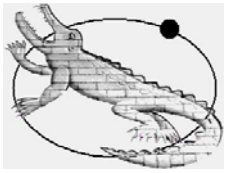


A Code of Practice for the Use of Substances and Preparations in the Department of Physics

(Includes Chemical Substances, Biological Samples and Items that Generate Airborne Contaminants Such as Dusts)

Contents

1. Scope and definitions
2. Registration of substances that are prohibited for certain uses
3. Core legal requirements
4. The main hazards associated with substances
    - 4.1 The scope of the term ‘substance’
    - 4.2 How substances gain entry to the body
        - 4.2.1 Inhalation
        - 4.2.2 Absorption through the skin
        - 4.2.3 Ingestion
        - 4.2.4 Target organs
    - 4.3 Harmful effects – chemical
        - 4.3.1 Corrosives
        - 4.3.2 Irritants
        - 4.3.3 Toxicity
        - 4.3.4 Harmful substances
        - 4.3.5 Sensitisers
        - 4.3.6 Carcinogens
        - 4.3.7 Mutagens and substances toxic to reproduction
        - 4.3.8 Substances causing harm to the environment
    - 4.4 Harmful effects – physical
        - 4.4.1 Flammability
        - 4.4.2 Explosive qualities
        - 4.4.3 Oxidisers
    - 4.5 Substances presenting biological hazards
5 Undertaking risk assessments for work involving substances
    - 5.1 The basic framework
    - 5.2 Sources of Information
        - 5.2.1 Manufacturers’ labelling
        - 5.2.2 A route map for the Material Safety Data Sheet (MSDS).
        - 5.2.3 Other sources
6 Controlling the risks
    - 6.1 The standard hierarchy of control measures
    - 6.2 Carcinogens, mutagens and substances toxic to reproduction
    - 6.3 Other substances with exposure limits or particular problems
        - 6.3.1 Workplace exposure limits (WELs)
        - 6.3.2 Asthmagens
    - 6.4 Health surveillance
    - 6.5 Maintenance of control measures
    - 6.6 Information, training and supervision
7 Storage arrangements
8 Spillages and other emergencies
9 Disposal arrangements
Appendices
    - A Risk phrases and hazard symbols
    - B Safety phrases
    - C Storage chart
    - D Risk assessment form
    - E Waste disposal form
    - F Substances that must not go into the drains

1. Scope And Definitions

This code of practice sets out methods of controlling the hazards presented by:

- chemical substances, and preparations,
- biological samples,
- items that generate dust, fume, vapours or droplets.

It includes the handling, use, storage and discharge of these substances.

In doing so it has integrated the requirements of legislation dealing with the following:

Control of Substances Hazardous to Health (better known as COSHH)
Dangerous substances and explosives atmospheres regulations
Control of lead at work
Environment Act and its subsidiary legislation

This Code is in accordance with the University Hazardous Substances Policy.

There is an explicit legal requirement to undertake risk assessment for work with substances that are hazardous to health or are potentially dangerous.

These substances are defined as having one or more of the following attributes:

- Classification as very toxic, toxic, harmful, corrosive, sensitising or irritant,
- Having a workplace exposure limit,
- Carcinogenic, mutagenic or toxic to reproduction,
- A biological agent, disease-causing agent or derived toxins, cell cultures, human endoparasites,
- Dusts of any kind when present in substantial concentrations in air,
- Any substance that could by its release cause a state of oxygen deficiency,
- Any flammable substance, including gases,
- Any substance that is hazardous because it is kept at low temperature,
- Explosives and oxidisers.

The objective is to reduce the risk so far as is reasonably practicable and to comply with any exposure limits or other explicit legal requirements (see, in particular, the section on carcinogens and substances toxic to reproduction).

Suitable arrangements must also be made for storage, disposal and for reasonably foreseeable emergencies.

Certain activities cannot take place without official notification to the Health and Safety Executive. These include work with most biological materials and if you are planning to work in this field you should contact the Safety Officer or the Department Biological Safety Officer at the first possible opportunity to ensure that notification is made in good time.

This code does NOT include the handling of radioactive substances, which are covered in the Code of Practice for Ionising Radiation. Likewise, it does not include asbestos.

2. Registration Of Substances That Are Prohibited For Certain Uses

The Department must maintain a register of 'prohibited' substances, i.e. those whose use is restricted by the Environment Agency, Home Office, or the COSHH Regulations. The register needs to be kept up to date and records of the maximum amounts held will normally be required.

Prohibited substances include those listed in Schedules to the following legislation:

COSHH schedule 2 http://www.opsi.gov.uk/si/si2002/20022677.htm#sch2
Anti-terrorism, Crime and Security Act 2001 – schedule 5,
http://www.opsi.gov.uk/acts/acts2001/ukpga_20010024_en_18#sch5
Environmental Protection (Prescribed Process and Substances) Regulations 1991 – Schedule 5 for discharge to water (also known as the 'Red' list)
http://www.opsi.gov.uk/si/si1991/Uksi_19910472_en_6.htm
Poisons Act 1972 – Schedule 1 poisons as amended, see http://www.admin.cam.ac.uk/cam-only/offices/safety/chemical/poisons.html

3. Core Legal Requirements

Risk assessments that address the hazards presented by substances MUST be carried out before work begins. The significant findings of the risk assessment MUST be recorded in writing (this can be electronic). The people likely to be affected by the work activity MUST be informed of the results of the risk assessment.

The risk assessment MUST be reviewed whenever there is evidence to suggest that it is no longer valid, or there has been a significant change in the work activity to which it relates. All assessments should be checked annually and must be reviewed after a maximum of three years.

Significant events that should trigger review include:

Changes to the process,
Changes to the engineering controls,
Relocation of a laboratory,
Changes of workers,
The results of monitoring of the workplace or its personnel,
New information on health risks,
Technological developments.

People working with hazardous substances MUST be competent to do so without creating undue risks to themselves, or others. If they are undergoing training they must be working under the CLOSE supervision of a competent person. Persons must be provided with suitable and sufficient information, instruction, training and supervision. Records must be kept of training.

The reduction of risk must follow the hierarchy of control:

Elimination
Substitution by something less hazardous
Reduction of quantities to a minimum
Use of a substance in a safer form
Enclosure of the process
Partial enclosure of the process and use of local exhaust ventilation
Good general ventilation
Sound systems of work that minimise exposure
Reducing the numbers of people potentially exposed
Personal protective equipment
Hygiene measures

Arrangements must be devised and recorded to deal with reasonably foreseeable emergencies, including spillages.

Where necessary the workplace/personnel should be monitored to ensure that exposure is kept below any relevant exposure limit.

For carcinogens, mutagens, substances toxic to reproduction, sensitisers and nanoparticles, health records must be kept.

4. The Main Hazards Associated With Substances

4.1 Scope of the term 'substance'

The term 'substance' is used very widely. Some examples are:

- A single chemical bought from a supplier, such as hydrochloric acid, chlorine or
- ethanol,
- A preparation purchased or mixed for a specific purpose, such as toilet cleaner or an etch,
- The products of a reaction,
- Substances released into the atmosphere during a process – for example fume from welding, dust from grinding or blasting,
- Degradation products, e.g. from burning polymers,
- Disease-causing organisms such as campylobacter.

The hazard from a substance or preparation is defined as its intrinsic ability to do you harm. This could include (and this is not an exhaustive list) its:

- toxicity,
- temperature,
- flammability,
- reactivity, and
- asphyxiant properties.

We must also address its ability to harm the environment.

How much harm it will **actually** do to **health** is a complex function of its physical form, the route of entry to the body, the quantity that is involved, its intrinsic properties and the response of the body. Never forget that you are in more danger standing knee deep in a completely non-toxic dust than you are if you have the most toxic substance in the world sealed in a robust container in your pocket.

Substances can also be **dangerous** – they may be very reactive, so may present a considerable hazard in taking part in runaway reactions or even explosions. They may be highly flammable, and pose a threat in the form of fire.

4.2 How substances gain entry to the body

4.2.1 Inhalation

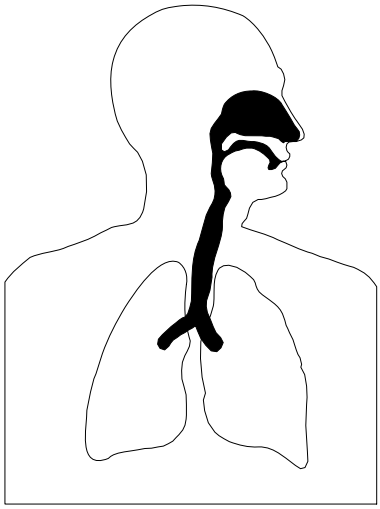


Figure 1: Where the particles go:

Nasopharyngeal region: here air velocity is high, particles of approximate diameters 5-30 μm are deposited

Trachea and bronchial region: air velocity is slowing, particles 1-5 μm are deposited

Alveolar region: air velocity here is minimal and particles are deposited largely by diffusion. Gases and vapours and particles typically 2 μm diameter or less reach this region. Fortunately a high proportion of sub-micron particles are breathed out before they get the chance to be absorbed.

One major route of entry to the body is by inhalation. We pass more than 10 cubic metres of air through our lungs daily when we are at rest, and the throughput can go up by more than a factor of ten during vigorous exercise.

Anything in the air in a physical form that can be inhaled is likely to be drawn into our bodies. How far the contaminant gets depends largely on the aerodynamic size of its particles. This is slightly different from their geometric size, and depends on their shape – in particular, fibres can reach much further into the respiratory system than their maximum dimension would suggest. Particles greater than around 100 μm aerodynamic diameter are unlikely to be inhaled, as they fall out of the air very quickly. Particles below this size are readily inhaled, and their fate depends on a number of factors. Figure 1 shows, in schematic form, the likely fate of inhaled particles.

Insoluble particles deposited in the nasal passages tend to provoke sneezing, which expels them. The medium-sized particles are trapped by a moving ‘carpet’ of mucus that lines the airways. This ‘carpet’ is propelled by hairs, and will sweep the particles to the throat, where they are coughed out or swallowed.

The smallest particles reach the alveoli, where they either stay suspended in the air (and have a good chance of being exhaled) or are deposited and dealt with by large cells called macrophages. The macrophages attempt to engulf and destroy foreign material. Substances such as silica and asbestos

damage the macrophages, causing an inflammatory reaction in the alveoli – a type of scarring known as lung fibrosis. This scarring can impair lung function. Some of these deposits can form carcinomas. Indigestible matter is removed from the lung via the blood stream or the lymph system, and may sometimes be found years later in the lymph nodes that drain the lung.

Soluble substances are readily absorbed at any point in the respiratory tract, and may cause a local reaction, such as excessive mucus secretion. From there they enter the bloodstream, and are free to travel to their target organ – the organ that is most vulnerable to their harmful effects. Many inhaled pollutants can cause damage to DNA, and hence eventually lead to the development of cancer. The lung may develop an immune response to some substances, leading to an allergic form of asthma.

4.2.2 Absorption through the skin

A second major route of entry is by absorption through the skin or outer surface of the body. The surface of our skin acts as a reasonable barrier under most circumstances, but it can be breached in several ways – abrasions, cuts, and chemical attack. A corrosive substance may break through the barrier. The eyeball is vulnerable as a route of entry by surface absorption.

If a person is exposed to a substance by inhalation that is also readily absorbed through the skin, the total dose received may be well in excess of that estimated since the doses are additive.

Washing away a chemical contaminant using an organic solvent will generally increase the harm done to the casualty, because the solvent aids the absorption of the substance – always read the first aid advice and follow it carefully. If in doubt, use nothing other than water to wash off a chemical.

4.2.3 Ingestion

While you would not normally deliberately ingest a substance hazardous to health, it is easy to do so accidentally. Workers who handle lead sheeting have become poisoned by the lead through failing to wash their hands before meal breaks and/or before smoking and drinking. Another means of accidental ingestion is through poor housekeeping, allowing benches, etc, to become contaminated.

Substances that have been inhaled and are expelled via the mucus lining of the airways are also frequently ingested.

4.2.4 Target organs

Once a substance is in the bloodstream – by whatever route of entry, it then has the opportunity to be circulated and lodge in whatever organ is susceptible. While the body will attempt to eliminate unwanted chemicals from the body, damage may be done to one or more organs before this has taken place.

4.3 Harmful effects – chemical

In going through the list of harmful effects below, you should not forget that many substances have more than one property. For example, hydrofluoric acid is both corrosive **and** toxic and, in considering exposure to HF, its toxicity is generally the more important property. It is also customary only to label a substance or preparation with the 'worst' two properties and this can lead to your overlooking further significant properties unless you read the data sheet carefully.

4.3.1 Corrosives

These substances attack human tissue on contact, burning it or otherwise killing it. Common examples are mineral acids, alkalis and phenols. They present a hazard through direct contact with the skin or eyes. If the fumes or mists are inhaled they may damage the lungs or mucous membranes, and if they are ingested they may damage the gastro-intestinal system. Corrosive liquids pose a very significant hazard because liquids splash easily. Therefore the use of protective eyewear is essential when handling them. Corrosive gases and vapours are a hazard to the whole body.

4.3.2 Irritants

Irritants are substances that cause significant inflammation of the skin persisting for more than 24 hours, or cause defatting. Irritation of the eyes by substances classified as irritants can cause permanent damage.

A simple reaction to an irritant is local and is not extreme except where exposure has been excessive. However some irritants provoke an allergic response and can give rise to occupational asthma or dermatitis. These substances are also sometimes classified as 'harmful'. Examples include solder fume (due to the rosin in the flux), flour dust and pollens.

4.3.3 Toxicity

Toxicity is an ability to cause death, disease or an interference with the normal bodily mechanisms. A very large number of substances have this ability, and the danger depends on the quantity that is encountered, and in what form.

Very toxic substances are those where a small dose (e.g. by ingestion <25 mg kg^{-1} body weight) has been shown to kill laboratory animals. Examples include thallium compounds, arsine, beryllium and cyanides.

Toxic compounds can also kill, but require higher doses. Examples include ammonia, chlorine and carbon monoxide.

In recognition of the fact that many substances are also toxic if encountered in repeated very small doses, the substance may be labelled to indicate this.

The toxin may have both short and long term effects, and may attack a target organ remote from the site of entry. For example, ethanol has temporary effects on the central nervous system, but also has a chronic and sometimes fatal effect on the liver. It can also cause cancers of the throat. The response of one individual may be significantly different from another and there may be important age or sex-related differences. For example, exposure to lead is particularly harmful to women who are pregnant due to the harm that it can do to the unborn child.

4.3.4 Harmful substances

Harmful substances are those that can kill in very large doses by ingestion, inhalation or skin absorption. This class also contains substances that can cause **irreversible** effects, possibly after a single exposure, or serious damage after prolonged or repeated exposure. Read the small print in this class with **great** care.

4.3.5 Sensitising substances

Some substances are known to cause asthma. The precise pattern of exposure leading to the disease is not known, nor is it possible to predict whether any particular individual is likely to succumb. Two types of asthma can be identified – a type that is a direct result of exposure to an irritant, and a type that is an allergic reaction to a substance that has been inhaled. Agents of the former type include sulphur dioxide, chlorine and fire smoke. Examples of the latter type include stainless steel welding fume, isocyanates, the rosin in solder fume and latex.

Asthmagens and substances that can cause dermatitis through skin contact are labelled with the 'harmful' symbol. Watch for the risk phrase R42 (may cause sensitisation by inhalation), and R43 (by skin contact).

4.3.6 Carcinogens


Carcinogens are substances that can induce a cancer. The organ affected may not be the same as the organ that was exposed, and the quantity required cannot be defined. It does appear that for many carcinogens, many small doses can do more harm than one large dose. The latent period between exposure and the development of the disease can be very long (40 years or more).

These substances are placed in one of three categories:
Category 1 – known human carcinogens. Examples are benzene, arsenic, chromium (VI) compounds and asbestos. For these, the causal link between exposure and cancer is proven.
Category 2 – suspected human carcinogens. Examples are cadmium compounds, beryllium and its compounds
Category 3 – evidence for the production of cancers is available from animal studies, but a human link is not proved.

The legal status is that categories 1 and 2 are strictly controlled, and are labelled 'toxic' with the skull and crossbones label, and the risk phrase is likely to be R45 or R49. Advice on control is included in section 6.2, and the list of known category 1 and 2 substances is available via a link from the Code of Practice webpage.

Category 3 carcinogens are labelled 'harmful', and are not subject to such strict controls – but it would be wise to treat the category 3 compounds as potential carcinogens.

4.3.7 Mutagens and substances toxic to reproduction


This category is concerned with:
Loss of fertility
Harm to the unborn child
Hereditable genetic damage
They are categorised according to a similar classification as carcinogens, with categories 1 and 2 labelled 'toxic', and category 3 labelled 'harmful'. Risk phrases to look for are R46, R60, R61, R62, R63, R64.
The list accessed from Appendix C contains the known substances in categories 1 and 2.

4.3.8 Substances causing harm to the environment


This category contains the substances that can cause harm to wildlife, the ozone layer, watercourses and soil organisms. Watch for R50, R51, R52, R53, R54, R55, R56, R57, R58 and R59.

4.4 Harmful effects – physical

4.4.1 Flammability


These are classified on the basis of 'flashpoint', which is the temperature at which the vapour, offered a source of ignition, burns briefly and then extinguishes.

Extremely flammable substances are those that have a flashpoint below 0°C, and a boiling point below 35°C. Examples are acetylene, butane, diethyl ether.

Highly flammable solids are those that readily catch fire after brief contact with a source of ignition and continue to burn when the source is removed. Highly flammable liquids have a flash point below 21°C, but are not extremely flammable. Examples include ethyl acetate, isopropyl alcohol.

Flammable substances have a flashpoint greater than 21°C but less than 55°C – they do not get a flame symbol assigned to them. Examples include acetic acid, turpentine, xylene.

4.4.2 Explosive qualities

The explosive symbol is given to those substances and preparations that have been tested and found to be explosive according to Annex V of Directive 67/548/EEC. Examples would be picric acid, PETN, certain organic peroxides.

Many substances that do not carry the explosive symbol are nevertheless potentially explosive. Virtually any dust formed from a substance that can oxidise, e.g. custard powder, flour, metal dusts, can, when mixed with air in the right proportion, form an explosive atmosphere. Gaseous and volatile flammable substances, such as methane, propane, ether and hydrogen, can also form explosive atmospheres.

4.4.3 Oxidising

This category includes substances that can cause fire even when not in contact with combustible materials (e.g. some organic peroxides), substances that can cause fire or enhance the risk of fire when in contact with combustible material, such as inorganic

peroxides. The category also includes substances that can become explosive when mixed with combustible materials, for example some chlorates. Note that the use of the word oxidizing in this classification is not precisely the same as the chemist's definition.

4.5 Substances presenting biological hazards

These include viruses, bacteria, and parasites. Problems can arise from contact with animals or animal products, excavation work, fungi or fungal spores, water droplets, human tissue.

Groups of people whose jobs might expose them to particular biological hazards include:

- maintenance personnel or gardeners, who may have to tackle items that have moulds or fungi growing on them, or may encounter items contaminated by rats or other disease vectors,
- first aiders, who may come into contact with human tissue and blood.
- persons whose experiments use human and animal material (such as blood).

Moulds and fungi, especially from decaying organic material, can give rise to breathing problems in susceptible persons. Material contaminated by animals such as rats can give rise to diseases, such as Weil's disease. Soil can contain tetanus and other infections (tetanus is endemic in this region). Human tissue and blood can be the carriers of hepatitis, tuberculosis, HIV (rare), and various other conditions. Animal tissue can also give rise to disease. Food products can become contaminated with salmonella, campylobacter, etc, and can be the source of gastroenteritis.

While the COSHH Regulations do concern themselves with the requirements for work that includes biological hazards, the University Guidance which outlines the legal requirements for licensing, notification and control measures is in separate documents. See the University Safety Office website.

5 Undertaking Risk Assessments for Work Involving Substances

5.1 The basic framework

Risk assessment is **mandatory**. There is a suggested form in Appendix D. The logical sequence is as follows

- Investigate the properties of the substance and the possible ways in which it may cause harm or present danger,
- Decide what you intend to do with it, and check for any adverse reactions, etc, and/or the properties of any reaction or degradation products.
- Assess who might be exposed (e.g. you, the cleaners, undergraduates, members of the public, women of childbearing age, etc – identify any that are at greater risk).
- Assess the likelihood and severity of the harm or danger, which is a function of the quantity, its properties, the way in which it is to be used and, for a substance hazardous to health, the length of time a person may be exposed to it, their susceptibility and the frequency of exposure.

Then, for a substance hazardous to health:	***For a substance that is potentially dangerous:***
• Decide how you will prevent that exposure, or mitigate it. In particular, take strict precautions if you find that it has an exposure limit, is a carcinogen, mutagen or is toxic to reproduction. • Look ahead to the possibility of spillage, fire, accidental exposure, disposal, • Plan your controls, protective measures, health surveillance, etc. See Section 6	• Decide how you will prevent fire/explosion by ensuring that the substance is not released, or that a source of ignition is not present when it is released • Look ahead to the possibility of spillage, fire, disposal, • Plan your controls, protective measures, intrinsically safe electrical equipment, gas monitoring as necessary. See Section 6

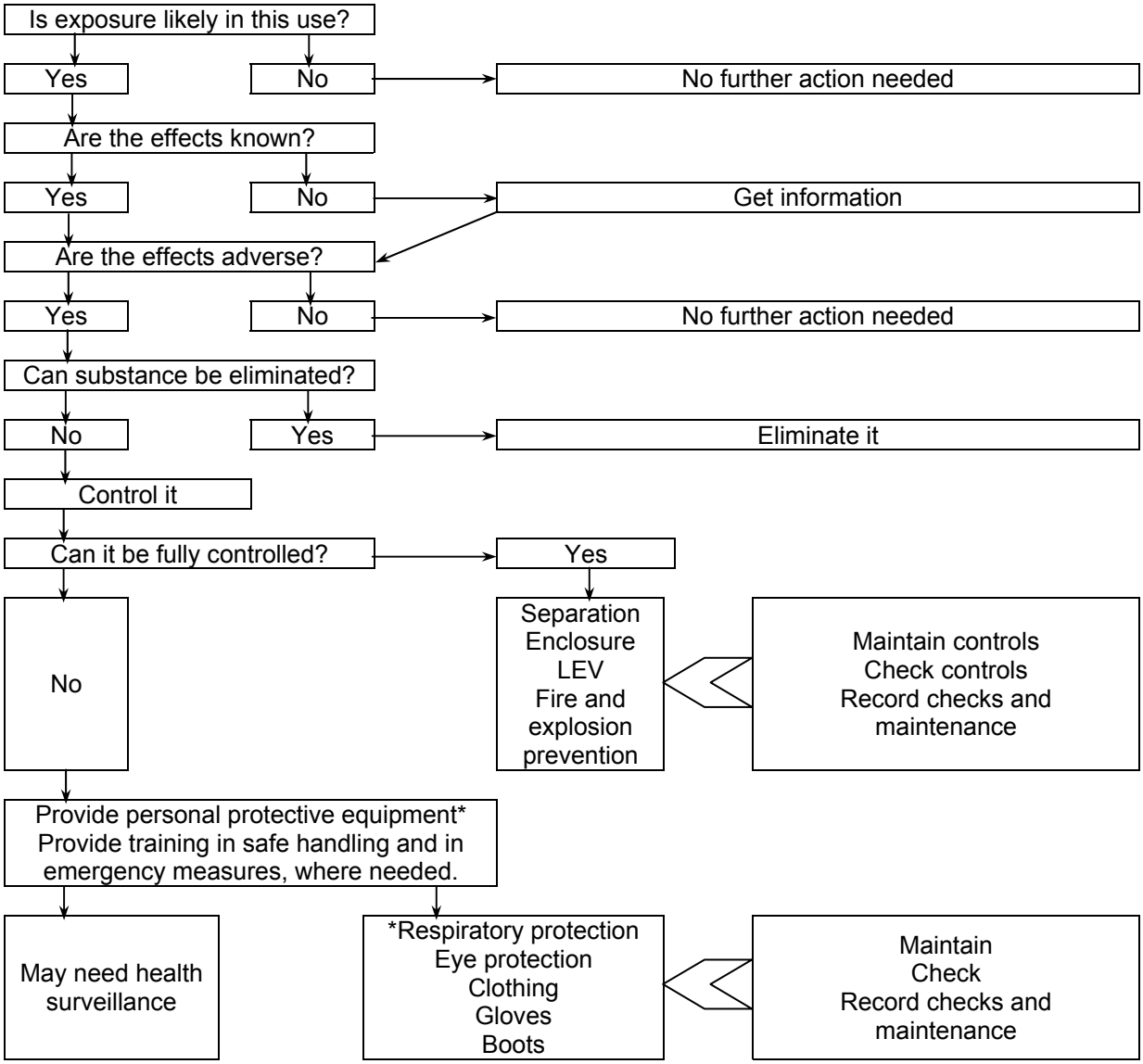
For all substances:

- Ensure that everyone knows about your decisions and the reasons for them (e.g. to wear protective clothing or to use a fume cupboard),
- Make sure that the controls are properly used,
- Record your assessment in writing,

Review the assessment

- If it proves inadequate, which may become apparent as a result of an incident,
- When someone new joins the team,
- If you materially change the process, thus significantly changing the risks,
- At approximately annual intervals, to check that it is still valid.

Figure 2 shows, in flow chart form, the decision making tree for substances that are hazardous to health. For substances that pose a threat of fire or explosion, a similar route should be followed, with a view to eliminating or greatly reducing the probability of fire or explosion.



** Note: PPE (clothing and eye protection) may need to be worn in all circumstances where hazardous substances are used.*

Figure 2: Assessment of a substance that may be hazardous to health or may be dangerous

5.2 Sources of information

5.2.1 Manufacturer's labelling

Since the advent of Regulations requiring manufacturers to supply detailed information regarding the hazards presented by substances to their customers it has been relatively easy to get the information needed to do risk assessments. The hazard warning symbols used in section 4 are used universally with the meanings described. You need to be aware that a substance may not be given the labels for all of its hazardous properties, but only the most significant.

In addition to hazard warning labels, there are 'risk phrases' and 'safety phrases' for substances and preparations. Risk phrases and safety phrases are coded R and S. A complete listing is included in appendices A and B.

5.2.2 A route map through the Material Safety Data Sheet (MSDS)

MSDS's come in a fixed format, as follows:

Section 1: The product name or chemical identification.
Section 2: The composition, possibly with several pseudonyms or common names.
Section 3: The identification of the hazards, e.g. 'Very toxic by inhalation, causes severe burns'.
Section 4: First aid measures.
Section 5: Fire fighting measures.
Section 6: Handling spillages, accidental release.
Section 7: Storage and handling recommendations.
Section 8: Exposure controls/ personal protection.
Section 9: Physical and chemical properties.
Section 10: Stability and reactivity (supplements Section 9).
Section 11: Toxicological information (supplements Section 3).
Section 12: Ecological information.
Section 13: Disposal instructions.
Section 14: Transport information.
Section 15: Regulatory information – any **statutory exposure limits** will appear here, along with the **statutory risk and safety phrases**.
Section 16: Other information.

Most of the information you need is there – all you need to do is read it and use it!

5.2.3 Other sources

Not all substances come with an MSDS, flour and wood are prime examples of those that do not. Further reading and research will be required to establish the hazards and the protective and preventive measures needed.

Advice may be obtained from:

The Chemical Safety specialist – Mr Suresh Mistry, 37010, sm380@phy.cam.ac.uk
The Safety Officer – Jane Blunt, 37397, fjb27@phy.cam.ac.uk

There is some further information in the Library for substances, where an MSDS cannot be obtained:
Sax's Dangerous Properties of Industrial Materials, 03L3-5
Croner's Substances Hazardous to Health 03C4-6

From the Internet (but beware – be discriminating!)

Toxicity data from the USA – Concentrations 'immediately dangerous to life or health':
www.cdc.gov/niosh/idlh/intridl4.html

Gas data:
http://www.airproducts.com/msds/search.asp

6 Controlling The Risks

6.1 The standard hierarchy of control measures

To control the risk from substances, you should follow a standard hierarchy in all cases. More specific details are given in the succeeding sections:

- Replace hazardous substances by less hazardous substances,
- Use it in a safer form (e.g. as tablets rather than powder)
- Limit the quantity that is used to a minimum,

- Limit the number of people potentially exposed to the minimum, and

For substances hazardous to health:	***For substances that are dangerous:***
• For the most hazardous substances, totally contain the process so that access to the substance is not possible, or work in a fume cupboard to minimise exposure. Partial enclosure may be used for certain processes, such as welding and woodwork, • Where this is not possible **and** the substance is of relatively low risk, general ventilation may be adequate. • Minimise the release of dusts, droplets, etc into the air, • To the extent that this does not adequately control the risk of exposure, issue and wear personal protective clothing to ensure the safety of the personnel. This may include clothing, gloves, eye protection, breathing protection (of the **right** type in each case). • For certain substances, health surveillance may be required, • For certain substances, air monitoring may be required, • For certain higher risk activities, the first aid team may need to be notified (certain work with HF and cyanide) before work begins on each occasion,	• Make calculations to determine the potential for the formation of an explosive atmosphere • Reduce the probability of release of the substance, e.g. by making high integrity joints • Control the release of the substance at source, e.g. by the provision of interlocks or shut off valves accessible outside the work room. • Ensure that any release is collected, contained and removed to a safe place or rendered safe • Provide explosion pressure relief and suppression equipment, or provide equipment that can withstand explosion, • Avoid sources of ignition, including electrostatic discharges. This may mean that certain areas are 'zoned' and intrinsically safe electrical equipment is installed, • Segregate incompatible substances • Where necessary, provide audible warning signals to warn that a dangerous substance has been released • Train personnel in the steps to take if an emergency develops.

For all substances:

- Ensure that people are informed, instructed and trained on the nature of the risk and how they are to avoid danger,
- Ensure that people know how to deal with a spillage or release,
- Use labelling to ensure that the substances are easily identifiable.

Air monitoring is likely to be required where a toxic substance that cannot be smelt is present, and may be released without being detected (e.g. carbon monoxide), or where the release of a flammable gas must be detected and stopped (e.g. methane), or where the atmosphere may become asphyxiating. Where such monitors are installed, they must be maintained in good working order, calibrated as necessary, and a notice placed on the laboratory door indicating what action to take should the alarm sound. All personnel in the group and the immediate surroundings must be made aware of the meaning of the alarm and what to do in the event of an emergency.

6.2 Carcinogens, mutagens and substances toxic to reproduction

Carcinogens, mutagens and substances toxic to reproduction require much stricter control, because the effects are insidious and the harm may not become apparent for up to 40 years or so.

Substances that fall into Categories 1 and 2 are subject to strict control. In the following text wherever the word carcinogen is used, it applies equally to mutagens and substances toxic to reproduction.

By law, you must do **all** of the following:

First, replace the carcinogen (etc) with something that is not carcinogenic, if this is feasible, but if not:

1. A register of the use and location of carcinogens should be maintained and updated regularly.

2. Store the materials securely in clearly labelled, closed containers, segregated from other substances. Keep the quantity stored to a minimum. Totally enclose the process and handling systems, unless this is not reasonably practicable,
3. Eating and drinking are prohibited in all lab areas, but particularly in those areas that may be contaminated by carcinogens.
4. If a carcinogenic material is to be transported in a glass container, secondary containment must be used to prevent a spillage if the container is dropped.
5. Use plant, process and systems of work which minimise the generation of, or suppress and contain, spills, leaks, dust, fumes, and vapours of carcinogens,
6. Limit the quantities of a carcinogen at the place of work.

The risk assessment MUST identify

- The type of hazard (e.g. gas, fume, dust etc)
- The route of entry (inhalation, ingestion, skin penetration)
- The level of exposure

It must address the operating instructions and procedures (where applicable), and the maintenance and emergency procedures.

The control measures should involve:

1. Total containment where possible
2. Where not possible, the use of a fume cupboard or high containment efficiency, where practicable. NOTE: A LAMINAR FLOW WET BENCH IS NOT DESIGNED TO CONTAIN FUMES, IT IS DESIGNED TO PROTECT THE SAMPLE. You should NOT handle carcinogens on a standard laminar flow wet bench.
3. Where not practicable, the use of Local Exhaust Ventilation (LEV), e.g. wood dust extraction systems, and Respiratory Protective Equipment (RPE).
4. Labelling glove boxes and fume cupboards that are being used for carcinogenic materials with a warning sign.
5. Keeping the number of people who might be exposed to the carcinogen and the potential time of exposure, to a minimum,
6. The wearing of personal protective equipment.
7. Ensuring that there are adequate washing facilities and that the work place is kept clean and tidy,
8. Ensuring that weighing, transferring, manipulation, etc is done in a way to minimise the generation of dusts, mists, spillages,
9. Ensuring that control measures prevent the spread of contamination from one place to another via gloves, etc.
10. Safe disposal,
11. Good hygiene.

Attention is drawn to section 6.4, Health Surveillance.

6.3 Other substances with statutory exposure limits or particular properties

6.3.2 Workplace Exposure Limits (WELs)

These replace the MEL and OES system. They constitute Statutory exposure limits on the listed substance, and are defined in relation to exposure by inhalation. However be aware that, when the system was introduced, a large number of compounds for which there was insufficient evidence to provide a defendable safe figure were omitted from the list. This includes a large number of **very toxic** substances, so the absence of something from the list does not mean it is safe.

Since so many hazardous substances no longer have a Statutory exposure limit, you should also check the MSDS to see whether the substance has an OSHA PEL, or and ACGIH TLV. There are useful as a guide to toxicity.

If adequate control of exposure to a substance with one of these exposure limits cannot be maintained by engineering means, then respiratory protective equipment may be needed. Refer to the guidance ‘Selection and Use of Respiratory Protective Equipment’ available from the University Safety Office.

6.3.3 Asthmagens

Since there is no way to predict who will be affected, the requirement is to identify the known causal agents and prevent exposure so far as is practicable to prevent ill effects from occurring. Health surveillance is appropriate where asthmagens are in use.

Many asthmagens are substances for which MSDSs are not normally found, e.g. flour, wood dust, animal dander. Further information about asthmagens is available from the HSE webpages: http://www.hse.gov.uk/asthma/index.htm

6.4 Medical surveillance, health surveillance and health records

In certain cases medical surveillance will be advised, to ensure that a substance is not being absorbed, or is not causing an adverse effect.

Health surveillance is appropriate where a substance is known to put people at risk of a medical condition and there are valid techniques for detecting the condition. Examples in this Department include those who work with arsenic.

The decision-making tree on the following page is intended to make it clearer where medical surveillance, health surveillance and health record forms are appropriate.

In the University, medical surveillance and health surveillance are provided by Occupational Health. If your risk assessment indicates a possible exposure to a substance in the above categories, contact them direct, and inform the Safety Officer that you have done so. Records of health surveillance are stored for 40 years after the last entry was made (longer for entries regarding ionising radiation). Health records are generated and stored in the department.

Note the following, from the decision tree:

- Medical surveillance is prescribed if you are undertaking any activity listed in Schedule 2 of COSHH, normally prohibited by law, but for which you have an exemption certificate. An example would be the use of sand for blasting. For the full list of prohibited substances/activities, see http://www.legislation.hmso.gov.uk/si/si2002/20022677.htm
- Where there is the potential for exposure to a carcinogen and certain other substances then health or medical surveillance is required.
- Where exposure is prevented by the use of a fume cupboard (not a laminar flow bench) or by complete enclosure, then a health record is required.
- Health surveillance is appropriate where asthmagens are being used.
- Health surveillance is appropriate where substances that cause severe dermatitis are being used.

Health records must be passed to the Safety Officer at the end of each Academic year. Records relating to individuals must be stored for a minimum of at least 40 years.

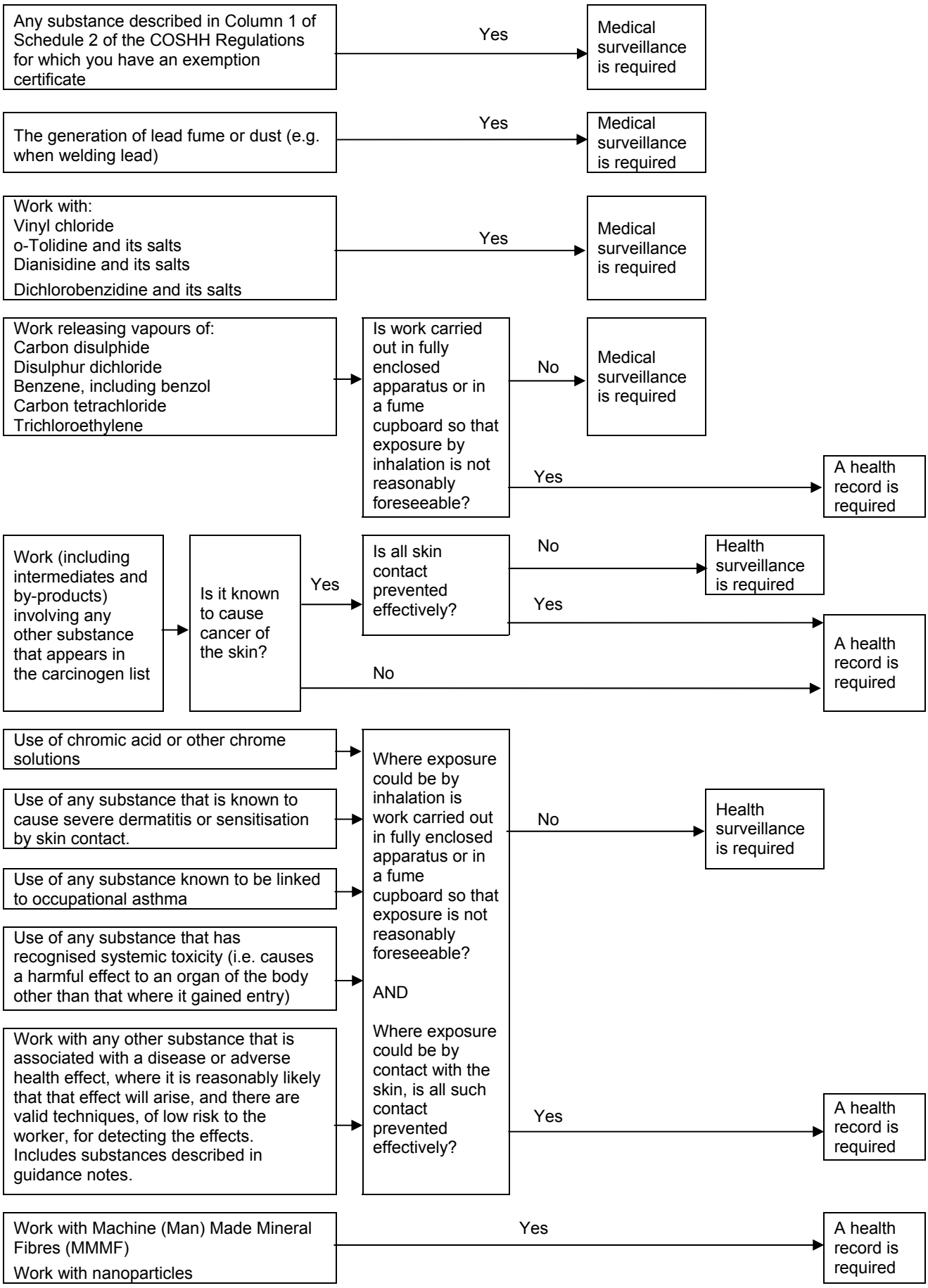


Figure 3 Decision tree for health surveillance

6.6 Maintenance of control measures

All engineering control measures – i.e. fume cupboards, local exhaust ventilation, must be maintained in efficient working order and in clean condition. They must be tested every 14 months as a minimum, or more frequently if specified by the risk assessment. The records of these tests must be retained for at least five years.

All personal protective equipment that is re-used must be examined routinely. Re-usable respiratory equipment must be tested at least once a month. Clothing, such as overalls, must be laundered regularly. Single use masks must not be left lying about and re-used.

6.7 Information, training and supervision

People MUST be shown the risk assessment and be made aware of the safe system of work. They must be competent to undertake the work, or be under supervision to ensure that they do not expose themselves to risk. Records must be kept of any training given.

7 Storage Arrangements

As a general principle, substances which are hazardous to health should be stored in a secure area.

There are several rules regarding segregation because, if containers were to break, the ensuing reactions could be potentially hazardous. Segregation may be either by distance or by fire resisting barriers. Containers of hazardous liquids should be in trays large enough to contain the whole of the contents of the largest single container if they should break or leak. HSE guidelines suggest that the tray should have a capacity of 110% of the contents of the largest container. (Proprietary storage cupboards usually have shelves that are designed to fulfill this purpose, provided that they are put in the right way up).

In a store with racking, care should be taken to avoid storing one material above another with which is it chemically incompatible. The area should be well ventilated. Spills are reasonably foreseeable, and the electrical fittings must be suitable for the atmosphere which is likely to develop. A senior member of staff should be responsible for the store, having suitable qualifications, training and experience. This person should be aware of what is in the store, so that in the event of the emergency services being called, adequate information can be given to them.

Highly flammable liquids (e.g. any container 500 ml or over, full, part full or containing any vapour of a liquid such as acetone, with a flashpoint below 32^{o}C) must be stored in a bin or cupboard which will retain its integrity for at least half and hour in fire, with an adequately sealed door. Wooden cupboards are not adequate. The shelves must incorporate spill trays which will contain 110% of the contents of the largest container on the shelf.

No more than 50 litres of highly flammable liquid (aggregate) may be stored in any work area for reasons of fire protection.

The table in Appendix C summarises the allowable combinations of substances within a store area. Note that it is not possible to produce simple prescriptive rules.

8 Spillages and Other Emergencies

It is necessary to consider what to do if things go wrong, such as a quantity is spilt, or there is a fire. If the consequences could be serious, then it is better to have thought through a plan of action beforehand. Good housekeeping will prevent many spills – e.g. not leaving glass bottles on the floor, not having too much clutter on the bench.

Spillages are usually higher risk events than normal work due to the fact that normal exposure controls tend to fail (e.g. the substance should have been in the fume cupboard but is now on the floor), and the quantities can be much greater than normal work (a whole bottle instead of the 5ml sample!).

Large spillages of substances may be a threat to the University from three sources. There is a strict limit on what we may allow to enter the drainage system, and Anglian Water will take action in the event that we contravene our consent order. Spillages of certain substances are reportable to the HSE. Release of certain items into the atmosphere could bring action from the Environment Agency as they may be a statutory nuisance. Spillages could be a threat to YOU as well.

Spills should be dealt with promptly, and if they are simple you can deal with them yourself. You should have:

- Appropriate first aid facilities, including emergency eye wash
- Washing facilities
- Appropriate chemical spill kits
- Fire-fighting equipment as appropriate
- Warning alarms, as appropriate
- Suitable personal protective equipment to handle the spill.

You will almost certainly need help if any of the following apply:

- Someone is injured,
- The chemical is unknown,
- The substance spilt is mercury,
- There is more than one chemical involved in the spill,
- The spill is of a highly toxic, flammable or reactive substance,
- The spill is in a public place,
- The spill can spread easily, e.g. through a ventilation system,
- You do not know how to clean it up,
- The spill may endanger the environment.

If in any doubt whatsoever, ask for help immediately, from one or more of the following:

- The Chemical Technician, Mr Suresh Mistry, 37010.
- The Safety Officer, Jane Blunt, 37397.

Don't delay – the longer you dither, the further the offending substance will have spread!

The Safety Officer must be told about any significant spillage as soon as possible. We MAY have to report it to sundry authorities and the sooner we get the facts, the better. DON'T DELAY, the Authorities are normally exceedingly displeased if we delay in contacting them.

9 Disposal Arrangements

The user or person ordering the substance is responsible for ensuring that it is disposed of correctly, so that no contamination of the environment occurs. Unfortunately it sometimes happens that a person will leave without having done this, and it then falls to the Research Group to deal with it.

The main route for disposal is the hazardous waste stream. We can be prosecuted for incorrect disposal of waste. The table in Appendix F lists those items that under no circumstances are to be permitted to go down the drain.

Waste to go into the hazardous waste stream must be deposited in the Chemical Waste Store alongside the Link Building. The keys are kept at stores. The waste must be properly labelled showing the contents, and in sound containers. A form must be filled in, see Appendix E, indicating who is disposing of the waste, and the quantities and substances. This form should be photocopied so that one copy stays with the waste and the other copy goes to the Safety Officer.

Note: Biological waste (e.g. blood, tissue, etc) must not go into any of these waste streams, and the Cavendish Laboratory does not, at present, have a disposal route for biological waste. An important part of setting up any project using biological material is planning the waste disposal route.

Appendix A: Risk Phrases

R1		Explosive when dry
R2		Risk of explosion by shock, friction, fire or other sources of ignition
R3		Extreme risk of explosion by shock, friction, fire or other sources of ignition
R4		Forms very sensitive explosive metallic compounds
R5		Heating may cause an explosion
R6		Explosive with or without contact with air
R7		May cause fire
R8		Contact with combustible material may cause fire
R9		Explosive when mixed with combustible material
R10		Flammable
R11		Highly flammable
R12		Extremely flammable
R13		Obsolete phrase, withdrawn
R14		Reacts violently with water
R15		Contact with water liberates extremely flammable gases
R16		Explosive when mixed with oxidizing substances
R17		Spontaneously flammable in air
R18		In use, may form flammable or explosive vapour-air mixture
R19		May form explosive peroxides
R20		Harmful by inhalation
R21		Harmful in contact with skin
R22		Harmful if swallowed
R23		Toxic by inhalation
R24		Toxic in contact with skin
R25		Toxic if swallowed
R26		Very toxic by inhalation
R27		Very toxic in contact with skin
R28		Very toxic if swallowed
R29		Withdrawn (formerly ‘contact with water liberates toxic gas’)
R30		Can become highly flammable in use
R31		Contact with acids liberates toxic gas
R32		Contact with acid liberates very toxic gas
R33		Danger of cumulative effects
R34		Causes burns
R35		Causes severe burns
R36		Irritating to eyes
R37		Irritating to respiratory system
R38		Irritating to skin
R39		Danger of very serious irreversible effects

R40		Limited evidence of a carcinogenic effect (prior to 2002 this signified 'possible risk of irreversible effects')
R41		Risk of serious damage to the eyes
R42		May cause sensitisation by inhalation
R43		May cause sensitisation by skin contact
R44		Risk of explosion if heated under confinement
R45		May cause cancer
R46		May cause heritable genetic damage
R47		[there is no number 47]
R48	 or	Danger of serious damage to health by prolonged exposure
R49		May cause cancer by inhalation
R50		Very toxic to aquatic organisms
R51		Toxic to aquatic organisms
R52		Harmful to aquatic organisms
R53		May cause long-term adverse effects in the aquatic environment
R54		Toxic to flora
R55		Toxic to fauna
R56		Toxic to soil organisms
R57		Toxic to bees
R58		May cause long-term adverse effects in the environment
R59		Dangerous to the ozone layer
R60		May impair fertility
R61		May cause harm to the unborn child
R62		Possible risk of impaired fertility
R63		Possible risk of harm to the unborn child
R64		May cause harm to breastfed babies
R65		Harmful: may cause lung damage if swallowed
R66		Repeated exposure may cause skin dryness or cracking
R67		Vapours may cause drowsiness and dizziness
R68		Possible risk of irreversible effects (prior to 2002 this was signified by R40)

Appendix B: Safety Phrases

S1	Keep locked up	S33	Take precautionary measures against static discharges
S2	Keep out of the reach of children	S35	This material and its container must be disposed of in a safe way
S3	Keep in a cool place	S36	Wear suitable protective clothing
S4	Keep away from living quarters	S37	Wear suitable gloves
S5	Keep contents under ... (there follows the name of a liquid)	S38	In case of insufficient ventilation, wear suitable respiratory equipment
S6	Keep under …... (there follows the name of an inert gas)	S39	Wear eye / face protection
S7	Keep container tightly closed	S40	To clean the floor and all objects contaminated by this material, use .... (there follows suitable cleaning material)
S8	Keep container dry	S41	In case of fire and / or explosion do not breathe fumes
S9	Keep container in a well-ventilated place	S42	During fumigation / spraying wear suitable respiratory equipment
S12	Do not keep the container sealed	S43	In case of fire use ... (there follows the type of fire-fighting equipment to be used.)
S13	Keep away from food, drink and animal foodstuffs	S45	In case of accident or if you feel unwell, seek medical advice immediately (show the label whenever possible.)
S14	Keep away from ... (a list of incompatible materials will follow)	S46	If swallowed, seek medical advice immediately and show this container or label
S15	Keep away from heat	S47	Keep at temperature not exceeding...
S16	Keep away from sources of ignition	S48	To be kept wet with (there follows a material name)
S17	Keep away from combustible material	S49	Keep only in the original container
S18	Handle and open container with care	S50	Do not mix with ...
S20	When using, do not eat or drink	S51	Use only in well ventilated areas
S21	When using do not smoke	S52	Not recommended for interior use on large surface areas
S22	Do not breathe dust	S53	Avoid exposure - obtain special instructions before use
S23	Do not breathe vapour	S56	Dispose of this material and its container at hazardous or special waste collection point
S24	Avoid contact with skin	S57	Use appropriate container to avoid environmental contamination
S25	Avoid contact with eyes	S59	Refer to manufacturer / supplier for information on recovery / recycling
S26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice	S60	This material and its container must be disposed of as hazardous waste
S27	Take off immediately all contaminated clothing	S61	Avoid release to the environment. Refer to special instructions / safety data sheets
S28	After contact with skin, wash immediately with plenty of soap-suds	S62	If swallowed, do not induce vomiting; seek medical advice immediately and show this container or label
S29	Do not empty into drains	S63	In case of accident by inhalation, remove casualty to fresh air and keep at rest
S30	Never add water to this product	S64	If swallowed, rinse mouth with water (only if the person is conscious)

Appendix C: Storage Arrangements

	Hazard Class												
I	Flammable Gases 		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
II	Non-flammable gases	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
III	Highly flammable liquids 	NO	NO		NO	Y	NO	NO	NO	NO	NO	NO	NO
IV	Oxidising substances 	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO
V	Flammable liquids	NO	NO	Y	NO		Y	Y	Y	Y	Y	Y	Y
VI	Flammable solids 	NO	NO	NO	NO	Y		Y	Y	Y	Y	Y	Y
VII	Toxic substances 	NO	NO	NO	NO	Y	Y		Y	Y	Y	Y	Y
VIII	Harmful substances 	NO	NO	NO	NO	Y	Y	Y		Y	Y	Y	Y
IX	Corrosive substances 	NO	NO	NO	NO	Y	Y	Y	Y		Y	Y	Y
X	Irritant substances 	NO	NO	NO	NO	Y	Y	Y	Y	Y		Y	Y
XI	Other combustible substances *	NO	NO	NO	NO	Y	Y	Y	Y	Y	Y		Y
XII	Substances without hazard label	NO	NO	NO	NO	Y	Y	Y	Y	Y	Y	Y	
	To be stored with Hazard Class	**I** 	**II**	**III** 	**IV** 	**V**	**VI** 	**VII** 	**VIII** 	**IX** 	**X** 	**XI**	**XII**

** e.g. paper*

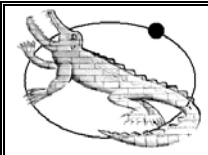
NO *Store separately. Each class must be protected from the others by a compartment which resists fire*

Y *May be stored together, subject to:*

a) Only substances in the same hazard class (e.g. flammable, toxic, corrosive) may be stored in the same vertical stack or in the same vertical plane.
b) Substances which react together to give potentially dangerous consequences must not be stored in the same vertical plane (e.g. sodium hypochlorite and hydrochloric acid)
c) flammable liquids and flammable solids which become molten as a result of fire should be stored in an area designed to prevent the unimpeded spread of the liquid.

Where two or more classes are stored together, the facilities must be to the standard required by the most hazardous class.

Appendix D: Risk Assessment Form



DEPARTMENT OF PHYSICS

CHEMICAL HAZARD RISK ASSESSMENT FORM

Completing this document will help you to fulfill the requirements of the COSHH and DSEAR Regulations relating to written risk assessment

Date:	**Review Date:**	**Assessment Reference:**

Title of Experiment or Procedure

Description of Experiment or Procedure (include reaction conditions, i.e. temperature, pressure, solvent, work up procedures, frequency)

Risks associated with the procedure (what are the hazards and risks**):**

Risk Implications:

Is there any substance used or formed that might give rise to a fire or explosion (e.g. flammable gases/liquids)? **If yes,** how can you ensure that no explosion occurs?	Y/N
Is it reasonably foreseeable that the lower explosive limit will be reached in the event of a leak or spillage? **If yes,** a more detailed risk assessment is required**.**	Y/N
Is there likelihood of copious amounts of gas being released or thermal runaway?	Y/N
Are there any Red List substances used?	Y/N
Can any of the substances be substituted by a less hazardous substance?	Y/N
What could happen if there was a catastrophic failure of the apparatus?	
In the event of an accident, who might be exposed?	

Substances to be used (List ALL substances, including solvents, expected products and by-products):

Substances Used	Approx. quantity	Physical form i.e. dust, vapour, volatile liquid, etc	Hazards i.e. flammable, corrosive, irritant, readily absorbed through skin, etc.	Exposure route e.g. skin, eyes

Are any of the substances listed above R42, R43, R45, R46, R49, R60, R61, R64? Or, are they in the Cambridge List of Carcinogens, etc? (If yes, contact Occupational Health and refer to the University Code of Practice on the safe use of Carcinogens etc.)	Y/N

Control measures to be used:

Containment:		*Personal Protective Equipment:*	
Fume cupboard		Lab coat/Overalls	
Glove box/Isolator		Chemical Apron	
Safety cabinet		Gloves	
Local exhaust ventilation		Eye Protection	
Other (specify)		Respiratory Protective Equipment	
		Other (specify)	

Are any additional controls required? (Consider nearby sources of ignition, formation of explosive atmospheres/mixtures, asphyxiation in confined spaces).

Disposal measures to be used during and after the procedures: (also consider by-products and washings).

Emergency procedures (emphasise any special hazards):

- *Shut Down Procedures*
- *Action in the event of Fire (type of extinguisher):*
- *Action in the event of spillage or uncontrolled release:*
- *Emergency treatment for personnel in the event of contamination, exposure to fumes or other adverse effects:*

Eyes:

Skin:

Inhalation:

Name of assessor:

Signature: **Date:**

Name of co-signatory: (e.g. Supervisor/authorised Deputy)

Signature: **Date:**

Note: This risk assessment should be reviewed at least annually and when there is any significant change in procedure

Appendix E: Waste Disposal Form

UNIVERSITY OF CAMBRIDGE
APPLICATION FOR DISPOSAL OF HAZARDOUS CHEMICALS

Department of Physics

Date: …… Phone: ……

Requested by: …… Room: ……

ITEM NO.	NAME OF CHEMICAL – CONTENTS USE FULL CHEMICAL NAME(S). LIST ALL CONSTITUENTS OF MIXTURES, (OR CONTAMINANTS). **DO NOT USE ABBREVIATIONS OR FORMULAE.**	VOLUME/ WEIGHT OF CONTENTS	VOLUME OF CONTAINER	CONTAINER NUMBER AND TYPE *	HAZARD CATEGORY ¥
1					
2					
3					
4					
5					
6					
7					
8					

* C - Card box
P - Plastic bottle
G - Glass bottle
M - Metal can
B - Plastic bag (double bag)
S - Sharps/Cin bin

¥ H - Harmful
F - Flammable
C - Corrosive
I - Irritant
T - Toxic
O - Oxidizer
E - Explosive
P - Pressurised vessel

Chlorinated and non-chlorinated solvents are disposed of separately and **must not be mixed.**

After completion **one copy** of this form should be left with the chemical waste, in the **Chemical Waste Store** (the key is obtained from Stores).
A **second copy** is to be lodged with the Department Safety Officer, Dr Jane Blunt, room 220, phone 37397.
Further advice on chemical safety issues can be obtained from Mr Suresh Mistry, 37010, or the Safety Officer.

For internal use only March 2002

Appendix F: Substances that must not go into the drains

The following must NEVER be disposed of down the drains.

THEY MUST go to the chemical waste facility:

• Petroleum spirit and other volatile or flammable organic solvents. • Calcium carbide. • Cyanide salts. • Waste liable to form viscous or solid coatings or deposits on or in any part of the sewerage system through which the trade effluent is to pass. • Substances of a nature likely to give rise to fumes or odours injurious to persons working in the sewers through which the trade effluent is to pass. • Halogenated hydrocarbons. • Halogen substituted phenolic compounds. • Thiourea and its derivatives. • Ethidium Bromide	Substances listed in Schedule 1 of the Trade Effluent (Prescribed Processes and Substances) Regulations 1989 Prescribed Substances - Schedule 1, i.e.: o Aldrin (and isomer isodrin) o Atrazine o Azinphos-methyl o Mercury and its compounds o Cadmium and its compounds o Carbon Tetrachloride o DDT o 1,2-Dichloroethane o Dichlorvos o Dieldrin o Endosulfan o Endrin o Fenithrothion o Gamma-hexachlorocyclohexane o Hexachlorobenzene o Hexachlorobutadiene o Malathion o Pentachlorophenol o Polychlorinated Biphenyls o Simazine o Tributyltin compounds o Trichlorobenzene o Trifluralin o Triphenyltin compounds