

ASRCT
SAFETY MANUAL

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F O R E W O R D

Safety is a matter which concerns each and every one of us. Everyone, irrespective of status or type of work, has a part to play in preventing accidents.

It might be thought that high accident rates would exist in ASRCT, because so much of our work is in relatively new and unexplored fields where well-tried and standard procedures have not yet been developed. Fortunately, this has not been the case, although new lines of work are likely to bring new risks for which we must always be prepared. Most of our accidents have arisen from carelessness in familiar situations and in the use of familiar techniques.

It is the duty of every one of us to observe safety practices at all times. The leader of each team, large or small, has a special responsibility in this regard. By personal example and precept, he is able to convince his staff of the vital need to take sensible precautions in their work. He must see that each newcomer to his staff is warned of the hazards to be avoided and is informed of the best ways of dealing with them. This applies particularly in the case of young, inexperienced, and non-technical workers.

This manual describes many of the situations in which hazards may arise and accidents occur, and indicates methods of preventing these mishaps. Its aim is to stimulate that positive thinking about safety which is essential in eliminating accidents in any organization. You are urged to read the various sections carefully, to note any hazards which may not have occurred to you, and to make sure that the precautions recommended are taken in your own work.

Experience has shown that the most common types of accident

in laboratories are cuts and lacerations from glass and injuries to the eye from the splash of chemicals. Senior research workers, and members of the staff, are always prepared to advise on safety measures. These notes on general matters are intended to assist you in the maintenance of safe working conditions.

SOME COMMON HAZARDOUS SUBSTANCES

<u>Substance</u>	<u>Recorded fatal dose</u>	<u>Substance</u>	<u>Recorded fatal dose</u>
Acids conc. }	1 ml or	Cyanides (HCN) }	50 mg
Alkalis ,, }	1 g	F ₂ , HF, etc. }	
Arsenic (As ₂ O ₃)	100 mg	Mercury salts	1 g
Barium salts	800 mg	Heavy metal salts	5 to 10 g
Bromine	120 mg	Phenol	10 g

Benzidine, β -naphthylamine, N-nitrosodimethylamine, β -propiolactone are extremely hazardous.

Maximum concentration for working day exposure

<u>Substance</u>	<u>Gas ppm v/v</u>	<u>Fumes-dust mg/m³</u>	<u>Substance</u>	<u>Gas ppm v/v</u>	<u>Fumes-dust mg/m³</u>
Be Os Pt salts		0.002	Aniline	5	
Nickel carbonyl		0.007	SO ₂	5	
Mercury organics		0.01	NO ₂	5	
Chromates as CrO ₃		0.1	Cyanide as CN	-	5
Mercury		0.1	Dimethyl sulphate		5
Parathion, warfarin		0.1	HCN	10	
Acrolein	0.1		H ₂ S	10	15
Bromine	0.1		Phenol		19
Ozone	0.1		CS ₂	20	60
Nitrobenzene	1		Benzene	25	80
meta-dinitrobenzene		1	NH ₃	50	
DDT		1	Amyl alcohol	100	
H ₂ SO ₄		1			

There are six main hazards in the chemical profession:-

Cuts, splashes and eye accidents

Toxic hazards

Fire

Electrical faults

Explosions

Radiation

CUTS, SPLASHES, EYE ACCIDENTS

The most common laboratory accidents arise from the careless handling of glassware. The following rules must be observed:

- (1) Fire polish the ends of all glass tubing.
- (2) Before inserting glass tubing into corks, rubber tubing or stoppers, make sure that the hole is large enough, and moisten the tubing or stopper. Hold the stopper, etc., between thumb and forefinger, not in the palm of the hand. Grasp the glass tubing close to the end that is to fit into the stopper and push the tubing with an even pressures. Glycerine may be used as a lubricant instead of water. If moderate pressure is to be used, a towel or cloth between hand and glass is a wise precaution.
- (3) Never use force to remove rubber or cork from glass tubing. If necessary, cut the rubber or cork away from the glass.
- (4) Do not try to force an oversize stopper into a flask. A cork may be made smaller and softer by rolling it.

Eye injuries, whether from chemical or mechanical causes, must always be considered as serious. The best treatment for chemical injury to the eye is immediate and prolonged flushing with *water*. Steps should be taken to obtain medical advice for any eye injury. Suitable protective glasses should be worn.

FIRE

Many solvents are fire hazards, e.g., carbon disulphide, ether, benzene, toluene, alcohol, ethyl chloride, methyl chloride, and acetone. All these may cause fire due to the ignition of their vapours. Their physical properties, flash-points and auto-ignition temperatures vary, and must be studied to assess the hazard. For example, contact with a hot surface will ignite carbon

disulphide. Ether vapour is heavier than air and will roll along a bench, or over the edge to the floor, and may be ignited there.

Precautions and prevention

(1) Large quantities of flammable solvents must not be stored in the laboratory. No more than 500 ml of any one flammable solvent should be kept in bottles on laboratory benches or shelves.

(2) Before beginning an experiment, carefully analyse the fire danger likely to be encountered. You should be familiar with the location of the fire extinguishers in the vicinity of your working area and you should also know the proper method of using these extinguishers.

(3) Flammable liquids should not be poured from one vessel to another near an open flame, nor heated near an open flame.

(4) Where an experiment requires the use of some form of heating, careful attention must be paid to the heating medium, the choice of which will depend to a large extent on the temperature required. For further details, consult a suitable laboratory manual such as Vogel's Practical Organic Chemistry.

(5) Low boiling solvents (boiling point less than 100°C at 760 mm Hg) should be heated on a steam bath, or an electrically heated water-bath, or with an electric mantle. Higher boiling solvents should be heated on a bath filled with oil or under reduced pressure on a steam or water-bath. All electrics must be enclosed.

(6) The use of gas flames or hot plates for heating is always attended with the danger of ignition of uncondensed flammable vapours or of the cracking of glassware.

(7) Vapours given off must be efficiently condensed so that

none escapes into the laboratory. Whenever possible, such experiments should be carried out in a fume cupboard.

(8) Adjust the heating, so that liquid does not accumulate in the condenser. If this happens the liquid may be blown from the apparatus and set on fire from a distant flame.

(9) Glass apparatus used for heating flammable liquids must be carefully examined for defects, for example, small cracks, scratches and uneven thickness.

(10) Joints should fit perfectly so that no leaks can occur.

Many other liquids or molten solids are flammable when heated, e.g., nitrobenzene, naphthalene, and the oil used in oil baths.

The risk of serious fire, particularly in those rooms where large quantities of inflammable materials are stored, should never be underestimated. 'No Smoking' signs, displayed wherever fire danger is great, must always be obeyed.

The majority of fires in laboratories or workshops are small and do not constitute serious hazards if dealt with properly. However, if even a small fire occurs in a building that has been left unattended, there is a grave risk that the building may be completely destroyed. For this reason, it is essential that gas burners should not be left burning overnight; a Bunsen burner 'burning back' will readily ignite its rubber tubing. Electrical appliances also should be left in a safe condition overnight.

Do not carry lighted pieces of paper or tapers around laboratories or buildings. Matches are convenient and cheap.

The possibility of explosion must always be kept in mind when the risk of fire is present. For example, not only fire

but explosion also may result if a mixture of inflammable material with air is ignited in a confined space. The inflammable material may take the form of a gas, a vapour, finely divided droplets, or a finely ground dust, such as coal or flour. Metallic powders - for example, zinc, iron, magnesium, and aluminium - can also be dangerously inflammable. Preventive measures include cleanliness, good ventilation, segregation of dusty operations, use of an inert gas, and elimination of sources of ignition.

Fire risks with solvents

The flash points of some frequently used solvents are given on pages 8-10. Solvents with flash points below normal room temperatures are dangerously inflammable.

To reduce fire hazards, store only the minimum quantity of solvents, and use tins instead of bottles for storage. Inspect your stocks regularly with a view to reducing them.

If it is essential to hold more than 2 litres of any solvent, arrange for a suitable storage cabinet to be made so that it is not necessary to keep the stock on shelves.

When transferring solvents from one container to another, make sure that both vessels are earthed effectively.

Keep solvent containers sealed when not in use. Store them in cool places, out of direct sunlight and well away from possible sources of ignition.

Operations involving the heating of solvents should be carried out in a fume cupboard and by means of a steam or electrically-heated water bath. Solvent vapours, being heavier than air, tend to accumulate in sinks, drains, and ducts, and at points close to the floor. They do not readily diffuse into the air and may flow to sources of ignition many yards away; cases

have been recorded of a vapour flowing a distance of as much as 30 ft and being ignited. This is a common cause of fires when solvents are being distilled. The hazard may be eliminated by employing an air-tight seal between the condenser and the receiver and by venting the latter to a safe point outside the building.

Common dangerous substances

The 'Maximum allowable concentration' is the maximum atmospheric concentration to which persons may be exposed for an eight-hour working day without injury to health.

The 'Flash point' is the lowest temperature at which a liquid gives off sufficient vapour to form an inflammable mixture of vapour and air immediately above the surface.

Organic substances

	Maximum allowable concentration (ppm)	Flash point (°C)	Lower explosive limit (% vol. in air)
acetic acid	10	42	4.0
acetic anhydride	5	53	
acetone	500	-18	2.2
acetylene			2.5
aniline	5	71	
benzene	25	-11	1.4
carbon disulphide	10	-30	1.0
carbon tetrachloride	25		
chlorobenzene	75	29	
chloroform	100		
cresol	5	81	
dimethyl sulphate	1		

Organic substances

	Maximum allowable concentration (ppm)	Flash point (°C)	Lower explosive limit (% vol. in air)
dioxane	100	12	
ether	400	-45	1.7
ethyl alcohol	1000	12	3.3
ethylene			3.0
formaldehyde	5		
kerosene		38 to 74	1.1
methyl alcohol	100	11	6.0
methyl bromide	20		13.5
methyl chloride	100		1.2
nitrobenzene	1	92	
petrol (octane)	500	-44	1.3
phenol	5	79	
phosgene	1		
tetrachlorethane	5		
tolucne	100	4	1.3
trichlorethylene	100		
xylene	100	17	1.0

Inorganic substances

	Maximum allowable concentration (mg/m ³)
antimony	0.5
ammonia	70
arsenic	0.5
bromine	0.7
cadmium	0.1

Inorganic substances

	Maximum allowable concentration (mg/m ³)
carbon monoxide	60
chlorine	3
chromic acid and chromates (as CrO ₃)	0.1
fluorine	0.2
hydrogen chloride	7
hydrogen cyanide	11
hydrogen fluoride	1.6
hydrogen peroxide	1.4
hydrogen sulphide	30
iodine	1
lead compounds (as lead)	0.15
manganese compounds	2
mercury	0.1
nitrogen dioxide ('nitrous fumes')	9
ozone	0.2
phosphorus trichloride	3
sulphur dioxide	13
sulphuric acid	1
vanadium	0.1
zinc oxide	10

Electrical fires

Most electrical fires are caused by intense local heating due to a fault in, or failure of, a component in an electrical installation or equipment. The sparks which can occur when a switch is opened or closed, or at the commutator of a motor, generally represent a negligible hazard except where explosive

materials are present. If your work involves any such risks, check with your safety officer that the wiring system of the building and the equipment itself satisfies the requirements for such situations. Also guard against the accumulation of static electrical charges by eliminating unnecessary friction and by installing adequate earthing arrangements.

Standard electrical appliances, properly installed and connected by wiring of adequate capacity, represent a small fire risk in themselves. They should, however, be so placed that a fire cannot be started by radiant heat from them, or by direct contact with some part which becomes hot when an appliance is in use.

By far the most serious hazards come from experimental equipment, temporary hook-ups, and devices which are not subject to prior inspection and approved by an electrical authority. If you are not conversant with the wiring rules and regulations, have your equipment checked by a qualified electrician. All electrical equipment should be protected by fuses or thermal circuit breakers of appropriate rating, so that excessive current cannot pass, and it should be placed well clear of inflammable materials and of the main switch, so that in the event of a fire occurring it will not spread and the power can be switched off immediately.

The preferred method of dealing with a fire in electrical equipment is to spray it with a jet of carbon dioxide from a CO₂ extinguisher.

Fires to clothing

There are two circumstances to consider:

(1) What is the best thing to do if your own clothing catches fire? If large areas of clothing are involved, any

impulse to run should be resisted at all costs. The last piece of advice needs qualification. Many laboratories are fitted with special showers, the location of which you should know. If you are reasonably close to one of these, the obvious thing is to move smartly and place yourself under the spray that they are capable of providing. If, however, you are not near one of these showers and there is no one in the vicinity to help you, the best thing to do is promptly to lie on the floor and roll over and over in an attempt to smother the flames.

(2) What is the best way of assisting a person whose clothing is alight? Prompt action is all-important; there may be only a few seconds in which to act. After that, it may be too late to prevent fatal burns. If you are near one of the special showers, you should force the victim under the spray of water as quickly as possible. If, however, you are in a laboratory where no shower is available, two important points should be kept in mind:

(a) Since flames fly upwards, it is imperative that a person whose clothing is alight be forced into a prone position immediately. This is to prevent flames reaching the eyes and entering the respiratory passages.

(b) The second point is that the flames must somehow be smothered. Do not use a fire extinguisher. This is dangerous because the extinguishing material may be strongly acid or extremely cold. Even if these dangers did not exist, precious seconds are likely to be lost searching for an extinguisher. Flames must be extinguished by a rolling action or better still by a blanket. Since the latter will, in all probability, be more than three (3) seconds away, probably the best thing to use is one's coat. This must be closely and swiftly applied to the

burning material and in such a way that one does not set one's own clothing afire.

IN A LABORATORY WHERE MUCH SOLVENT IS USED AN ABSORBENT BLANKET IS A GOOD INVESTMENT.

Procedure in case of fire

Give the alarm.

Turn off gas, electricity. Close windows.

Immediately evacuate all personnel from the building.

Summon the fire brigade, if the fire continues to spread.

If the building is threatened, use fire hoses. Attach the canvas hose to the millcock and run out to full length before turning on the water.

Where the only way of escape is through smoke and fumes, stoop as low as possible to take advantage of cooler and cleaner air near floor level. If possible, breathe through wetted cloth.

If a person's clothing is alight roll him on the floor to prevent his hair catching fire, and smother the flames with coats, towels, or blankets.

Apply first-aid treatment and arrange for conveyance of casualties to hospital if necessary.

Report the fire so that the extinguishers are replaced as soon as possible.

When handling explosive, or potentially explosive, materials the following general precautions should be observed:

- (1) If possible, avoid handling the material in a dry state.
- (2) Hard tools must not be used; wood or soft metals, such

as aluminium or brass must be employed.

(3) Avoid friction and blows.

(4) Do not store in bottles fitted with glass stoppers or screw caps.

(5) Small quantities only should be used.

(6) The materials must not be heated with oxidants, or with compounds which are easily oxidised, or are themselves flammable.

(7) Suitable precautions, such as the use of screens, face-shields, goggles, neck wrappings and gloves, must be taken.

Certain compounds while harmless in themselves, can easily become explosive under certain conditions: examples are readily called to mind, but it must not be overlooked that liquid air or liquid oxygen with any organic matter, even the lint left from a cotton cloth after "cleaning" a piece of apparatus becomes explosive.

The following 18 atomic groupings are associated with the possibility of explosion:

Acetylide	$-C \equiv C - \text{metal}$	Nitrate	$-O - NO_2$
Amine oxide	$> \overset{+}{N} - \bar{O}$	Nitrite	$-O - NO$
Azide	$-N = \overset{+}{N} = \bar{N}$	Nitro	$-NO_2$
Chlorate	$-ClO_3$	Nitroso	$-NO$
Diazo	$-N = N -$	Ozonide	$\begin{array}{c} -O-O- \\ \\ O \end{array}$
Diazonium	$\overset{+}{N} \equiv N \bar{X}$	Peracid	$\begin{array}{c} O \\ \\ -C \\ \\ O-O-H \end{array}$
Fulminate	$-O = N = C$	Perchlorate	$-ClO_4$
N-Haloamine	$>N - \text{halogen}$		

Hydroperoxide -0-0-H

Peroxide -0-0-

Hypohalite -0-halogen

TOXIC HAZARDS

Hazards by ingestion

Hazards by ingestion arise as soon as there is a departure from clean habits. Persons who drink water from a beaker, who do not wash on leaving the laboratory, who eat in the laboratory, who smoke cigarettes while handling toxic chemicals, all run a risk of ingesting toxic materials.

Inhalation

Materials used or produced in the laboratory which may be present in toxic concentration in the air must be considered: solvents; gases evolved from or used in a reaction. If in any way hazardous, they must be used or produced under conditions of exhaust ventilation in a fume cupboard.

A wide range of solvents is used in the laboratory; many are hazardous because of the very properties that make them valuable as solvents—their ability to dissolve things, their low boiling point, high vapour pressure and low surface tension. A common solvent with a toxic hazard is benzene. It is absorbed by inhalation, but as it is a fat solvent, it is also readily absorbed through the skin. Its main effect is as a chronic poison, that is, one absorbed in small quantities over a long period of time. Its effects are on the blood, and blood-forming organs. The chlorinated hydrocarbon solvents have been called safe because they are not flammable. This is very misguided. Chloroform and carbon tetrachloride are common laboratory solvents, and they can have a chronic effect on the liver and

kidneys. Carbon disulphide is respected for its fire and explosion risks, but is it as widely known as a solvent with chronic toxicity?

Because of these hazards, solvents and most other chemicals should never be pipetted by mouth, but by using a rubber suction bulb.

Mercury is another material with vapour hazard. Its toxicity has been realized in industry, but far too little regard has been paid to it in laboratories, especially constant-temperature laboratories. As with the solvents, the main hazard is from chronic, insidious poisoning, from small amounts inhaled over a long period of time. If spilled mercury is not immediately cleaned up, it will break down into smaller and smaller globules until it can penetrate into the pores of wooden tables and concrete floors. Once there it will persistently saturate the air with poisonous vapours.

Laboratories where mercury is handled must be adequately ventilated, but there are some points in the techniques of handling mercury which should be understood. All containers of mercury should be stoppered or covered, but if this is not possible the mercury surface should be covered with a layer of water. Filtering devices for cleaning mercury should be used in a fume cupboard. Transfer of mercury should involve as little agitation of the surface as possible, and if it is a lengthy procedure it should be done in a fume cupboard. Any process which involves the heating of mercury should be done with extra care—again in a fume cupboard. Spillage over heated areas, such as oven tops for example, must be avoided.

Mercury should always be handled over trays, preferably with a water layer to catch any spillage.

Gases.— The commonest of all is perhaps hydrogen sulphide. Fortunately for those carrying out routine qualitative analysis, it is not a cumulative poison, but many people do not know that high concentrations have no smell, a fact believed to be due to paralysis of the olfactory nerves. Sulphur dioxide is another commonly used gas with poisonous, irritant properties. How many chemists have considered the toxic properties of ozone? Most organic research laboratories have an ozonizer, and ozone is produced by sources of ultraviolet light, and by spectrophotometer lamps. Because of its effects as a lung irritant, the limit set as a maximum acceptable concentration is very low, 0.1 parts per million.

The hazards from vapour, fume or gas must be recognized, the method of handling and the conditions under which they are used or produced modified accordingly.

Skin absorption, chemical burns and dermatitis

(a) A classic example of absorption through the skin occurs with aniline. Aniline and related substances are very fat-soluble and so pass rapidly through the skin— it usually results from splashing on the skin, which is not immediately washed away with water. Thus, immediate washing is very important. There is a case on record in 1950 when four babies died, due to nappies marked with aniline dyes, which were used unwashed.

The more severe cases of aniline poisoning result from a failure to remove contaminated clothing and wash the affected skin, which means that the aniline remains in fairly intimate contact with the skin for some time and allows for maximum absorption. Most laboratory workers would take care to wash off immediately small spillages of concentrated acid, and many are now wearing rubber or p.v.c. gloves.

(b) *Chemical burns*.—Experience has shown it to be important to wear goggles to prevent splashing in the eye when handling concentrated acids, alkalis and ammonia. In addition to the substances generally accepted as corrosive, equal care must be exercised in handling such materials as glacial acetic acid, chloroacetic acid, chlorosulphonic acid, sulphonyl chloride, phosphorus chlorides and thionyl chloride. When handling these materials, rubber or p.v.c. gloves and goggles or face-shield should be worn, but even with this protection special care must be taken with HF which causes penetrating and painful burns.

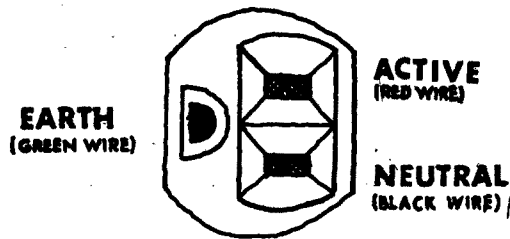
The solvents—fat solvents—can have an effect on the skin, causing it to dry and crack. Each crack is a break in the natural protective layer of the skin, and a means of entry for other chemicals and infection. Apart from these physical effects, burning and drying of the skin, there is the more insidious risk of dermatitis.

(c) *Dermatitis*.—May be of two types. (1) Primary irritants which act immediately on contact and irritate the skin. This action may be due to their acidity, alkalinity, or ability to dissolve the fat from the skin or by drying the skin. These materials upset the skin of all persons on first exposure provided they are present in sufficient concentration and exposure is long enough. (2) In contrast, some chemicals, e.g., many amino compounds, cause contact dermatitis. The first exposures may be harmless and very little effect may be seen. However, if exposure is continued or repeated even in small amounts, perhaps after the lapse of a number of days, dermatitis develops because the first exposure sensitized the skin.

ELECTRICAL FAULTS

Use of the 220-V power line

Power is supplied to the laboratories by the usual outlets (see figure). For safety, one contact is connected to earth. The other two contacts are intended to carry the power:



One power contact (the active wire) delivers 220 volts with respect to earth while the other (the neutral wire) is at earth potential. Unfortunately, the convention as to which wire is active is seldom observed in practice and it is essential to treat both power wires as dangerous. When connecting equipment to the power line or operating equipment with which you are unfamiliar, you should observe the following precautions:

(1) Always switch off the power at the power point and remove the plug before connecting or making alterations to equipment.

(2) Always use 3-core cable when connecting equipment to the power line and make sure the earth lead is securely screwed down in contact with bare metal of the frame of the equipment. American equipment is often of the 2-wire type without a separate earth wire. For safety, it is necessary to run a separate wire to earth from the frame of such equipment. Continental European equipment often has colour coding different from local

practice. Don't make the frame live by mistake.

(3) If a power switch is included in the equipment, it should be of the double-pole type. A single-pole switch is dangerous because it may simply open the neutral line and leave the active line connected to the equipment. In this condition, the equipment is potentially "live".

(4) It is unwise to touch equipment which you suspect to be "live". Muscular action may cause you to cling to it.

Secure a competent technician.

(5) If you go to the assistance of a person who has received an electric shock, make sure the power is disconnected first or insulate your hands.

Precautions against fire or explosion of electrical origin

(1) Never bring a naked flame near a lead accumulator which is being charged. The gases evolved will explode violently and sulphuric acid will be splattered around.

(2) Sparks and heat generated by (a) short-circuited condensers of large size, (b) short-circuited batteries and (c) exposed relay contacts, are a potential source of fires. Always make sure there is sufficient resistance present to limit the current in cases (a) and (b). A condenser placed across the relay contacts will usually eliminate chatter and sparking in case (c).

(3) Use CO_2 or dry powder extinguishers on electrical fires; CCl_4 (CTC) may only be used in a well-ventilated room or in an open area and where the evolution of corrosive acid will do no harm. Do NOT use soda-acid or foam extinguishers on electrical fires.

Electrical hazards

In ordinary usage there is a risk of electric shock in the handling of electrical equipment supplied or operating at voltages above 'extra low' voltage, i.e. voltage above 32 A.C. or 110 D.C. The chief hazard arises from the fact that one of the mains supply wires is connected to ground, or 'earthed', and in many situations, therefore, an electrical circuit through the body can be completed by touching 'live' equipment at only one point.

To minimize this danger it is standard practice for the exposed metal of any electrical equipment operating above these voltages to be earthed through the green conductor of a three-core flexible cord (unless it is definitely known that the equipment is double insulated in accordance with recognized standards). This ensures that the equipment itself will not become live should the insulation fail within it or a live conductor come adrift and touch the casing. Instead the fault current will flow harmlessly to earth, blow the fuse (or open the circuit breaker), and so cut off the supply.

Earthing can, of course, be relied on to give protection only if there is good electrical continuity from the frame of the equipment right through to the installation earthing system. It is imperative therefore that the correct type of cord fittings be used and that all connections be correctly made.

In many fittings and equipment the earth terminal is marked with the letter 'E' or the word 'Earth' and the green conductor of the flexible cord is the earthing conductor. The possibility of changing the earthing conductor from green to white is under discussion in places.

RADIATION

This most insidious hazard may not concern you today but don't neglect making yourself familiar with at least the rudiments of Radiation Safety for the future.

If at any time you work with materials emitting radiation, then become thoroughly trained. Radiation doesn't jolt like .880 ammonia, but its invisible effects can be disastrous.

WORKSHOP HAZARDS

Good housekeeping

Good housekeeping, including the maintenance of clean and tidy conditions, is very important in preventing accidents.

To facilitate rapid evacuation of staff in an emergency, passageways and exit doors should be kept clear.

Electricity, gas, water, etc., should be turned off after use.

Staff should familiarize themselves with the positions of the main gas and water valves and the electrical switchboard for the particular rooms in which they work.

Floors should be of a non-slip type. Only non-slip polishes should be used on linoleum or vinyl tile floors.

Floor coverings should be replaced as soon as they begin to wear seriously, before they become a stumbling or tripping hazard.

Spillages on benches or on floors should be cleaned up immediately.

Any material spilled on the outside of bottles should be

wiped or rinsed off immediately.

Sufficient suitable containers should be provided for rubbish and broken glassware, and should be emptied regularly.

There should be separate covered containers for waste substances such as inflammable solvents immiscible with water as well as for corrosive materials; the contents should be disposed of regularly.

Care of the eyes

Eye injuries can occur very easily under a wide variety of circumstances, many of which are outlined subsequently in this booklet. Safety glasses should be worn for work involving any possible danger to the eyes. Overall chemical goggles should be worn where a risk of chemical splash exists. Various types of safety glasses are available, depending on the degree of protection required - glasses with plain lenses, overall goggles designed to fit over spectacles, or complete face shields (see illustrations below). Ordinary optical spectacles offer only a limited degree of protection and are not shatter-proof.



If, despite precautions, a foreign body reaches the eye, it should be removed by means of a piece of blotting-paper cut to a point or a moist wisp of cotton wool. Any foreign body which

cannot be removed in this way may be more serious than it appears and should be attended to by a doctor. Tweezers or other instruments should never be used on an eye.

Safe opening of bottles

Care is necessary in such a common operation as opening bottles. If any risk is suspected the operation should be carried out in a fume cupboard, the bottle covered with a cloth, and the stopper pointed away from the face and the body. When stored in bottles some substances - for example, aluminium chloride - generate gas by interaction with moisture, and a considerable pressure may build up.

Bottles containing very volatile compounds such as ammonia or ether may develop high pressures during hot weather and should be cooled with tap water before being opened in a fume cupboard. Bottles of inflammable solvents should not be opened close to naked light.

Some explosive chemicals - for example, benzoyl peroxide - are usually kept moist to reduce their sensitivity to detonation. Screw-top jars containing such compounds have, nevertheless, been known to explode while being opened, probably owing to the presence of an accumulation of dry compound in the screw threads of the cap.

Safe use of gas cylinders

The most frequently used form of pressure apparatus is the gas cylinder. Although fatal accidents caused by the misuse of gas cylinders are not uncommon, the hazards associated with them are often overlooked, owing no doubt to their familiarity.

A suitable form of cylinder trolley should be used for moving cylinders. Cylinders should not be dropped or allowed to

strike against each other. They should be stored upright, out of direct sunlight, in a cool position under cover. To avoid confusion, full cylinders should be stored apart from empty ones. There should be three separate areas - for oxygen, for inflammable gases, and for poisonous gases. This precaution will reduce the hazard should a fire occur.

In use the cylinders should be properly secured in an upright position and away from any source of heat. Any movement of a cylinder could upset apparatus to which it was attached. Furthermore, if an unsecured cylinder were to fall over, the outlet valve could be broken off. If the contents were inflammable or toxic, the consequences of their escaping into the room could be serious. In addition, the sudden escape of gas from an unanchored cylinder could propel it as a dangerous missile.

The contents of gas cylinders should always be withdrawn through a pressure regulator. Before a pressure regulator is attached to a cylinder the outlet valve should be opened slightly and then closed, to confirm that it is in working order. The regulator should not be relied upon to isolate apparatus from the cylinder, and the cylinder valve should be closed when the cylinder is not in use. Cylinder valves should always be opened slowly. Regulators should always be removed before cylinders are moved. The cylinder valve should be tightly closed before the regulator is removed.

When a cylinder is not in use, the outlet valve should be kept tightly closed even though the cylinder is considered empty. When a cylinder has been exhausted, the outlet valve should be closed and the protecting cap screwed securely into position. The cylinder should then be returned to the store.

Only the special wrenches and tools provided by the manu-

facturer should be used on cylinder valves. Valve keys should be removed from cylinders when the cylinders are in use.

It is not advisable to run experiments overnight which use compressed inflammable gases supplied from cylinders, as small leaks at connections may be accidentally ignited and burn for hours unnoticed, until they start a major fire. Cylinders of poisonous gases should not be left in a laboratory overnight unless special provision has been made to prevent the accumulation of dangerous concentrations of gas caused by leakage.

Objects should not be rested on cylinders, especially if welding or cutting is in progress.

Valves on oxygen and fluorine cylinders must never be greased or oiled.

Acetylene is a highly inflammable gas. Moreover, even if not mixed with air or oxygen it can explode violently under some conditions. Especial care must therefore be taken to avoid subjecting cylinders of acetylene to heating or to mechanical impact, and to repair any leaking connections immediately they are noticed. If an acetylene cylinder becomes hot for any reason, all personnel must be cleared from the area without delay and the cylinder must be cooled immediately and with great caution - for example, using a fire hose from a distance. Once it is cold, the cylinder should be moved carefully to an open space and its contents discharged gradually until it is quite empty.

Working overhead

No attempt should be made to work aloft without secure platforms or slings. Standing on service pipes to work at otherwise inaccessible points is dangerous.

While work is in progress on iron grating flooring, the

lower ground level should be cordoned off, and notices posted, to prevent injury to people below from the accidental dropping of tools and equipment. If gratings are removed during the progress of the work, any gaps must be securely guarded and the gratings replaced immediately the work has been completed.

Fire (pages 4-15)

Electrical hazards (page 21)

Procedure in case of accident

Call out for assistance.

Release the victim from the source of shock by the quickest possible means (e.g. turn off switch, pull out plug, or use a coat or rope to pull the patient away). Make sure you do not receive a shock yourself.

Immediately apply artificial respiration (described on pages 31-35). A few seconds lost in releasing the victim and beginning artificial respiration could mean the difference between life and death.

If nobody is nearby, continue with artificial respiration till somebody comes. Do not leave the patient merely to summon assistance.

Treat any burns.

Specific workshop hazards

Specific hazards encountered in workshops are mainly due to moving machinery and sharp-pointed and heavy metal objects. Such hazards may be grouped as follows:

Pinching hazards.—These occur wherever two mechanical parts approach so close to each other that fingers or other parts of the body may be crushed. Examples are dies and rivetters.

Shearing hazards.—These occur when two objects pass close enough together to shear a part of the body. Examples are shears, guillotines, grinding wheels, and reciprocating parts.

Running-in hazards.—These occur where two objects are in contact and are running in together - for example, belts and sheaves, chains and sprockets, gears in mesh, rolls, ropes and pulleys, cables and drums, wheels and tracks.

Tangling hazards.—These occur where objects such as moving drills, reamers, shafts, chucks, cutters, keys and spindles have corners, teeth, or rough surfaces upon which clothing or parts of the body may be caught.

Cutting hazards.—These are associated with swarf, metal trimmings, splinters, glass, nails, saws, worn or sharp hand tools, jagged edges, or raw stock.

Precautions include eliminating the hazard in the original design of the particular machine or, if this is not possible, guarding or enclosing the hazard, maintaining good housekeeping, careful control of manual movements, and correct training of staff.

Switches

Before using a machine with which you are not familiar, always make sure you know how to switch it off. Test the switches by starting and stopping the machine motor.

Make yourself familiar with the location of all 'Stop' switches and safety switches in the workshop.

Electrical equipment with damaged switches, covers, or cases should never be used. The defects should be reported immediately and danger tags displayed until the repairs have been completed.

Refrigeration equipment

Where refrigeration work is carried out, the working space should be well lighted and should be adequately ventilated to ensure rapid dispersal of toxic gases and fumes. The maximum allowable concentrations of the common refrigerants (sulphur dioxide, ammonia, methyl chloride, and Freon 12) are 10, 100, 1000, and 2000 ppm respectively. Methyl chloride, although of relatively low toxicity, may reach dangerous concentrations before its presence is noticed.

Heat-treatment salt baths

Heat-treatment baths involve six special hazards. These are listed below, with the appropriate precautions:

Cyanide case-hardening baths.—Attend to cleanliness. Keep antidote near salt bath.

Tempering salt bath nitrate/nitrite mixtures.—Organic matter must never be put into molten nitrate/nitrite baths. Articles heated in cyanide must never be placed in a nitrate/nitrite bath until free from cyanide.

Putting articles into a salt bath.—Any article put into a salt bath must first be heated to at least 300°C, thus ensuring that it is free of oil, grease, and water.

Quenching from a salt bath.—When quenching in water, use goggles, as hot salt may be splashed. There is a risk of fire when quenching in oil.

Remelting a salt bath.—When remelting a bath, always apply heat from the top, otherwise molten salt may be formed at high pressure and may spray out at the edge of the solid crust.

Water dripping from a roof into a molten salt bath.—This hazard should never be overlooked. In large workshops without a

ceiling between the main roof and the working area, careful attention should be paid to the watertightness of the roof.

Dangerous workshop practices

Leaving chuck keys in chucks.

Leaving chucks not fully secured to spindles.

Removing chips or swarf while work is in motion.

General safety measures in workshops

Observe the particular safety regulations in force in your workshop.

Do not operate any machine unless you are qualified and authorized to do so.

If you are not sure how a particular operation should be performed, ask your workshop supervisor.

Make sure you are familiar with the hazards of any operation on which you are engaged.

Before using a machine, make sure that all guards and safety devices are in position and in working order.

Report defective guards, safety devices, or machinery immediately.

Wear the appropriate type of safety goggles wherever their use is called for - in particular, when using grinding and welding equipment and for all salt bath work. Keep goggles clean and smear-free.

Do not wear dangerous clothing - for example, dangling neckties, frayed or torn trouser or sleeve cuffs, trailing bootlaces, or worn boots.

If your hair is long, protect it by a suitable cap. Wear

safety boots or shoes - they are cheaper and give greater protection than ordinary footwear, yet are of equal appearance.

Use a respirator or mask when dressing wheels dry.

When you are carrying a length of pipe, wood, or similar material go slowly and beware of obstructions both behind and in front of you.

Avoid placing lengths of pipe or wood so that they project from the end of a bench; or if placed, see that they are conspicuously marked.

Report any skin irritation caused by oil or other substance used on the job to the workshop supervisor, so that remedial measures may be taken.

Keep machine working spaces clear of obstruction.

Clean up spillage of oil, grease, or water immediately.

Remove swarf by means of a rake or brush, not by hand.

Place it in bins, not on the floor.

Use compressed air only for the purpose for which it is provided. Never direct a stream of compressed air towards your own body or that of another person.

ARTIFICIAL RESPIRATION

Treatment for electric shock

Switch off the power.

Free the patient from contact with any live conductors, using only dry non-conducting materials, e.g. rubber gloves, boards, rope, broom handle. Do not use metal or any damp material.

If the patient is not breathing, begin artificial respiration immediately. Do not stop at this juncture to loosen the patient's clothing.

Holger Nielsen method

(1) Quickly place the patient in the prone position and check the airways for any obstructions.

(2) Extend the head backwards with the chin hooked over the back of one hand which is superimposed on the other hand. A second operator lying at the side of the patient should hold the head in position by placing one arm under the armpit of the patient so that the hand grips the chin, while the other hand holds the head steady in the extended position.

(3) Kneel on one knee about six inches from and directly in front of the patient's head, with the heel of the other foot at the side of the patient's elbow.

(4) Place the hands on the back of the patient so that the fingers project beyond the shoulder-blades. The tips of the thumbs should be touching and positioned over the backbone of the patient with the fingers spread comfortably outwards and downwards. The wrists should be about one inch below an imaginary line joining the patient's armpits. This is the starting position.

(5) Keep the outstretched arms straight, and rock forwards until they are almost vertical. The time taken for this movement is approximately two seconds.



(6) Rock backwards on the knees, removing the hands from the patient's back and grasping the patient's arms just above the elbows. The time taken for this movement is approximately one second.

(7) Lift the patient's arms with a slightly forward pull until resistance is felt at the patient's shoulders.

The operator's arms are kept straight and the lift is obtained by straightening the body. This movement produces a forced inspiration and occupies approximately two seconds.

(8) Lower the arms and return the hands to the shoulder-blades ready to repeat the movements described above. The time taken for this movement is approximately one second.

The movements described above should be repeated in a steady, regular rhythm between 10 and 12 times per minute.

Silvester-Brosch method

(1) The patient is quickly placed on his back and the airways checked for any obstruction. Some possible ways of ensuring clear air passages are:

The release of tight-fitting clothing, especially the collar.

The examination of the mouth and the removal with the forefinger of any dentures, froth, mucus, sand, or weed.

(2) The shoulders are elevated by using any available material such as sand or clothing.



(3) The operator kneels at the head of the patient and extends the patient's neck.

(4) The patient's arms are then grasped at the wrists and pressed against the chest of the patient by the operator leaning forwards.

(5) The arms are lifted and extended backwards as far as possible.

(6) The arms are returned to the chest and the cycle is continued at the rate of 10-12 movements per minute.

To prevent the patient's head from rotating, either a second operator should hold the head in the extended position or the operator may rest the forward foot against the patient's head.

Direct mouth-to-mouth method

Apply resuscitation without delay.

Place victim on back.

To clean out any foreign matter, turn victim's head to side, force mouth open, wipe out throat and mouth with fingers or cloth. Remove false teeth.

Take up a kneeling position on victim's left, beside his head.

Method for adults

Insert thumb of your left hand between victim's teeth. Pull the jaw upward into a jutting-out position so that the head is tilted backward. This will prevent the base of the tongue from blocking the air passageway. Close nostrils with your



right hand. Take a deep breath and place your mouth tightly over victim's mouth and your own thumb. Blow forcefully enough to make victim's chest rise. Take your mouth off to let him exhale passively. Repeat inflations every three or four seconds. Listen for the victim exhaling air when you remove your mouth. If there is no flow of air, re-check the head and jaw position and continue artificial respiration. If there is still no flow of air, turn the victim on his side and give him several sharp blows between the shoulder blades. Clean out any foreign matter, dislodged in this way, from the victim's mouth.

FIRST AID

This is not a complete set of directions. It merely indicates some major points.

First-aid implies second aid

Do not become too ambitious. One acts only to help the patient and then the doctor when he arrives.

Be fair to the doctor

The doctor you are likely to consult in an emergency should be warned of your possible hazards, which may lie outside his normal practice. This preparedness may be vital.

Injections

Must be left strictly to medical practitioner. Sterile solutions and syringes should be kept handy.

Glass wounds

Do not probe—leave this to the doctor.

Bleeding

Pressure bandages are very much better than tourniquets,

especially in the layman's hands.

Burns—heat

Minor ones—use a protective cream, e.g., brulidine. Major ones—sterile dressings only and prevent infection; treat patient generally for shock.

Splashes—chemical burns

Wash copiously with water. Use soap, etc., as removal demands.

Eyes

Wash continuously with changing water only for at least 15 minutes. Plastic reservoir-type eye rinses are recommended. Always be sure to see the doctor. Avoid bicarbonates.

Artificial respiration (pages 31-35)

Poisons swallowed

Oral antidotes used with emesis (vomiting). If no antidote is known, use milk (canned), or "universal" antidote, or (even) just water. Do not give an unconscious patient oral antidotes.

Emesis

Avoid it with corrosive materials, and certain liquids (kerosene) which may thus enter the windpipe. Avoid also if the patient is in convulsions.

Emesis may be difficult to induce with salt, mustard, etc. Tickling the throat is better, but it also fails with some people.

Acid or alkali swallowed

Most important to dilute these quickly (about a hundred-fold) with water. Neutralizing antidote should be taken when

ready, but not waited for. Avoid carbonates.

Biological infections

If implanted in a laboratory accident, wash quickly and report immediately to the doctor.

Antidotes

A handy antidote table in the lab may be of great assistance. Premeasure in single doses, keep in individual small containers. Label layout is important for quick finding of antidotes.

Safety showers

May be inexpensively devised with an overhead plastic container and gravity fed nozzle, suitably hung.

Accidents must be reported. Anyone who has suffered an injury should attend the First Aid Centre to learn of any further treatment that may be necessary.

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