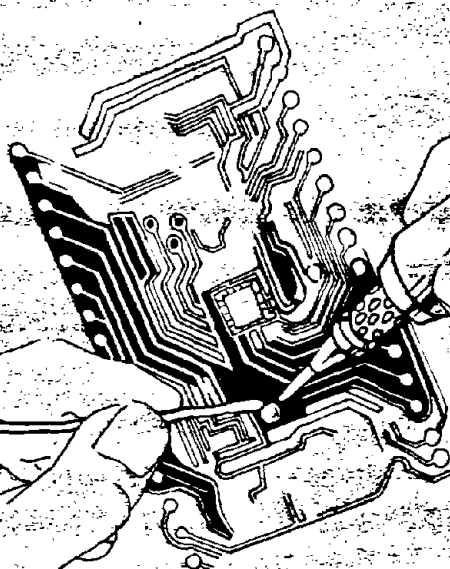


NIOSH

**SAFETY and HEALTH in
SOLDERING and BRAZING**



U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

**HEALTH AND SAFETY ASPECTS
OF
SOLDERING AND BRAZING**

**U.S. DEPARTMENT OF HEALTH, EDUCATION,
AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Division of Technical Services
Cincinnati, Ohio
September 1978**

ABSTRACT

This publication is intended to instruct employees who work with soldering and brazing equipment in the proper health and safety practices of their occupation. This employee good practices manual briefly discusses each type of soldering and brazing operation and what specific hazards that are involved in each process. Other topics discussed in this publication are adequate preparation of the worksite, personal protective equipment, environmental controls, and first aid treatment for specific injuries that might occur while soldering or brazing. Special emphasis is put on preventive measures to minimize the hazards involved in soldering and brazing operations.

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INTRODUCTION

This publication is intended to instruct employees who work with soldering and brazing equipment in the proper health and safety practices when soldering or brazing. Special emphasis is put on preventive measures that solderers and brazers can employ to minimize their on-the-job hazards.

Soldering and brazing are hot metal operations used for joining metal parts by application of molten metal. While similar in concept, brazing and soldering are not identical. Generally speaking, brazing involves the introduction of a non-ferrous filler material, which has a melting temperature of *over 800° F*, but lower than the melting temperature of the base metal. The major brazing filler metals are copper, brass, bronze, and silver alloys. Soldering is the uniting of two pieces of metal with a non-ferrous filler material which has a melting point of *less than 800° F*. Lead and tin alloys are the major soldering filler metals used. Base metals involved, specific type of work being done, and the mechanism of fusion are also different.

To solder or braze in a safe and healthful manner, you should be aware of several aspects related to these metal fusing methods. They include preparation of the worksite, inspection of soldering and brazing equipment, knowledge of the hazards you might encounter, a check of available environmental control equipment, and the use of the proper personal protective equipment.

This guide discusses each of the above items in some detail. Also discussed are special considerations when soldering and brazing in confined spaces, and a short discussion of applicable first aid procedures.

CHECK YOUR WORKSITE

Before beginning soldering or brazing operations preparation of the worksite must be made. This should include the following:

Remove all Combustible and Flammable Materials

A significant hazard involved in soldering and brazing is the potential for fires. Soldering and brazing should not be undertaken in or near rooms containing flammable or combustible materials, or on surfaces or in any container which holds or may have held such materials. Clear your worksite of combustible materials such as oil, soiled rags (especially from table tops or benches), woodchips, waste paper, paint residue, or other items which, if touched by a random spark or flame, could possibly ignite or explode. All drums which may have contained flammable or combustible liquids should be thoroughly cleaned, preferably steam cleaned. If you're working near material which can't be removed, use sheet metal or fire resistant tarpaulins to separate the hazardous material from your work area.

Fireproof the Floor

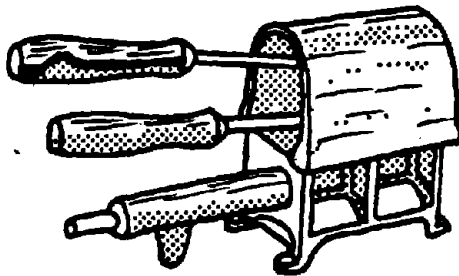
Assuming that the work area is free of combustible or flammable materials, determine if the floor material could be hazardous. If the floor is made of wood or some other combustible material, it should be covered with a fire resistant material. Remember that a wooden floor, even though covered, can be ignited if the covering is open in areas or if a substance landing on the covering is hot enough to ignite the floor below.

KNOW THE SPECIFIC PROCESS HAZARDS

Different soldering and brazing processes involve the use of various equipment. You should be familiar with the equipment you work with and the potential hazards they present.

Soldering Irons

The traditional soldering tool is the soldering iron with a copper bit. This bit is usually heated electrically or with a gas flame. The gas flame can be used in a heating stove, or it can be used to internally heat the bit.



Flame Heated Soldering Iron with Heating Stove

One of the most common hazards associated with using soldering irons is burns. You should make sure that the soldering iron is equipped with a properly insulated holder before using it. When not in use, your soldering iron should be placed in a fireproof holder (or back in the stove) and never allowed to lie on the floor, chairs, or tables where it can come in contact with combustible materials or accidentally be touched by any person. Never leave a hot soldering iron unattended. If it is electric, make sure it is disconnected.

Electrically Heated Irons

Before you use an electrically-heated iron, you should make the following safety checks:

- Check the thermostatic control (if the soldering iron has one) to make sure that it is working properly and that it is adjusted to the proper temperature.
- Check the lead cord for proper insulation and make sure that it is free from grease and oil. Also make sure that the cord is not laying in walkways where it could present a tripping hazard.
- Check all electric tools and extension cords. They should be fitted with a three-prong plug for proper grounding.
- All electric soldering irons should be stored in a dry place. Check the iron before using it to be sure it's dry.

Flame Heated Irons

- Check the hose connections, particularly the stove connection, for gas leaks. Also check the connections at the cylinder valve if a "bottled" fuel gas is used. (Soap and water may be used.)
- If you are using an internally-fired bit, see the following section.
- Remember that gas-fired irons are not thermostatically controlled so care must be taken to prevent overheating of the metals which could result in generation of excess fumes.

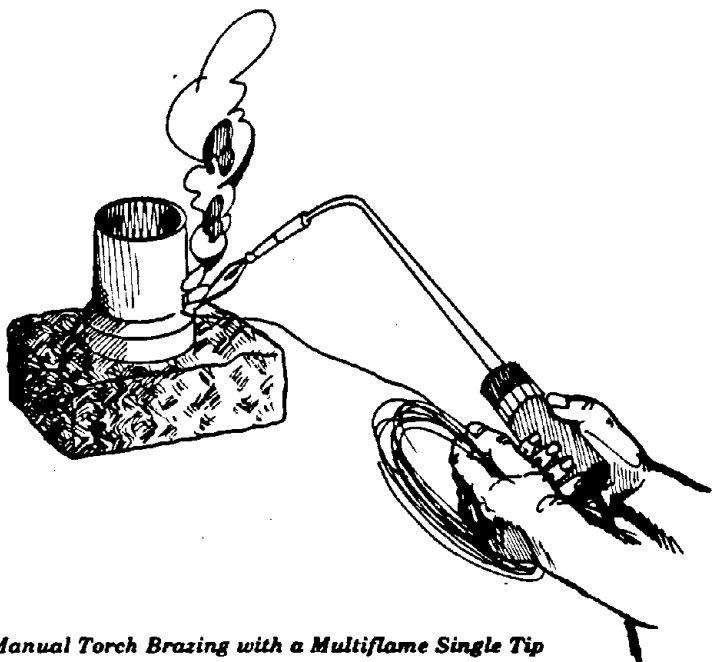
Torch Soldering and Brazing and Flame Heated Soldering Irons

To work safely with torch soldering and brazing equipment and flame heated soldering irons (especially internally-fired) you must be aware of the hazards of the gases involved as well as the torch itself. The following safety checks apply to this equipment:

Check Cylinder Placement and Storage

- All gas cylinders stored inside must be located in a well-protected, well-ventilated, dry location. They must be located at least 20 feet from highly combustible materials, sparks, open flames, excessive heat, and away from elevators, stairs, or gangways.
- Cylinders connected for use must be lashed or chained to prevent them from toppling over. Stored cylinders must also be secured.
- All acetylene cylinders must be stored with the valve end up.
- When cylinders are not connected for use, valve protection caps must be in place unless the cylinder is not designed to accept a cap.
- Stored oxygen cylinders must be separated from stored fuel gas cylinders or combustible materials (especially oil or grease) by at least 20 feet or by a non-combustible barrier. This barrier must be at least 5 feet high and have a fire resistance rating of one-half hour.
- All cylinders must be legibly marked to identify their contents.
- Indoor storage of fuel gas is limited to a total capacity of 2,000 cubic feet or 300 pounds of liquified petroleum gas.
- Be careful that cylinders are not placed so as to become a part of an electrical circuit.
- Mark empty tanks "MT", close the valves, and replace valve caps securely:





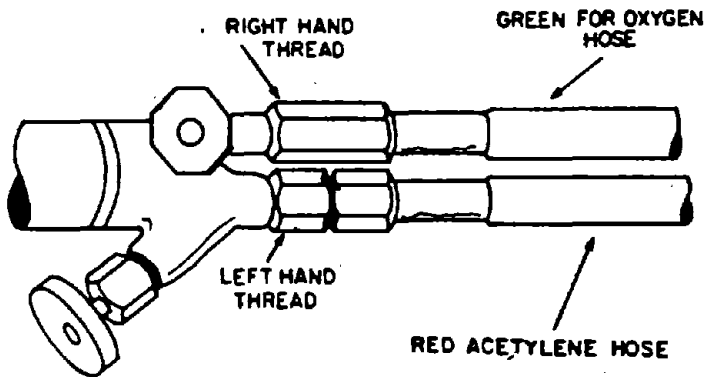
Manual Torch Brazing with a Multiflame Single Tip

Regulator Attachment and Regulator Check

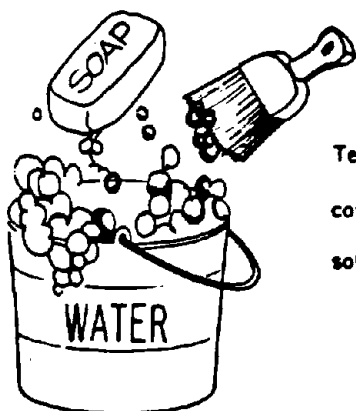
The regulator is a delicate piece of equipment and must be attached carefully to the cylinder. Before you attach the regulator, "crack" the cylinder valve to clean the dust and dirt from it. When attaching the regulator to the cylinder, use only an open-end wrench of proper size. Cylinder valves which do not have fixed hand wheels must have a key, handle, or non-adjustable wrench on the valve stem while the cylinder is in use. Check the regulator for "creep" ("creeping" of a regulator is indicated by a gradual increase in pressure after the *regulator* valves are closed). If it does, have it repaired or replaced immediately.

Hoses, Torch Valves, and Connections

- Hoses showing leaks, burns, or worn places must be replaced or repaired.
- Hoses should be color-coded to avoid accidental mixing.



- Check hose connections for proper threading. Standard hose connections are threaded right-hand for oxygen and left-hand for acetylene or other fuel gas. This will prevent an accidental switch of oxygen and fuel gas hoses.



Test connections for leaks by covering with a leak-test solution of SOAPY WATER.

- Test the hose for leaks by immersing it — under normal working pressure — in water. Do not try to repair hoses with tape.
- Use only approved bronze or brass fittings. Copper fittings must never be used on acetylene cylinders. Under certain conditions, the acetylene might react with the copper to produce an explosive compound.
- Do not use oil, grease, or similar substances on any torch or regulator. Oil and grease in the presence of oxygen may burn with explosive force.

Work Practices

After the preliminary safety checks have been performed, safe work practices are in order. Some good practices to follow are:

- Always point cylinder outlets away from each other before hookup.
- To prevent injury from malfunctioning valves, never stand directly in front of a gauge while opening the cylinder valve — stand to one side.
- There is a proper way to light a welding torch:

First, the hoses must be purged:

Open the valve on the acetylene cylinder. This should never be opened more than one and one-half turns, and three-fourths of a turn is preferable. Open the acetylene torch valve one-fourth turn. Adjust the acetylene to working pressure [less than 15 pounds per square inch on the gauge (psig) or absolute (psia)] with the gas regulator screw. Close the acetylene torch valve.

Follow the same procedure with the oxygen cylinder and torch:

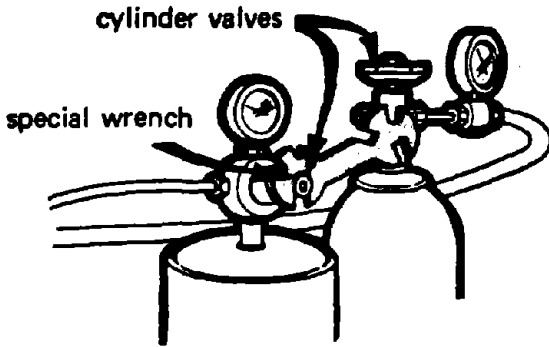
Slowly open the oxygen cylinder all the way. Open the oxygen torch valve one-half turn. Adjust the oxygen to working pressure with the gas regulator screw. Close the oxygen torch valve.

The final steps are the actual lighting of the torch:

Reopen the acetylene torch valve one-fourth turn and light the gas with a friction lighter. (Never use matches.)



Open the oxygen valve one-fourth turn. Adjust the flame.

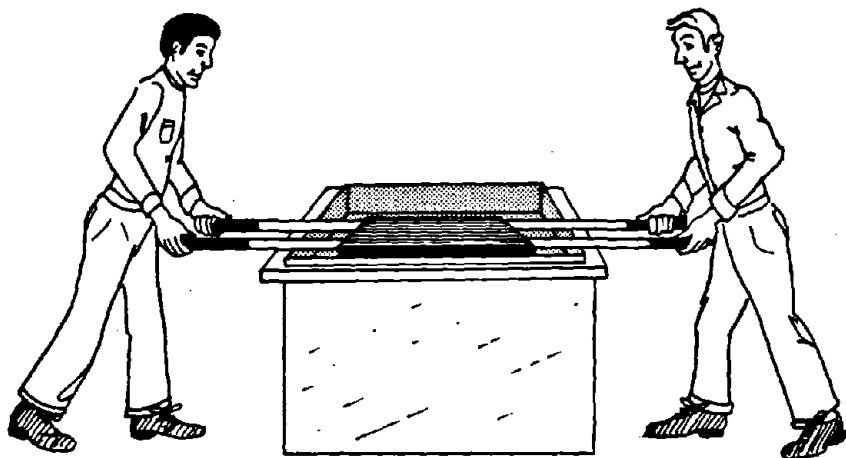


Torch Solderer and Gas Cylinders

- There is also a proper way to shut off the torch:
Close the torch valves, *acetylene first*, then oxygen.
Close the cylinder valves, again *acetylene first*, then oxygen.
Open both torch valves to release the pressure.
Shut off the regulator adjusting handle until you no longer feel any spring tension.
Close the torch valves.
This procedure reduces the possibility of regulator fires when the oxygen cylinder valve is opened again. It will also prevent leaks of acetylene or oxygen while the equipment is not in use.
- Leave the valve wrench on the acetylene cylinder whenever the valves are open. This permits emergency shut-off of the gas.
- Do not leave pressure in the hoses when leaving the area. Shut off the oxygen and acetylene at the cylinder and "bleed" the remaining acetylene and oxygen out of the hose — first one line and then the other.
- Never use a hard, sharp tool for cleaning tips, except where such tools may be specifically recommended by or supplied by the tip manufacturer. Use appropriate tip cleaners or a copper or brass wire.

Dip Soldering and Brazing

Dip soldering finds use in the soldering of radiator cores, side seams of cans, and printed circuit boards. In a typical dip solder operation, the part goes thru degreasing, cleaning, and fluxing processes, followed by immersion into a solder pot — some of which, depending on the part size, contain 5 tons of solder. Another dip soldering process, whole wave soldering, is used for printed circuit boards. In the process, the solder “floats” on a bath of oil or molten salt (to reduce the amount of solder needed in the wave).

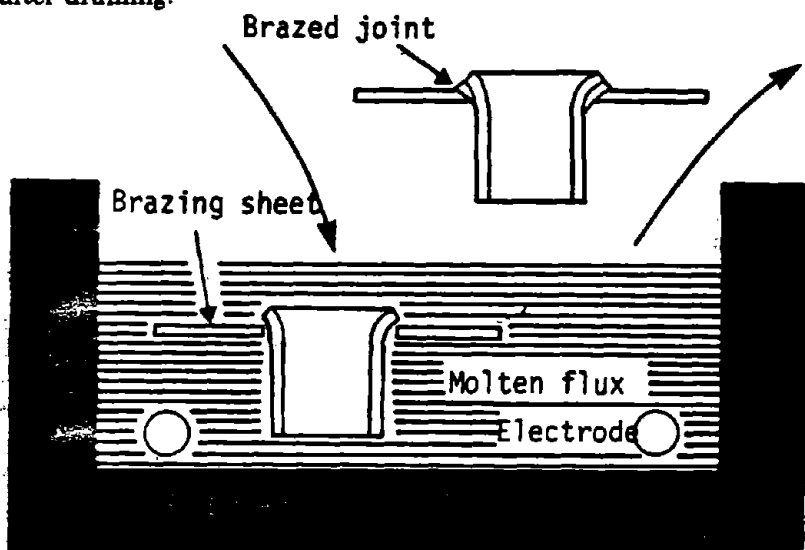


A Dip Soldering Operation

Dip Brazing is done by either of two methods: molten metal bath, used for small assemblies such as wire connections, and molten chemical (flux) bath, used in aluminum brazing. Molten metal bath brazing is similar in principle to the dip solder process, except that a flux is maintained over the molten filler metal so as to pre-coat the assembly before the filler metal is “added.” In the chemical (flux) bath method, a pot of molten flux is maintained. Brazing filler metal is replaced (as enclosed rings, washers, slugs, etc.) on the base metal and then dipped into the flux bath.

The significant hazard involved in dip soldering and brazing is burns, either by touching the pot itself or touching the molten metal bath within the pot. Water can also present a hazard in dip soldering and brazing operations because at operating temperatures, any water introduced into the pot below the surface of the molten bath becomes superheated steam. It expands rapidly and violently and will cause the molten bath to blow out of the pot. Not only can burns result, but the spattered molten bath can be a fire hazard. Before a dip pot is used, it should be allowed to heat up so as to evaporate any moisture before solder is put into the pot. Also filler metals which have been stored out of doors may have a lot of condensation on them when brought into the workroom. These materials should therefore be allowed to dry, and even then they should be put into the pot very slowly and carefully to avoid possible spattering of molten metal.

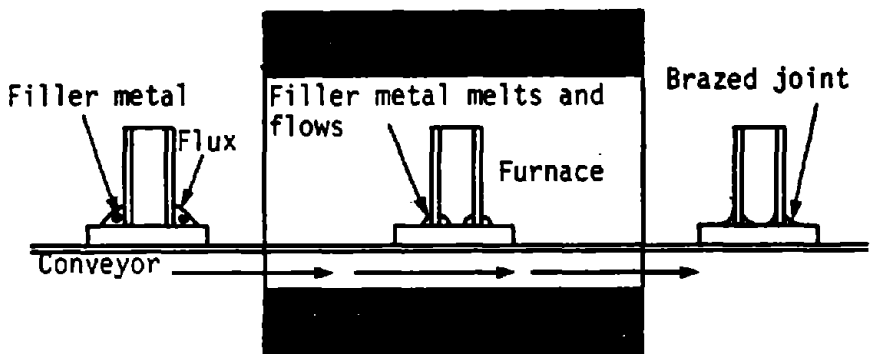
Besides the burn hazard and fire potential, hazardous decomposition products of the flux, potentially hazardous molten metal fumes, and hazardous decomposition products of printed circuit board insulating materials can be generated. All dip operations should be carried out in well-ventilated areas. In buildings equipped with automatic water sprinklers, the pots should be placed where water will not be sprayed onto the pot. Also, if you're going to be draining the pot, make sure that the drain tube is clean and that the drain stem is tightly closed after draining.



Dip Brazing Operation

Furnace Brazing

Furnace brazing is used extensively for production of high quality joints. The four types of furnaces generally used are box, conveyor, retort, and bell. They usually are heated by electrical resistance elements, gas or oil, and have automatic time and temperature controls. Each type furnace presents hazards related to heat and electricity. Furnaces at high temperatures can radiate significant amounts of heat; the electrical element in the furnaces could also present a shock hazard.



Furnace Brazing Operation

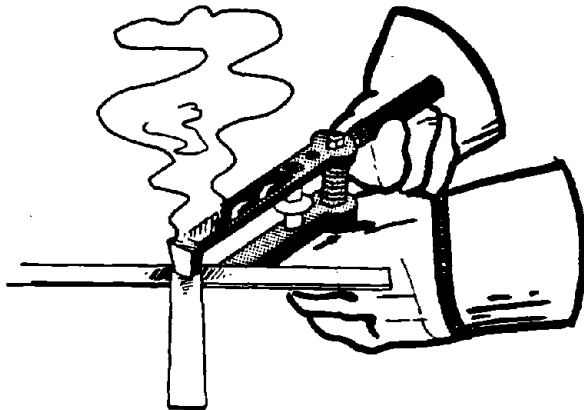
Special hazards may exist when a brazing atmosphere is utilized in a furnace. Some of these atmospheres may become explosive if air seeps in the furnace. Few problems, however, are found with vacuum or inert gas (argon and nitrogen) atmosphere furnaces since these atmospheres are not explosive. Furnaces or retorts which have flammable brazing atmospheres must be purged to remove any explosive mixtures.

Induction Soldering and Brazing

In the induction soldering or brazing process, parts which are good electrical conductors are placed in or near a coil which carries a high frequency alternating current. Because of the magnitude of the induced current, be careful not to touch the coil. Make sure that the equipment is properly grounded and all cables well insulated. Do not wear rings or bracelets near the coil, since a current can be "induced" in the metal, resulting in a burn.

Resistance Soldering and Brazing

Resistance soldering and brazing is used for joints which have simple configuration — since uniform current distribution is important for proper fusion. When using resistance heating with carbon blocks for soldering or brazing, make sure that the operating voltage is set properly for the work done. Check to see that equipment is grounded securely. Be careful not to touch the energized electrodes or heated parts as these can cause severe burns. Also, when working with the equipment, do not apply too much pressure to the electrode because it can crack. Do not interrupt pressure during current flow, as arcing may occur.



Soldering Aluminum with a Resistance Soldering Tool

Spray Gun Soldering

Spray gun soldering involves spraying of molten solder on previously fluxed and heated workpieces. The most common spray guns utilize propane with oxygen, natural gas with air, or electricity as a heat source. Hazards from those which use gas are similar to hazards present when using a gas-fired torch. Those which use electricity present hazards similar to those encountered with the use of an electric soldering iron. In each case, there is the danger of accidentally spraying molten solders on combustible surfaces such as wood, paper, etc., or getting a burn by accidentally touching the hot parts of the spray gun, the preheated workpiece, or the work surface where the preheating of the workpiece is accomplished. Additionally, check with the manufacturer of the spray gun equipment for any special instructions.

Infrared Brazing

Infrared brazing uses high intensity quartz lamps and is often used in brazing of honeycomb assemblies. In addition to presenting the typical hazards of a hot surface, infrared brazing also presents radiation hazards relating both to visible radiation and invisible infrared radiation. Visible radiation or glare can dazzle your eyes, causing momentary blindness which may lead to an accident. Because infrared radiation, which is heat radiation, is invisible, you may not realize that you are being exposed to it. Prolonged exposure can result in skin burns. Eye damage can also result from long term exposure. When working with infrared brazing equipment, use appropriate eye protection and wear "full-length" clothing to minimize skin exposure.

Hot Air Fusion Soldering

This type of soldering, used in delicate work such as electronic watches, involves the use of hot jets of air to melt a solder paste. Again, the significant hazard is one of burns from the hot air jets. Since the process is, for the most part, automated, appropriate guards should be installed to prevent fingers from getting in the way of the hot air jets.

FIRE PROTECTION

Fire Extinguishers

Fire extinguishing equipment must be maintained for instant use in all brazing areas, and is recommended in soldering areas. Extinguishing equipment must be appropriate to the hazard present. Any portable soldering or brazing unit should be equipped with a fire extinguisher.

Fires in the workplace generally fall into one of the classes listed in the table. Portable, hand-operated fire extinguishers may be charged with any of the several substances shown. It is important to identify the class of fire and to select and use an appropriate type of extinguisher.

	CLASS A	CLASS B	CLASS C
Fuels	Wood, paper, textiles	Flammable liquids, grease, gas, oil paints	Electrical equipment—motors, switches, etc.
Extinguisher require- ment	Foam	Foam	
		Carbon dioxide	Carbon dioxide
	Soda acid		
	Pump tank		
	Gas cartridge		
	Multi-purpose dry chemical	Multi-purpose dry chemical	Multi-purpose dry chemical
Ordinary dry chemical	Ordinary dry chemical	Ordinary dry chemical	

Table

It is also important to use the extinguisher properly:

Foam extinguisher: Don't spray the stream into the flames. Allow the foam to fall lightly on the fire.

Carbon dioxide extinguishers: Direct discharge as close to the base of

the fire as possible. Start at the edge of the flames and move gradually forward and upward.

Soda acid, gas cartridge extinguishers: Direct the stream at the base of the flames.

Pump tank extinguisher: Place a foot on the footrest and direct the stream at the base of the flames.

Dry chemical extinguishers: Direct at the base of the flames. **CLASS A FIRES** — follow up by directing dry chemicals at remaining material that is burning.

Fire Watchers

Fire watchers are required in brazing areas where other than a minor fire may develop, and when:

- combustible materials, in building construction or contents, are located closer than 35 feet to the soldering or brazing operation;
- combustibles are located more than 35 feet away but are easily ignited by sparks;
- wall or floor openings within 35 feet expose combustible materials in adjacent areas; or
- combustible materials (which could be ignited by conduction or heat radiation) are located on the opposite side of a metal wall, partition, ceiling, or roof.

HEALTH HAZARDS

The health hazard potential of any soldering or brazing operation depends on, among other things, the types of filler metals, fluxes, coatings, cleaning agents, gases, and base metals used. It is important, therefore, that you know what materials you are working with and what hazards/symptoms they present. It is also important that if you begin to experience any of these symptoms, you report to the company dispensary or seek prompt medical advice. The following discussion talks about some of the materials and exposure symptoms you might encounter:

Cleaning Agents

Acids

For the most part, acids used for cleaning should be diluted with water. (IF YOU MUST DO THE DILUTING YOURSELF, HOWEVER, THE FOLLOWING "RULE OF THUMB" APPLIES: ALWAYS PUT THE ACID INTO THE WATER; NEVER PUT WATER INTO ACID. ALSO, A FULL FACE SHIELD AND PROTECTIVE GLOVES SHOULD BE WORN.) However, even diluted acids can cause skin burns and can generate irritating fumes. Therefore, working with any acids should be carried out in well-ventilated areas and face shield and protective gloves worn. Some specific acids that you might encounter include:

- *Hydrochloric or Muriatic Acid:* A corrosive acid, yellowish in color, inhalation of hydrochloric acid fumes will cause a choking sensation,
- *Sulfuric Acid:* Sulfuric acid is intensely irritating to the respiratory system and skin. When used to remove rust, scale, and oxide from metals, it can form hydrogen, a flammable gas,

- *Phosphoric Acid:* Although not as hazardous as sulfuric acid, exposure to phosphoric acid can result in inflammation of the mucous membranes and skin irritation,
- *Nitric Acid:* This acid can cause severe skin burns and severe irritation of the respiratory tract.

Alkalies

Alkali mixtures used in cleaning operations typically contain sodium or potassium hydroxide. When sodium or potassium hydroxide is put into water to make a solution, it can cause the water, depending on the amount added, to boil. This causes bubbling and splashing, so that concentrated solutions or bits of the solid alkalies can get on the skin or in the eyes of the person mixing the solution. Inhalation of the fumes can irritate the tissues and membranes of the respiratory tract. Skin contact with these alkalies will cause irritation.

Organic Solvents

Organic solvents are used to remove oils and grease from the workpiece. Most organic solvents are flammable and thus are potential fire and explosion hazards. Exposure to vapors of organic solvents can result in irritation of the eyes, nose, throat, and lungs; dizziness; headaches; and sensations of drunkenness. Organic solvents containing chlorine may break down due to the heat and generate phosgene gas which at low concentration (less than 1 part per million), has a sweet odor. At about 1 ppm it smells like musty or new mown hay. Phosgene is a severe pulmonary irritant and, in high concentrations, can cause death. Prolonged or continued skin contact with most organic solvents will remove essential skin oils which will lead to dry, cracking skin and possibly irritation and/or infection.

Ultrasonic Cleaning

Passing an ultrasonic soundwave through a solution creates a vibratory force which breaks off particles and contaminants from small metal parts that were placed in the solution for cleaning. If you use ultrasound cleaning methods, follow the manufacturer's instructions and check with your supervisor for any special protective clothing required.

Soldering Fluxes

Many fluxing agents are used in soldering and brazing operations. The fluxing agent is determined by the metals to be joined. In most cases, these fluxes give off acid or alkali fumes when heated. Because they contain acids and/or alkalis, they can irritate the skin. Again, conducting soldering and brazing operations in well-ventilated areas (see section on Ventilation) and use of protecting clothing and gloves is recommended.

Soldering fluxes are classified into three main groups, depending on the nature of their residues. A brief discussion on the health aspects of some of the major fluxes in each of these groups includes:

Corrosive Fluxes

These fluxes leave a chemically active residue after soldering,

- **Zinc Chloride:** The main ingredient in corrosive fluxes used in soldering of stainless steel, galvanized iron, cast iron, and aluminum. Zinc Chloride fumes can irritate the eyes, nose, and lung tissue, and skin contact with this fluxing agent can cause chemical burns,
- **Ammonium Chloride:** Inhalation of these fumes will be irritating to respiratory passages,
- **Stannous Chloride:** Not considered a serious health hazard. Fumes are irritating to respiratory passages.
- **Acids:** Frequently used as ingredients with fluxes. See discussion under Cleaning Agents.

Intermediate Fluxes

Lactic, benzoic, and glutamic acids frequently are used in the mild intermediate fluxes. These organic acids can produce mild irritation of the skin upon contact. Fumes can be mildly irritating to respiratory passages.

Noncorrosive Fluxes

Rosin dissolved in an organic solvent is the common type of noncorrosive flux. Typical solvents are alcohol, turpentine, or petroleum spirits — all of which are flammable. Exposure to these solvents can result in irritation of respiratory passages and some central nervous system effects (see Organic Solvents). Rosin dissolved in trichloroethylene — which is non-flammable — is also used. If trichloroethylene is the solvent, special attention must be given to providing adequate ventilation when soldering with this type of flux due to its potential for generation of phosgene. Fumes generated from the decomposition of these fluxes are irritating to respiratory passages.

Brazing Fluxes and Atmospheres

Depending on the type of brazing and base metals used, either a flux or a controlled atmosphere may be used to promote the formation of a brazed joint.

The most hazardous brazing fluxes are the fluoborates, fluorides, potassium, and sodium hydroxide.

- **Fluoborates:** When heated, the fluoborate can release fluorine fumes which are a severe lung irritant. Overexposure to these fumes is usually minimized, however, due to operator reaction to the sharp odor.
- **Fluorides:** These compounds are used in brazing with silver, magnesium, and aluminum-silicon filler metals. Fluoride fumes generated are severe lung irritants. Skin contact with fluoride compounds will cause irritation.
- **Sodium and Potassium Hydroxide:** A fluxing ingredient used on molybdenum alloy steels. (See previous discussion on Alkalies.)

Controlled brazing atmospheres, commonly employed in furnace brazing, are used to prevent formation of oxides during brazing. Typical brazing atmospheres used are hydrogen, carbon monoxide, carbon

dioxide, dissociated ammonia, and nitrogen. To prevent a safety hazard, the work should be done in a physical enclosure or by using local exhaust ventilation. When this is done properly, they present little or no problem of toxicity. However, some mixtures of gases may be explosive. Therefore, before heating the furnace, the atmosphere must be purged with the gas to remove all air.

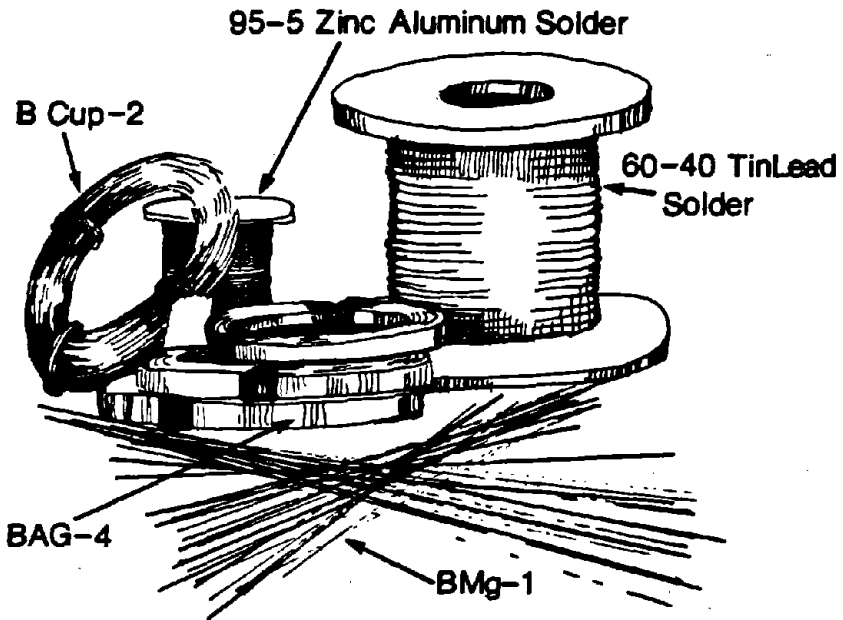
Base and Filler Metals

You will encounter a variety of different metals and alloys during the soldering and brazing process. Probably the four most hazardous metals found are lead, cadmium, beryllium, and zinc.

- **Lead:** Lead is used in the soldering process in the form of lead-tin and lead-silver filler metals. When heated, lead oxide fumes are formed. Excessive exposure to lead oxide fumes can result in lead poisoning. Symptoms include loss of appetite, indigestion, nausea, vomiting, constipation, headache, abdominal cramps, nervousness, and insomnia.
- **Cadmium:** Cadmium is found in some silver and zinc solders and in some base metals. When heated, cadmium oxide fumes can be generated. Excessive exposure to these fumes can result in cadmium poisoning, symptoms of which include dry cough, irritation of the throat and nasal passages, tightness of chest, and restlessness. Cadmium has been suspected of causing cancer of the prostate.
- **Beryllium:** Beryllium is used in magnesium filler metals for furnace brazing, and in some aluminum brazing filler metals. While soldering, temperatures are normally too low to generate fumes from beryllium, but the heat involved in brazing can generate beryllium fumes, which are extremely hazardous. Short term exposure to these fumes may result in a chemical pneumonia. Long term effects include shortness of breath and chronic cough, loss of weight, and fatigue. NIOSH has considered beryllium to be a potential human lung carcinogen.
- **Zinc:** Zinc is used in large amounts in zinc-cadmium and zinc-aluminum solders, and in some base metals. When heated, zinc oxide fumes are generated. Excessive exposure to freshly formed

zinc oxide *fume* can give you an illness called metal fume fever or "zinc chills." Symptoms include the presence of a sweetish or metallic taste in the mouth, dryness and irritation of the throat, coughing, a feeling of weakness, fatigue, and a general malaise condition similar to that of the flu. Usually the illness disappears in a day or so with no permanent after-effects. The presence of zinc oxide *dust*, which is the end product several minutes after zinc oxide fume formation, presents little or no health problems.

- **Other Metals:** Other trace metals present in base and filler metals which give off toxic fumes include antimony, arsenic, chromium, bismuth, cobalt, nickel, selenium, thorium, vanadium, or compounds of these metals. NIOSH has stated that arsenic is a suspected lung and lymphatic carcinogen; chromium (hexavalent) a suspected lung carcinogen. The amount of fumes generated from these trace metals is usually small, and hazardous concentrations are not normally found. But soldering and brazing with filler or base metals containing these trace elements should be conducted in well-ventilated areas to be absolutely sure that hazardous concentrations do not exist.



Typical Soldering and Brazing Filler Metals

Gases Used in Torch Brazing and Soldering

Torch brazing and soldering use acetylene as the heating fuel, and to a lesser extent, propane and natural gas.

- **Acetylene:** Acetylene, classified as a simple asphyxiant, can displace oxygen from the air, thus potentially reducing it below that required by the body for normal functioning. The major hazard associated with acetylene, however, is its explosive nature. Because acetylene becomes unstable at excessive pressures, do not pressurize it to above a 15 psi gauge (or 30 psi absolute).
- **Propane, Natural Gas:** Both of these substances can be classified as asphyxiants. Because of their flammability, however, care must be taken to prevent the accumulation in the workroom air.

Carbon Monoxide, an odorless, poisonous gas, is generated, to some degree, in the combustion of the above gasses. However, the amount produced would not be expected to cause any health problem, except in confined or poorly ventilated spaces.

ENVIRONMENTAL CONTROL

After checking to see that the soldering and/or brazing equipment is mechanically and/or electrically sound, engineering and administrative controls for the contaminants produced by soldering and brazing processes should be assessed.

Dilution Ventilation

For many soldering and brazing operations, control of fumes and vapors generated by dilution ventilation will be sufficient. That is, enough fresh air is added to the contaminated air that hazardous concentrations do not develop. However, the effectiveness of dilution ventilation depends on several factors:

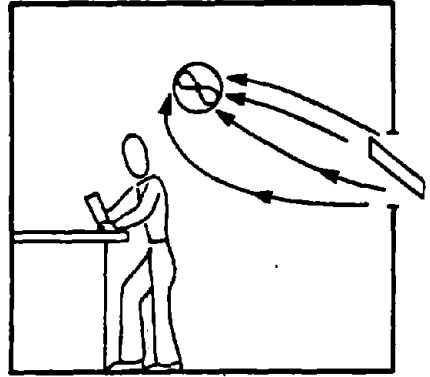
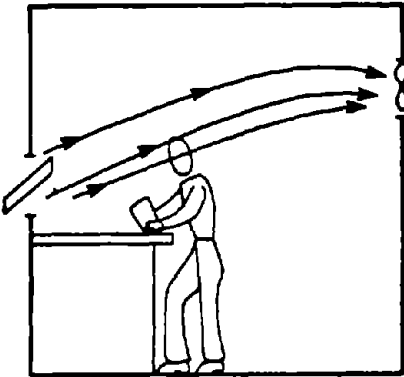
- The size of the space in which soldering or brazing is done, especially the height of the ceilings;
- the total number of workers working within the space; and
- the hazardous chemical or physical agents produced by the soldering or brazing.

When using dilution ventilation, there are several points to keep in mind:

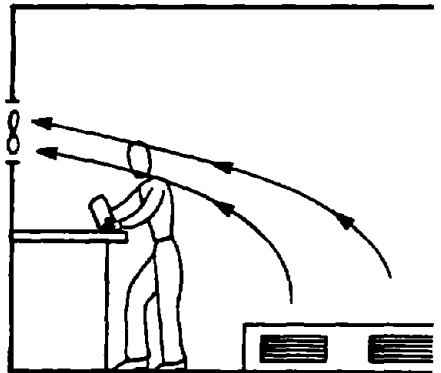
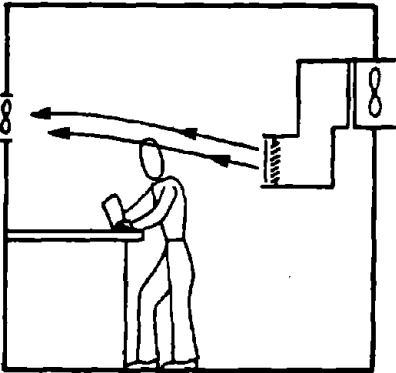
- Wall-mounted exhaust openings should be located as close as possible to the source producing the contaminant;
- to keep the contaminants out of the breathing zone of the worker, the fresh air applied to the work space should first pass through the worker's breathing zone, then across the work space where the contaminant is produced, and into the exhaust system as rapidly as possible;
- unless the exhausted air is discharged far away from the fresh air intake duct, the fresh air can become contaminated.

Examples of possible arrangements (both good and bad) for dilution ventilation of a work space are depicted in these figures:

General Ventilation



Poor General Ventilation and Fair General Ventilation

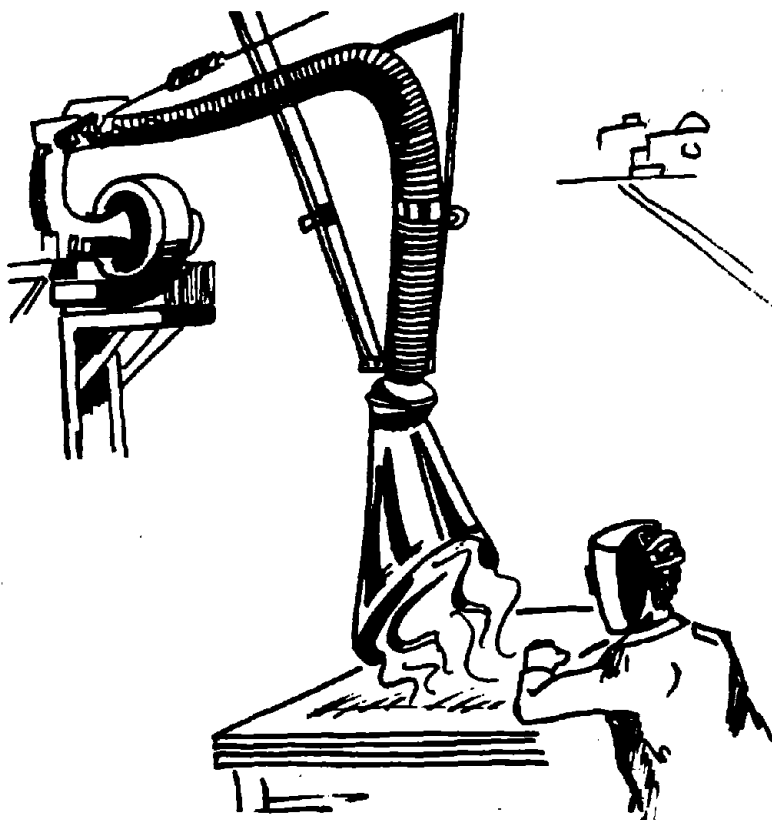


Good General Ventilation and Best General Ventilation

Local Exhaust Ventilation

Local exhaust ventilation is the most effective means of control for airborne contaminants produced by the soldering or brazing process. Local exhaust ventilation can be provided by several types of equipment: freely movable hoods, fixed enclosures (booths), and down-draft benches.

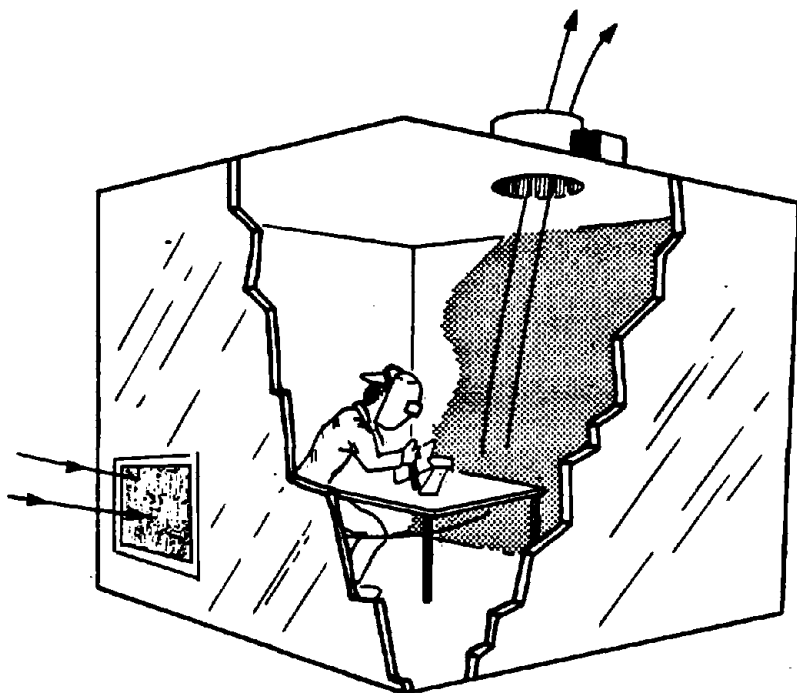
- **Freely movable hood** - This consists of a movable hood attached to a fan. The fan draws air from the work space and exhausts it outdoors, either directly or through a dust collection system. The hoods are normally constructed so that they can be moved into place by the solderer as shown below.



Example of Use of Movable Exhaust Hood

The air handling system should move air at least 100 feet per minute across the soldering site at even the most remote point from the exhaust opening. It is important that the exhaust hood be placed as near as possible to the work being done. A freely movable hood is useless if it is not moved when the solderer shifts his position. This form of ventilation, to be effective, is dependent on the conscious effort of the solderer.

- **Fixed enclosures** - In some instances soldering or brazing operations carried out in a fixed location can be provided with a fixed enclosure. This is a structure built around the soldering or brazing operation which has a top and at least two sides. A means for drawing air through the work area is provided so that the work space is flushed continuously with fresh air.

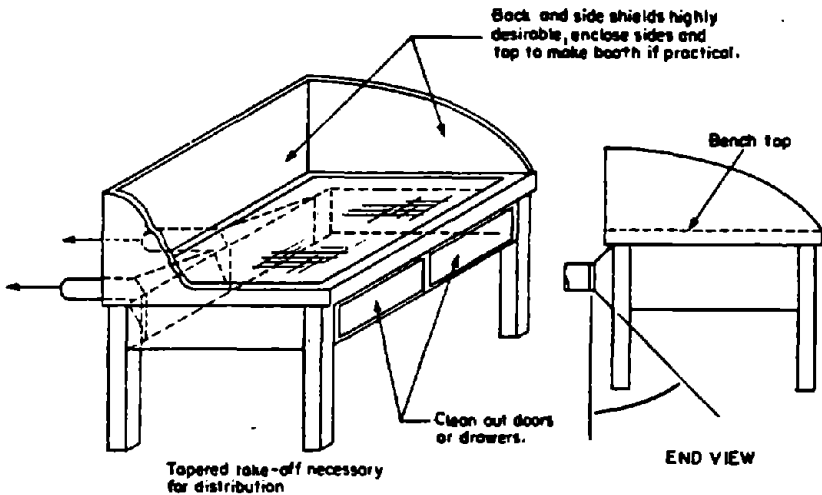


Fixed Enclosure for Soldering or Brazing Operations

Within such an enclosure, work should be arranged and conducted in such a way that the *fresh air enters the enclosure through the worker's breathing zone* and then through the work space in which the contami-

nants are produced. For most fixed enclosures, the air should move at least 100 feet per minute across the entrance to enclosure.

- **Down-draft benches** - A third type of local exhaust ventilation systems is the down-draft bench or table. The soldering or brazing is performed on a bench or table which has an open grid as the work surface. Air is drawn downward through the grid, into the duct work, and then exhausted, preferably outdoors. This prevents the contaminants from rising into the worker's breathing zone. However, to function properly, the work being done on the bench must not be of such a size that it covers most of the work surface. This would obstruct the airflow into the exhaust system.



Typical Downdraft Bench

Administrative Control

If engineering controls cannot be installed, or while they are being put into effect, administrative controls may be necessary to limit exposure. Soldering or brazing can be scheduled so that no individual worker is exposed to airborne contaminants above the acceptable concentration or time limit. In other words, if a particular operation presents exposure above acceptable limits if performed full-time, the exposure can be "shared" by splitting the assignment between two solderers.

PERSONAL PROTECTIVE EQUIPMENT

After environmental controls have been analyzed, personal protective equipment should be considered. Most workers involved in soldering and brazing recognize the need for personal protective equipment, particularly for the eyes and skin.

Eye and Face Protection

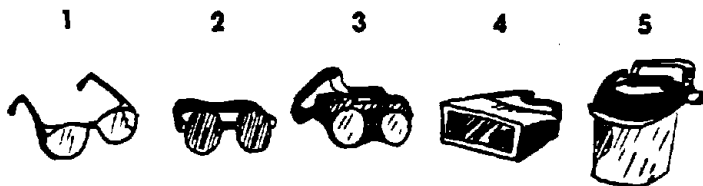
One of the primary concerns in soldering and brazing is the protection of the eyes, face, and neck against flying sparks and spattering of molten metal. To properly protect the eyes and face, protective glasses or shields — with the proper filter plate — should be used for all soldering and brazing. Proper filter plates recommended by the National Bureau of Standards are identified by shade number and are primarily related to the type of flux used (especially for torch brazing and soldering). For example, fluxes which contain sodium salts give off a bright yellow glare thus requiring a darker tint. For potassium salts, commonly used in silver brazing, a soft tint provides good protection. This table is a guide of suggested shades of protective equipment for the eyes.

<u>Operations</u>	<u>Suggested Shade Number</u>
Soldering.....	2
Brazing.....	3 or 4

Goggles should have vents near the lenses to prevent fogging. Cover lenses or plates should be proven to protect the filter lens and helmet. All glass used for lenses should be ground properly so that front and rear surfaces are smooth. Filter lenses must be marked so that the shade number can be readily identified.

A general guide for the selection of eye and face protective equipment is presented below:

APPLICATIONS		
OPERATION	HAZARDS	RECOMMENDED PROTECTORS
SOLDERING	Sparks, harmful rays, molten metal and chemical splash	2, 3, 4
BRAZING	Sparks, molten metal, chemical splash	1, 5



Proper Eye and Face Protective Equipment

1. Spectacles, metal-plastic frame, with sideshields.
2. Soldering goggles, eyecup type, tinted lenses.
3. Soldering goggles, coverspec type, clear safety lenses.
4. Soldering goggles, coverspec type, tinted plate lens.
5. Face shield (available with plastic or mesh window).

- Non-combustible or flame-proof screens or shields should enclose the soldering or brazing operation to prevent flying sparks or molten metal spatter from striking nearby workers. To facilitate ventilation of the "enclosure," leave a one foot gap at the lower edge of the screen.

Skin Protection

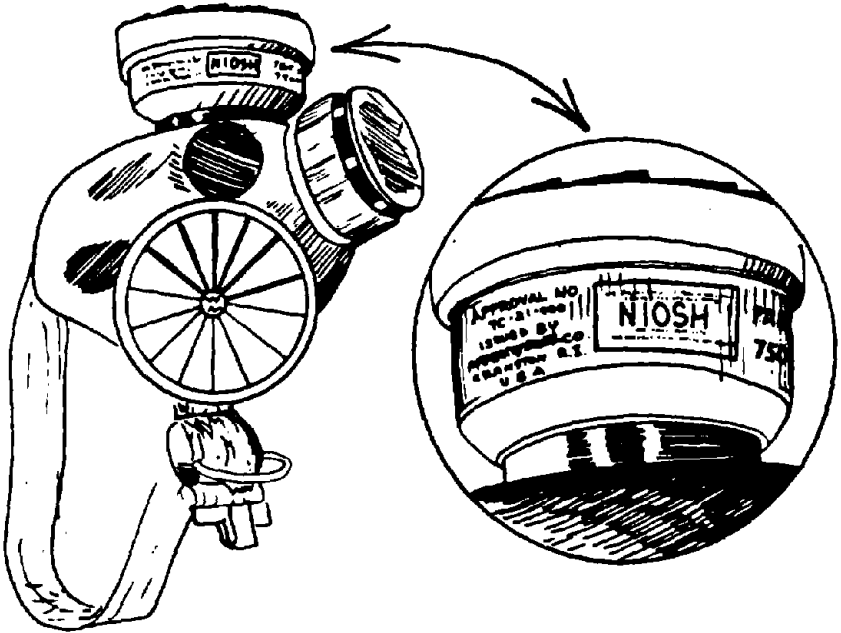
Protective clothing should be worn by all workers doing soldering or brazing.

- Protective gloves, preferably the gauntlet type, should be worn for brazing operations. Durable, flame-resistant cotton gloves or leather gloves should be used.
- Protective gloves, such as the light duty type cotton gloves, are suitable for soldering operations.
- Flameproof aprons should be used when additional protection against sparks and heat is needed.
- Woolen clothing is preferable to cotton because it is not readily ignited and also helps protect the worker from changes in temperature. Cotton clothing, if used, should be treated with a flame-retardant. Clothing treated with non-durable flame retardant materials should be treated again after each wetting or cleaning.
- Sparks may lodge in rolled-up sleeves, pockets, or cuffs. Therefore, sleeves and collars must be kept buttoned and pockets should be removed from the front of clothing. The legs of trousers or coveralls should not be rolled up on the outside.

Respiratory Protection

The nature or location of the brazing or soldering process may make ventilation difficult to use. Or, the brazing or soldering operation may generate an extremely toxic metal fume (cadmium oxide, for example). In this case, it may be necessary to use respirators.

The respirator you wear must be approved by the National Institute for Occupational Safety and Health (NIOSH) for protection against the specific contaminant(s) in the work area. The accompanying figure shows a respirator and cartridge and the printed approval by NIOSH.



Respirator

SPECIFIC REQUIREMENTS - VENTILATION AND RESPIRATORY PROTECTIVE EQUIPMENT

There are specific requirements concerning ventilation and respirators when brazing on the following:

- Stainless steel, lead, zinc, or cadmium;
- metals coated with materials (such as paint) which contain lead or mercury;
- fluxes or other materials containing fluorides.

These requirements are summarized below:

Requirements for Ventilation and Respirators When Brazing

Brazing Materials Containing or Coated With	<u>Location of Operations</u>		
	Confined Spaces	Indoors	Outdoors
Lead	A or B	A	C
Zinc	A or B	A	—
Cadmium*	A or B	A or B	C
Beryllium*	A and B	A and B	A and B
Mercury*	A or B	A or B	C
Fluorine*	A or B	—	—
Stainless Steels	A	A	A

*Unless atmospheric tests under the most adverse conditions have established that the workers' exposures are within acceptable concentrations defined by the General Industry Standards 29 CFR 1910.1000 (OSHA).

A = Mechanical local exhaust ventilation by means of either hoods or booths with sufficient airflow to maintain a velocity, away from the worker, of at least 100 linear feet per minute.

B = NIOSH approved supplied-air respirator.

C = NIOSH approved respiratory protective equipment.

ADDITIONAL SAFETY AND HEALTH CONSIDERATIONS

Confined Spaces

Within each confined space, ventilation must be provided to prevent the accumulation of toxic or combustible materials, and to supply oxygen.

- Replacement air must be clean and respirable. If ventilation cannot be provided, an approved air-line or hose-mask respirator must be worn. Oxygen must not be used for ventilation.
- Workers exposed to substances immediately hazardous to life must wear either an air-supplied respirator or self-contained breathing equipment.
- Gas cylinders and soldering machines must be left outside the space. Heavy equipment mounted on wheels must be securely blocked to prevent accidental movement.
- If the entry to the space is through a small opening or manhole, or if the atmosphere is immediately hazardous to life, means must be provided for quick removal in case of emergency. If safety belts and lifelines are used, they must be attached so that the worker may be easily removed. An attendant trained in rescue procedures must be continuously present outside to observe and assist if needed.

Labels

Information on symptoms of overexposure, first aid procedures, and control of employee exposure is usually provided for substances such

as filler metals, fusible granular materials, and soldering fluxes. This information is frequently printed on tags, boxes, or other containers. If not, the equipment manufacturer should be contacted by your supervisor. Become familiar with these directions and follow them.

General Work Practices

- Personal hygiene is an important consideration when handling materials containing lead such as solder alloys. Always wash your hands before smoking or eating.
- Each solderer is responsible for marking the hot metal or providing some means of warning for others to keep away.
- Hard hats or other head protection may be required where sharp or heavy falling objects, or bumping in confined spaces, are a hazard.

FIRST AID

Program

There should be a first aid program where you work, providing adequate care to all employees during working hours. There should also be medical personnel available for further advice and consultation. If this is not possible, arrangements should be made with a consulting industrial physician or clinic. One or more persons should be designated as responsible for the whole first aid program.

A first aid program should consist of the following:

- First aid training for designated employees;
- properly trained individuals in first aid designated on every shift;
- a first aid unit and supplies or first aid kit;
- a detailed and explicit manual of first aid;
- posted instructions for calling a physician and notifying the hospital that a patient is on the way;
- posted method for transporting ill or injured employees and instructions for calling the ambulance or rescue squad;
- an adequate system of recording all cases in which first aid is rendered.

Supplies

Regardless of the type of work being done, an adequate supply of first aid supplies should be available. The specific items and the number of each should be based on the recommendations of a physician. Some suggestions are given in the table below:

<i>ITEM</i>	<i>NUMBER OF EMPLOYEES</i>		
	<i>1-50</i>	<i>51-100</i>	<i>101-200*</i>
Adhesive bandage, individually packaged	16	32	64
Burn compound, tube or package	1	2	2
Ammonia inhalant	1	1	1
Antiseptic swabs, individually packaged	10	20	30
3" x 3" gauze pads, individually packaged	10	20	30
2" x 10 yd. gauze bandage	2	2	2
Triangular bandage	1	1	1
Adhesive tape, rolls	2	2	3
Scissors	1	1	1
Tweezers	1	1	1
Cleansing tissue, package	1	1	1
Antiseptic solution, aqueous mercury pre- ferred	1	1	1
Mild soap, capped squeeze bottle	1	1	1
Elastic bandage	1	1	1
Resuscitation mouthpiece	1	1	1

*Greater than 200 employees: Provide additional first aid cabinets or increase supplies as demonstrated by past use.

Suggested Minimum First Aid Supplies

Treatment and Procedure

Electrical Shock

Use non-conducting materials to shut down the source of electricity. If this is impossible, pull the victim away from the electrical source, again using non-conducting materials (e.g., a wooden pole). Work with dry hands or gloves and stand on a non-conducting surface.

If the victim is not breathing, give artificial respiration. If he revives before medical treatment is available, avoid any undue strain, particularly on his heart. Keep the patient lying down and warm. Do not move the individual if there is any possibility he has internal injuries or fractures.

Exposure to Airborne Contaminants

Remove the victim from the contaminated area. Apply artificial respiration if breathing has stopped. Keep the patient warm and at complete rest and immediately call for professional medical treatment. It is particularly important for the physician to know the contaminants which might have been present in the workroom air.

Thermal Burns

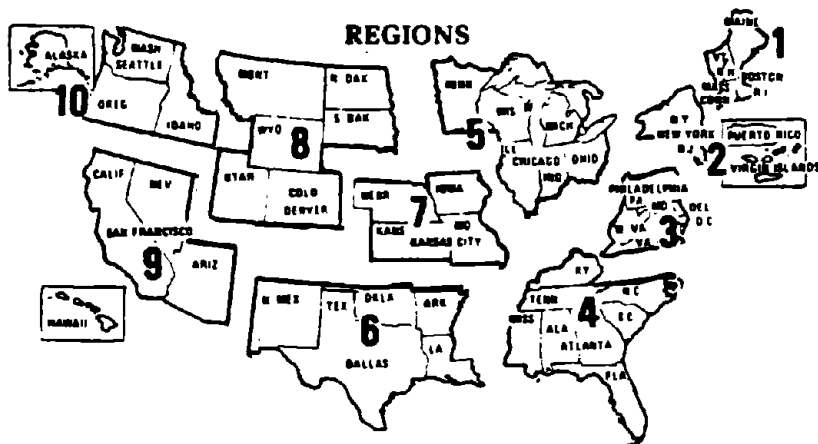
First aid for burns is aimed at relieving pain and preventing contamination of the burn until formalized medical treatment, if needed, can be obtained. For the majority of burns expected in the soldering and brazing operation — i.e., first or second degree burns — apply cold water or submerge the burned area in cold water.

REFERENCES

1. **Soldering Manual, American Welding Society, Miami, Florida**
2. **Brazing Manual, American Welding Society, Miami, Florida**
3. **General Industry Standards, 29 CFR 1910.252**
4. **American National Standards Institute 287.1 - 1968**

NIOSH AND OSHA REGIONAL OFFICES

The following pages list NIOSH and OSHA regional offices. Either of these facilities serving the state can provide information on the Occupational Safety and Health Act including questions on standards interpretations, voluntary compliance information, copies of the OSHA Standards, OSH Act, Employee Rights Posting Notice, and other OSHA publications.



NIOSH REGIONAL OFFICES

DHEW, Region I
JFK Federal Bldg.
Room 1401
Boston, Massachusetts 02203
617/223-6668

DHEW, Region II
26 Federal Plaza, Room 3300
New York, New York 10007
212/264-2485

DHEW, Region III
P. O. Box 13716
Philadelphia, PA 19101
215/596-6716

DHEW, Region IV
101 Marietta Tower
Atlanta, GA 30323
404/221-2396

DHEW, Region V
300 South Wacker Dr.
33rd Floor
Chicago, IL 60606
312/886-3651

DHEW, Region VI
1200 Main Tower Bldg.
Dallas, Texas 75202
214/655-3081

DHEW, Region VII
601 E. 12th St.
5th Floor West
Kansas City, Missouri 64106
816/374-5332

DHEW, Region VIII
11037 Federal Bldg.
Denver, Colorado 80294
303/837-3979

DHEW, Region IX
50 United Nation Plaza, Rm. 231
San Francisco, CA 94102
415/556-3781

DHEW, Region X
1321 Second Ave., Mail Stop 502
Seattle, Washington 98101
206/442-0530

OSHA REGIONAL OFFICES

Region I

U.S. Department of Labor
Occupational Safety and Health Administration
JFK Building, Room 1804
Boston, Massachusetts 02203 Telephone: 617/223-6712/3

Region II

U.S. Department of Labor
Occupational Safety and Health Administration
1515 Broadway (1 Astor Plaza), Room 3445
New York, New York 10038 Telephone: 212/671-5941/2

Region III

U.S. Department of Labor
Occupational Safety and Health Administration
15220 Gateway Center, 3535 Market Street
Philadelphia, Pennsylvania 19104 Telephone: 215/596-1201

Region IV

U.S. Department of Labor
Occupational Safety and Health Administration
1375 Peachtree Street, N.E., Suite 587
Atlanta, Georgia 30309 Telephone: 404/528-3573/4 or 2281/2

Region V

U.S. Department of Labor
Occupational Safety and Health Administration
230 S. Dearborn, 32nd Floor
Chicago, Illinois 60604 Telephone: 312/353-4716/7

Region VI

U.S. Department of Labor
Occupational Safety and Health Administration
555 Griffin Square Building, Room 802
Dallas, Texas 75202 Telephone: 214/749-2477/8/9 or 2567

Region VII

U.S. Department of Labor
Occupational Safety and Health Administration
Federal Building, Room 3000, 811 Walnut Street
Kansas City, Missouri 64106 Telephone: 816/374-5881

Region VIII

U.S. Department of Labor
Occupational Safety and Health Administration
Federal Building, Room 15010, 1901 Stout Street
Denver, Colorado 80202 Telephone: 303/837-3883

Region IX

U.S. Department of Labor
Occupational Safety and Health Administration
9470 Federal Building, 450 Golden Gate Avenue
Post Office Box 36017
San Francisco, California 94102 Telephone: 415/556-0584

Region X

U.S. Department of Labor
Occupational Safety and Health Administration
6048 Federal Office Building, 909 First Avenue
Seattle, Washington 98174 Telephone: 206/442-5930

KIND OF FIRE

DECIDE THE CLASS OF FIRE YOU ARE FIGHTING...



...THEN CHECK THE COLUMNS TO THE RIGHT OF THAT CLASS



CLASS A FIRES
USE THESE EXTINGUISHERS

ORDINARY COMBUSTIBLES

- WOOD
- PAPER
- CLOTH
- ETC.



CLASS B FIRES
USE THESE EXTINGUISHERS

FLAMMABLE LIQUIDS, GREASE

- GASOLINE
- PAINTS
- OILS, ETC.



CLASS C FIRES
USE THESE EXTINGUISHERS

ELECTRICAL EQUIPMENT

- MOTORS
- SWITCHES
- ETC.



APPROVED TYPE OF EXTINGUISHER

MATCH UP PROPER EXTINGUISHER WITH CLASS OF FIRE SHOWN AT LEFT

FOAM Solution of Aluminum Sulphate and Bicarbonate of Soda	CARBON DIOXIDE Carbon Dioxide Gas Under Pressure	SODA ACID Bicarbonate of Soda Solution and Sulphuric Acid	PUMP TANK Plain Water	GAS CART- RIDGE Water Ex- pelled by Carbon Dioxide Gas	MULTI- PURPOSE DRY CHEMICAL	ORDINARY DRY CHEMICAL
X	X	X	X	X	X	X
X	X	X	X	X	X	X
X	X	X	X	X	X	X

HOW TO OPERATE

FOAM: Don't Play Stream Into the Burning Liquid. Allow Foam to Fall Lightly on Fire.



CARBON DIOXIDE: Direct Discharge as Close to Fire as Possible. First at Edge of Flames and Gradually Forward and Upward



SODA-ACID, GAS CARTRIDGE: Direct Stream at Base of Flame



PUMP TANK: Place Foot on Footrest and Direct Stream at Base of Flames



DRY CHEMICAL: Direct at the Base of the Flames. In the Case of Class A Fires, Follow Up by Directing the Dry Chemicals at Remaining Material That is Burning

