemical or physical agents produced by the welding or cutting.

Local exhaust ventilation

This is the most effective means of control and has the advantage of providing a cleaner, healthier environment. It handles a smaller volume of air and so results in a smaller heat loss from the workroom.

Care must be taken that:

- Exhaust openings are located as close as possible to the source of the contamination.
- Contaminants are kept out of the breathing zone of the worker. Exhaust hoods should be placed so as to draw fumes away from the worker's breathing zone.
- The exhausted air is discharged outside, and in a place where it cannot contaminate fresh air being drawn into the work room.

Ventilation cont'd

Some types of ventilation systems are described below.

FREELY MOVABLE HOOD. This is a movable hood, attached to a fan, which draws air from the workspace and exhausts it, via flexible ducting, to the outside. It should provide an air velocity of at least 0.5m/s across the welding site at even the most remote point from the exhaust opening. The hood must always be placed as close as possible to the work being done.

FIXED ENCLOSURE. This is a structure with a top and at least two sides enclosing the welding or cutting operation. Ventilation is provided so the area is continuously flushed with fresh air.

Air movement should be at least 0.5 m/s and the work should be arranged and performed so that the fresh air enters the enclosure through the worker's breathing zone and then passes through the space in which contaminants are produced.

DOWN-DRAFT BENCH. This is a bench or table which has an open grid as the work surface. Air is drawn downward through the grid, into exhaust ducting, and then expelled outside.

The contaminants should not be able to rise into the worker's breathing zone. Workpieces must not be so large as to cover too much of the ducting or the exhaust effect will be lost.

EXTRACTOR NOZZLES. Semi-automatic welding processes, such as the metal inert gas (MIG) processes, are now being supplied with built-in slotted exhaust chambers. Contaminated air from around the welding operation is drawn through the slotted exhaust chamber, which is positioned to allow the welder a clear view of the electrode, and into the exhaust system.

ELECTROSTATIC PRECIPITATORS. These are air cleaning systems capable of very high efficiency. By recycling the already-warmed air in the workplace they can make worthwhile savings in energy use, especially during winter. Both fixed and portable models are available.

Many of these units have been designed particularly for welding workshops. Contaminated air is drawn into the unit and passes through an electrical field. The airborne particles receive a strong electric charge. The air then passes into a second section containing electrically-charged metal plates. These plates attract and capture the ionised particles and the clean air is then returned to the room.

VENTILATION SYSTEMS

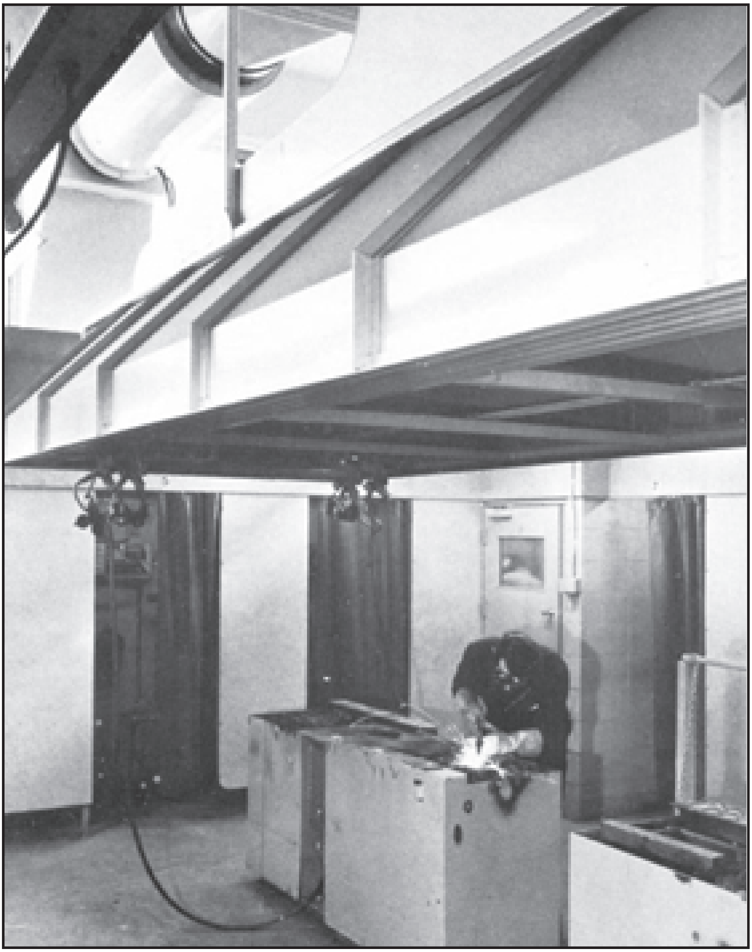

Fig. 9 The Petone Technical Institute is an example of what can be achieved when a workshop and its mechanical extraction system are designed and built for welding and cutting.
The hood above the operator has a dual function. Around the outer rim are slots which allow a down-draught of air to effectively seal off the work area from the rest of the workshop, confining any fumes or particles within the immediate area. At the same time, an up-draught sucks any fumes up through the vents in the central part of the hood.
Each of the small work bays, which are curtained off from the main workshiop, is fitted with a extraction ducts which are connected to a large common duct.

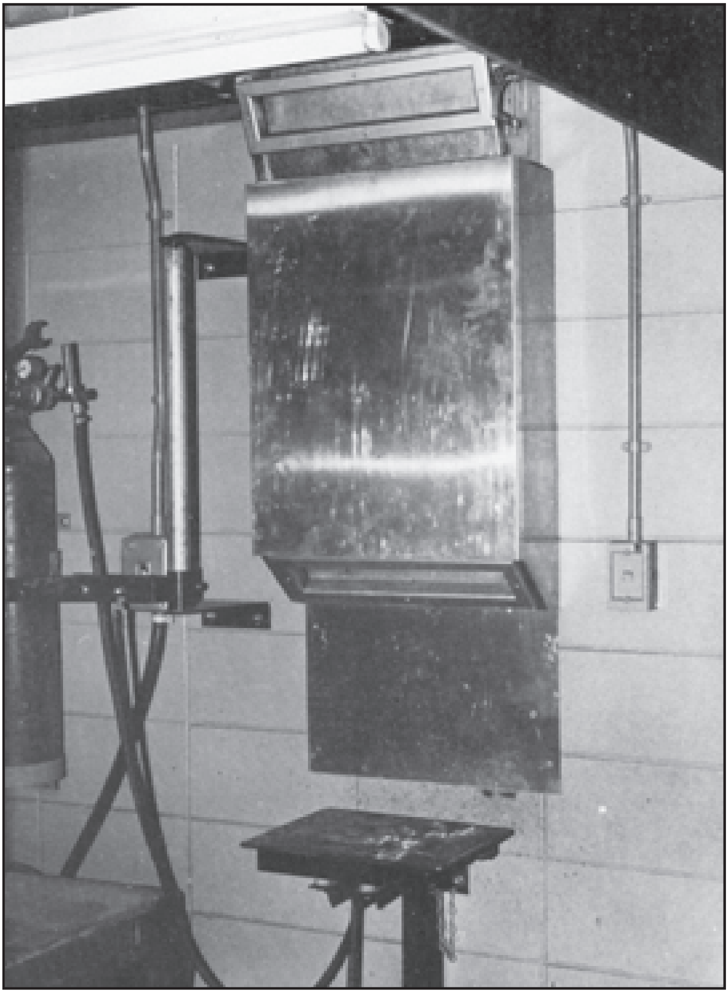

Fig. 1O An example of a fixed fume extraction unit in a welding bay at Petone Technical Institute. There is a low-level vent, just above the work table, to remove particles and heavy fumes. A high-level vent removes the lighter fumes from near the ceiling. This type of unit works particularly well when a blower or fan is used to push the air in the direction of the extractor vents.

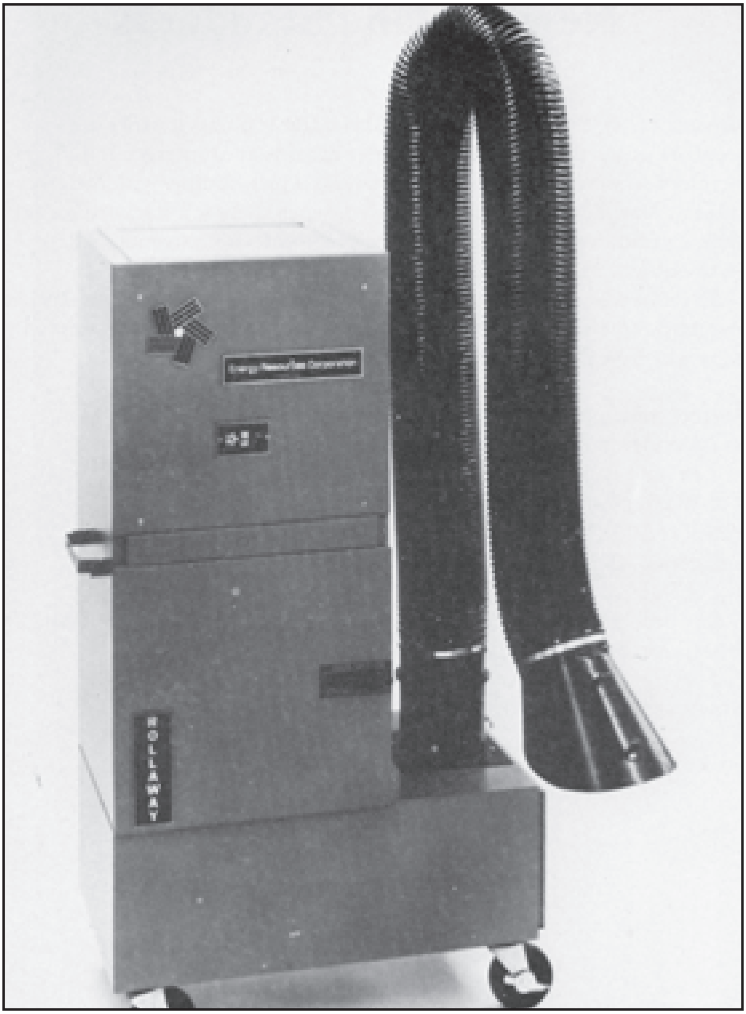

Fig. 11 There are many designs of electrostatic precipitator available. They are an efficient means of removing welding or cutting contaminants from the air. In situations where the costs of heating or cooling the workshop are significant, these units are highly suitable. The unit shown is mounted on a trolley, making it fully portable.

New Zealand Standards

NO PROTECTIVE clothing or equipment is suitable unless it provides adequate protection from the particular hazards encountered. It is therefore recommended that only products which comply with the relevant New Zealand Standard be used, when there is a standard for the item. Examples are eye protection, hearing protection, overalls, safety footwear, and fire extinguishers.

All items which have been accepted as complying with the New Zealand Standard, or with a suitable overseas Standard which has been accepted for use in New Zealand, will bear a Standard Certification Mark.

Further information may be obtained from:

Standards Association of New Zealand,
Private Bag,
Wellington.
Phone 842 108.
Telex-NZ 3850.
Telegrams-Standards Wellington.

Any problems or questions may also be referred to the nearest branch of the Health Department, Labour Department or NZ Fire Service.

NEVER TAKE CHANCES WITH YOUR SAFETY OR WITH ANYONE ELSE’S

Special cutting and welding systems

THE FOLLOWING is a brief description of specialised cutting and welding systems and their associated hazards.

TAGS (TIG) WELDING. A non-consumable tungsten electrode is surrounded by a shield of inert gas. Weld metal is added by means of a suitable uncoated filler rod without the use of a flux.

ATOMIC HYDROGEN WELDING. The arc is struck between two tungsten electrodes, and a jet of hydrogen is directed into the arc.

CARBON ARC WELDING. The electrode used is a carbon rod. The hazards for this and the above two processes are as for ordinary electric arc welding and the usual precautions should be taken i.e., protective clothing and equipment and ventilation.

UNDERWATER WELDING. Ordinary welding techniques and gases are used. Apart from the diving hazards, the main problem is poor visibility. Burns are the most common injury.

PROJECTION WELDING. Is a variation of spot welding. The machines used are basically similar, except that the electrodes are replaced by flat copper platens which exert a uniform pressure over the joint area. Raised projections on the workpiece melt when the current is passed through them and collapse, forming a spot weld.

FLASH WELDING. Is another way of using resistance heating to obtain fusion. Two parts are clamped with a small gap between the faces and are wired up to a large transformer.

A voltage of about 10V is used. As the parts are moved together, the high points of the irregular surfaces come into contact and a high current flows at these points, which melt through resistance heating. Droplets of metal flow and other arcs form, which heat the whole surfaces.

The two workpieces are gradually moved together and more high spots touch, melt, and form molten droplets. This is called flashing, and it removes contaminants as well as heating the two surfaces to a uniform temperature. Eventually, enough force is applied to forge the two surfaces together and any remaining molten metal is forced out to the surface.

Special systems cont'd

Currents in excess of 100,000A can flow across the interface and power inputs of up to 200kVA may be used. Obviously, electrical safety is particularly important, as is the use of suitable eye protection.

ARC-PLASMA WELDING. The temperature in a tungsten arc during TAGS welding is about 11,000°C. By surrounding the arc with a water-cooled copper tube, the area of the arc is restricted and the temperature almost doubles, to about 20,000°C. The plasma gas is passed through this and expands rapidly, issuing from the hole in the nozzle as a high-temperature ionised gas jet.

MICRO-PLASMA WELDING. A low-current version of the above method, used in welding metal less than 1 mm thick. Operates at only about 0.1 to 10A.

ARC-PLASMA CUTTING. Is the most common use for arc-plasma. Unlike oxy-acetylene cutting, a chemical reaction does not occur to achieve melting, so it is useful for cutting non-ferrous metals, such as stainless steel, aluminium, copper and nickel.

The hazards associated with plasma welding and cutting are similar to those for ordinary electric welding and oxy-acetylene cutting, and the same precautions in respect of electrical safety, protective clothing and equipment, and work methods, should be taken. There are, however, two additional hazards-noise and fumes.

The plasma jet is ejected through the torch nozzle at very high velocities, generating high-frequency noise. All personnel in the vicinity of plasma torches must be provided with suitable hearing protection. The noise generated increases in relation to the thickness of the material being worked, so the hearing protection should be suitable for use with the thickest material that will be used.

The Departments of Health and Labour can arrange to measure actual noise levels, and will advise on the control of noise to surrounding areas and on suitable hearing protection for operators.

Plasma systems are used on metals such as stainless steel, aluminium, copper and nickel, which give off various toxic fumes and gases when they are vaporised. As the high temperatures and fast cutting speeds result in a build-up of these fumes, it is essential that adequate mechanical ventilation is provided, preferably by means of a down-draft exhaust through a water quench tank, or a boxed-in cutting table. It is stressed that no one at all should be allowed to breath these fumes.

Special systems cont'd

THERMIC LANCING. Is a method of oxygen cutting, particularly useful on large blocks of reinforced concrete, or underwater.

A steel tube is packed with steel rods and oxygen is passed down the tube, where it reacts with the iron in the rods. To start the iron/oxygen reaction, the end of the lance is heated to a dull red by an ordinary cutting or welding torch. Intense heat is produced by the chemical reaction, which is self-sustaining as long as oxygen is fed down the tube. No fuel gas is used through the lance. The lance is consumed in the process.

There are no additional hazards to those involved in ordinary oxy-acetylene cutting.

LASER SYSTEMS. Laser is an abbreviation of 'Light Amplification by Simulated Emission of Radiation', and refers to a high-energy beam of light. For welding and cutting, the beam is generated in a Cot laser tube. Material up to about 10 mm thick has been successfully welded. In cutting, a jet of gas such as nitrogen or oxygen is often used in conjunction with the beam to blow molten material out of the hole.

Although the beam is focused and guarded, there is always a possibility of reflection from various objects, and suitable eye protection should always be worn by anyone in the vicinity of a laser system.

Welding terminology

MAGS: Metal arc gas-shielded.
Alternative names: MIG metal inert gas
MAG metal active gas
GMAW gas metal arc welding
CO_2 welding
semi-automatic welding

MMA: Manual metal arc.
Alternative name: electric arc welding

TAGS: Tungsten arc gas-shielded.
Alternative names: TIG tungsten inert gas
GTAW gas tungsten arc welding
Argonarc welding

OXY-ACETYLENE WELDING: Alternative name: gas welding

PLASMA:A body of ionised gas produced when a welding arc generates a temperature high enough to enable a gas to dissociate into positive ions and electrons. The gas in the centre of the arc is dissociated into a plasma. It then flows away from the centre of the arc and reassociates itself to produce neutral atoms, giving up its energy in the form of heat.