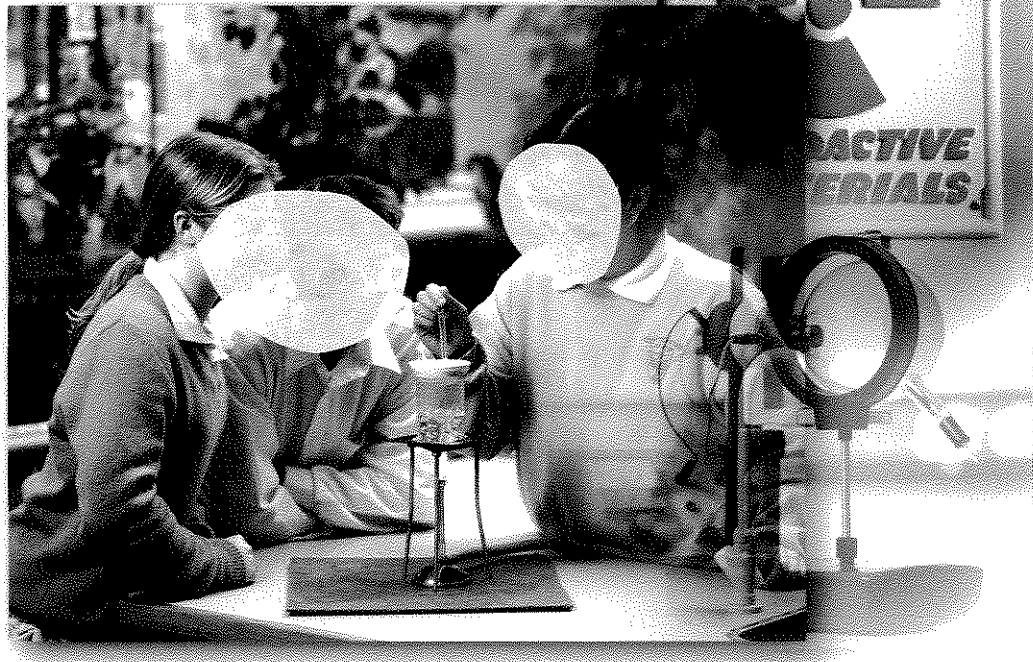


safety and

science

Revised Edition



A Guidance Manual for New Zealand Schools



MINISTRY OF EDUCATION

Te Tāhuhu o te Mātauranga

Learning Media
Wellington

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Edited by Sylvia Hill

Designed by Penny Newman

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Foreword

Safety and Science: A Guidance Manual for New Zealand Schools: Revised Edition replaces the earlier edition distributed to schools in 1998 to provide teachers and boards of trustees with information necessary to establish sound health and safety policies and procedures. Since the first manual was distributed, there have been several legislative changes affecting science teaching in schools.

Safety and Science: A Guidance Manual for New Zealand Schools: Revised Edition interprets and applies the Health and Safety in Employment Act 1992, the Hazardous Substances and New Organisms Act 1996, and other relevant Acts and Regulations within the context of science teaching in New Zealand schools. The manual also refers to other statements with which teachers and boards of trustees should be familiar, especially the National Administration Guidelines.

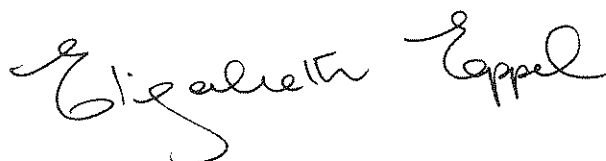
Not only these Regulations, but also the national curriculum statements in science, biology, chemistry, and physics refer to science being taught in a safe and healthy learning environment. To meet these various legislative requirements, teachers of science need to consider how they can eliminate, isolate, or minimise hazards for their students.

Science activities, by their very nature, can be potentially hazardous. The purpose of this manual is to provide teachers with fundamental safety guidelines and information on the more common classroom and laboratory procedures. Advice given here may also be applicable to activities in other subject areas.

For the safety of students and teachers, some activities have been forbidden in schools. Since this manual was first published, a number of serious injuries to students and incidents relating to the inadequate storage of hazardous substances have occurred in schools. In some cases, these have involved forbidden substances being stored on school property and teachers and/or students performing forbidden experiments. Therefore, I must again emphasise, to boards of trustees and principals, the importance of ensuring that all science teachers are familiar with these guidelines and that school policies reflect their intent.

Most of the potential hazards in science that teachers will face are well known, and their effects can be minimised. However, it should not be assumed that the warnings and precautions stated in this manual are all-inclusive. In situations where teachers of science engage in practices that involve risk, additional information may have to be sought in order to prevent unsafe classroom practices.

I am grateful to all those who have contributed their experience and expertise to the development of these guidelines, and to the New Zealand Chemical Industry Council for providing the yellow hazardous substances stickers which accompany this manual.



Elizabeth Eppel
Group Manager
Ministry of Education

1.1 Legislation

The subject of health and safety in New Zealand schools is covered by several Acts and Regulations and by requirements of the Ministry of Education.

The Health and Safety in Employment Act 1992

The purpose of this Act is to promote sound management practices in relation to health and safety in the workplace. The obligation is on the board of trustees, as employer and occupier, to ensure the health and safety of employees and other persons in the workplace. Under section 15 of the Health and Safety in Employment Act 1992, in the case of schools, "other persons" includes students.

The Act is administered by the Occupational Safety and Health Service (OSH) of the Department of Labour.

Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools

The Health and Safety in Employment Act 1992 and the Health and Safety in Employment Regulations 1995 set out the standards to be achieved for health and safety in schools. Other Acts listed in the code of practice also set out requirements for safety in schools.

Compliance with all aspects of the *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*, as well as with these Acts and Regulations, is binding on such schools.

This code of practice was republished in 1998, and copies were sent to schools. It can also be found on the Internet at www.minedu.govt.nz/Property/HealthSafety

Integrated schools and independent schools negotiate their own codes of practice with the Department of Labour because they are not on Crown land, but they may wish to adopt the Ministry of Education code as a guide.

The Hazardous Substances and New Organisms (HSNO) Act 1996

Upon its commencement, the Hazardous Substances and New Organisms (HSNO) Act 1996 will restate and reform the law relating to managing hazardous substances and new organisms to protect the health and safety of people and the environment. As such, it will have ramifications for boards of trustees and teachers.

The HSNO Act 1996 will repeal the Dangerous Goods Act 1974, the Explosives Act 1957, the Pesticides Act 1979, and the Toxic Substances Act 1979. Principals and boards of trustees will be notified of the commencement date of this Act. In the interim, the current legislation will apply.

The Regulations to be promulgated under the Hazardous Substances and New Organisms (HSNO) Act 1996 will:

- define a "hazardous substance";
- classify each substance according to its hazard;
- set acceptable levels of exposure to a hazard;
- provide specifications for each substance's packaging, containers, labelling, data sheets, and disposal;
- state requirements for emergency management systems, such as first aid and firefighting;
- specify the skills and experience required of people handling hazardous substances;
- include information about controls on compressed gases, and the requirements for laboratories handling substances covered by the legislation.

Although the HSNO Act binds schools, section 33 of the Act exempts small-scale chemistry for teaching or scientific investigation if:

- the experiment is carried out in a laboratory that meets the prescribed requirements, and
- the experiment does not create or use a substance for which approval has been applied for and declined under the HSNO Act.

The Ministry of Education will be preparing a code of practice for schools once the HSNO Regulations are made available.

Other Acts

The requirements of a number of other Acts and Regulations should be read together with the *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*. These Acts and Regulations include:

- The Animal Welfare Act 1999
- The Building Act 1991
- The Education Act 1989
- The Electricity Regulations 1993
- The Fire Safety and Evacuation of Buildings Regulations 1992
- The Gas Act 1992
- The Health Act 1956
- The Radiation Protection Act 1965
- The Resource Management Act 1991
- The Wildlife Act 1953.

After implementation of the HSNO Act, the Regulations for the Acts that are repealed by it will continue for existing substances until the end of a transitional period. These Acts are:

- The Dangerous Goods Act 1974
- The Explosives Act 1957
- The Pesticides Act 1979
- The Toxic Substances Act 1979.

Other Regulations and Codes of Practice

A number of other Regulations and codes of practice apply to schools; details of these are given in clause 37 of *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*. The New Zealand Educational Institute and the Post Primary Teachers' Association also have codes of practice for teachers.

Local Authorities

Some local authority by-laws made under the Local Government Act 1974 will also apply to issues of health and safety in school science. As these by-laws may vary from place to place, boards of trustees and teachers should consult their own local authority for advice where necessary.

1.2 Standards

The set of Australian standards AS 2243 *Safety in Laboratories* provides recommendations to promote the safety of people and property in laboratories. Copies may be found in the local library or are available for purchase from:

Standards New Zealand,
Private Bag 2439, Wellington
Telephone: (04) 498 5990, Fax: (04) 498 5994
e-mail: snz@standards.synet.net.nz

Wherever possible, this set of standards quotes the New Zealand standard, for example, NZS 0000 followed by the year of registration. Sometimes it refers to a combined Australian and New Zealand standard, for example, AS/NZS 0000, or, where no equivalent New Zealand standard exists, it gives the Australian standard (AS).

(Note that there are currently some inconsistencies between AS 2243: 10–1993 *Safety in Laboratories – Storage of Chemicals* and the Dangerous Goods Regulations.)

Standards New Zealand also have an Internet website address, containing a catalogue of their available standards, at: www.standards.co.nz

1.3 School Policies and Procedures

Boards of trustees and teachers should be aware that the revised National Education Guidelines (published in *The New Zealand Education Gazette*, 29 November 1999, Number 21) also make reference to health and safety. National Administration Guideline 4(iii) states that:

According to legislation on financial and property matters, each Board of Trustees is also required in particular to comply with the negotiated conditions of any current asset management agreement, and implement a maintenance programme to ensure that the school's buildings and facilities provide a safe, healthy learning environment for students.

National Administration Guideline 5 states that:

Each board of trustees is also required to:

- i provide a safe physical and emotional environment for students;*
- ii comply in full with any legislation currently in force or that may be developed to ensure the safety of students and employees.*

Boards of trustees should have a policy that ensures the health and safety of staff and students involved in science activities (see Appendix 1 on page 71 for a sample policy). This policy should refer to other policies existing within the school, such as those for reporting accidents and for identifying and assessing hazards as required by the *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*.

School staff are required to adopt the safety policies and procedures that have been developed in conjunction with the board of trustees. In turn, boards of trustees are required to provide adequate safety training, facilities, and resources and to allow time for safety procedures to be implemented.

It is important that all science staff accept the agreed policies, practices, and procedures to promote safety. In all science safety situations, common sense should prevail.

Accident Recording, Reporting, and Investigating

There should be a school policy on recording accidents and serious incidents that have affected students and staff. See clause 18.8 of the *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*, page 28.

The recording of accidents that have seriously harmed staff or students is compulsory under section 25(1)(a) of the Health and Safety in Employment Act 1992. To ensure compliance with the National Education Guidelines, schools should have a system for recording this information on a master accident and incident file. Commercial books that are available from a first-aid supplier or safety-equipment company may be adequate for such a register, or the school may choose to use forms supplied by OSH. In the case of staff, such accidents must also be reported to the nearest OSH office as soon as possible and in writing within seven days [section 23(3)]. In addition, OSH recommends that schools have a system for recording minor accidents that have harmed or might have harmed staff.

All electrical accidents should be reported to:

The Ministry of Commerce
Energy Inspection
Office of the Chief Electrical Engineer
PO Box 1473
Wellington
Ph: (04) 472 0030
Fax: (04) 473 2395
24 hour pager: (026) 102 008

Under section 16 of the Electricity Act 1992, in the event of an electrical accident, the above office must be notified immediately and, within two weeks, a completed Electrical Accident and Notification report forwarded to the Ministry of Commerce. Electrical accidents to employees that result in serious harm must also be reported to OSH. In deciding which accidents should be reported to OSH, schools should be aware that section 2(4) of the Health and Safety in Employment Act 1992 defines an incident as "serious harm" when it involves:

- *any of the following conditions that amounts to or results in permanent loss of bodily function, or temporary severe loss of bodily function: respiratory disease, noise-induced hearing loss, neurological disease, cancer, and dermatological disease, communicable disease, musculoskeletal disease, illness caused by exposure to infected material, decompression sickness, poisoning, vision impairment, chemical or hot-metal burn of eye, penetrating wound of eye, bone fracture, laceration, crushing;*
- *amputation of a body part;*
- *burns requiring referral to a specialist registered medical practitioner or specialist doctor's outpatient clinic;*
- *loss of consciousness from lack of oxygen;*
- *loss of consciousness or acute illness requiring treatment by a registered medical practitioner, from absorption, inhalation, or ingestion, of any substance;*
- *any harm that causes the person harmed to be hospitalised for a period of forty-eight hours or more, commencing within seven days of the harm's occurrence.*

Any register of first-aid treatments is required to record:

- the nature of the first-aid treatment given;
- the date on which it was given;
- the name of the person to whom it was given;
- the nature of the injury or illness for which it was given;
- the date, time, and place the accident occurred;
- the cause of the accident;
- whether the injury was referred to a doctor or nurse;
- the name of the person giving the first aid and their first-aid qualifications.

Schools should also have an accident investigation procedure designed to discover underlying causes and to determine whether the situation was caused by or arose from a significant hazard.

Detailed information relating to accidents and investigations can be found in the OSH leaflet *Three Steps to Make Your Business Safer and Healthier*.

Animals in Schools and Animal Ethics

Schools should have an animal ethics policy that meets the legal requirements of the Animal Welfare Act 1999 or any successive legislation. This policy should be checked before any experiments are carried out involving vertebrate animals. However, all animals, vertebrate, invertebrate, living or dead, must be treated with care and respect. Thought needs to be given to the kinds of experiment that students carry out so that unnecessary distress is not caused to any animal. Experiments that inflict cruelty and harm are not acceptable.

To determine whether the approval of an animal ethics committee is needed, ask:

1. Is it an **animal**, as defined by the Animal Welfare Act 1999?
2. Is the animal being **manipulated** for the purposes of teaching; research; experimentation; diagnostic, toxicity, or potency testing; or the production of biological agents?

If the answer to both these questions is “yes”, then ethics committee approval is required. Refer to Section 2 of *Caring for Animals*.

Rather than each school having an animal ethics committee (AEC), it may be possible for a school to be “parented” by the animal ethics committee of a nearby organisation such as a hospital, tertiary educational institution, or research establishment.

A range of simple studies can be carried out without the approval of an animal ethics committee, such as:

- observing behaviour, movement, and locomotion;
- observing body structure and function;
- regular weighing to chart a growth curve;
- observing diet preferences (without restricting the animal’s access to a normal diet);
- using breeding pairs in teaching about reproduction and development;
- using animal care and handling techniques.

However, ethical approval is required if the animal is to be exposed to:

- drugs, including coffee;
- parasites;
- electricity;
- abnormal nutrition;
- deprivation of usual care.
- concentrated chemicals;
- radiation;
- unusual activities;
- surgery;

Further information can be found on page 31.

Education Outside the Classroom

If the board of trustees approves an education outside the classroom (EOTC) activity, the teacher will be considered to be at work while involved in the EOTC activity. The responsibilities of the board of trustees and the teacher are the same as if the teacher and students were on the school site. Even if the work is of a voluntary nature, such as a teacher taking a sports team, the board of trustees has responsibility.

Waivers are not acceptable because they imply that risk has been identified that should have been eliminated, isolated, or minimised.

Further information on requirements for field trips can be found in Appendix 2 on page 71.

Emergency Procedures

A teacher's first duty in times of emergency is to ensure the safety of the students.

Section 6(e) of the Health and Safety in Employment Act 1992 requires employers to develop procedures for dealing with emergencies that may occur while employees are at work. Section 12(a) of this Act requires employers to ensure that employees have been informed about what to do in an emergency. Advice on developing these procedures can be obtained from *Three Steps to Make Your Business Safer and Healthier*. Staff need to be familiar with these policies and procedures. Specific procedures required for the science classroom cover small problems, such as a minor spill or small contained fire, and when emergency services should become involved.

Fire

The Fire Safety and Evacuation of Buildings Regulations 1992 require each school to have a fire evacuation scheme. A properly organised and monitored fire evacuation drill is required once per term. Teachers should be aware of the school's policy and procedures to be followed in the event of a fire. Boards of trustees are responsible for ensuring that the fire safety equipment meets minimum standards.

First Aid

School management is required to provide and maintain appropriate first-aid facilities, appliances, and requisites in accordance with clause 18 of the *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*.

All science rooms should have a first-aid kit within easy access.

The Occupational Safety and Health Service (OSH) suggests that, as an example, two laboratories sharing a preparation room between them should require only one first-aid kit in the preparation room but that a science room or laboratory on its own should have its own first-aid kit. (Refer to page 67 for a recommended list of contents for a first-aid kit.) The Occupational Safety and Health Service (OSH) also recommends that each school have a minimum of two trained first-aiders (or nurses). However, this is at the discretion of the principal.

Hazard Identification and Assessment

Where significant hazards are identified, the board must manage them by applying the hierarchical steps of elimination, isolation, and minimisation. In the leaflet *Three Steps to Make Your Business Safer and Healthier*, OSH identifies these steps.

Eliminate the hazard from the workplace.

If this is not practicable, or the hazard cannot be totally eliminated; then

Isolate employees from the hazard, e.g. guarding machinery; or

If this is not practicable, or the hazard cannot be totally isolated; then

Minimise the likelihood of harm from the hazard, e.g. use safe working practices, provide personal protective clothing and equipment, monitor the environment, and ensure information and training is given.

Boards of trustees are required to take all practicable steps with regard to managing hazards. Where a hazard is identified that the board of trustees cannot deal with, the board is required to notify the Ministry of Education. If the board fails to notify the Ministry, the board will be liable for any costs of prosecution. A sample notification document may be found in *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*.

For every science experiment involving substances that are hazardous to health, an assessment should be made of the hazards involved and the measures needed to eliminate, isolate, or minimise those hazards. After the hazards and risks involved have been analysed, the decision may be to not carry out the procedure.

The person designing or recommending an activity is obliged to inform others of the hazards relating to the activity or substances involved. This includes students, technicians, teachers and, possibly, visitors. Senior teachers are responsible for advising inexperienced teachers of the hazards involved in particular procedures and how to minimise them.

Hazard assessment involves:

- identifying hazards;
- considering the educational justification for introducing the hazard;
- assessing risk;
- assessing the consequences if something should go wrong;
- reducing to acceptable levels the risk of something going wrong.

In making hazard assessments, teachers should consider that:

- **no experiment is completely safe and without risk;**
- **any experiment worth doing is worth doing safely;**
- **no scientific concept is important enough to teach through experiment if it cannot be taught safely.**

Where a teacher has to make a decision whether to carry out an experiment that has an element of potential harm, it may be useful to consider:

- if hazardous materials are involved, whether less hazardous substances can be substituted that still achieve the same effect;
- whether the activity is so educationally desirable that the risk can be afforded;
- if there is a safer technique that can demonstrate the same concept.

Natural Disasters

Boards of trustees are required to have policies and procedures in place in case of a natural disaster, such as an earthquake or a flood. Teachers should be aware of the school's policy and procedures to be followed in the event of a civil emergency.

Supervision of a Laboratory or Science Room

All science-room doors should be locked when not in use.

In some schools, however, doors for alternative exit in the event of fire are provided in rooms. Fire-exit doors are not to be interfered with and must be able to be opened readily, without using keys, from the inside.

In general, students should be supervised in science laboratories. If it is necessary for students to work without a teacher present, the teacher must be satisfied that all reasonable precautions have been taken. No students should be allowed to work without another student or staff member present, and no apparatus or chemical should be used for purposes not sanctioned by the teacher.

Trainee teachers should not be left unsupervised during practical lessons.

Responsibilities of the Board of Trustees

These responsibilities are consistent with the Health and Safety in Employment Regulations 1995 and with *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*.

These pieces of legislation require boards to ensure that:

- the school has health and safety procedures;
- health and safety responsibilities are implemented;
- responsibility for each laboratory or workshop has been assigned to a specific staff member;
- all science staff and students have been instructed in health and safety procedures to be used in laboratories;
- consuming food or drink in a laboratory is prohibited;
- all circumstances and activities for which protective clothing and/or equipment should be used are identified;
- protective clothing and equipment are provided to safeguard all staff or volunteers against any risk or danger to their health;
- all persons use protective clothing and equipment provided by the school management whenever the circumstances for which they are provided occur;
- all protective clothing and equipment complies with any relevant New Zealand standard or code of practice, gives adequate protection from the risk it is designed to eliminate or minimise, and is adequately maintained;
- adequate instruction is given in using and maintaining protective clothing and equipment;
- all goods, materials, substances, and equipment are stored, secured, and kept so that they do not endanger people in their vicinity, and employees and students who may be responsible for these substances are fully instructed about their safe storage in accordance with any specific regulations, standards, or codes of practice;
- all actual or potential hazards are identified and eliminated, isolated, or minimised;
- all school facilities are safe;
- a register of accidents that either harmed, or might have harmed, any employee or student is maintained. As students are not employees, there are no specific requirements to report student accidents, serious or not, to OSH although OSH recommends that a register of student accidents is kept within the school. In regard to staff, schools are specifically required to report serious-harm accidents to OSH and to keep records, within the school, of minor and serious accidents. (See Accident Recording, Reporting, and Investigating on pages 7–8.)

It is good practice to have a telephone or other communications system, that can be easily accessed in emergencies, readily available in the science teaching area.

Responsibilities of the Teacher in Charge of Science

These include responsibility to ensure that:

- a school policy on health and safety in science has been developed in conjunction with the board of trustees;
- all practicable steps have been taken to ensure the safety of students and staff while in science classes;
- hazards have been identified and significant hazards eliminated, isolated, or minimised;
- hazards that cannot easily be eliminated, isolated, or minimised have been reported in writing to the board of trustees;
- science staff are informed, trained, and supervised so that they ensure safety in science classes;
- all accidents are recorded in the school's accident register;
- in conjunction with the board of trustees, protective clothing and equipment are specified;
- protective clothing and equipment are used;
- the safety procedures identified are displayed and conveyed to all staff and students;
- there are fully equipped and accessible first-aid facilities in or close to each science room;
- chemicals are correctly stored and labelled;
- an inventory of hazardous substances is kept, and a register of material safety data sheets (MSDS) is available for all chemicals purchased and used in science or science-related activities;
- all hazardous substances are appropriately labelled;
- an emergency information sheet listing all emergency numbers is provided for each laboratory;
- the disposal of wastes has been arranged;
- procedures for emergencies in laboratories or science classrooms have been established;
- the teacher in charge of science is familiar with the contents of *Safety and Science: A Guidance Manual for New Zealand Schools*;
- all science staff in charge of laboratories check the safety of their laboratories. A safety checklist is provided in Appendix 3 on page 72.

Responsibilities of a Science Teacher

These include responsibility to ensure that:

- hazards, such as unsafe equipment, have been identified and reported in writing to the teacher in charge of science;
- all significant hazards have been eliminated where possible, or isolated and reported in writing to the teacher in charge of science;
- where elimination or isolation is not practicable, any remaining significant hazard has been minimised and reported, in writing, to the teacher in charge of science, bearing in mind that any processes or EOTC activity may have to be stopped if the hazard is not adequately controlled;
- all accidents have been entered in the school's register of accidents, as specified in the school policy;
- appropriate protective equipment and clothing are used when needed;
- safety procedures are displayed in the classroom or in the experimental manual;
- the locations of the fire extinguisher, first-aid kit, sand bucket, nearest telephone, gas shut-off valve, and mains switches are known;
- the fire exits are not blocked;
- safety checks for the laboratory or science classroom are carried out as specified in the school policy;
- any damaged or dangerous equipment has been reported promptly;
- classroom benches are kept as clean and tidy as possible;
- equipment is kept clean and in good repair;
- the material safety data sheets (MSDS) are referred to before any chemicals are used;
- science students are instructed in appropriate safety procedures and rehearse them;
- all waste materials are disposed of correctly and in accordance with the school's policy;
- science teachers are familiar with the contents of *Safety and Science: A Guidance Manual for New Zealand Schools*;
- science teachers understand the safety requirements and attributes of all experiments to be used and have determined any special care that should be taken by themselves and by the students;
- science teachers have taken all practicable steps to ensure their own safety and the safety of students while in science classes and that no action or inaction on their part causes harm to any other person. A safety checklist is provided in Appendix 3 on page 72.

Responsibilities of the Students

Students in science classes need to have a basic code of conduct for operating safely in science classes. It is recommended that a set of rules be developed in conjunction with students and that a copy be given to each student at the start of the year or when students join the class during the year. A copy should also be displayed in each room used for science.

If special rules apply to a particular procedure, they should be given at the start of the lesson concerned.

A science room Student Code of Conduct could include the following statements.

- Enter the room only when instructed (or according to the school policy).
- Move around the room only when instructed to do so.
- Do not touch hazardous substances or equipment unless told to do so.
- Avoid behaviour that could lead to accidents.
- Confine long hair and loose clothing.
- Know what to do in an emergency.
- Do not eat and drink in a science room.
- Use the appropriate safety equipment.
- Report any accidents to the teacher immediately.
- Do not leave any experiment unattended unless instructed to do so.
- Never conduct experiments on your own.

1.4 Building Facilities

Where property issues are concerned, boards of trustees and teachers should be aware that the Building Act 1991 does not require buildings that existed before 1 July 1991 to be upgraded to comply with the standards now required under the Act unless such buildings are being altered or improved or are considered dangerous or unsanitary. If a building has been declared unsafe or can be shown to be unsafe, then the Property Management Group of the Ministry of Education should be contacted.

However, schedule 44 of the Building Act 1991 does require specific systems and features in buildings to be identified in a compliance schedule issued by a territorial authority and to be subject to inspection, maintenance, and reporting procedures. If buildings have these features, whether they are being altered or upgraded is irrelevant, and they must comply with schedule 44 of the Act. Subsequently, the owner (the Ministry of Education for state schools) must supply the territorial authority with an annual building warrant of fitness stating that the requirements of the schedule have been fully complied with.

The Ministry of Education *Property Management Guidelines 1999* contain the relevant details. Contact the Property Management Group of the Ministry of Education if assistance is needed.

Appropriate HAZCHEM warning signs should be placed on the external walls of buildings that house hazardous substances, including laboratories. Consult the local authority for advice or contact the New Zealand Chemical Industry Council in Wellington, phone: (04) 499 4311, for *New Zealand Chemical Industry Council Code of Practice: Warning Signs for Premises Storing Hazardous Substances*.

Storage

Science rooms should have adequate storage facilities for equipment and hazardous substances not currently being used. The objective is to ensure that incompatible substances are not stored together. For guidance refer to Appendix 4 on page 74. For specific advice, consult OSH or the nearest local authority. Refer also to the Dangerous Goods Regulations.

Shelves

Shelves should have an anti-roll lip to prevent bottles tipping over in an earthquake, and shelf assemblies should be only five shelves high. Enough narrow shelving must be provided for storing chemicals, which should be stored no more than two deep on a shelf that is not above head height. Shelf assemblies should be firmly secured to the walls. Specific advice should be sought from OSH about the use of shelving. In some cases, it may be acceptable or necessary to store chemicals on polythene or unplasticised PVC trays on wooden shelves. Large containers should be stored on low shelves. Avoid storing chemical containers on the floor or in positions where they may be kicked.

NZS 4104: 1994 *Seismic Restraint of Building Contents* contains detailed information on earthquakes and the storage of materials. Contact the local library or

Standards New Zealand
Private Bag 2439
Wellington
Telephone: (04) 498 5990
Fax: (04) 498 5994



Chemicals should not be stored in a fume cupboard as flammables will nullify electrical zoning approvals.

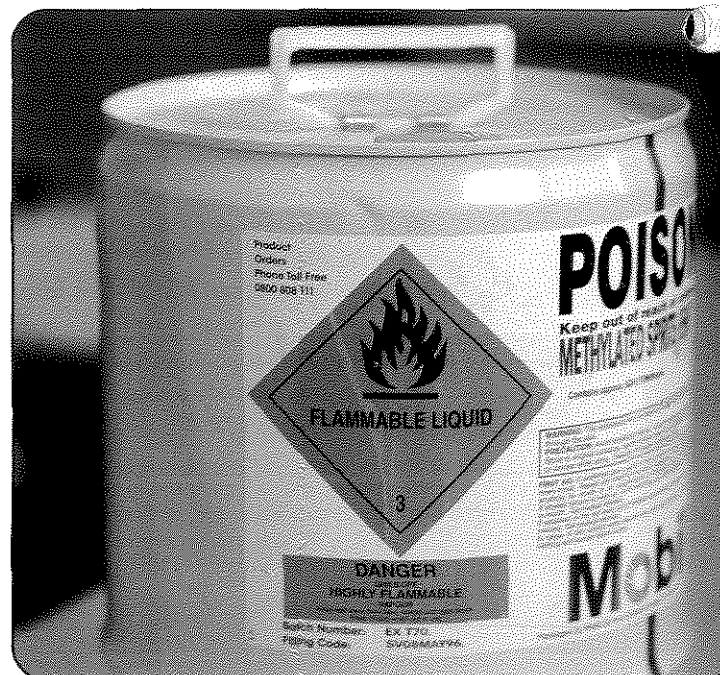
If a school lacks specialised storage facilities but requires small quantities of chemicals for teaching purposes, the chemicals should be stored in a locked cupboard.

Dangerous-goods cabinet

A dangerous-goods cabinet must be provided wherever flammable materials of up to 15 litres are stored. Refer to page 17 for detailed information on the construction features and operational restrictions for dangerous-goods cabinets.

Bulk dangerous-goods store

A dangerous-goods store is necessary where more than 15 litres of flammable materials are stored in one place. If the store contains more than 15 litres of Class 3(a) products (with a flashpoint of less than 23 degrees Celsius), a dangerous-goods licence is required. Storage of up to 100 litres of Class 3(b) products (with flashpoints between 23 and 61 degrees Celsius) is permitted without a licence provided that no dangerous goods of Class 3(a) are stored within 5 metres of the Class 3(b) products. This amount should not be stored in a preparation room, laboratory, or classroom. The store should have the appropriate HAZCHEM sign and must be capable of being locked. Materials to be kept in this store include turpentine, methylated spirits, acetone, kerosene, solvents, thinners, contact glue, and lubricating oil.



Dangerous-goods Cabinets

The construction features and operational restrictions for dangerous-goods cabinets required to meet the Dangerous Goods (Class 3 Flammable Liquids) Regulations 1985 and comply with Ministry of Education policy are as follows.

1. The cabinet should contain not more than 15 litres of Class 3 products in containers.
2. The cabinet should be constructed of metal, with riveted or welded joints.
3. It should have a tight-fitting door that is fitted with a device to ensure that the door closes automatically if a fire occurs either inside or outside the cabinet.
4. To contain any spillage of liquid, a metal lip should be constructed at the bottom of the door opening or a separate metal tray should be fitted inside the cabinet. The lip or tray should be able to hold at least half the contents of dangerous goods stored inside (or whatever greater quantity an inspector may require for a particular application).
5. The cabinet should be securely mounted on incombustible supports.
6. The cabinet should be adequately isolated from any combustible material, including any part of the building in which it is situated. This may be either by:
 - (a) lining the cabinet with non-absorbent, fire-resistant board (compatible with the products in the cabinet), so as to give a fire-resistant rating (FRR) of one hour, or
 - (b) lining the part of the room, furniture, or fittings that is adjacent to the cabinet's permanent location with fire-resistant board so as to give a fire-resistant rating (FRR) of one hour.
7. The cabinet should be labelled with a "Flammable Liquids – No Smoking" sign and a flammable liquids Class 3 "Diamond" label (with sides measuring 400 mm). It is also recommended that HAZCHEM signs be placed outside all entrances to the room and the building.
8. Material safety data sheets should be available for all products stored and used.
9. Protective clothing and equipment for safe handling should be available. All staff should be trained in using this equipment safely and instructed in the correct steps to take if a spillage or emergency occurs.
10. One fire extinguisher of type 2, 3, 4, or 5 (as covered by Regulations 171–179 and 188 of the Dangerous Goods Regulations 1985) should be provided for each cabinet.
11. Irrespective of the ventilation of the storage area, electrical zoning of the cabinet and the general area around it (as defined by section 4.3(c) of AS/NZS 2430.3.3: 1997) should be:
 - (i) Zone 1 for the interior of the cabinet;
 - (ii) Zone 2 for the exterior of the cabinet, from ground level to 1 metre above the cabinet and 3 metres to either side.

Note: All electrical equipment fitted or falling within these zones should be inspected and approved by an electrical inspector.

Adapted with permission from *Dangerous-goods Cabinets*, Dunedin City Council

Poisons cupboard

A locked poisons cupboard should be provided in the laboratory preparation room or science storage area for all poisonous materials (refer to the MSDS). There are also commercial cabinets available that meet these requirements. This cupboard should be labelled with a poisons hazard-warning label. Contact the New Zealand Chemical Industry Council for advice or refer to their website at: www.nzcic.org.nz

POISON



Bulk chemical store

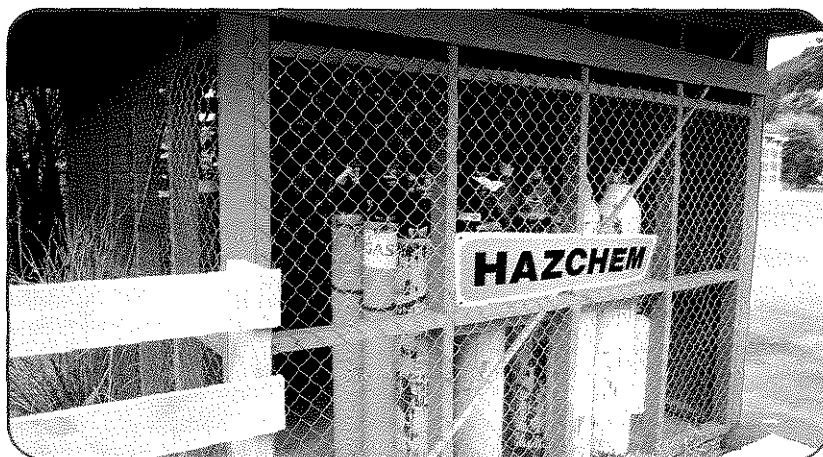
Many schools have a bulk chemical store for other chemicals. These chemicals include corrosive liquids and solids. Bulk chemicals should be dispersed and distributed from this room, which should contain a stainless steel sink and an emergency drench-type shower. It should also have a ventilation fan that operates automatically when the shower is turned on but that can also be operated independently. Special attention should be paid to security for this room.

It is recommended that no more than one 250-millilitre (mL) bottle of each undiluted chemical be kept in laboratories, classrooms, or preparation rooms. Corrosive materials should be stored close to the ground on polythene or unplasticised PVC drip trays.

Storage areas are required to have natural ventilation at all times.

Bulk gas storage

Bulk gas storage should be outside the building, protected by a locked, galvanised-mesh grill. This store must conform with local authority by-laws or Regulations and with the Dangerous Goods (Class 2 Gases) Regulations 1980. (See Gas Cylinders on page 26).



Teaching Space

The optimum number in a science class will depend on the students' age, ability, and degree of responsibility, the type of work being attempted, and the experience of the teacher. If, in a teacher's professional judgment, a class is too large to attempt a particular piece of practical work safely, then other strategies must be considered. These may include abandoning that particular activity, having only part of the class doing practical work at any one time, or adopting student-assisted teacher demonstrations.

In clause 23.1, *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools* describes standards for avoiding overcrowding in teaching areas. If problems persist, the teacher in charge of science should notify the principal and board of trustees in writing.

The key factors in achieving safe procedures in science classrooms are:

- controlling students' behaviour and movement in practical situations;
- storing and handling materials and equipment properly;
- providing safety, firefighting, and first-aid equipment.

Students should learn to use equipment and materials safely and take increasing responsibility for their own health and safety. In order to do this, they need clear instruction by the teacher in the correct use of equipment and materials at the start of an activity. It is always preferable to demonstrate correct techniques while instructing students. Teachers should also know the easiest means of obtaining help in an emergency and the location of the nearest telephone.

The most likely hazards that students will be exposed to include:

- chemicals splashing onto their own or some other person's body (for example, onto eyes and hands);
- cuts and abrasions from broken glass;
- burns and fires;
- injury from handling substances improperly, particularly while moving around.

Teachers should always consider:

- what could go wrong;
- what can be done to prevent something going wrong;
- what must be done if something does go wrong.

2.1 Electrical Equipment

Teachers need to know how to deal appropriately with electric shock.

How Much Current Is Too Much?

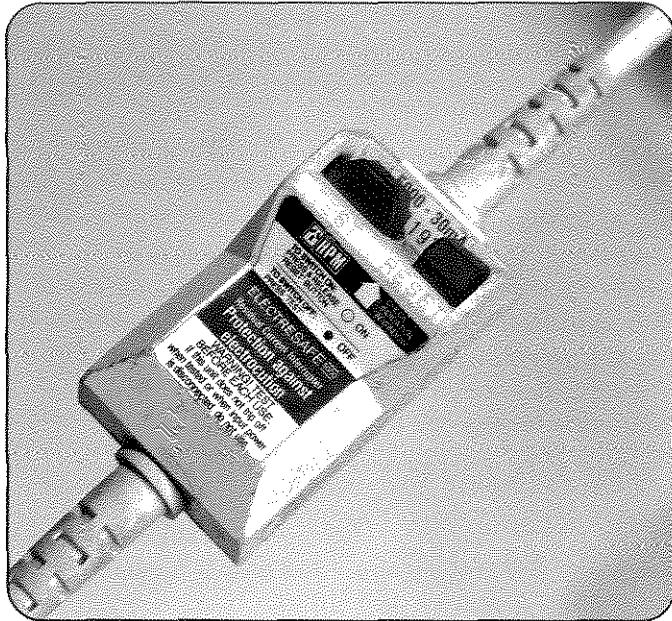
The key factor is the size of the current passing through the body, particularly the heart. A current of 1 milliamperes (mA) may cause a nasty jolt, but a current of 20 mA could be fatal. A power pack with a maximum voltage of 15 volts (V) should not be able to deliver a fatal shock to a dry person.

It is recommended that students should not use any supply over 30 V.

However, a high-voltage supply with an output current limited to 5 mA may be used by teachers or by senior students under the close supervision of a teacher. Although the current from electrical devices may be small, some students are more sensitive than others, and it is possible that a heart pacemaker might be damaged.

Electrical Equipment (Mains Powered)

Where possible, all circuits used by students should be protected by a residual current device (RCD). The teacher needs to know where the circuit master-switch is so that all sockets can be disconnected if necessary.



Capacitors

A high-grade capacitor can have a residual effect as high as 10 percent of its original potential difference (voltage). A discharge of 10 joules (J) can be a danger to life, and 0.25 J can give a shock. Therefore, complete discharge of the following, for example, could present a serious hazard:

- 0.2 microfarads (μF) charged to 10 000 V, or
- 2000 μF charged to 100 V.

High-grade capacitors should be stored and handled carefully, for example, by keeping them short-circuited when not in use, if they are ever to be connected to a high voltage.



Electrical leads

Plugs and sockets should be in serviceable condition, and leads should not be weakened by pulling on them. Where multiple connections are necessary, a multibox should be used rather than piggybacking “tap on” plugs.

Power supplies should be fitted with a pilot light to indicate when they are connected to the mains. Three-pin plugs wired by students should not be plugged into the mains. They are for demonstration purposes only.

Socket switches should be turned off before any equipment is plugged in or unplugged. Electrical equipment should not be handled with wet hands or when standing on a wet surface.

The use of extension cords should be avoided wherever possible, but if they are needed, the two cables should be looped together before connection so that they cannot be pulled apart. Such leads should not trail across an area where people may walk. Any equipment used outside the classroom or laboratory should be connected through an RCD.

Electrostatic generators

Electrostatic generators contain capacitors (see page 20). Van de Graaff generators can produce high voltages but low currents and therefore should normally be safe. However, they may pose a risk to someone with a heart pacemaker. A Wimshurst machine can give a nasty shock, and the knobs should be discharged before being touched.



Electrical zoning

At all times, compliance with AS/NZS 2430.3.3: 1997 is required (see page 17 [11]).

Frequency of inspecting electrical equipment

The Occupational Safety and Health Service (OSH) recommends that a competent person, such as a teacher or technician, must inspect mains-powered electrical equipment at least annually for observable defects. A registered electrician must carry out any repairs required to mains-voltage equipment.

Carrying out the following checks annually will meet the requirements of AS/NZS 3760: 1996 *In-service Safety Inspection and Testing of Electrical Equipment*.

Check:

- that the equipment is free from obvious external damage;
- visually for any defective components or damage in the accessories, connectors, plugs, or outlet sockets;
- that flexible cords are effectively anchored;
- that the warning, indicating the maximum load to be connected to each portable outlet device, is intact and legible;
- that control knobs, covers, guards, and the like are secured in the manner intended by the manufacturer or supplier;
- that mechanical safety facilities and devices are in good working order and that ventilation inlets and exhausts are unobstructed;
- that any controls and alarms are in good working order and that, where the ratings of any replaceable protective devices are accessible to the user, they are correctly adjusted;
- that the inner cores of flexible supply cords are not exposed and that the external sheaths are not cut, worn, or damaged to such an extent that the insulation of the inner cores is visible.

For low-voltage equipment and cord extension sets, the use of clear-backed or integrally moulded (non-rewireable) plugs and sockets is recommended. Clear-backed plugs and sockets simplify inspecting the cord colours and the condition of the terminations, whereas integrally moulded accessories are less prone to damage and incorrect connection.

Extension cords should have the following checks carried out annually. Repairs must be carried out by a registered electrician or by a registered electrical service technician.

Check:

- that the cord and its plug sockets are free from obvious external damage;
- visually for any defective components or damage in the plug sockets;
- that the inner cores of the cords are not exposed and that the external sheaths are not cut, worn, or damaged to such an extent that the insulation of the inner cores is visible.

Portable RCDs should have the push button tested by the user every three months or before every use, whichever is the longer. They should have a full test every two years carried out by a registered electrician or by a registered electrical service technician.

High-voltage power supplies

Only units intended for school use and limited to 5 mA should be used.

Induction coils

If possible, the age of an induction coil should be established. A modern (1970 or later) induction coil from a reputable supplier of school equipment should be incapable of giving too high a current. However, older ones should have a resistor to limit the current to 5 mA.

Lasers

Schools should be using lasers, obtained from a reputable supplier, that are intended only for use in schools. Old equipment from other sources should not be used. Lasers and their use must conform to

- NZS 5821.3: 1981 *Plain Language Code of Practice for the Safe Use of Lasers in Teaching*, and
- AS/NZS 2211: 1997 *Laser Safety – Equipment classification requirements and user guide*.

Schools should only use continuous-wave (CW) lasers that emit light in the visible spectrum, because the concentrated pulse of light from a laser can cause eye damage.

Although it is acceptable to use Class 1, Class 2, and Class 3A lasers, schools buying new equipment are advised to buy only Class 1 or 2 lasers.

Class 3B and Class 4 lasers must not be used.

Class 1 lasers, such as supermarket barcode readers, are low-powered and safe under all conditions.

Class 2 and Class 3A lasers may be used, provided the following precautions are taken.

- Lasers must be used under the strict supervision of the teacher, who is required to warn students not to look directly into the beam. Prolonged viewing is considered to be longer than 0.25 seconds, which is the time for the blink reflex.
- Students should be positioned so that they cannot receive direct or indirect light from the laser, and they should maintain these positions. The beam should be either above or below eye level.
- People should avoid laser reflections coming towards their eyes from reflecting surfaces.
- The room in which the laser is used should be as brightly lit as possible so that the pupil of the eye is small.
- The laser should be positioned to ensure that nobody can enter the room and walk into its beam. It should be securely mounted when not in use so that a knock does not redirect the beam.
- The laser should be run in a blacked-out room for a short time when no students are present so that the teacher can detect the presence of any stray reflections.
- If the laser is used on a benchtop, the students should be standing up so that they are looking down on the beam.
- When not in use, the laser should be turned off, or the beam should be terminated by a shutter mounted on the laser head. At other times, the laser should be locked away, or a key switch should be used to lock the high-voltage power supply. The laser should be stored securely so that it is accessible only to authorised staff.
- Appropriate laser hazard symbols should be placed both inside and outside the demonstration area and in locations giving access to the area.

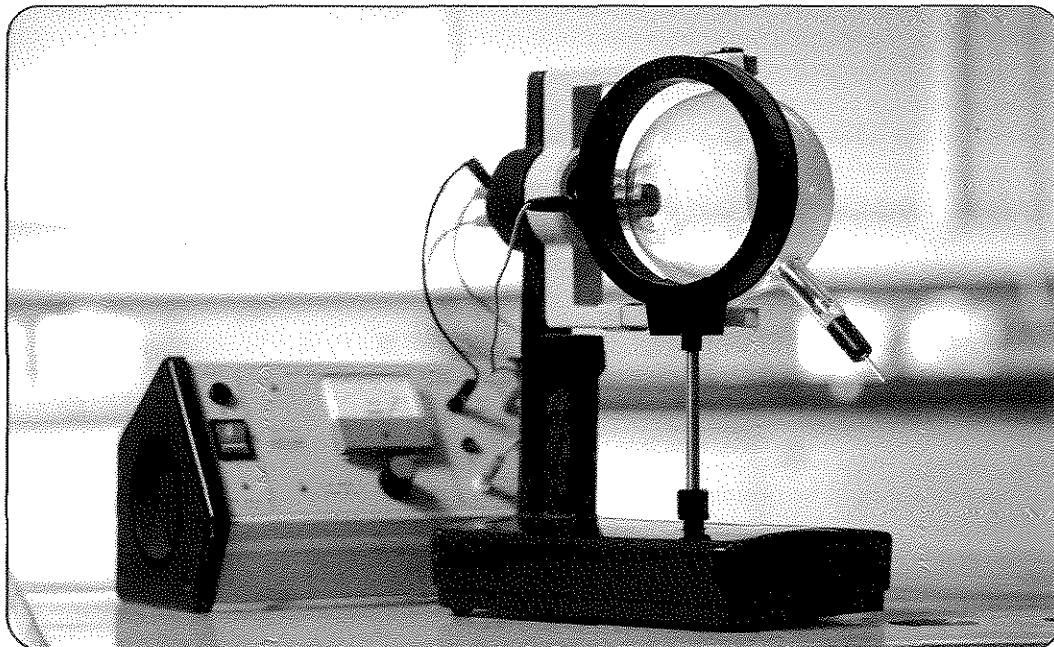
Old equipment

Although dismantling old equipment may be useful for investigating how things work, caution is required. Old refrigerators should not be pulled apart in such a way that there is any risk of the refrigerant escaping. Television tubes can store lethal charges. Equipment that contains electrical parts and vacuum tubes (for example, television sets) needs to be handled with great care and should not be connected to a power source again after dismantling. Plugs should be cut off.

Radiation equipment

Refer also to Radioactive Substances on page 45.

Schools should take great care with any X-ray source. Some old X-ray tubes still found in schools give dangerously high levels of radiation. Some cathode-ray tubes that operate on very high voltages (for example, tubes of the maltese cross type) may produce X-rays. If in doubt, contact the National Radiation Laboratory, and have such equipment checked by an appropriate person before it is used. Devices such as gas discharge tubes, maltese cross devices, and other similar apparatus operated at voltages above 5000 V are extremely hazardous.



The acquisition of X-ray machines is controlled by section 15 of the Radiation Protection Act 1965, which requires that they cannot be used without a licence. Licences are not normally issued for educational use of these machines in schools. In order to keep such equipment as museum pieces, they must be rendered totally inoperative. If a school desires to have such a device to use for experimental purposes, then a staff member will have to apply for a licence, and the equipment will have to be totally enclosed to prevent the release of any primary or scatter radiation.

Smoke detectors

Refer to Smoke detectors on page 25.

Sound

Refer to Sound on page 30.

Strobe lamps

At certain frequencies, strobe lamps can trigger health problems in susceptible people. Those who are known to have epilepsy should not be present when there is this risk. Frequencies between 5 hertz (Hz) and 15 Hz should be avoided.



Ultraviolet light

Eyes can be seriously damaged by exposure to ultraviolet (UV) light. Lamps should be arranged so that it is not possible to look directly at them nor at a reflection of their light. Lamps should have a hazard-warning label pointing out the danger of looking directly at them.

Electrical Equipment (Not Mains Powered)

Cells and batteries

Dry cells are useful for a range of experimental activities. Car or motorcycle wet-cell batteries may be used in senior secondary-school classes, for demonstration. However, great care should be taken, because they can give a spark, the acid can spill, they are too heavy for many students to lift safely, and when recharging, they give off a flammable gas. The short-circuit current is sufficient to cause burns from hot wires.

Anyone cutting open a dry cell to investigate the structure should wear gloves. Alkaline manganese cells, button cells (for example, from a calculator or watch), and rechargeable cells should not be cut open.

Rechargeable cells can be used in equipment but should not be used for investigating circuits. Rechargeable cells have a low internal resistance and can therefore give a high current if the resistance in the external circuit is small. They should be recharged only with a proper trickle charger at the correct rate, not with a power pack.

Smoke detectors

Cutting open smoke detectors to obtain the radioactive source is not considered particularly hazardous. The National Radiation Laboratory can provide schools with the contents of smoke detectors free of charge, or teachers may obtain their own.

Contact address for information and advice:

National Radiation Laboratory
PO Box 25-099
108 Victoria Street
Christchurch
Telephone: (03) 366 5059
Fax: (03) 366 1156

2.2 Other Equipment

Asbestos and Asbestos Mats

Asbestos is not permitted in schools, except in mineral form in a sealed container. Worn or broken asbestos mats or pads are a health hazard because of the asbestos dust.

Asbestos wool should not be used. "Rocksil", a mineral wool, is a suitable alternative. Hardiflex sheets, obtained from hardware merchants, are a suitable alternative in some activities.

Binoculars

Students should never be permitted to look at the daytime sky using binoculars or a telescope in case they accidentally get the sun in their line of vision. (Refer to *Making Better Sense of Planet Earth and Beyond: Levels 1-4*, pages 102 and 121.)

Bunsen Burners

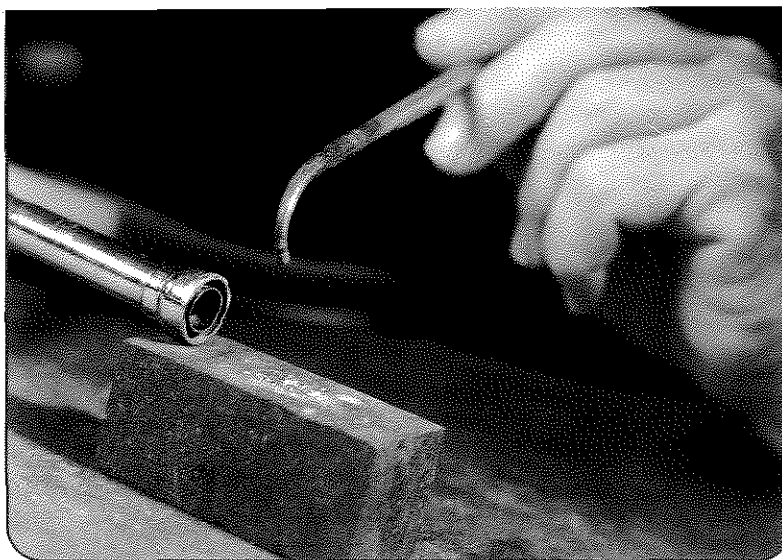
Refer also to Heating Hazardous Substances on page 51.

Bunsen burners should be turned off when not in use. If it is necessary to keep the Bunsen burner alight, the flame should be made luminous. A tripod should be placed over any Bunsen burner supplied with gas fuels that cannot be made luminous. Matches, wood splints, or friction lighters should be used for lighting Bunsen burners, because these materials are cleaner and safer than paper or wax tapers.

Bunsen burners should be used with caution on window benches where curtains could be ignited. Curtains should be tied back or secured.

Charcoal Blocks

If heated correctly, a charcoal block can be held in the hand. Alternatively, the block may be mounted on a heat-resistant base. After heating, blocks should be allowed to cool for several hours on a metal tray. If they are not cold by the end of the school day, they



should be immersed overnight in cold water. Putting charcoal blocks in cold water immediately after heating tends to make them brittle and unusable.

Electrolysis

It is recommended that electrolysis of molten salts take place and be demonstrated only in a fume cupboard. An aqueous *solution* of sodium chloride can be electrolysed in an open room provided that the risk associated with the generation of chlorine is minimised by:

- ensuring adequate ventilation;
- using only dilute solutions of sodium chloride;
- ensuring that students do not sniff the gas.

Fire Extinguishers

A recognised training provider should train staff on selecting and using fire extinguishers appropriately. Fire extinguisher sales staff should not be used as training providers unless they possess a recognised qualification.

Flexible Tubing

The correct tubing should be used for the job. Reinforced tubing has to be used where the tubing is to be exposed to pressure. Plastic tubing is preferable for permanent installations as it is less likely to perish. Tubing should be secured by the appropriate hose clips and checked regularly for damage or deterioration. For vacuum work, thick-walled or reinforced tubing should be used so that the tubing does not collapse. The tubing suppliers can provide advice when necessary.

Gas Cylinders

All gas cylinders must be stored and handled in a manner that prevents the delicate cylinder valves from fracturing because of a fall or knock. Cylinders must be correctly labelled with the name of the gas, with any hazard associated with that gas, and with where the cylinder should be stored. All users must know and understand the hazards associated with oxygen. Gas cylinders must be stored in accordance with AS/NZS 2243.3: 1995–1997 *Safety In Laboratories – Microbiology*. (See Bulk gas storage on page 18.)

In general, gas cylinders should be stored:

- in a well-ventilated area that is free from fire risk, such as flammable solvents;
- away from sources of heat and ignition and not in direct sunlight;
- in an upright position, firmly secured either on a trolley or on a purpose-built rack, or in a secure harness (strap and base) fixed to a wall or to some other means of support;
- away from areas that students use, and not in science classrooms.

Gas cylinders must be moved only when secured to a suitable trolley or carrier. Small cylinders (for example, the size of fire extinguishers) may be carried carefully by hand.

When in use, cylinders must always be connected directly to a gas-pressure regulator and secured in an upright position. Gas-cylinder handlers must wear eye protection and appropriate protective clothing.

Care must be taken to ensure that all valves, pressure regulators, pipes, and joints are dry and free from dirt, oil, and grease. Cylinder valves and connections must be regularly checked for leaks. This can be easily done by brushing the valve or connection with a solution of dilute soap or detergent. The presence of bubbles will confirm a leak. Soap solution must be applied only to the assembled apparatus. Detergent must never be allowed inside the valves and connections because this is an explosion hazard.



Advice on the Use of Gas Cylinders

Gas cylinder	Colour code	Advice
Sulfur dioxide	Yellow/white	<p>This is a corrosive gas. Containers of sulfur dioxide should be stored in a cool, well-ventilated area (not in the fume cupboard).</p> <p>See also Sulfur Dioxide on page 51.</p>
Carbon dioxide	Black, or black with white stripe	<p>Carbon dioxide cylinders are often used for preparing dry ice (solid carbon dioxide). Dry ice is hazardous and causes cold burns. Carbon dioxide can also be corrosive in the presence of moisture. Protective gloves and glasses should be worn when preparing dry ice.</p> <p>Dry ice should not be stored in gas-tight containers because the volume increases when the solid changes to gas.</p> <p>Carbon dioxide is also heavier than air, so it will collect in confined, unventilated spaces.</p> <p>See also Carbon Dioxide on page 48.</p>
Hydrogen	Red	<p>The ignition of hydrogen-and-air mixtures is a common source of explosions in school laboratories. Although not risk-free, cylinders of compressed hydrogen can provide a safe source of hydrogen.</p> <p>Particular care is needed with hydrogen because it is flammable and diffuses easily.</p> <p>See also Hydrogen on page 49.</p>
Oxygen	Black	<p>Care must be taken not to let gas escape when transferring oxygen from cylinders to gas jars or test tubes for students' use, since there is a risk of clothing becoming saturated with oxygen. In an atmosphere containing as little as 25 percent oxygen, materials ignite at a much lower temperature and burn furiously.</p>

Adapted from *Safety and Science: A Manual of Guidance for Hampshire Schools*

Glassware

Careless handling of glassware can cause many accidents in science. Teachers and students should observe the following procedures.

- Use suitable test tube holders when heating test tubes.
- Do not use metal tongs for holding, carrying, or heating glassware. They were not designed for such purposes.
- Do not put pressure on a glass tube or thermometer with the hand, even when wearing gloves.
- Warn students about the danger of attempting to remove glass tubing from, or inserting tubing into, corks or bungs. To insert glass tubing into bungs, select the smallest cork borer that fits over the glass tubing, lubricate the borer with glycerol or detergent, and insert into the bung. Then slide the glass tube into the cork borer, and remove the cork borer, leaving the glass tube in place. This procedure can be carried out in reverse to remove a tube. Safety glasses must be worn when carrying out the procedure.
- To cut glass tubing, make a scratch with a glass cutter, hold the tube in a cloth, and gently break the glass by pushing away with both thumbs.
- Only teachers or technicians should open glass ampoules.
- To remove sharp edges of glass that often protrude from freshly broken surfaces, heat the broken surface in a flame until the surface is rounded.
- Dispose of broken glassware in a container reserved specifically for the purpose.
- Carry long lengths of glass tubing upright.

Gloves

Gloves may be used in a number of situations, but they should be used with caution. There is a danger that gloves can actually reduce safety in handling bottles because gloves become slippery when wet. Anyone handling chemicals should not wear gloves with small holes, because spilled chemicals can come into contact with the skin unnoticed, allowing corrosive chemicals to remain on the skin longer. If no gloves are worn, the spill is more likely to be noticed and attended to immediately. In some circumstances, gloves can create a false sense of security and lead to careless handling of chemical solutions.

Gloves used in the science classroom are generally made of polyethylene (clear, lightweight, flexible), neoprene (black rubber), nitrile (household rubber gloves), and latex (surgical gloves). All these types of gloves need to be available for teachers and technicians. Wrist-length polyethylene gloves should be available for student use.

Hot Equipment

Students should be discouraged from carrying hot equipment, such as tripods, to the sink and cooling them under running water. Tripods can simply be left to cool. Cold water on hot objects produces steam, which can cause scalds. Cold water on hot glassware will often break it, and cold water on hot metal objects can change the temper of the metal.

Lenses and Mirrors

Care is needed to avoid sharp edges on handheld lenses and mirrors. The edges of mirrors should be taped, and it is a wise precaution to also tape the back of glass mirrors.

Microscopes

Never allow students to use the sun as a light source for viewing through microscopes because doing this can cause blindness.

Pipetting

Pipetting by mouth is not acceptable. A suction device, such as an automatic pipette filler, should be used.

Projectiles

When using any sort of projectile, such as a water rocket, it is essential to ensure that nobody is in the line of fire or leaning over the projectile when it is being prepared. Safety glasses should be worn when projectiles, such as ball-bearings, are fired from a spring.



Protective Clothing

Polycotton is preferred to pure cotton because it does not disintegrate as readily when splashed with acid. In some circumstances, protective clothing can restrict movement.

Sharps (for example, razor blades, scalpel blades, needles, and pins)

Syringes and needles should be mutilated in order to prevent their possible reuse. Autoclaving will make most plastic syringes unusable. Scalpel and razor blades should be placed in a suitable, labelled, secure container before disposal. Dispose of appropriately as "Sharps" (see the HSNO Disposal Regulations). Refer also to Sharps on page 56.

Sound

At certain frequencies, sound can trigger health problems. Frequencies below 40 Hz should be avoided.

A strobe lamp, and sound below 40 Hz, should never be used at the same time.

Loud sound can induce hearing loss and can mask warning messages or signals. For the protection of hearing, an instantaneous sound should never exceed 115 decibels (acoustic) (dBA) unless all present have appropriate hearing protection, and the general ambient sound over the school day should not exceed 70 dBA. For general health purposes, the ambient sound over the day should not exceed 55 dBA.

Stirrers

Wherever possible, a magnetic stirrer or glass stirring rod should be used. The stirring speed on a magnetic stirrer should be set to low before the device is turned on. Using thermometers as stirring rods is not good practice.

Thermometers

Where possible, alcohol thermometers should be used rather than mercury thermometers. Thermometers should not be used as stirring rods, and laboratory thermometers should not be used as clinical thermometers. If the alcohol separates in the tube, placing the thermometer in a freezer will recombine the liquid.

Section 3

Safe Procedures with Living Organisms, Rocks, and Minerals

3.1 Animals

General Precautions

Animals should always be treated with respect. If animals are kept in schools, they should be healthy and be obtained from reliable sources, such as biological supply firms, universities, or approved breeders. Schools must not keep such animals as cockroaches, possums, hedgehogs, and rodents caught in the wild because they may be carrying disease. Animals can transmit infections, parasites, and diseases to humans.

Students must wash their hands before and after handling any animals, and existing cuts or abrasions must be covered to prevent infection. Bites from laboratory animals should be treated immediately. In the case of puncture wounds, a doctor should be consulted. Teachers need to remember that some people may have allergic reactions, such as skin rashes, asthma, or sneezing, when exposed to the hair, dried urine, and excreta of particular species.

All schools are required to comply with the Animal Welfare Act 1999. See page 9 of this manual for general ethical guidelines. Other ethical and legal obligations in the care of animals for schools and early childhood education centres can be found in *Caring for Animals*, available from: Orders, Learning Media Limited, Box 3293, Wellington. Freephone: 0800 800 565. Freefax: 0800 800 570.

Care for animals must include:

- keeping the animal in a secure cage or container, with space for it to move around freely and display normal patterns of behaviour;
- providing adequate food, water, and shelter;
- preventing discomfort to the animal caused by exposure to noise, draughts, direct sunlight, and improper handling;
- attending to hygiene by providing adequate clean bedding, changing it regularly, and keeping the cage or container clean;
- removing unhealthy animals and seeking veterinary attention for them;
- checking that when animals go home with students, responsibility is taken for the animals' security and welfare;
- providing appropriate weekend and holiday care.

Native Animals

Under the Wildlife Act 1953, it is illegal to keep native animals without a permit from the Department of Conservation.

Bones and Feathers

Items such as birds' nests and feathers, which can carry microbes and other creatures such as mites, can be placed in a plastic bag to prevent spread.

Bones should be sterilised or disinfected. Bones can be placed in a 10 percent hypochlorite (household bleach) solution, following the instructions on the container. Feathers should be disinfected in a common household disinfectant by following the instructions on the container.

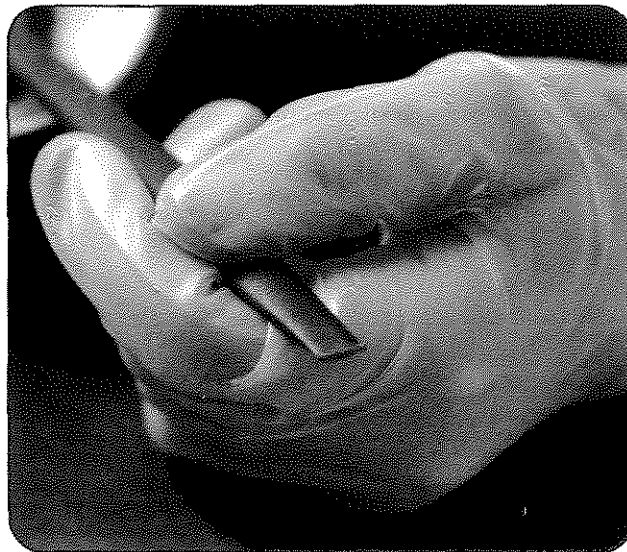
Cheek-cell Scrapes

Students should wash their hands before and after carrying out this procedure. The Ministry of Health advises that there is minimal risk associated with making slides of cheek cells. Students should not exchange saliva. Applying sellotape to the inside wrist is a suitable alternative to using cheek cells.

Dissections

Teachers should be aware of the following.

- All material for dissections must be obtained from a reputable source, for example, abattoir, tertiary institution, butcher's shop.
- During any dissection, the material must be treated with respect.
- Before anyone proceeds with a dissection, all their cuts and grazes must be covered.
- Surgical-type gloves should be worn but need not be sterile.



- Clean, sharp dissection equipment should be used.
- After the dissection, the dissection equipment must be washed and either sterilised or disinfected. Any readily available disinfectant is acceptable. Scalpels and razor blades should be placed in a clearly labelled, puncture-proof container before disposal. The animal remains and gloves must be disposed of safely: preferably incinerated, buried, or through a commercial waste-disposal company (see the HSNO Disposal Regulations).
- All bench surfaces must be washed and disinfected.
- All people involved must wash their hands afterwards with soap and hot water.
- Teachers could consider using alternatives to dissection.

Eggs

Eggs should be washed before use, and students must wash their hands before and after handling them.

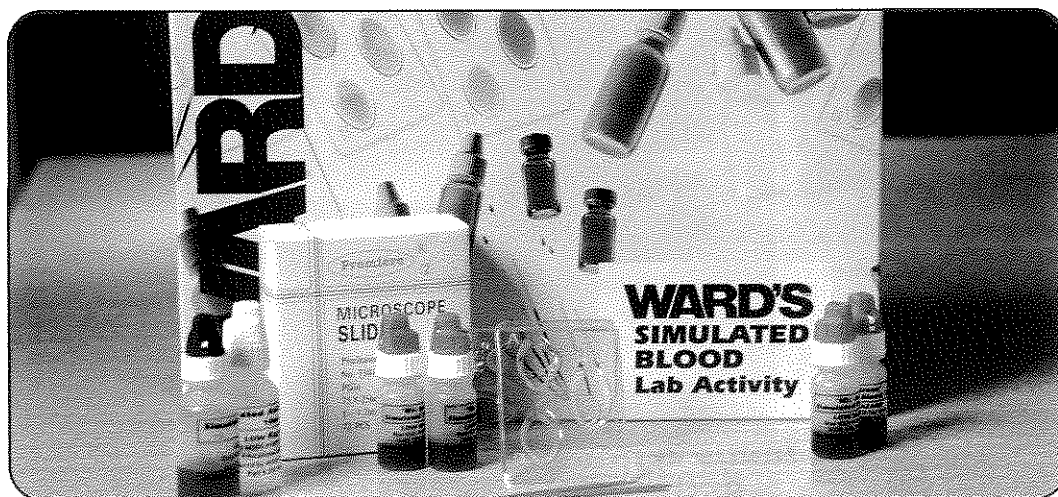
Involving Students as Experimental Subjects

When undertaking any practical activity where students are subjects, the teacher must consider the risks of both physical and psychological harm and be aware of the potential effect of drawing attention to individual differences.

Activities that can be safely carried out include the following.

- The safe measurement of blood pressure, using computer-linked data-capture devices. There are dangers in using sphygmomanometers. A person with appropriate training, such as a nurse, may be of assistance.
- The use of disclosing tablets to show the presence of plaque on teeth. If toothbrushes are used, they must not be shared between students.
- The use of simulated blood-typing kits that are commercially available.

Any other activity with students as subjects of an experiment must have Human Ethics Committee approval. Contact details for local committees can be obtained from The Royal Society of New Zealand, Box 598, Wellington, telephone (04) 472 7421, fax (04) 473 1841. Individual permission is required for any activity involving collection or disclosure of information from individuals.



Any equipment used where students are ingesting substances orally must be hygienically prepared, and students must not share such equipment. Refer to Section 3: Safety and Biotechnology in *Safety and Technology Education: A Guidance Manual for New Zealand Schools*, particularly page 33, and pages 40–41 of *Health and Physical Education in the New Zealand Curriculum*.

Stethoscope earpieces must be sterilised or disinfected, and spirometers must have disposable mouthpieces, or the mouthpiece must be sterilised or disinfected.

Saliva

The Ministry of Health advises that there is minimal risk associated with using saliva in school practical situations (for example, as a source of enzymes) because small quantities are required. Students should be responsible for their own experiments and not exchange saliva. Spit or saliva must not be used when culturing micro-organisms.

Urine Testing

Students testing their own urine is an acceptable activity, provided that normal hygienic practices, such as hand washing, are carried out. Substituting cattle urine is not acceptable owing to the risk of leptospirosis.

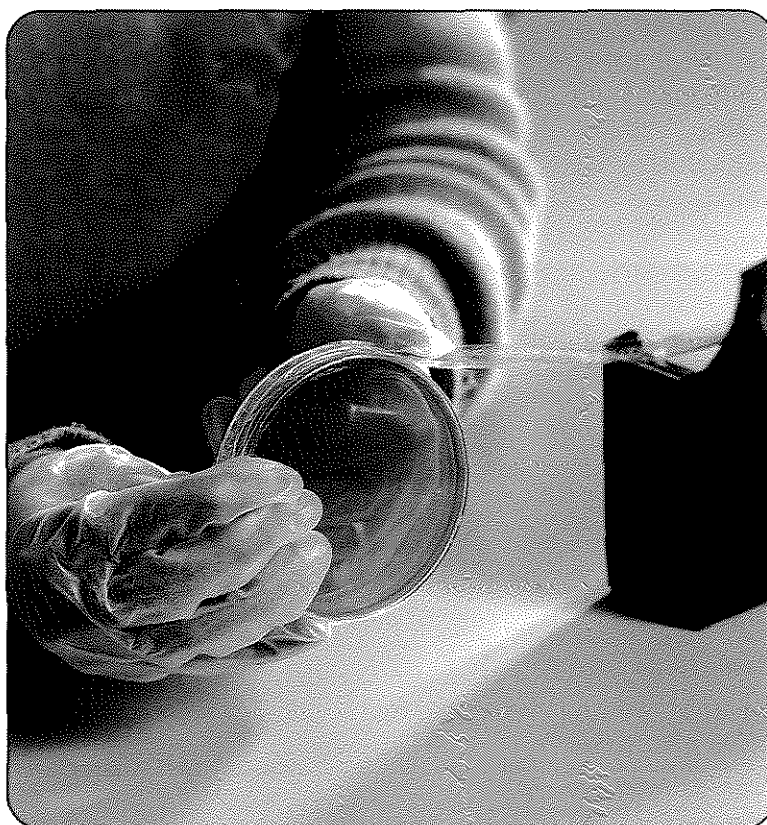
3.2 Micro-organisms

The major groups of micro-organisms are algae, protozoans, fungi, bacteria, and viruses. Many micro-organisms release spores into the air and must be carefully used in schools. Hands should be washed after handling micro-organisms. Micro-organisms can be destroyed by heat, bleach, and disinfectants.

Culturing Micro-organisms

Teachers should be aware of the following.

- Human or animal sources of micro-organisms, other than skin, must not be used (for example, blood, saliva, pus, urine, and faecal material).
- Skin surfaces may be used only if cultures remain sealed.
- Samples must not be taken from toilets and toilet areas, including sinks and door handles.
- Known pathogens, other than genetically crippled strains of *Escherichia coli*, must not be used.
- Samples must not be taken from rubbish bins and drinking taps.
- Sterile swab sticks should be used to inoculate plates.
- All cultures should be labelled with students' names and the date.
- Petri dishes should be covered and sealed to prevent contamination and the spreading of spores. Adhesive tape can be used to securely seal the dishes.
- Petri dishes should be incubated upside down.
- Subculturing should be carried out only on known non-pathogenic organisms that can be obtained commercially.
- Lids of petri dishes must be held open, at an angle to the base, for the minimum time that allows a transfer of material.
- All microbiological transfers must be conducted close to a Bunsen burner flame. Safety glasses must be worn.
- Incubating at 35 to 40 degrees Celsius (°C) must be avoided because this tends to select organisms adapted to the human body. Temperatures of 25°C or below should be used.
- Glassware used for fermentation experiments must either be lightly plugged with cotton wool or be covered with aluminium foil and not sealed.



- All cultures must be destroyed before disposal by being heated in a pressure cooker for at least twenty minutes, and plastic dishes must be disposed of. As an alternative, dishes could be soaked in a 10 percent hypochlorite (bleach) solution for three days.
- Spillages of cultures should be dealt with by a teacher or technician wearing disposable gloves. The broken container and/or spilled culture should be covered with a cloth soaked in a disinfectant of 10 percent hypochlorite (household bleach). After ten minutes, the disinfectant will have had time to work, and the spillage must be cleared away using paper towels and a dustpan. The contaminated material should be placed in a disposal bag, along with the gloves, and be disposed of. The dustpan should also be disinfected.

Micro-organisms suitable for use in schools include:

- soil micro-organisms (for example, *Azotobacter* spp.);
- vinegar-producing micro-organisms (for example, *Acetobacter* spp.);
- baker's yeast;
- mildew and rust from plants;
- yoghurt bacteria;
- cheese bacteria and fungi;
- some fungal diseases on plants and rotting fruits;
- potato blight;
- black spot on roses;
- yeasts from grapes;
- fungi from jams and jellies.

Note: Some micro-organisms that are part of the normal flora of humans or animals may be pathogenic for immuno-compromised persons.

3.3 Plants

These are excellent for observing as living organisms. Many are perfectly safe to use, but some flowers, berries, and seeds are poisonous, and some produce allergies. References can be found in a library.

Fungi include toadstools, mushrooms, moulds, puffballs, and so on and may be very poisonous. Care should be taken when collecting or handling fungi. Plastic gloves or a plastic bag over the hands should be worn while doing so, and hands should be washed after removing the gloves. Fungi should never be placed near the mouth or nose.

Seeds purchased from retailers may have been treated with insecticidal or fungicidal substances. Students should wash their hands thoroughly after handling them.

Native Plants

It is not illegal to keep native plants.

Where plants growing in New Zealand bush are concerned, it is the area or ground that is protected, so native plants cannot be taken from a reserve or national park.

3.4 Rocks and Minerals

Heating rocks or minerals is not recommended because they can explode or give off poisonous gases. When fragmenting rocks or treating them with acids, students must wear safety glasses. Samples of the mineral asbestos must not be handled. They should be kept in a sealed container. Refer to Asbestos on page 47.

Safe Procedures with Hazardous Substances

It is important to realise and accept that we are constantly in contact with chemicals and other hazardous substances in our daily lives. Our bodies, the food we eat, and the air we breathe are all composed of “chemicals”. As well, there is no such thing as a totally safe chemical. Ensuring the safe use of a hazardous substance is the responsibility of the classroom teacher. A hazardous substance is defined under the legislation as a substance that has one or more of the following properties:

- explosiveness;
- flammability;
- a capacity to oxidise;
- corrosiveness;
- toxicity (including chronic toxicity);
- ecotoxicity (with or without bioaccumulation);

or that, on contact with air or water (except air or water where the temperature or pressure has been artificially altered), generates a substance that has one or more of the properties above.

People tend to continue to use materials and procedures that either they, or others, have used over a period of time, sometimes using chemicals for which a less hazardous material could be substituted without adversely affecting the process or its results. Particularly in teaching situations, every effort should be made to reduce the risks to staff and students. Substitute with health and safety in mind.

Precautions for Teachers and Students

The use of safety glasses, pipette fillers, fume cupboards, and safety screens must be made part of the normal routine.

- Teachers should be familiar with the location of fire extinguishers and how to use them.
- Ensure that adequate ventilation is provided.
- Use minimum quantities of chemicals in practical work.
- Use a spatula when transferring solids.
- Do not return unused chemicals to the reagent container.
- All reagents must be adequately labelled. Refer to Storage and Labelling on page 39. Read labels on reagent bottles carefully and handle the bottles with the label in the palm of the hand so that drips do not affect the labelled side of the bottle. Clean reagent bottles down immediately if the contents have been spilled down the sides.
- Waft a gas to the nose by moving the palm of the hand across the top of the container.
- Do not allow one student to hold a test tube while another pours a substance into it.
- A safety shower must be provided in the area where chemical solutions are being prepared.

- Dispose of wastes responsibly. Dispose of solvent wastes as soon as practicable. Do not accumulate wastes so that they become a potential hazard.
- Using the fume cupboard as a storage facility is not good practice.

4.1 Material Safety Data Sheets (MSDS)

Teachers and, where appropriate, students must know the hazards associated with substances they use.



Do not use a chemical without referring to a material safety data sheet.

Material safety data sheets (MSDS) are safety reports. They contain hazard information and should be supplied by the manufacturer or supplier with every chemical purchased. MSDS cite threshold limit values (TLV), permissible exposure limits (PEL), and other precautions or warnings for each chemical.

No person working with hazardous chemicals should be exposed to concentrations greater than the threshold limit values or permissible exposure limits.

A set of MSDS should be stored centrally in a school, where they are available for any staff member wishing to use them.

Material safety data sheets and related science-safety information can also be obtained on the Internet from:

www.ilpi.com/msds/index.shtml

www.msdsonline.com

www.hazard.com

As an alternative, MSDS can be obtained commercially. A set of three manuals of MSDS, developed for Australian schools, is available from:

School of Information Technology
Charles Sturt University/Mitchell
Panorama Ave
Bathurst NSW 2795
Australia

An MSDS software package called *BDH HDS v3.0 for Windows* is available from:

BDH Chemicals New Zealand Limited
PO Box 1246
Palmerston North
Telephone: (06) 358 2038 Fax: (06) 356 7311

In case of a medical emergency, contact:

National Poisons Centre
Urgent information: (03) 474 7000
Non-urgent information: (03) 479 1200
Fax: (03) 477 0509 e-mail: poisons@otago.ac.nz

Information about poisons and hazardous substances is available from:

The New Zealand Chemical Industry Council
PO Box 5069, Wellington
Phone: (04) 499 4311 Fax: (04) 472 7100
Website: www.nzcic.org.nz
National Emergency Response service: 0800 CHEMCALL (243 622)
(twenty-four hours a day, every day)

Environmental Risk Management Authority (ERMA) New Zealand
Hazardous Substances Adviser
During office hours – Phone: (04) 473 8426 Fax: (04) 473 8433



4.2 Storage and Labelling

(Refer to clauses 25 and 26 of the *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*.) The organisation of storage for chemical substances should be simple and straightforward and should minimise potential hazards. Storage areas must be secure and lockable, and access to chemical storage areas should be limited to staff. Wherever possible, the quantities purchased should be small enough to ensure a rapid turnover. Only approved containers, suitably labelled, should be used for repackaging and storing chemicals. If storage facilities are limited, more frequent purchasing may be necessary.

Labelling

Schools should develop a sensible labelling policy to ensure that the contents of all containers are clearly identified. This policy should be consistent across all chemical substances, including those made up within the school. When chemicals are received from the supplier, ensure that any labelling contains the:

- name of the chemical (including alternative names);
- formula;
- date purchased;
- date for disposal;

- degree of hazard, for example: “Caution – extreme danger”;
- type of hazard, for example: “Poison”, “Corrosive”;
- precautions to be taken, for example: “Keep away from heat”.

Stock Control and Storage

A good chemical inventory or stock-record system should be developed. The record should include:

- the room being inventoried;
- the name of the person in charge;
- the date of the inventory (a new date should be added each time the inventory is revised, and a copy should be kept in a location away from the laboratory);
- the location of each chemical;
- a cross-listing of any common or alternative name for each chemical;
- the chemical’s formula and a description of its form (for example, crystal or powder);
- the quantity;
- a receipt or purchase date and the date the container is received (this last date should be written on the container);
- the expiry date, which should also be written on the container.

Chemicals cannot be stored indefinitely, and so dates should be assigned for their disposal. Occasionally manufacturers assign expiration dates. Chemicals that have not been used for 5 years should be disposed of in an appropriate fashion.

In making decisions about disposal, a visual inspection may identify any of the following signs of obsolescence:

- darkening or colour change;
- cloudiness in liquids;
- spotting on solids;
- caking of anhydrous materials;
- liquids in solids or solids in liquids;
- pressure build-up in containers;
- evidence of reactions with water;
- unusual odours;
- damaged containers.

It is common today to find chemicals stored in plastic containers that should be suitable for the task. In some circumstances, reagents with a concentration greater than one mole per litre (1.0 mol L^{-1}) should not be stored in plastic containers, nor in laboratories. Consult the appropriate material safety data sheets (MSDS).

Under no circumstances should concentrated nitric or sulfuric acids or strong oxidising agents be stored in plastic containers.

Because some organic liquids are solvents for the fillers used in some plastics, those liquids should be stored in glass. Some chemicals, for example, silver nitrate, need to be stored in dark-coloured glass containers. Volatile chemicals should not be stored in direct sunlight or in warm places.

The containers in which chemicals are delivered may be unsuitable for long-term storage. Paper bags and metal containers should be checked regularly because they may deteriorate and the contents may need to be repacked. The Occupational Safety and Health Service (OSH) suggest that schools restrict orders of liquid chemicals in plastic containers to no more than one year's planned supply, and that chemicals be turned over within five years.

When accidentally mixed, incompatible chemicals can react together to cause an adverse chemical reaction. Schools should possess a straightforward storage system that keeps incompatible materials as far apart as realistically possible. Within any school storage area there are reactive incompatibles and chemicals that have more than one hazardous property. Reactive incompatibles should be separated by space and physical barriers wherever possible. A variety of systems for storing different classes of chemicals could be applied, but any system needs to be manageable and apply sound, sensible judgment.

Incompatible Chemicals

All chemicals should be stored according to their compatibility.

Keep:

- acids separate from bases;
- oxidising agents separate from reducing agents;
- active metals separate from oxidising agents;
- volatile solvents separate from oxidising agents;
- concentrated acetic acid, concentrated nitric acid, and concentrated sulfuric acid separate from one another.

A chart providing a guide to chemicals that should not be stored together can be found in Appendix 4 on page 74.

A possible school storage system to separate incompatible chemicals could consist of the following classes.

- **Concentrated acids.** Concentrated sulfuric acid is both corrosive and an oxidising agent. Store it apart from other inorganic acids, bases, reducing agents, and solvents.
- **Oxidising agents**, such as nitric acid, permanganates, silver nitrate. Do not store oxidising agents directly on wooden shelves. Spills may react with the organic portion of the shelf and cause spontaneous ignition. Place the containers on plastic trays made from unplasticised PVC or polypropylene, and renew the trays at least every two years.

Hypochlorite solutions, such as household bleach, are oxidising agents that will release chlorine gas on contact with acids. Keep them separated from acids.

Small quantities – 1 kilogram (kg) or less – of solid oxidising agents may be stored on wooden shelves with other “dry” laboratory chemicals.

- **Bases**, such as ammonia, sodium hydroxide, potassium hydroxide.
- **Organic solvents**, such as acetone, acetic acid, citric acid, methanol.
- **Water reactives**, such as sodium, calcium oxide.
- **General “dry” lab chemicals.** These are the relatively innocuous or unreactive materials commonly found in school science rooms.
- **Compressed gas cylinders.**

4.3 General Substance Information

Acids

Refer to specific acids under the alphabetical list of hazardous substances (see pages 46–51).

The following guidelines should be observed.

- Protective clothing and safety glasses should be worn when handling these substances.
- Store concentrated acids and alkalis in a way that minimises risk from spillage, for example, low on shelves but not on the floor where they can be kicked.
- Ensure students understand the difference between dilute and concentrated acids.
- Do not use cleaning mixtures that contain acids. Such mixtures can be replaced by commercially available cleaning agents.
- To prevent a build-up of gas pressure, pour acid only into wide-mouthed containers.

• When diluting acids, always add concentrated acid slowly to larger volumes of water, stirring until well mixed. Do not do this alone. Another responsible person should be nearby. Wear protective clothing.

- When reacting acids with metals, take the following precautions.
 - Use only small amounts of metals.
 - Carry out reactions in large test tubes, conical flasks, or beakers as some metals react vigorously, effervesce, produce high temperatures, and may boil.
 - Do not use powdered metals such as aluminium, magnesium, and zinc.
- Do not react sodium, lithium, and calcium with acids.

Adhesives

Follow manufacturers' recommendations. Restrict access to adhesives that have the potential for solvent abuse.

Alkalis

Refer to specific alkalis under the alphabetical list of hazardous substances (see pages 46–51).

Teachers and students should be aware of the following.

- Protective clothing and safety glasses should be worn when handling these substances.
- In their solid form, sodium hydroxide, potassium hydroxide, calcium oxide, and calcium hydroxide can react violently with concentrated acids and water.
- The fumes evolved from alkalis can affect the respiratory system of a person handling them.
- Wet material in contact with calcium oxide may generate excessive heat, which can cause an explosion.
- All alkalis (especially sodium hydroxide) are corrosive and very dangerous to the skin.
- Care should be taken when mixing aluminium or zinc with solutions of strong alkalis because hydrogen is evolved.
- Solid pellets of alkalis should be handled only with tweezers or a scoop to avoid burns.
- Contact with most reducing agents should be avoided.
- Solid and concentrated sodium hydroxide and potassium hydroxide are dangerous when mixed with many metals, chlorides, and hydrochloric acid.
- Care should be taken when making a solution of sodium hydroxide or potassium hydroxide. Always use a fume cupboard and a magnetic stirrer and, if possible, stand the mixing beaker in a larger bowl of cold water to dissipate the heat produced.

Cosmetic Preparations

Before using any ingredients for cosmetic preparations, teachers must make themselves aware of any potential hazards or risks associated with flammable solvents, acids, and alkalis used in them. Care must be taken when using “excess” alkali in a preparation. The pH must be tested at the end of a procedure and adjusted, if necessary, to ensure the resulting preparations are neutral. Preparations must be disposed of after the lesson and not stored or kept for future use. Students who may have sensitive skin should not use these preparations. Students must not make toothpaste for their own or others’ use.

Crystal Making

Refer to Making crystals on page 62.

Diffusion Experiments

Before carrying out any diffusion experiment involving gases, teachers must inform themselves of any hazards associated with the gases involved.

Dyes and Stains

Teachers need to be aware that many stains are potentially harmful although the risk is limited by the small quantities used. Consult MSDS for specific advice. Dyes and stains may cause allergic reactions and should be kept off the skin. Toluidine blue should not be used because it is a carcinogen. Aceto-orcein stain is corrosive, can burn the skin, and can irritate the respiratory system. Methylene blue can be harmful if swallowed, and the fumes can irritate the eyes and skin. Some stains are flammable, and it is a wise precaution to keep them away from naked flames.

Ethers

Ethers, and compounds that contain the ether grouping, are especially prone to oxidation, by air, to peroxides. Do not keep them for long periods in half-empty bottles or in clear-glass bottles. When a little-used bottle is nearly empty, discard the residue. Do not distil ether from such bottles because it may explode. Even though an ether has been treated to destroy peroxide, stop distillation when about 15 percent remains in the flask.

Evaporating to Dryness

Teachers and students need to be aware of the following.

- Always carry out evaporation in an evaporating dish or crucible.
- Remove the heat before the water has totally disappeared.
- Spitting may occur when solutions are being evaporated to dryness, so do not remove safety glasses even when the heat has been turned off.
- A steam bath may be used when evaporating to dryness.

Explosives

Making explosives is forbidden.

The following substances are commonly used in the manufacture of explosives. Students’ access to them should be restricted.

Aluminium powder	Ammonium nitrate	Charcoal
Flammable chemicals	Naphthalene	Nitric acid
Potassium dichromate	Potassium nitrate	Stearic acid
Sulfur	Urea	

Refer to Heating Hazardous Substances on page 51.

Metals

When using metals for experimental procedures, teachers and students should be aware of the following.

- Alkali metals can react explosively with water. Because of their sensitivity to water vapour, they are stored under hydrocarbon oil.
- Lithium is less violently reactive but must still be treated with caution.
- Calcium is the most suitable metal to use for water-metal-reactions, but to show group trends, a teacher may place rice-grain-sized pieces of sodium and lithium in shallow water in a large deep trough *for demonstration only*.
- Caesium, rubidium, or potassium must never be added to water.
- Before starting an experiment, bulk supplies of chemicals should be removed, and lids placed on all containers.
- Finely divided metals such as aluminium, magnesium, and zinc are easily ignited and burn furiously. Because using water extinguishers on these fires is both dangerous and ineffective, use sand.
- Metal powders should not be in contact with, or mixed with, oxidising agents, such as nitrates and peroxides, because they form explosive mixtures.
- Metal powders, such as magnesium and zinc, react violently with sulfur. Carry out the reaction between powdered zinc and powdered sulfur by using only small quantities in a crucible or on a tin lid. The reaction between powdered sulfur and iron filings is safe in a dry test tube.
- When heating metals, only small pieces of metal should be used. Use metal tongs to hold in the flame.

Organic Substances

Minimum quantities should be stored in laboratories or preparation rooms. Bulk supplies should be kept in a dangerous-goods store.

The following common solvents and organic reagents have flashpoints below 30°C and should be kept in a well-ventilated area.

Butanone (methyl ethyl ketone)	Cyclohexane
Cyclohexene	Ethanal (acetaldehyde)
Ethanol (ethyl alcohol)	Ethyl ethanoate (ethyl acetate)
Ethoxyethane (diethyl ether)	Methanol (methyl alcohol)
Methyl benzene (toluene)	Pentane
Pentyl ethanoate (amyl acetate)	Petroleum ether
Propanone (acetone)	Propan-1-ol (n-propyl alcohol)

Oxidation Reduction Reactions

Reactions that involve oxidation and reduction may produce heat and could lead to a fire.

Reductions involving magnesium, aluminium, and zinc powders must be demonstrated only.

When burning metals in oxygen, use only a small sample, for example:

- 2 cm² of aluminium foil;
- 2 cm lengths of magnesium ribbon;
- 1 cm² of granulated zinc.

Take care when burning metals in air. Small fires can be extinguished by placing sand on the fire.

Do not use hydrogen, ammonia, and carbon monoxide for gaseous reductions of metal oxides. Liquid petroleum gas (LPG) can be used as a substitute. Do not react aluminium with bromine because it can become incandescent owing to energy production. In many oxidation-reduction reactions, there may be large energy transfers in the form of heat. It is possible for constituents of the reaction to explode. For metal or metal-oxide reactions, the rate of reaction depends on the metals' relative positions in the activity series. Do not react sodium, lithium, and calcium with other metal oxides. Magnesium, aluminium, zinc, iron, tin, lead, and copper can be reacted with metal oxides, but do not use powdered metals in such reactions.

Paint

Follow manufacturers' instructions. Be aware of the potential for solvent abuse with some products.

Pesticides

Store pesticides in a locked cupboard. Use them only under strict supervision and in accordance with the manufacturers' instructions.

Do not dispose of pesticides into the sewerage system. If large quantities need to be disposed of, contact the local authority.

Pesticides such as insecticides, herbicides, and fungicides, which are deadly or dangerous poisons (Schedule 1 and 2 poisons), should not be used.

Plastics

Refer to Fibres, Fabrics, and Plastics on page 53.

Proteases

Proteases may cause allergic reactions. Use only small quantities.

Radioactive Substances

Schools may use sealed radioactive materials prepared for the purposes of instruction or demonstration. However, there are limitations. When the radioactive source is not in use, keep it in a locked cupboard with the standard radioactive-warning symbol on the outside. When radioactive sources are no longer required, send them to the National Radiation Laboratory. Contact the National Radiation Laboratory for advice about transportation requirements.



The following sealed radioactive materials are the only ones permitted.

- The nuclides sodium-22, cobalt-60, strontium-90, caesium-137, and thallium-204 in activities not exceeding 1 megabecquerel in each source.
- The nuclides polonium-210, radium-226, thorium-232, uranium-238, plutonium-239, and americium-241 in activities not exceeding 0.3 megabecquerel. (1 Bq = 1 disintegration/s)

Radioactive materials other than those listed above require a licence from the National Radiation Laboratory. The National Radiation Laboratory will consider applications from schools and in some cases may approve a restricted licence.

Contact address for information and advice:

National Radiation Laboratory
PO Box 25-099
108 Victoria Street
Christchurch
Telephone: (03) 366 5059
Fax: (03) 366 1156

Restriction Enzymes

Restriction enzymes may cause allergic reactions. Use only small quantities.

Solvents

The term "solvent" is often used for organic liquids that tend to be used in large quantities. They are often flammable, highly volatile, and hazardous because of the quantities involved. The vapour presents the greatest hazard as it may harm the eyes or the respiratory tract. Before using any solvent, find out whether any hazards or risks are associated with the substance and refer to the MSDS. Where directed, use a fume cupboard. Methylated spirits, surgical spirits, and white spirits are highly flammable.

4.4 Specific Hazardous Substance Information

Teachers need to be aware of potential hazards when they choose chemicals for use in their classrooms. Potential hazards must be identified and minimised. The information provided here is not intended to be definitive and considers only the more common chemicals used in schools. The corresponding MSDS should always be consulted.

Acetic Acid (Ethanoic Acid)

Handle glacial acetic acid only in a fume cupboard. It has a flashpoint of 40°C and should be heated only in a water bath. The vapour is an irritant and should be avoided. The liquid causes severe burns.

Acetone (Propanone)

Acetone is highly flammable, causes severe corneal damage, and the fumes are irritating if inhaled. Use a fume cupboard.

Acetyl Chloride (Ethanoyl Chloride)

Do not mix acetyl chloride with water. The reaction is violent at room temperature, producing an acidic solution and hydrogen chloride gas, which is irritating and corrosive.

Acetylene

Refer to Ethyne on page 49.

Ammonia

Ammonia (0.88) has similar properties to those of caustic alkalis. It produces toxic ammonia gas, which builds up pressure in stock bottles. Breathing the vapour is extremely irritating and can lead to severe poisoning. Take care when opening stock bottles in a fume hood. Concentrated ammonia can be stored in plastic, provided the containers are kept cool. Ammonia forms dangerously explosive substances with chlorine, bromine, and iodine.

Ammonium Dichromate

Store ammonium dichromate away from reducing agents and treat it as a suspected carcinogen. The heating of ammonium dichromate in the "volcano" demonstration must not be carried out in the open classroom, although it may be demonstrated in a fume cupboard.

Ammonium Nitrate

Store ammonium nitrate away from combustible substances.

Asbestos

Asbestos is not permitted in schools, except in mineral form. Store mineral asbestos in a clear, sealed container to prevent students from opening it. The container must carry an appropriate hazard-warning label stating that it is for external examination only and must not be opened.

Barium Nitrate

Store this away from combustible substances.

Bromine

Bromine is corrosive, has an irritant vapour, causes severe burns, and is very toxic when inhaled. Handle it in a fume cupboard with care. When handling bromine liquid or vapour, wear protective clothing, eye protection, and PVC gloves because it causes severe burns. Bromine is dangerous with ammonia solution (explosive products can be formed), potassium, sodium, aluminium, magnesium, mercury, alcohols, acetone, and ethers (violent reactions).

When bromine is used, a beaker containing an approximately 1.0 mol L⁻¹ solution of sodium thiosulfate should be available to treat spillage and to neutralise unused bromine liquid and contaminated glassware. If bromine comes in contact with the skin, immerse the skin immediately in the sodium thiosulfate solution, and then wash it thoroughly in water. Treat as for acids.

It is strongly recommended that bromine be purchased and stored only in ampoule form. Dispose of used bromine at the end of an experiment. Store bromine in a well-ventilated store. Take care also when using aqueous bromine.

Butan-1-ol and Butan-2-ol

Do not store these with oxidising materials or aluminium. These must be used in a well-ventilated area because swallowing or breathing them is harmful.

Calcium Hydroxide and Calcium Oxide

Solid calcium hydroxide and calcium oxide react violently with concentrated acids and water. Wet material in contact with calcium oxide may generate excessive heat that could cause an explosion, and the fumes can affect the respiratory system. Neither calcium hydroxide nor calcium oxide should be brought into contact with most reducing agents. Wear protective clothing and safety glasses.

Carbon Dioxide (Solid) – Dry Ice

Wearing eye protection and protective gloves when handling dry ice is recommended because it burns skin. Carbon dioxide can be corrosive in the presence of moisture. Because it is heavier than air, the gas will collect in confined, unventilated areas. Carbon dioxide increases greatly in volume on phase-change from solid to gas, so do not store it in gas-tight containers.

Chlorides

Phosphorus pentachloride, phosphorus trichloride, silicon tetrachloride, aluminium chloride, and titanium chloride react violently with water. These chlorides should not be handled near water or allowed to come into contact with the skin. Gloves must be worn. Full protection is required when opening samples of liquid chlorides. The container of liquid chloride should be cooled and then opened in the fume cupboard. Bottles of these materials stored in warm places have been known to explode.

Chlorine

The teacher should prepare chlorine only in a fume hood. The contents of a single gas jar of chlorine dispersed throughout an average laboratory will produce a concentration several times higher than the safe threshold.

Chromates

Teachers need to be aware that these can cause ulcerations on contact with the skin and can cause nasal cancer if inhaled.

Cobalt Chloride

Teachers need to be aware that this is a suspected carcinogen and limit students' exposure to it.

Copper Sulfate

Refer to Making crystals on page 62.

Copper sulfate is harmful if swallowed, and it irritates the skin and burns the eyes.

Dichromates

Refer to Chromates above.

Diethyl Ether

Refer to Ethers on page 43.

This is harmful if swallowed or breathed in, and it irritates the eyes and degreases the skin. It has a low flashpoint.

Dry Ice

Refer to Carbon Dioxide above.

Dyes and Stains

Some dyes and stains can be harmful. Refer to Dyes and Stains on page 43.

Ethanoic Acid

Refer to Acetic Acid on page 46.

Ethanoyl Chloride

Refer to Acetyl Chloride on page 46.

Ethyl Ethanoate (Ethyl Acetate)

This chemical irritates the eyes and respiratory system and can be harmful if swallowed, causing liver and kidney damage.

Ethyne (Acetylene)

This gas should be collected in small test tube quantities. It must never be mixed with pure oxygen.

Helium

Breathing small quantities of helium at ambient pressure is unlikely to cause any health concerns. In view of solvent abuse, however, teachers should consider whether introducing students to the idea of inhaling for fun is desirable. Breathing of helium, or any gas from a pressurised cylinder, is extremely dangerous because the lungs could over-inflate if the pressure is greater than ambient conditions. Helium balloons would not present this hazard.

Hydrochloric Acid

Concentrated hydrochloric acid is highly corrosive. The gas, hydrogen chloride, is a very toxic irritant and is continually released from the liquid. The acid is dangerous with sulfuric acid and with reactive metals such as sodium, aluminium, and magnesium. Do not bring the acid into contact with methanal (formaldehyde) or its vapours since they can react to produce a carcinogen. For this reason, store concentrated hydrochloric acid well apart from methanol and methanal.

Hydrogen

Hydrogen is a flammable gas and forms an explosive mixture with air. Methane can replace hydrogen in some reduction reactions. Hydrogen can be prepared on a test tube scale, and igniting such amounts in the air presents little hazard. Prepare hydrogen by reacting zinc or magnesium with dilute hydrochloric or sulfuric acid. If zinc is used, a little copper sulfate can be added as a catalyst.

Hydrogen Peroxide

Concentrated hydrogen peroxide is damaging to skin and eyes. Handle it with care and keep it free from organic and particulate matter. It decomposes very readily. Nothing above 20 volume (this is a measure of the total volume of oxygen that could be produced) hydrogen peroxide should be needed in a school. Even at this strength, pressure can build up in tightly sealed containers. It must be stored in a cool, dark place away from reducing agents and transition metal compounds.

Hydrogen Sulfide

Do not prepare hydrogen sulfide because it is highly toxic. Small quantities can be detected through the smell, but after exposure the nose becomes desensitised, so smell is unreliable as a means of detection.

Iodine

Both the solid and the vapour are very dangerous to the skin and eyes, and it is toxic if swallowed. Do not heat iodine in the open laboratory or leave diffusion experiments set up in the laboratory. Use the fume hood. Iodine is dangerous with ammonia solution (explosive), potassium, sodium, aluminium, magnesium, and zinc.

Lead and Lead Salts

Do not breathe the dust of lead and lead salts because the effects are cumulative and may have serious chronic consequences.

Mercury

Mercury is very toxic by swallowing, breathing, and skin contact. There is a danger of cumulative effects. Restrain mercury spillages if possible. Residual mercury can be removed by covering it with powdered sulfur or zinc powder and sweeping it up or by

using a specially designed vacuum or suction apparatus. A plastic dropper or syringe can be used to suck up mercury droplets. All materials should then be disposed of in a safe manner. (Refer to Mercury on page 54 and Mercury Waste on page 55.)

A small, clear, sealed plastic container of mercury may be kept for external examination. The container must have its opening sealed to prevent student access, as well as an appropriate hazard-warning label stating that it is for external examination only and must not be opened.

Methanol (Methyl alcohol)

This is toxic, has a low flashpoint, is damaging if splashed in the eyes, and can be absorbed through the skin.

Naphthalene

Naphthalene fumes have been shown to be carcinogenic and possibly mutagenic and teratogenic. Naphthalene must not be heated.

Nickel

Nickel metal and salts cause allergic skin reactions in some people. Avoid skin contact with nickel salts or solutions. Wash off promptly with water.

Ninhydrin

Handle this with extreme care, using a fume hood, gloves, and safety glasses. Refer to the MSDS.

Nitric Acid

Concentrated nitric acid is highly corrosive, is a powerful irritant, and reacts vigorously with organic substances. It can build up excessive pressure in sealed containers. Perform reactions requiring concentrated nitric acid in a fume cupboard and avoid contact or storage with ethanol, propanol, reactive metals, and thiosulfates.

Reacting nitric acid with metals can produce harmful oxides of nitrogen as well as hydrogen, so it is suggested that this acid not be used to illustrate typical metal-acid reactions. Avoid contact with the skin and eyes.

Do not attempt to clean glassware by adding ethanol to nitric acid.

Nitrogen Dioxide

Prepare nitrogen dioxide only in a fume cupboard because it is toxic. If it is inhaled, seek medical attention because the effects may not show for several hours. Nitrogen dioxide is dangerous with sodium, magnesium, and iron.

Phenolphthalein

Phenolphthalein solution is flammable and should be kept away from naked flames. It is a powerful laxative and ingestion is harmful, causing stomach upset and diarrhoea.

Potassium Hydroxide

Potassium hydroxide is corrosive and very dangerous in contact with the eyes and the skin. It is dangerous when mixed with aluminium and zinc because hydrogen is evolved. Handle solid pellets only with tweezers or a scoop to avoid burns.

Solid potassium hydroxide dissolves in water and generates considerable heat. The fumes can affect the respiratory system. Wear protective clothing and safety glasses.

Avoid contact between potassium hydroxide and most reducing agents. Solid and concentrated potassium hydroxide are dangerous with sodium, with many other metals and chlorides, and with hydrochloric acid. Take care when making a solution of potassium hydroxide. Always use a fume cupboard and a magnetic stirrer, and if possible, stand the mixing beaker in a larger bowl of cold water to dissipate the heat produced.

Propan-2-ol

This must be used in a well-ventilated area because breathing or swallowing it can lead to a range of conditions, some potentially fatal.

Silver Nitrate

The solid and its solution cause severe eye irritation. Skin contact will cause stains and may cause burns.

Sodium Hydroxide (Caustic Soda)

Sodium hydroxide is corrosive and very dangerous in contact with the eyes and the skin. It is dangerous with aluminium and zinc because hydrogen is evolved. Handle solid pellets only with tweezers or a scoop to avoid burns.

Solid sodium hydroxide dissolves in water and generates considerable heat. The fumes can affect the respiratory system. Wear protective clothing and safety glasses.

Avoid contact between sodium hydroxide and most reducing agents. Solid and concentrated sodium hydroxide are dangerous with sodium, with many other metals and chlorides, and with hydrochloric acid. Take care when making a solution of sodium hydroxide. Always use a fume cupboard and a magnetic stirrer, and if possible, stand the mixing beaker in a larger bowl of cold water to dissipate the heat produced.

Sulfur Dioxide

This is an irritating, toxic, and corrosive gas. Store containers of sulfur dioxide in a cool, well-ventilated area (not in the fume cupboard). Experiments with the potential to produce large quantities of sulfur dioxide gas must be carried out in a fume cupboard.

Sulfuric Acid

Concentrated or fuming sulfuric acid reacts vigorously with water. Avoid contact with the skin and eyes because it causes severe burns; wash it off with large quantities of water.

Concentrated sulfuric acid forms dangerous and even explosive mixtures with acetone, permanganates, perchlorates, and chlorates. It also reacts vigorously with most reducing agents, including sodium and many other metals, and with chlorides. The reaction between sulfuric acid and sugar should be conducted in a fume cupboard since evidence suggests that carbon monoxide is produced. The acid should not be used as a drying agent for gases.

Urea

Urea must be kept away from phosphorus pentachloride.

4.5 Heating Hazardous Substances

Heating samples of unknown composition could result in hazardous fumes and is forbidden. The burning of polyurethanes is also forbidden for health reasons.

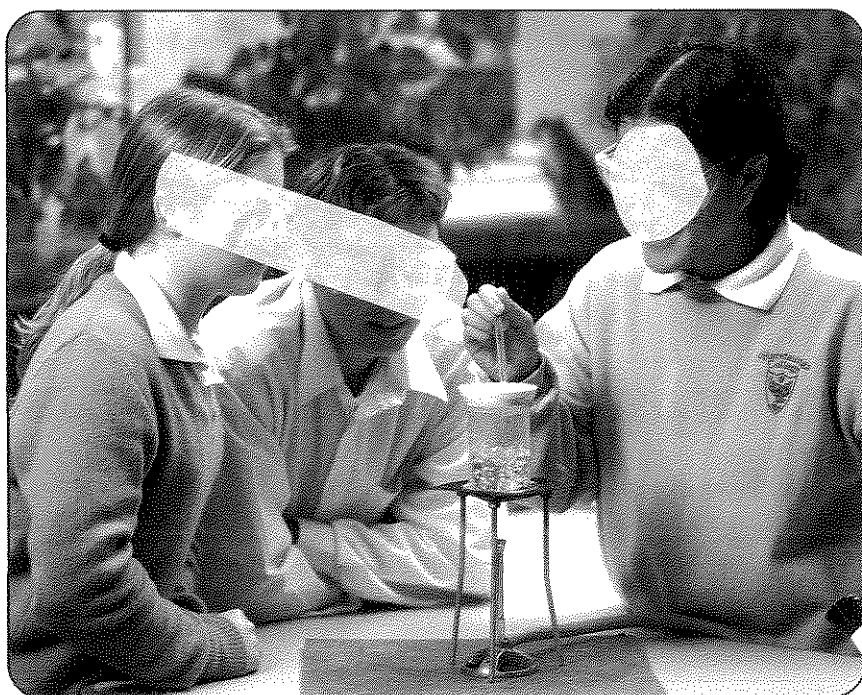
When heating chemical substances, there is a risk of explosion. The following guidelines should apply.

- Wear eye protection when heating chemical substances.
- In the open laboratory, do not heat substances that are likely to give rise to harmful fumes. These substances include sulfur, iodine, and lead nitrate (which gives off oxides of nitrogen).
- When the whole class, or a substantial part of the class, is involved in heating chemical substances, the laboratory must be adequately ventilated.

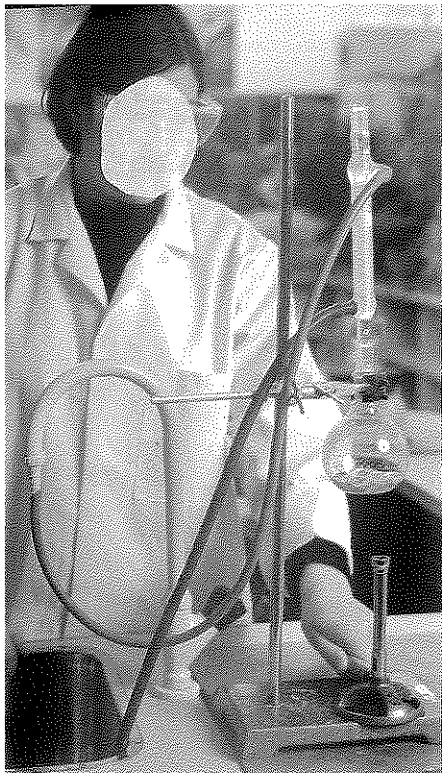
- Do not keep low-flashpoint liquids or hydrogen generators on the same bench as a naked flame or hot plate.
- Never bring unknown liquids near naked flame.
- When heating paraffin wax, do not leave it unattended because it can vaporise, reach the temperature of the flashpoint, and spontaneously ignite. It should be heated in a water bath.
- Never heat flammable liquids near a door because, if an accident occurs, students may not be able to leave the room.
- Never place heating devices of any kind, whether gas or electric, on a bench that is not protected by heat-resistant material.
- Do not place charts on walls above gas outlets used for heating purposes, for example, in laboratories where burners are used on the side benches.
- When heating substances in a test tube, do not point the open end at another person.
- When heating liquid in a test tube, ensure that the liquid is no deeper than twice the diameter of the tube.
- Never use a naked flame to heat a volatile or flammable liquid. Instead, always use a water bath or heating mantle.

When working with flammable chemicals, teachers should also be aware of the following.

- Serious dangers arise because of the ease with which some chemicals ignite. Check MSDS before using flammable chemicals.
- Some substances are spontaneously flammable.
- People handling flammable chemicals should never work alone.
- Flammable chemicals should be used in as small a quantity as possible.
- Students should not be permitted to carry stock bottles of flammable liquids around the laboratory. Junior students should not have access to stock bottles. In the event of an accident, the teacher should be aware of the necessary action to be taken, and any injury should be treated immediately.



- Fire-fighting equipment should be readily available. Do not use water on flammable liquids. Do not pour flammable liquids down the drain but soak them into dry sand or vermiculite. Do not place contaminated sand in the fire bucket.



- Quantities of flammable chemicals in the area must not exceed immediate requirements.
- Lids must be kept on containers of flammable substances.
- A water bath should be used to heat liquids to below 90°C. For many “test tube” experiments, a beaker that has been filled with boiling water from a kettle is often suitable. If an open flame has been used to heat the water bath, then extinguish the heat source before introducing the flammable liquid. Heating mantles may be used.
- To heat liquids to above 90°C, an oil bath should be used. Yellow liquid paraffin is suitable for schools but should not be heated above its flashpoint of 250°C. Make sure that oil baths are stable, and leave them to cool after use.
- Wherever possible, flammable chemicals should be heated in distillation apparatus, and the receiving vessel connected to a condenser with a small vent or to a flask with a reflux condenser.
- Continuous and undivided attention should be given to preparations and distillations.

Fibres, Fabrics, and Plastics

Carry out any heating of fibres, fabrics, and plastics of known composition in either a fume cupboard or a well-ventilated room. If possible, use only small pieces, 1 cm² or less. Do not use samples of unknown composition.

4.6 Dealing with Spillages

Refer to *New Zealand Chemistry Industry Council Code of Practice: Handling Small Spills of Hazardous Substances* from The New Zealand Chemistry Industry Council (Internet website: www.nzcic.org.nz).

Teachers need to have considerable training and experience before taking responsibility for cleaning up a major spillage.

Cleaning up Chemical Spillages

Teachers should consider the nature of the spilled chemical, how hazardous it is, and if it is within their capabilities to clean up, or whether they need to call in outside assistance from organisations such as the fire service or a commercial contractor. Schools should not have large quantities of extremely hazardous materials stored. For more specific advice, consult MSDS.

Safety equipment required includes:

- safety glasses;
- gloves;
- gumboots;
- protective clothing;
- 5 kg of sand, vermiculite, or other inert proprietary absorption material.

Materials to soak up spillages should be readily available. Absorbent materials include vermiculite or sand. Cloths may be used, unless the spillage is of a strong oxidising agent. If contamination of a cloth is small, it can be washed immediately with detergent and rinsed well. A more seriously contaminated cloth should be placed in a lidded metal bin that is emptied daily.

Acids

For small spillages of acids, flush the area with water but not to the extent of spreading the spillage unnecessarily. Acid spillage can be absorbed with earth or sand and neutralised carefully with soda ash or sodium bicarbonate. After absorbing and neutralising smaller quantities of acids, dispose of them down the sink, using large amounts of water.

Alkalis

Absorb spillages of alkalis by using sand or earth. Use citric acid or sodium bisulfate to neutralise the alkali before clean-up. Any alkali left after the clean-up should be washed with water, provided the contaminated water does not contact aluminium or zinc containers. Once they have been neutralised, alkalis can be disposed of down the sink using plenty of water.

Mercury

Refer to Mercury on page 49 and Mercury Waste on page 55.

Restrain mercury where possible. Residual mercury can be removed using zinc powder or sulfur powder, a proprietary mercury-spill kit, mercury sponges, or a specially designed vacuum-and-suction apparatus. Dispose of it safely. Consult the nearest local authority or a commercial waste-disposal company.

Organic Solvents

Absorb spillages of organic solvents by using sand, diatomaceous earth, or a suitable proprietary product. Clean up flammable solvents with absorbent rags and then place them in a drum for disposal.

Oxidising Agents

Never use rags or sawdust to clean up spills of oxidising agents. Consult MSDS for specific advice.

4.7 Waste Disposal

If the school holds any dangerous or unwanted chemicals that are no longer needed, the local authority should be contacted. In some cases, regional councils can provide appropriate advice. There are also commercial waste-disposal companies that could be contacted.

Waste disposal must be planned for before the start of any practical activity. Containers for waste disposal should be appropriate for the particular type of waste. Laboratory wastes need to be segregated into the following categories in separate containers:

- paper;
- plastics;
- broken glass;
- sharps, such as razor blades, needles, and scalpel blades;
- chemical wastes;
- biological wastes.

Acids and Bases

Discard these down the sink once they have been neutralised.

Alkalis

Do not store alkalis in aluminium or zinc containers.

Large quantities of waste acid or alkali should be stored and a commercial waste-disposal company contacted.

Aqueous Solutions of Most Salts

These are relatively stable and, if properly labelled, can be stored indefinitely.

Biological Waste

Animal carcasses

It may be appropriate in some areas to bury these; otherwise they should be incinerated. Contact a commercial contractor if necessary.

Microbiological waste

Destroy all cultures before disposal by heating them in a pressure cooker for at least 20 minutes, and then dispose of any plastic dishes as plastic waste. Alternatively, soak the dishes in a 10 percent hypochlorite (household bleach) solution for 3 days.

Chemical Waste

Advice on disposing of chemical wastes should be sought from the nearest local authority.

Do not allow wastes to accumulate but dispose of them regularly. If the substance does not adversely affect the environment, small quantities of water-soluble materials can often best be disposed of by diluting and pouring down the drain. Small quantities of volatile substances are best dealt with by placing them in a large trough in a fume cupboard with the door open slightly and leaving the fan on to allow the substances to evaporate.

Stored chemical wastes can be divided into the following classes:

- aqueous solutions;
- heavy-metal solutions;
- water-insoluble waste;
- chlorinated solvents;
- peroxides.

Collected chemical wastes should be carefully labelled, and each label should specify:

- the substance name;
- the major ingredients if the waste is a mixture;
- any special hazard warnings and precautions;
- the date.

Mercury Waste

Refer to Mercury on pages 49 and 54. Contact the nearest local authority or a commercial waste-disposal company.

Organic Solvents

Dispose of these in small quantities by placing an open container in a fume cupboard with the door open slightly and leaving the fan on to allow the solvents to evaporate. For larger quantities, contact a commercial waste-disposal company.

Radioactive Waste

See Radioactive Substances on page 45–46 for a contact address.

Salts of Heavy Metals

Salts in aqueous solutions – for example, barium (II), cobalt (II), copper (II), lead (II), nickel (II), and silver (I) – will commonly precipitate as either metal oxides or hydroxides with 1.0 mol L⁻¹ sodium hydroxide, although some metal oxides and hydroxides redissolve at high pH. Seek advice as to the best way to dispose of these wastes.

Sharps

Seek commercial advice as to the best means of disposal or check with the local authority. Local medical supplies companies can provide specific containers for sharps. Note that many disposal companies will not accept sharps in non-approved containers. Refer also to Sharps on page 30.

4.8 Commercial Waste-disposal Companies

A number of commercial companies in larger centres specialise in disposing of hazardous waste, such as chemical, medical, and veterinary wastes, pathological specimens, and pharmaceuticals. These companies may provide a hazardous-waste incineration service and could be consulted for advice on chemical and biological waste disposal. Check the Yellow Pages for details. Schools having problems disposing of hazardous waste should consult their local authority or regional council.

Section 5

Forbidden Chemicals, Forbidden Experimental Procedures, and Forbidden Equipment

5.1 Forbidden Substances

The following substances are forbidden in schools.

- Acid green (biological stain)
- Aniline
- Antimony and its compounds
- Aromatic amines
- Arsenic and its compounds (except when in commercially available water test kits)
- Asbestos (except in mineral form in a sealed container)
- Auramine (biological stain)
- Benzene
- Benzidene
- Benzoyl peroxide
- Bismuth and its compounds
- Cadmium and its compounds
- Carbon disulfide
- Carbon tetrachloride
- Chloroform (use dichloromethane in its place)
- Chlorates and perchlorates
- Chromic acid
- Coal tar and crude petroleum (except in sealed containers)
- Cyanides
- Deadly poisons (Schedule 1 poisons) and dangerous poisons (Schedule 2 poisons). Refer to The New Zealand Chemical Industry Council's website www.nzcic.org.nz
- Dianisidine
- 2,4-dinitrophenylhydrazine
- Ethidium bromide
- Explosives, including fireworks
- Highly carcinogenic substances, such as polycyclic aromatics and their derivatives. Refer to MSDS. Some reactions can produce highly carcinogenic substances, such as fuming sulfuric acid and sawdust.
- Hydrofluoric acid
- Magenta I (biological stain)
- Nitrobenzene and related compounds

- Paris green (biological stain)
- Perchloric acid
- Picric acid
- Phenols and phenolic compounds
- Poisons – Deadly and dangerous (Schedules 1 and 2 of the Toxic Substances Regulations)
- Polyacrylamide
- Potassium
- Prussic acid
- Phenylthiocarbamide (PTC) and phenylthiourea (PTU) papers and solutions
- Pyridine
- Radioactive materials (apart from those specifically mentioned in the section on radioactive materials)
- Sudan IV (biological stain)
- White phosphorus.

5.2 Forbidden Chemical Procedures

The following procedures are considered to be very dangerous and are forbidden in schools.

- Mixing strong oxidising agents with strong reducing agents. As a general rule, anything with a lot of oxygen, and anything that will burn, must not be mixed. Common strong *oxidising agents* include nitrates, peroxides, and permanganates. Common strong *reducing agents* include sulfur, phosphorus, carbon, powdered metals (particularly magnesium, aluminium, and zinc), and low-valency cations of metals that have multiple valencies (for example, stannous chloride, which seems fairly harmless but explodes on heating).
- Heating calcium, lithium, and sodium.
- Exploding hydrogen and chlorine, oxygen and ethyne (acetylene), chlorine and ethyne (acetylene), oxygen and ethene, or large volumes of hydrogen and oxygen.
- Preparing nitrogen halides from mixtures such as ammonia and chlorine, or ammonia and iodine.
- Preparing oxides of chlorine.
- Preparing phosphine, phosgene, hydrogen cyanide, or cyanogen.
- The thermite reaction – mixing aluminium powder with iron (III) oxide, chromium (III) oxide, or silicon dioxide.
- Using liquid oxygen. To obtain very low temperatures, liquid nitrogen, obtainable from an industrial gas source, should be used instead of liquid oxygen. A blue tint in the liquid nitrogen indicates contamination with liquid oxygen, and it must be discarded. A suitable container is a thermos flask, which *must* have a hole bored in the stopper.
- Heating mercury oxide to obtain mercury, or conducting chemical experiments using mercury.
- Burning ammonia gas in oxygen.

- Heating ammonium dichromate with aluminium or magnesium powder.
- Preparing or heating ammonium nitrate or ammonium nitrite.
- Any reactions requiring cadmium salts.
- Preparing an ester using alkyl halides and water. Acetyl chloride (ethanoyl chloride) reacts violently and unpredictably with water at room temperature, producing an acidic solution and hydrogen chloride gas, which is irritating and corrosive.
- Using petrol as a solvent.
- Mouth pipetting concentrated solutions or toxic substances.
- Distilling crude oil. An alternative is:

50 grams (g) paraffin wax
 100 g soft wax (vaseline)
 125 mL of unused engine oil
 125 mL of kerosene

Heat on a water bath until dissolved.

Cool, and add 125 mL of technical petroleum spirit (not petrol) and a spatula full of powdered charcoal.

- Adding caesium, rubidium, or potassium to water.
- Heating naphthalene for a cooling curve. As an alternative, use phenyl-2 hydroxybenzoate (salol), 1,4-dichlorobenzene, octadecan-1-ol (stearol), or octadecanoic acid (stearic acid).
- Making explosives. This includes the activity of placing dry ice in polyethylene terephthalate (PET) bottles and screwing the lid on. Refer to Explosives on page 43.
- Mixing methanal (formaldehyde) and hydrochloric acid. Bis-chloromethylether (BIS-CME), a powerful carcinogen at very low concentrations, can be formed spontaneously from the vapours of methanal (formaldehyde) and hydrochloric acid. These substances must not be mixed or stored close by each other.
- Heating plastics, or other samples, of unknown composition, or burning polyurethanes.

Special note: The volcano experiment using ammonium dichromate is hazardous because the products are potentially carcinogenic. This experiment must not be carried out in the open classroom, although it may be demonstrated in a fume cupboard.

5.3 Forbidden Equipment

The following equipment is forbidden in school science classes.

- Gas barbecues and picnic stoves.
- Portable LPG cylinders for heating purposes.
- Class 3B and Class 4 lasers.

5.4 Forbidden Biological Procedures

The following biological procedures contain significant hazard and must not be attempted.

- Conducting experiments using human blood or urine, owing to the risk of contagious disease.

- Dissecting animals from unregulated sources.
- Tasting phenylthiocarbamide (PTC) and phenylthiourea (PTU).
- Students should not be instructed to hold their breath for as long as possible to measure their maximum exhalation pressure or to breathe in such a way as to risk hyperventilation.
- In microbiological experiments, taking samples from toilets or toilet areas, animal cages, dirty dishcloths and towels, and rubbish tins is considered hazardous and should not be attempted. Alternatives can be purchased from reputable sources, or some of the following can be used: yeast; mildew and rust found on weeds or garden plants, milk, cheese, bread, fruit, soil, or yoghurt; black spot on roses; mould and bacteria from rotting fruit.
- Using clinical thermometers in the mouth, unless they can be sterilised between use by each individual. They can be used under the armpit.
- Using polyacrylamide gels for deoxyribose nucleic acid (DNA) separations. Agarose gels should be used instead.
- Analysing cattle urine, owing to the risk of leptospirosis.

Specific Issues for Teachers in Primary Schools

Science in primary schools is generally a very safe activity. There should be, and usually are, few risks associated with science. However, as a precaution, teachers should read the relevant sections of this manual and check the safety of equipment before beginning any science lesson. Students need to be taught to use equipment safely, do activities safely, and avoid hazards.

Acting responsibly includes acting with due regard for the safety of oneself and others. Safe classrooms are planned classrooms, with equipment, layout, and activities thought out before the lesson. Potential hazards can be anticipated and minimised.

Students should be taught about safety issues and appropriate behaviours. It is important to discuss the safety aspects of an activity, such as the need to wash hands after working in practical science, and that students should never taste, smell, or touch substances unless they have been told to do so. Some general guidelines follow for teaching science safely. More detailed information is available, and can be referred to, in other parts of the document.

Animals

Refer to Animals on pages 9 and 31.

All schools are required to comply with the code of ethical conduct for the care and use of animals in school programmes, including the keeping of records.

Animal Dissections

Refer to Dissections on page 32.

Batteries

Refer to Cells and batteries on page 25.

Electrical Equipment

Refer to Electrical Equipment on page 19.

All electrical equipment should be purchased from a reputable supplier.

Glassware

Refer to Glassware on page 29.

When students go outside to collect things, they should use plastic containers. Yoghurt containers and other similar plastic containers are cheaper, and may be more suitable, than expensive glassware.

Normal glass cannot withstand dramatic changes in temperature, as can ovenware or Pyrex. Substances should be heated in ceramic, metal, or ovenware glass containers. For example, small quantities may be able to be heated in metal bottle tops.

Hazardous Substances

Refer to Section 4: Safe Procedures with Hazardous Substances on page 37.

Hazardous substances should be kept in a locked area to which no students have access. They should be stored in clearly labelled glass or plastic containers. Soft drink bottles, or bottles with a shape that is familiar to students as a drinkable-liquid bottle, should not be used.

Hazardous substances

Teachers need to be aware of the following.

- Any acid, for example, vinegar, when mixed with household bleach produces highly toxic chlorine gas.
- Copper sulfate is poisonous, and students' access to it should be limited. Because it can also seriously damage eyes, students must have eye protection before they use it.
- Burning plastics may give off poisonous, irritating vapours. Refer to pages 53 and 59.
- Ammonium dichromate (often used for the volcano experiment) should not be used unless the experiment can be carried out as a demonstration outdoors or in a fume cupboard. It is harmful if swallowed or inhaled and causes eye and skin irritations.
- Solvents: methylated spirits, surgical spirits, and white spirits can be used as solvents.
- Eye protection should always be used when using chemicals.
- Hands must always be washed after using chemicals.
- If chemicals must be smelled, the vapour should be waved towards the nose with a hand. A direct sniff should not be taken.
- Only small quantities of chemicals should be used.
- Spoons or spatulas should be used to handle chemical substances.

Examples of safer substances and reactions

Making crystals

The following chemicals may be used for growing crystals, but care needs to be taken because some are poisonous, flammable, or corrosive:

- Chrome alum (chromium potassium sulfate)
- Cobalt nitrate
- Copper sulfate
- Epsom salts (magnesium sulfate)
- Ferrous sulfate (iron (II) sulfate)
- Potash alum (aluminium potassium sulfate)
- Rochelle salt (potassium sodium tartrate)
- Salt (sodium chloride)
- Sugar (sucrose)
- Zinc sulfate.

The following substances may be used in a primary or intermediate school classroom with minimal risk:

- Alum (aluminium potassium sulfate)
- Baking powder
- Baking soda (sodium bicarbonate)
- Borax
- Carbonated drinks
- Chalk (calcium carbonate)
- Charcoal
- Citric acid
- Cream of tartar (tartaric acid)

- Detergent (dishwash liquid)
- Epsom salts (magnesium sulfate)
- Food colouring
- Glycerine
- Health salts
- Litmus paper
- Oils – vegetable
- Plaster of Paris (calcium sulfate)
- Salt (sodium chloride)
- Soap
- Sour milk (contains lactic acid)
- Steel wool
- Sugar (sucrose)
- Tartaric acid
- Tea (contains tannic acid)
- Vaseline
- Vinegar (contains acetic acid)
- Vitamin C (ascorbic acid)
- Washing soda (sodium carbonate).

Heat Sources

Refer to Heating Hazardous Substances on page 51.

Heat should be used only under teacher supervision. Eye protection is recommended. The best sources of heat for primary schools are:

- candles that cannot tip over, which should be placed in an appropriate flat container;
- electric hot plates;
- ovens;
- hairdryer, but not hot-air paint strippers;
- hot water (stored energy);
- the sun;
- meths burners. These need to be used with caution as the flame may be invisible. Standing the burner in sand in a metal tray is a wise precaution. The burner cap should be screwed on tightly.

Micro-organisms

Refer to Micro-organisms on page 34.

Mirrors

Refer to Lenses and Mirrors on page 29.

Plants

Refer to Plants on page 35.

Thermometers

Refer to Thermometers on page 30.

For information about poisons and hazardous substances, contact:

The New Zealand Chemical Industry Council

PO Box 5069,

Wellington.

Phone: (04) 499 4311

Fax: (04) 472 7100

Website: www.nzcic.org.nz

National Emergency Response service: 0800 CHEMCALL (243 622)

(twenty-four hours a day, every day)

AS 2982: 1997 *Laboratory Construction* prescribes standards for laboratory safety equipment. At present, there is no equivalent New Zealand standard.

The following must be available in every science classroom.

- A fire extinguisher where there is to be heating, burning, or use of flammable substances. The extinguishers should be serviced annually or after use.
- Eye-washing facilities. Water from the tap is adequate.
- Safety glasses.
- Protective gloves.

The following must be readily available, for example, in preparation rooms between two laboratories, or on a trolley that can be taken to the classroom where the science activities are being carried out.

- Adequate non-combustible absorbent material, such as vermiculite, for throwing on chemical spills. See AS/NZS 2243.2: 1995–1997 *Safety in Laboratories – Chemical aspects*.
- A first-aid kit.
- A manual for safety procedures and first aid.
- A fire blanket. Refer to AS/NZS 3504: 1995 *Fire Blankets*. Older asbestos-type blankets must be replaced.

A safety shower must be provided near the chemical store or where the technician prepares chemicals.

Wherever possible, the safety equipment should be stored near an exit.

Eyewash

Irrigate the eye as soon as possible with mains tap water. If this is not readily available, then sterile water or sterile saline solution in sealed, disposable, clearly marked containers should be provided. Each container should contain 300 mL and must not be re-used when opened.

Eyewash bottles should not be used for eye irrigation because they can force the chemical or material further into the eye. Water pressure from the tap may also be too strong for washing the eye. Where possible, water should be poured from a container such as a plastic squeeze bottle or jug, with the eyelid held open, for at least 15 minutes.

Some chemicals are particularly damaging to the eyes. These include:

- acids;
- alkalis and bases;
- dehydrating agents, such as sulfuric acid;
- oxidising agents, such as potassium permanganate;
- organic solvents;
- any chemical that reacts with water.

Fire Safety

A teacher's first duty in times of emergency is to ensure the safety of the students.

Teachers need to:

- be familiar with the school's fire drill and know the locations of fire alarms, extinguishers, and exits;
- be aware of anything that could fuel a fire, for example, overfilled rubbish bins, curtains near Bunsen burners, flammable materials;
- be familiar with the precautions needed when using flammable materials;
- prevent overheating of combustible materials;
- make sure that sand buckets are not used as rubbish receptacles.

Portable electric heaters are not to be used.

Heaters are required to be fixed to the wall, away from curtains and furniture. They must be switched off, with the plug disconnected, when the room is not in use.

Extinguishing fires

Do not attempt to extinguish a fire until after students have been evacuated and unless it can be done without the risk of injury.

If a person's clothing catches fire, lay that person down and roll them, ideally in a blanket. Take care not to smother the person's head.

Electrical fires

Switch off the power at the source. Use a carbon dioxide extinguisher instead of water, which has electrical-conducting properties. Even if electrical equipment is turned off, an electrical capacitor can still administer a dangerous shock.

Flammable-liquids fires

These liquids include fats, oils, paraffin, petrol, and alcohols.

A carbon dioxide extinguisher can be used, or sand. Sand should be thrown carefully to prevent the flaming fat from splashing. Do not use water.

Gas

If gas leaking from a gas cylinder or valve that cannot be turned off is burning, it is dangerous to attempt to extinguish the flame. Leaking gas can build up and reach the state where a dangerous explosion is possible. Leave gas escaping from the cylinder to burn, and call the fire service. If possible, cool the cylinder with water from a hose to prevent the fire from spreading. Do not stand close to the cylinder while hosing it.

Metals or phosphorus fires

Use sand, not water or carbon dioxide. Concentrate on preventing secondary ignition of other flammable materials.

Wood, paper, cloth, rubber, and plastics fires

Use a water or carbon dioxide extinguisher.

Fire extinguishers

When a fire extinguisher has been used, it must be serviced. Also, make immediate arrangements to have the sand bucket and extinguisher refilled.

Caution should be used in the selection and use of appropriate fire extinguishers. Advice can be sought from the Fire Service or from commercial safety companies. Fire extinguishers should be placed in convenient locations and near entrances.

When using a fire extinguisher, teachers need to be aware that:

- the force emanating from the extinguisher may cause objects to fall off shelves or benches;

- the flow of the extinguisher must be aimed at the base of the fire;
- fire extinguishers make considerable noise;
- the duration of discharge is quite short and so must be used effectively. Fire extinguishers need to have enough capacity to work effectively for over a minute.

First-aid Kit

Every laboratory should have a first-aid kit that is readily accessible; one between two science classrooms that share a preparation room may be adequate. Both OSH and the Order of St John recommend that the first-aid kit meet the requirements of the Factories and Commercial Premises (First Aid) Regulations 1985 and the Health and Safety in Employment Regulations 1995. It is important that all science teachers have first-aid training and that a second trained person be available who can take over if the science teacher is incapacitated or hurt.



The basic kit should contain:

- two 100-mm packets of adhesive wound-dressing strip;
- ten sterile dressings (75-mm x 75-mm packets);
- five sterile non-adhesive pads (100-mm x 100-mm packets);
- four sterile eye pads;
- one container for pouring water over the eye (for example, a plastic squeeze bottle);
- two 250-mL bottles of antiseptic liquids approved by the Medical Officer of Health;
- four triangular bandages;
- nine roller bandages (including crepe bandages in 50-mm and 75-mm sizes);
- one reel of waterproof, adhesive plaster (50-mm wide);
- one card of safety pins;
- one pair of surgical or equivalent stainless steel scissors;
- one pair of fine-point, stainless steel, splinter forceps;
- eight pairs of disposable gloves (large size or multfitting);
- a first-aid manual, such as one obtainable from the Order of St John or the Red Cross;
- an accident register and a pen or pencil;
- a card listing local emergency numbers;
- a receptacle for soiled dressings, such as a bucket with a foot-operated lid.

Telephone

The Occupational Safety and Health Service (OSH) recommend that a telephone with unrestricted access, capable of dialling emergency services and contacting other parts of the school, be readily available, particularly in laboratory areas (such as the preparation room). Emergency telephone numbers and instructions must be posted by each telephone.

Emergency procedures and telephone numbers

The emergency procedures must be prominently displayed at all times in rooms used for science teaching and in associated preparation rooms.

In addition, contact numbers for the following local and national services should be displayed.

- Ambulance
- Fire service
- Hospital
- Police
- National Poisons Centre.
Urgent information: Phone: (03) 474 7000
Non-urgent information: Phone: (03) 479 1200
Fax: (03) 477 0509
e-mail: poisons@otago.ac.nz
- The New Zealand Chemical Industry Council
National Emergency Response service: 0800 CHEMCALL (243 622)
(twenty-four hours a day, every day)
Phone: (04) 499 4311
Fax: (04) 472 7100
Website: www.nzcic.org.nz

Section 8

Specific Issues for Technicians

All equipment used should be maintained in an effective working condition in accordance with the relevant standard or the manufacturer's instructions.

Personal Protective Equipment

It is the responsibility of the board of trustees to provide the appropriate protective clothing.

Clothing

A cotton/polyester boiler suit, wrap-around gown, or laboratory coat for general laboratory work is recommended. Nylon is not recommended because it is easily destroyed by heat or acid.

Note: Place contaminated clothing in a plastic bag and have it laundered separately from any other clothes. For contaminants such as lead, use a commercial laundry, and inform the laundry of the hazard.

Barrier creams can provide protection in some circumstances but should not be used as a substitute for gloves. Gloves should be of suitable material, length, and weight. AS/NZS 2161: 1998 *Occupational Protective Gloves* describes the standards. Wearing gloves is essential when dealing with toxic, corrosive, cryogenic, dusty, and fibrous substances or with any substance that may cause a biohazard. Gloves are also the primary barrier to infections from biological materials and skin sensitisers. Use elbow-length gloves when sampling from tanks or handling hazardous substances.

When safety footwear is required, it should be selected in accordance with

- AS/NZS 2210.1: 1994 *Occupational Protective Footwear – Guide to selection, care and use*, and
- AS/NZS 2210.2: 1994 *Occupational Protective Footwear – Specification*.

Also recommended are rubber boots, leggings, and a plastic or rubber apron.

Open-toed shoes, sandals, jandals, or bare feet are not recommended.

Eye Protection

Contact lenses are not a substitute for normal eye-safety protection because they can trap chemicals or vapours between the eye and the lens, increasing the eye's exposure period. In general, students should wear glasses instead of contact lenses in a laboratory. Wear eye protection, selected and used in accordance with:

- AS/NZS 1337: 1992 *Eye Protectors for Industrial Applications*;
- AS/NZS 1338.1: 1992 *Filters for Eye Protectors – Filters for protection against radiation generated in welding and allied operations*;
- AS/NZS 1338.2: 1992 *Filters for Eye Protectors – Filters for protection against ultraviolet radiation*; and
- AS/NZS 1338.3: 1992 *Filters for Eye Protectors – Filters for protection against infrared radiation*;

and wear wrap-around eye protection when handling hazardous materials.



Use a safety shield:

- where glass apparatus is evacuated, recharged with gas, or pressurised;
- when pouring corrosive liquids;
- when using cryogenic fluids;
- when combustion processes are being carried out; and
- always where there is a risk of explosion or implosion.

Hearing Protection

Wear hearing protection when using ultrasonic cleaning apparatus or other apparatus that may damage or impair hearing.

Respirators

Use a dust mask or respirator when working with dusty materials. Dust masks do not provide any protection against gases or vapours. Acid/gas cartridges, available from safety equipment suppliers, are suitable for many vapours.

Safety Helmets

Wear a recommended safety helmet whenever there is a danger of objects falling from above.

Heavy Equipment

A trolley is strongly recommended for transporting heavy and/or dangerous goods. Lifting technique, age, level of fitness, and gender have a major bearing on how much a person can lift safely. The Occupational Safety and Health Service (OSH) recommends that schools aim to purchase chemicals in unit packages not exceeding 15 kg and, for corrosives, 5 kg or less. Drums of solvent of 220 litres are also acceptable, provided drum pumps are used.

Currently, the Dangerous Goods Regulations require that Class 3(a) substances should not be dispensed by gravity, such as through a drum tap, unless the containers are 25 litres or less. Over that capacity, a drum pump must be used.

Appendix 1: Sample Policy for Health and Safety in Science

Rationale

A safe workplace and safe working practices are essential for the health and safety of staff, students, and visitors in science classrooms and associated areas.

Purpose

In order to comply with the Health and Safety in Employment Act 1992, the Hazardous Substances and New Organisms Act 1996, the *Health and Safety Code of Practice for State Primary, Composite, and Secondary Schools*, and the requirements of *Safety and Science: A Guidance Manual for New Zealand Schools*, the school will do everything within its power and resources to implement health and safety codes of practice in science by:

- providing and maintaining a healthy, safe environment;
- providing training and instruction in science health and safety practices;
- providing appropriate safety devices and protective equipment in science;
- assigning responsibility for each laboratory or workshop to a specific staff member;
- promoting and encouraging science health and safety standards and practices.

Guidelines

1. The board of trustees will encourage participation in monitoring, improving, and promoting programmes to enhance health and safety standards in science.
2. The board of trustees will identify, record, and act upon all hazards and potential hazards relating to teaching science on the school's properties.
3. The board of trustees will liaise with the Ministry of Education's district property manager when hazards and potential hazards are identified.
4. The board of trustees will ensure that staff and students are trained in appropriate science health and safety matters.
5. The board of trustees will encourage all staff, students, visitors, and those with business on the school property to comply with the science health and safety requirements where necessary.

Appendix 2: Field Trips

Detailed information and guidance can be found in the Ministry of Education's manual *Education Outside the Classroom*. This document should be in all schools.

Field trips require special preparation and precautions, which include appropriate management procedures and the identification and assessment of risks. Details can be found in the Ministry of Education's manual *Education Outside the Classroom*.

Refer also to the school's EOTC policy.

Before any trip outside the school boundaries, the teacher must obtain approval from the school management.

Both the teacher and the students should be clear as to their objectives, ways of collecting and recording data, time allocations, and any particular precautions that need to be taken.

The teacher should previsit the area.

Model forms and permission slips can be found in the EOTC manual.

Appendix 3: Safety Checklist

Teachers can use this list to check the safety of their science rooms or laboratories.

Note: Some items may not apply.

Bags

- Can bags be put completely out of the way so that they are not a hazard when people are moving around the laboratory?

Chemicals

- Are all containers clearly labelled?
- Are large containers on low shelves and secure?
- Are chemicals placed so that they are secure on shelves?
- Are all containers in good condition?

Disposal

- Is there a separate, labelled container for broken glass?
- Is there a separate, labelled container for waste paper and harmless rubbish?
- Are there cloths and/or paper towels with which to mop up spilled chemicals and water?
- Is there a separate container for disposing of flammable solvents?
- Is there a separate container for disposing of immiscible solvents?
- Is there a separate container for sharp objects?

Electrical Equipment

- Are all power points in good condition?
- Are all power points switched off when they are not being used?
- Has the RCD earth-leakage system been checked recently?
- Has mains equipment been checked by a competent person in the last twelve months?

Exits

- Are all exits kept clear at all times?
- Can all doors be opened from the inside without keys?
- Are all exit doors that are also smoke-stop doors kept closed?

Floors

- Check that the floor is not highly polished.
- Check that the floor is clear of obstacles.

Furniture

- Is there enough space for students to work without overcrowding? (Approximately 90 cm width for each student is recommended.)
- Are working areas clear, and is all equipment stored away when not in use?
- Can stools be put out of the way when students are doing practical work?
- Are there heat-resistant mats to place under heating equipment?

Gas Taps

- Is the master control-switch readily accessible and turned off when the gas is not in use?
- Is the master control-switch turned off at the end of the period?
- Are all gas taps turned off when they are not in use?
- Is the gas system free from leaks?

Hygiene

- Is soap available?
- Are towels or other facilities available?
- Is hot water available?
- Is disinfectant available?

Living Organisms

- Are animal cages clean and well kept?
- Are cages out of the way of work areas? (They must also be out of draughts and not in direct sunlight.)

Safety Equipment

- Is there a first-aid kit in the room or nearby?
- Is there a bucket of sand in the room?
- Is there a serviced, carbon dioxide fire extinguisher in the room?
- Is the emergency checklist on the wall of the room?
- Are sets of safety glasses in the room for students' use?
- Are gloves available?
- Are safety screens available?

Storage Space

- Are cupboards, trays, and shelves clean and tidy?
- Is all stored apparatus clean?
- Is glassware stored in such a way that it is easily reached?

Students

- Are students wearing adequate footwear?
- Is their hair or loose clothing tied back?

Ventilation

- Is there adequate ventilation in the laboratory or room?
- Is there a working fume cupboard?

Water Taps

- Are all jets of water easy to control?
- Are all taps free from leaks?
- Are all sink outlets clear and not blocked?
- Do rubber hoses on taps stop short of the full water level of the sink?

When was the class last reminded of safety in science?

Appendix 4: Incompatible Chemicals

This chart is only a guide to chemicals that should not normally be stored together. It is not an all-inclusive list, and certain factors, such as the strength of acid solutions, may alter the storage requirements. An X indicates incompatibility.

Oxidising Agents				Organic Solvents										Metals			Bases				Acids													
* Sawdust	Hypochlorites	Potassium permanganate	Chlorates/Perchlorates	Chromates/Dichromates	Nitrates	Organic peroxides	Hydrogen peroxide	Phenol	Formaldehyde	Methylene chloride	Trichloroethylene	Other hydrocarbon solvents	Styrene	Toluene/Xylene	Kerosene/white spirit	Alcohols	Methyl ethyl ketone	Acetone	Other metals	Magnesium	Aluminium	Cyanides	Ammonia solution	Sodium carbonate	Caustic soda	Acetic acid	Perchloric acid	Nitric acid	Phosphoric acid	Sulfuric acid	Hydrochloric acid			
X	X	X	X	X	X	X	X												X	X	X	X	X	X		X	X			X		Hydrochloric acid		
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Sulfuric acid	
	X	X	X	X	X	X													X	X	X	X	X	X						X		Phosphoric acid		
X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	Nitric acid	
X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	Perchloric acid	
	X	X	X	X	X	X													X	X	X	X	X	X		X	X		X			X	Acetic acid	
						X	X			X										X					X	X	X	X	X	X	X	X	Caustic soda	
						X	X			X											X					X	X	X	X	X	X	X	X	Sodium carbonate
						X	X																			X	X	X	X	X	X	X	X	Ammonia solution
X	X	X	X	X	X	X	X													X						X	X	X	X	X	X	X	X	Cyanides
X	X	X	X	X	X	X	X			X														X	X	X	X	X	X	X	X	X	X	Aluminium
X	X	X	X	X	X	X	X			X													X				X	X	X	X	X	X	X	Magnesium
						X	X																			X	X	X	X	X	X	X	X	Other metals
X	X	X	X	X	X	X	X																				X	X		X				Acetone
X	X	X	X	X	X	X	X																				X	X		X				Methyl ethyl ketone
X	X	X	X	X	X	X	X																				X	X		X				Alcohols
X	X	X	X	X	X	X	X																				X	X		X				Kerosene/white spirit
X	X	X	X	X	X	X	X																				X	X		X				Toluene/Xylene
X	X	X	X	X	X	X	X																				X	X		X				Styrene
	X	X	X	X	X	X	X																				X	X		X				Other hydrocarbon solvents
		X	X	X	X	X	X													X	X						X	X		X				Trichloroethylene
		X	X	X	X	X	X																				X	X		X				Methylene chloride
X	X	X	X	X	X	X	X	X																			X	X		X				Formaldehyde
X	X	X	X	X	X	X	X	X	X																		X	X		X				Phenol
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Hydrogen peroxide
X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Organic peroxides
X						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X		X	X	X	X	X	Nitrates
X						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	Chromates/Dichromates
X						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X		X	X	X	X	X	X	Chlorates/Perchlorates
X						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	Potassium permanganate
X						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	Hypochlorites
	X	X	X	X	X	X	X																				X	X		X				* Sawdust

* Sawdust is only included because it should not be used to pack the chemicals indicated or to mop up any spillages of these chemicals.

Glossary

Accident

Any occurrence that results in a person's injury, disease, or death or in property damage.

Auto-ignition temperature

The lowest temperature at which a vapour will spontaneously catch fire in air, in the absence of a spark or flame.

Carcinogen

Cancer-causing agent.

Circuit breaker

A device that cuts off the current to a circuit if the current exceeds a certain level.

Combustible

Capable of or used for burning.

Corrosive

Capable of attacking (corroding) metals or of visibly destroying or permanently damaging human tissue.

dBA

Decibel (acoustic): a measure of sound level.

EOTC

Education outside the classroom.

Flammable (also Inflammable)

Capable of being ignited and burning in air.

Flashpoint

The minimum temperature at which, under specified test conditions, a flammable substance emits enough vapour to ignite immediately when an ignition source is applied.

Fume

Cloud of airborne particles arising from condensation of vapours or from chemical reaction.

Hazardous substance

This is defined on page 37.

Immiscible

Not able to be mixed or combined.

Incompatible substances

Materials that could cause dangerous reactions when they come in contact with each other.

Known carcinogen

A substance proved to cause cancer in humans.

MSDS

Material Safety Data Sheet. See section 4.1 on page 38.

Mutagenic substance

A substance capable of causing genetic mutations in humans.

OSH

Occupational Safety and Health Service of the Department of Labour.

Oxidation-reduction reactions

The exchange of electrons or oxygen.

Oxidising agent (oxidiser, oxidant)

A substance that oxidises another substance, being itself reduced in the process, and gaining electrons.

PEL

Permissible exposure limit.

Polyethylene terephthalate (PET) bottle

A plastic bottle, such as a 1.5-litre soft-drink bottle.

RCD (residual current device)

A device that limits the current flow if insulation fails or if a person accidentally touches live conductors.

Reducing agent (reductant)

A substance that brings about reduction by becoming oxidised and losing electrons.

Sensitisation

The development, over time, of an allergic reaction to a chemical.

Suspected carcinogen

A substance proved to cause cancer in animals and suspected to have the same effect on humans.

Teratogenic substance

A substance capable of causing birth defects in the offspring if the mother is exposed to it during pregnancy.

TLV

Threshold limit value.

Volatile

Evaporates readily at room temperature and pressure.

Consultation List

The Ministry of Education would like to thank the following organisations consulted during the development of these guidelines:

Animals in Schools Education Trust
Association of Proprietors of Integrated Schools
Auckland College of Education
Auckland Institute of Technology
Canterbury University
Central Institute of Technology
Christchurch College of Education
Christchurch Polytechnic
Department of Labour
Dunedin City Council
Dunedin College of Education
Eastern Institute of Technology
Education Review Office
Environmental Risk Management Authority
Hutt Valley Polytechnic
Independent Schools Council
Integrated Schools Association
Lincoln University
Manawatu Polytechnic
Manukau Institute of Technology
Massey University
Massey University College of Education
Ministry of Agriculture
Ministry for the Environment
Ministry of Health
Ministry of Research, Science and Technology
Nelson Polytechnic
New Zealand Chemical Industry Council
New Zealand Educational Institute
New Zealand Fire Service
New Zealand Free Ambulance
New Zealand Institute of Chemistry
New Zealand Institute of Physics
New Zealand Post Primary Teachers Association
New Zealand School Trustees Association
Occupational Safety and Health Service, Department of Labour
Otago Polytechnic
Otago University
Southland Polytechnic
Standards New Zealand
Order of St John
Tai Poutini Polytechnic
Tairāwhiti Polytechnic
Taranaki Polytechnic
Telford Rural Polytechnic
The Open Polytechnic of New Zealand
The Royal Society of New Zealand
UNITEC Institute of Technology
University of Auckland
University of Waikato
Victoria University
Wairariki Polytechnic
Waikato Polytechnic
Waikato University School of Education
Wellington College of Education
Wellington Polytechnic
Whitireia Community Polytechnic
Northland Polytechnic

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