

TECHNICAL GUIDANCE TOOLKIT

For Laboratories and Customs

Prepared by Mark Vaughan, under contract to the Secretariat for the Pacific Regional Environment Programme (SPREP).

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Technical Guidance Toolkit

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Executive Summary

Hazardous substances that are used in laboratory settings and/or transported across national borders can be very dangerous for human health and ecosystems because of their inherent hazardous qualities. Such items include banned or restricted chemicals and hazardous and toxic waste.

This technical guidance toolkit is designed to be used by Laboratory and Customs staff in Pacific Island Countries (PIC) for use as a technical reference guide in their daily work activities relating to hazardous substances. It contains 14 chapters which are further divided into sub-chapters; however the entire toolkit can be seen as 3 sequential larger sections.

Chapters 2-5 set out to define hazards, how they can be identified and assessed for risk in the workplace, outlines the universal classification of hazards and gives an overview of the common signs and symbols used to identify them.

Chapters 6-10 identify and focus on chemical, biological and radiation hazards relevant to laboratory and customs staff, and provide useful overviews of protective and emergency equipment needed when potentially exposed to these substances, as well as general storage and handling requirements.

Chapters 12-14 looks at the legislative requirements when dealing with hazardous substances, including Occupational Health and Safety, an overview of national legislation that may regulate work activities and looks at additional issues with regard to international legislative requirements around the legal export and movement of hazardous chemicals and waste.

1. Introduction

The sound management of hazardous chemicals and waste is essential for countries to achieve sustainable development, including the eradication of poverty and disease, the improvement of human health and the environment and the elevation and maintenance of the standard of living¹.

The Pacific Region is home to a variety of countries with fragile ecosystems, increasing population pressures and limited buffering capacities where an increasing number and volume of hazardous chemicals are used and hazardous wastes produced. While many are beneficial to economic development, their inadequate management often results in adverse impacts on human health and ecosystems. Unnecessary and unexpected exposure to hazardous substances can cause disease, disability and death.

In many laboratory and customs settings hazards are inherent to the workplace, making the informed assessment, management and reduction of risks to human health and the environment posed by chemicals and hazardous waste of high importance.

This technical guidance toolkit is designed to be used by Laboratory and Customs staff in Pacific Island Countries for use as a technical reference guide in their daily work activities relating to hazardous substances.

Although some chapters are particularly focussed on issues relating to laboratory situations, for example, ‘*chapter 6.6 Labelling Chemicals in the Laboratory*’, and others are specifically targeted towards customs staff, “*chapter 14 Additional Issues Around Legal Export and Movement of Hazardous Waste/Chemicals*’, most chapters are however, designed to be useful for both laboratory and customs staff.

2. Nature of hazard and work safety

2.1 What is a Hazard?ⁱⁱ

A *Hazard* is a source or situation that is capable of causing illness, injury or damage to people, equipment and property. In many cases hazards are inherent to the workplace so health and safety practices are put in place to ensure that a work environment is made safer, either by modifying the workplace and/or by modifying any unsafe work processes.

3. Dangerous Goods and Hazardous Substances

Exposure to hazardous substances and dangerous goods in the workplace can lead to a variety of serious health effects and injury.

3.1 What are hazardous substances?

Hazardous substances are those that, following worker exposure (both short and long term exposure), can have an adverse effect on health. Examples of hazardous substances include poisons, substances that cause irritation to nose, throat, and airways, chemical burns, sensitisation (e.g. asthma, dermatitis) and substances that may cause cancer, birth defects and organ specific diseases (lung, liver, bladder, central nervous system, skin). Many hazardous substances are also classed as dangerous goods (see “What are dangerous goods?” below).

Hazardous Substances Information System (HSIS)

The HSIS is an internet resource that allows you to find information on substances that have been classified in accordance with the *Approved Criteria for Classifying Hazardous Substances*. In addition to providing powerful search features, the HSIS also provides direct access to a consolidated list of all the classified substances contained in the HSIS databaseⁱⁱⁱ.

3.2 What are dangerous goods?

Dangerous goods are substances or articles that, because of their physical, chemical (physicochemical) or acute toxicity properties, present an immediate danger to people, property or the environment. Types of substances classified as dangerous goods include explosives, flammable liquids and gases, corrosives, chemically reactive or acutely (highly) toxic substances^{iv}.

4. Identifying Hazards

The first step in control of hazards is to identify and list them. There are many methods which are useful for identifying hazards, including:

- Conducting regular, systematic inspections of the workplace to identify potential chemical hazards
- Observing what hazards exist in the workplace and ask, 'what if?'
- Listening to feedback from the people performing the work with chemicals

4.1 Assessment of risk

When a hazard is identified it is useful to do a risk assessment. To conduct a risk assessment the following must be done:

- Gather information about each identified hazard
- Consider the number of people exposed to each hazard and the duration of the exposure
- Use the information to assess the likelihood and consequence of each hazard
- Use a risk assessment table to work out the risk associated with each hazard

Factors for consideration

You should consider the following factors during the risk assessment process

- The nature of the hazard posing the risk
- Combinations of hazards
- Types of injuries or illnesses foreseeable from exposure
- The consequences of duration and exposure to the hazard
- Workplace and workstation layout
- The introduction of new work processes
- Skill and experience level of employees
- Personal characteristics of employees exposed to the risk (colour blindness or hearing impairment)
- Existing control measures in place such as the use of clothing and personal protective equipment (see chapter 10. Personal Protective Equipment)

Occupational injury data from industry studies^v indicate that the injury rate is highest during the initial period of employment and decreases with experience. New staff should particularly be informed of potential hazards in the workplace or whenever staff are performing new tasks. It is also essential that **all** staff are taught what can go wrong, how to prevent such events from occurring, and what to do in case of an emergency.

5. Indicated Hazard

In the workplace, hazard communication ensures that workers who may be exposed to hazardous chemicals, substances or situations know about the hazards and understand how to protect themselves from exposure. This is called an indicated hazard. To ensure there is no confusion about hazardous substances, dangerous goods have been assigned 'classes', and generic visual warning signs.

5.1 Classes of Dangerous Goods^{vi}

There are nine classes of dangerous goods, some of which contain subsets. These classes were developed to easily communicate the correct storage, handling and health risk posed by dangerous goods. They are as follows:

Class 1 - Explosive Substances and Articles

Substances that have the potential to produce a sudden and violent expansion of gases usually associated with high temperatures. Examples include:

- Fireworks
- Ammunition
- Gelignite

Class 2.1 - Flammable gases

Flammable gases can be ignited in air. They may be lighter or heavier than air. Heavier than air gases can collect in low lying areas such as pits, depressions, and drains causing a fire and explosion hazard. Examples include:

- Liquefied petroleum gas
- Liquefied natural gas
- Hydrogen
- Acetylene

Class 2.2 - Non-flammable, non-toxic gases

Non-flammable, non-toxic gases are neither flammable nor toxic. Examples include:

- Nitrogen
- Carbon dioxide
- Compressed air
- Helium

Some of these may cause an asphyxiation hazard (e.g. nitrogen, carbon dioxide). When asphyxiating gases are heavier than air they can collect in low lying areas and cause suffocation by the dilution or displacement of oxygen in air.

Class 2.2 - Non-flammable, non-toxic gases sub-risk 5.1 (Oxidising gases)

Oxidising gases are non-flammable, non-toxic gases with a sub-risk of Class 5.1. These gases, although not flammable, can accelerate combustion and increase the risk of fire in the presence of combustible or flammable materials. Examples include:

- Nitrous oxide
- Entonox
- Nitrous oxide

Class 2.2 - Toxic gases

On inhalation these may cause death or injury. Many of these also have other properties (e.g. may be flammable, oxidising or corrosive). Examples of toxic gases include:

- Anhydrous ammonia
- Methyl bromide
- Sulphur dioxide
- Carbon monoxide

Class 3 - Flammable liquids

Flammable liquids produce vapour that can be ignited in air on contact with a suitable ignition source. By definition these must have a flash point of less than or equal to 60.5 degrees Celsius. Examples include:

- Unleaded petrol
- Xylene
- Kerosene
- Acetone

The flash point is the temperature at which a liquid can produce enough vapour to ignite in the presence of an appropriate ignition source.

Combustible liquids

Combustible liquids are not classified as dangerous goods but are designated as either C1 or C2 combustible liquids.

A C1 combustible liquid has a flashpoint between 60.5°C to 150 °C.

A C2 combustible liquid has flashpoint exceeding 150°C.

An example of a C1 combustible liquid is diesel fuel. Many lubricating oils and cooking oils are examples of C2 combustible liquids.

Class 4.1 - Flammable solids

These materials are easily ignited and may cause fire through friction heat or other ignition sources. Examples include:

- Red phosphorous
- Hexamine
- Naphthalene
- Camphor

Class 4.2 - Substances liable to spontaneous combustion

These materials are flammable solids that are capable of spontaneous combustion being heated up in contact with air or moisture in air. Examples include:

- White phosphorous
- Fish meal
- Cotton waste

Class 4.3 - Substances that in contact with water emit flammable gases

On contact with water these materials can become spontaneously combustible or liberate flammable or toxic gases. Examples include:

- Aluminium phosphide (liberates phosphine gas)
- Calcium carbide (liberates acetylene on contact with water)
- Sodium

Class 5.1 - Oxidising agents

These substances can contribute/accelerate the combustion of other combustible or flammable materials. Examples include:

- Ammonium nitrate
- Hydrogen peroxide
- Potassium permanganate
- Calcium hypochlorite

Class 5.1 - Organic peroxides

Organic peroxides are organic materials containing the peroxide reactive group. These chemicals may have the following properties:

- Liable to explosive decomposition
- Burning rapidly
- Sensitive to heat, shock or friction
- React violently with other materials.

Examples include:

- Benzoyl peroxide
- Methyl ethyl ketone peroxide

Class 6.1 - Toxic substances

These materials comprise substances liable to cause death or serious injury or harm from inhalation, ingestion or absorption through the skin. Some toxic materials may have other sub-risks (e.g. flammable or corrosive). Examples include:

- Paraquat
- Endosulfan
- Arsenic compounds
- Cyanide
- Toluene di-isocyanate (TDI)
- Many pesticides

Class 7 – Radioactive Materials

Materials which spontaneously emit ionising radiation

Class 8 - Corrosive substances

Corrosive materials are capable of causing the degradation and destruction of living tissue, steel and other materials on contact. Some may give off irritating vapours affecting the eyes, airways and skin. Corrosive material may possess other properties (e.g. flammability or oxidation). Corrosive materials are either acids or bases/alkalis.

Examples of acids include:

- Nitric acid
- Sulphuric acid
- Hydrochloric acid
- Lead acid batteries

Examples of alkalis include:















- Sodium hydroxide (caustic soda)
- Calcium hydroxide

Class 9 - Miscellaneous dangerous goods

This class comprises substances and articles that present a danger not offered by other classes. Some of the materials may be assigned to this class based on temperature properties (e.g. elevated temperature products). Examples of class 9 goods include:

- Dry ice
- Asbestos
- Molten bitumen

Table 1. Examples of dangerous goods warning signs

| | | | | | | |
|---|--|--|---|--|---|---|
| <p>1 Explosive</p>  <p>Orange Background</p> | <p>2.1 Flammable Gas</p>  <p>Red Background</p> | <p>2.2 Non-Flammable Non-Toxic Gas</p>  <p>Green Background</p> | <p>3 Flammable Liquid</p>  <p>Red Background</p> | <p>4.1 Flammable Solid</p>  <p>Red / White Vertical Stripe</p> | <p>4.2 Spontaneously Combustible</p>  <p>White Upper Red Lower</p> | <p>4.3 Dangerous When Wet</p>  <p>Blue Background</p> |
| <p>5.1 Oxidizing Agent</p>  <p>Yellow Background</p> | <p>6.1a Harmful</p>  <p>White Background</p> | <p>6.1b Toxic</p>  <p>White Background</p> | <p>6.2 Infectious Substance</p>  <p>White Background</p> | <p>7 Radioactive</p>  <p>White Upper Black Lower</p> | <p>8 Corrosive</p>  <p>White Upper Black Lower</p> | <p>9 Miscellaneous Dangerous Goods</p>  <p>White Upper Black Lower</p> |

Note: The absence of a warning on a label must not be interpreted as an indication that the substance can be used or handled without risk.

5.2 Material Safety Data Sheet

A Material Safety Data Sheet (MSDS,) is a detailed document that describes the chemical and physical properties of a material. It also includes details of health and physicochemical hazards, exposure controls, personal protective equipment, safe handling and storage instructions, emergency procedures and disposal advice^{vii}.

MSDS are an information source that may be used in the workplace to inform a program to control hazards associated with working with hazardous substances and dangerous goods. The label of the product in question is also an important source of this information.

Requirements for preparing a MSDS

The responsibility to prepare a MSDS for a hazardous substance and/or dangerous goods lies with the supplier. A supplier is defined as a manufacturer or importer of hazardous substances or dangerous goods. The supplier should provide a MSDS, at first supply of the material or on request. Below is an example of an MSDS with the distinct sections circled in red

Note: Not all countries use the same criteria for classification of hazardous substances and dangerous goods, or have equivalent requirements for MSDS.

Material Data Safety Sheet - Example

WORK-PRACTICE DATA SHEET - THIS IS A SUMMARY ONLY - FULL REPORT AVAILABLE

Chemwatch 1830 - HAZARDOUS SUBSTANCE. DANGEROUS GOODS. According to NOHSC Criteria, and ADG Code. - Company Contact No. 1800 022 037 (24H)

SULFURIC ACID

INGREDIENTS
sulfuric acid

CAS No
7664-93-9

%
>51

TWA
1 mg/m³



UN No: 1830
Hazchem Code: 2P
DG Class: 8
Subsidiary Risk: None
Packing group: II
Poisons Schedule: S6, S3NZ
Max Haz Rating: 4 (red)

EMERGENCY



FIRST AID

Swallowed:

Give water (if conscious). URGENT MEDICAL ATTENTION.

Eye:

Wash with running water (15 mins). Medical attention.

Skin:

Flood body with water. Remove contaminated clothing.

Wash with water & soap. MEDICAL ATTENTION.

Inhaled:

Fresh air. Rest, keep warm. If breathing shallow, give oxygen. Medical attention.

Advice to Doctor:

Airway problems 100% O₂. Treat burns as thermal.

Retract eyelids - irrigate 30 mins.

Fire Fighting:

Keep surrounding area cool. Water spray/fog.

Spills & Disposal:

Absorb with dry agent.

Dilute with water.

Neutralize with soda ash/ lime.

Stop leak if safe to do so.

Take off immediately all contaminated clothing.

This material and its container must be disposed of in a safe way.

To clean the floor and all objects contaminated by this material, use water.

PROPERTIES



Liquid.
Mixes with water.
Corrosive.
Acid.
Toxic or noxious vapours/gas.
Contact with combustible material may cause fire.
Does not burn.

HEALTH HAZARD INFORMATION



Acute Health Effects:

Toxic by inhalation.

Causes severe burns.

Risk of serious damage to eyes.

Chronic Health Effects:

May cause CANCER by inhalation.

Cumulative effects may result following exposure*.

* (limited evidence).

SAFE STORAGE WITH OTHER CLASSIFIED CHEMICALS



X: Must not be stored together
O: May be stored together with specific precautions
+: May be stored together

PRECAUTIONS FOR USE



Engineering Controls:

Local Exhaust Ventilation recommended.

Glasses:

Full face- shield.

Gloves:

1. NATURAL RUBBER 2. NEOPRENE

Respirator:

Type E-P Filter of sufficient capacity

Storage & Transport:

Keep locked up.

Keep container tightly closed.

Keep container in a well ventilated place.

Keep away from food, drink and animal feeding stuffs.

Store in cool, dry, protected area.

Restrictions on Storage apply. Refer to Full Report.

Fire/Explosion Hazard:

Vapours/ gas heavier than air.

Toxic smoke/fumes in a fire.

Attacks metals to liberate hydrogen.

Environment:

This material and its container must be disposed of as hazardous waste.



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Screening Information Data Set

UNEP Chemicals provides a useful online database of chemicals as part of its mandate to facilitate the access to information needed for health and environmental risk assessment of chemicals. The Screening Information Data Set (SIDS) provides the current state of knowledge of many chemicals, it can be accessed at: <http://www.chem.unep.ch/irptc/sids/OECDSIDS/sidspub.html>

5.3 Globally Harmonized System^{viii}

The Globally Harmonized System (GHS) for classification and labeling arose from the declaration at the 1992 Rio Conference on Environment and Development. The goals of the GHS are to enhance the protection of people and the environment, by:

- Providing an internationally comprehensible system for hazard communication
- Providing a recognized framework for those countries without an existing system
- Facilitating international trade in chemicals whose hazards have been properly assessed and identified on an international basis
- Reducing the need for animal testing and evaluation of chemicals

The GHS is a common and consistent approach to defining and classifying hazards, and communicating hazard information on labels and safety data sheets. The GHS covers all hazardous chemicals, which includes substances, products, mixtures, preparations, etc. It provides an internationally agreed upon system of hazard classification and labeling. It is targeted towards workers, consumers, transport workers, and emergency responders. Under this system, chemical substances and mixtures are classified according to their physical, health, and environmental hazards. The GHS is not a regulation or a standard.

Compliance with the GHS is **voluntary** for each country but companies in countries that do not adopt the GHS will be at a disadvantage when doing business internationally. The document, otherwise known as “The Purple Book”, is a guidance document that establishes criteria and methods for hazard classification and communication. The GHS document provides countries with the regulatory framework to develop or modify existing programs. A downloadable PDF version of the Purple Book is available at unece.org.

5.4 Common Safety Symbols and Signs

Safety signs and symbols within the workplace are useful for illustrating visually what safety requirements are expected in the workplace and to caution people around the sign that a hazard is located nearby; or that there is a hazardous material that they should be wary of. Here are some common safety signs/symbols examples:

Protective Clothing Required



Protective Footwear Required



Respiratory Equipment Required



First Aid



Head/Eye Protection Needed



Danger



Gloves Required



Caution



6. Chemical Hazard

Chemical hazards can exist in many forms in the work place, these include: flammable liquids and solids, oxidising agents, explosive, corrosive and toxic substances depending on the nature of the workplace.

Chemical safety in the workplace is the product of developing safe working procedures, which must be maintained at all times. Some basic points to remember are:

- Treat all chemicals as being potentially dangerous
- Like many places, a laboratory is a potentially hazardous environment
- Chemicals that may be safe separately can be unexpectedly dangerous when mixed together

- Although they may be potentially dangerous, no chemicals are dangerous if handled with “safety-conscious” habits, the vast majority of accidents are primarily due to lack of adequate care or planning^{ix}

6.1 Routes of Exposure^x

Chemicals can enter the body via a number of pathways:

Skin absorption

Chemicals can be absorbed through the skin (liquids and vapours) and the presence of broken skin (burns, cuts and scratches) can facilitate the absorption. The use of appropriate clothing reduces the risk of skin absorption (see chapter 10. Personal Protective Equipment). Any chemicals spilt on the skin should be immediately washed off.

Inhalation

Chemical vapours and toxic gases can be inhaled causing irritation to nose and lungs so chemicals should never be smelled directly. The use of appropriate respiratory equipment (see chapter 10. Personal Protective Equipment) and fume cupboards minimises exposure to harmful vapours.

Ingestion

Chemicals can be ingested via:

- Food and drink
- Smoking
- Chewing gum
- Chewing pens
- Biting nails

Avoid touching your face, mouth, eyes and nose whilst working around chemicals and always wash your hands thoroughly afterward.

Eye Damage

Chemicals can be splashed into the eyes. Appropriate safety glasses should always be worn when working with chemicals (see chapter 10. Personal Protective Equipment).

6.2 What are Exposure limits?

Exposure limits are intended to protect workers from excessive exposure to hazardous substances, they:

- Are established by health and safety authorities and chemical manufacturers
- Define the amount/concentration to which a worker can be exposed without causing an adverse health effect
- Typically pertain to the concentration of a chemical in the air, but may also define limits for physical agents such as noise, radiation, and heat

Exposure limits can usually be found on the Material Safety Data Sheets.

6.3 Identifying Chemical Hazards

We use thousands of chemical products throughout our lives, at home and at work. But most of us would be hard-pressed to distinguish safe products from hazardous ones without a warning. Anyone working with chemicals must understand the hazards associated with them. Because of this chemical manufacturers are required to make hazard information available on the product label and MSDS. It is also recommended to conduct a risk assessment of the laboratory work environment to ensure chemical hazards are identified (see chapter 4. Identifying Hazards) and the appropriate action is taken to mitigate any accidents.

6.4 Flammable Chemicals^{xi}

In addition to toxic hazards, hazards of flammability must be considered, particularly with respect to organic solvents. A short list of solvents likely to cause fires due to danger of flammability would include diethyl ether, petroleum ether, benzene, toluene, ethanol, methanol and acetone. For many chemicals, contact with a hot surface is sufficient to cause ignition. Solvents produce vapours that will flow many metres along a bench or floor, so the ignition point may be some distance from where the solvent is being used.

Definitions

- A **Flammable** chemical is any substance capable of ready ignition and combustion in air
- The **Flash Point** is the lowest temperature at which the application of a small flame will cause ignition of the vapour (ether, -40°C; acetone-20°C)
- The **Auto-ignition Temperature** is the lowest temperature at which the vapour will spontaneously ignite in air (e.g. carbon disulphide CS₂ is below 100°C)

Safety Measures

Take the following precautions when using flammable solvents:

- Before heating solvents, check glass apparatus for any defects like small cracks or uneven thickness
- Only use small quantities of flammable solvents. Preferably use bottles no larger than 500 ml. Minimise the number of bottles in a fume-cupboard, or on a bench, at any one time
- Do not handle flammable liquids near an open flame
- Heat solvents with low boiling temperatures on a steam-bath. Solvents with high boiling points can be boiled under reduced pressure on a steam-bath
- When distilling or boiling solvents, make sure that vapours are efficiently condensed so that none can escape into the laboratory, whenever possible use a fume cupboard and boiling chips to ensure gentle boiling
- Do not heat too fast, or liquid may accumulate in the condenser and then be blown from the apparatus

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

Explosions can be a more spectacular aspect of flammable systems. They usually occur because of the failure to recognise that some compounds, while harmless in themselves, can easily become explosive under certain conditions or when mixed with certain other chemicals. Note that explosions can have other causes, e.g. sudden pressure changes.

Ethers are particularly dangerous because of their low boiling points, high flammability, and the ease with which they form explosive peroxides. These peroxides are formed by the auto-oxidation of ethers. The peroxide has a higher boiling point than the ether, and so accumulates in distillation flasks until an explosive mixture is formed when only a small amount remains.

6.5 General Guidelines to Follow in the Event of a Chemical Accident or Spill^{xii}

Below are some recommended actions for specific emergencies.

Chemical in the Eye

- Flush the eye immediately with water while holding the eye open with fingers
- If wearing contact lens, remove and continue to rinse the eye with water
- Continue to flush the eye and seek immediate medical attention

Acid/Base Spill

For a spill not directly on human skin, do the following:

- Neutralize acids with powdered sodium hydrogen carbonate (sodium bicarbonate/baking soda), or bases with vinegar (5% acetic acid solution)
- Avoid inhaling vapours
- Spread diatomaceous earth to absorb the neutralized chemical
- Sweep up and dispose of as hazardous waste

For spills directly on human skin, do the following:

- Flush area with copious amounts of cold water from the tap or drench shower for at least 5 minutes
- If spill is on clothing, first remove clothing from the skin and soak the area with water as soon as possible
- Arrange treatment by medical personnel

Mercury Spill

- Evacuate the affected area
- Close off interior doors and windows, and heating and air conditioning vents in the incident room
- Open exterior doors and windows to move the inside air outside

- Follow specific clean-up instructions detailed by the US Environmental Protection Agency (www.epa.gov/epaoswer/hazwaste/mercury/spills.htm)

6.6 Labelling Chemicals in the Laboratory

Correct labelling of all chemicals is critical to work place safety and avoids costly disposal of unknown products. There are different labelling requirements for hazardous and non-hazardous substances and also for chemical wastes.

Commercially available chemicals should be appropriately labelled by the manufacturer. If a label is damaged, obscured, or chemicals are decanted into a new container or used to make a new solution, a new label is required.

The most important rule for labelling chemicals in the laboratory is **No unlabelled substance should be present in the laboratory at any time!**

Commercially Packaged Chemicals

Verify that the label contains the following information:

- Chemical name (as it appears on the MSDS)
- Name of chemical manufacturer
- Necessary handling and hazard information

Add:

- Date received
- Date first opened
- Expiration or “use by” date (if one is not present)

Secondary Containers and Prepared Solutions

When transferring a material from the original manufacturer’s container to other vessels, these vessels are referred to as “secondary containers.”

Label all containers used for storage with the following:

- Chemical name (as it appears on the MSDS)
- Name of the chemical manufacturer or person who prepared the solution
- Necessary handling and hazard information
- Concentration or purity
- Date prepared
- Expiration or use by date

Containers in Immediate Use

Containers in immediate use are chemicals that are to be used within a work shift.

Label all containers in immediate use with the following:

- Chemical name (as it appears on the MSDS)
- Necessary handling and hazard information

6.7 Chemical Waste

All containers used for chemical waste should be labelled with:

- “WASTE” or “HAZARDOUS WASTE”
- Chemical name (as it appears on the MSDS)
- Accumulation start date
- Hazard(s) associated with the chemical waste

6.8 Peroxide-Forming Substance

Some organic and inorganic compounds are capable of reacting with atmospheric oxygen to form potentially explosive peroxides. All laboratory workers must learn to label, recognize and safely handle peroxidizable compounds. Peroxide forming substances include: aldehydes, ethers (especially cyclic ether), compounds containing benzylic hydrogen atoms, compounds containing the allylic structure (including most alkenes), vinyl and vinylidene compounds^{xiii}. Peroxide-forming chemicals must be labelled with:

- Date received
- Date first opened
- Date to be disposed of

7. Safe Storage and Handling

Proper handling and storage plays an important role in chemical safety. Chemicals need to be handled, transported and stored in a responsible manner to ensure the chemical stays in its container.

7.1 Criteria for Storage Area

- Store chemicals inside a closable cabinet or on a sturdy shelf with a front-edge lip to prevent accidents and chemical spills; a ¾-inch front edge lip is recommended
- Secure shelving to the wall or floor
- Ensure that all storage areas have doors with locks
- Keep chemical storage areas off limits to those who don't need to use them
- Ventilate storage areas adequately

7.2 Organization

- Organize chemicals first by COMPATIBILITY—not alphabetic succession
- Store alphabetically within compatible groups

7.3 Chemical Segregation

- Store acids in a dedicated acid cabinet. Nitric acid should be stored alone unless the cabinet provides a separate compartment for nitric acid storage

- Store highly toxic chemicals in a dedicated, lockable poison cabinet that has been labelled with a highly visible sign
- Store volatile and odoriferous chemicals in a ventilated cabinet
- Store flammables in an approved flammable liquid storage cabinet (refer to *Suggested Shelf Storage Pattern* below)
- Store water sensitive chemicals in a water-tight cabinet in a cool and dry location segregated from all other chemicals in the laboratory

Suggested Shelf Storage Pattern

A suggested arrangement of compatible chemical families on shelves in a chemical storage room, suggested by the *NIOSH, Chemical Safety Guide*, is presented below.

- First sort chemicals into organic and inorganic classes
- Next, separate into the following compatible families

Table 2. Compatible chemical families^{xiv}

| Inorganics | Organics |
|---|---|
| 1. Metals, Hydrides | 1. Acids, Anhydrides, Peracids |
| 2. Halides, Halogens, Phosphates, Sulfates, Sulfites, Thiosulfates | 2. Alcohols, Amides, Amines, Glycols, Imides, Imines |
| 3. Amides, Azides [†] , Nitrates [†] (except Ammonium nitrate), Nitrites [†] , Nitric acid | 3. Aldehydes, Esters, Hydrocarbons |
| 4. Carbon, Carbonates, Hydroxides, Oxides, Silicates | 4. Ethers [†] , Ethylene oxide, Halogenated hydrocarbons, Ketenes, Ketones |
| 5. Carbides, Nitrides, Phosphides, Selenides, Sulfides | 5. Epoxy compounds, Isocyanates |
| 6. Chlorates, Chlorites, Hydrogen Peroxide [†] , Hypochlorites, Perchlorates [†] , Perchloric acid [†] , Peroxides | 6. Azides [†] , Hydroperoxides, Peroxides |
| 7. Arsenates, Cyanates, Cyanides | 7. Nitriles, Polysulfides, Sulfides, Sulfoxides |
| 8. Borates, Chromates, Manganates, Permanganates | 8. Cresols, Phenols |
| 9. Acids (except Nitric acid) | |
| 10. Arsenic, Phosphorous [†] , Phosphorous Pentoxide [†] , Sulfur | |

[†]Chemicals deserving special attention because of their potential instability.

Storage Don'ts

- Do not place heavy materials, liquid chemicals, and large containers on high shelves
- Do not store chemicals on tops of cabinets
- Do not store chemicals on the floor, even temporarily
- Do not store items on bench tops and in laboratory chemical hoods, except when in use
- Do not store chemicals on shelves above eye level
- Do not store chemicals with food and drink
- Do not store chemicals in personal staff refrigerators, even temporarily
- Do not expose stored chemicals to direct heat or sunlight, or highly variable temperatures

Proper Use of Chemical Storage Containers

- Never use food containers for chemical storage
- Make sure all containers are properly closed
- After each use, carefully wipe down the outside of the container with a paper towel before returning it to the storage area, properly dispose of the paper towel after use

8. BIOLOGICAL HAZARDS

Biological hazards, also known as biohazards, refer to biological substances that pose a threat to the health of living organisms, primarily that of humans. This can include medical waste or samples of a microorganism, virus or toxin (from a biological source) that can impact human health. It can also include substances harmful to animals^{xv}.

Safety in the workplace is the product of developing safe working procedures which must be maintained at all times. Treat all biological materials as being potentially dangerous - they are potentially more dangerous than even some of the most hazardous chemicals.

The United States' Centers for Disease Control and Prevention (CDC) categorizes various diseases in levels of biohazard, Level 1 being minimum risk and Level 4 being extreme risk.

Biohazard Level 1: Bacteria and viruses including *Bacillus subtilis*, canine hepatitis, *Escherichia coli*, varicella (chicken pox), as well as some cell cultures and non-infectious bacteria. At this level precautions against the biohazardous materials in question are minimal, most likely involving gloves and some sort of facial protection.

Biohazard Level 2: Bacteria and viruses that cause only mild disease to humans, or are difficult to contract via aerosol in a lab setting, such as hepatitis A, B, and C, influenza A, Lyme disease, salmonella, mumps, measles, dengue fever, and HIV.

Biohazard Level 3: Bacteria and viruses that can cause severe to fatal disease in humans, but for which vaccines or other treatments exist, such as anthrax, West Nile virus, Venezuelan equine encephalitis, SARS virus, variola virus (smallpox), tuberculosis, typhus, Rift Valley fever, Rocky Mountain spotted fever, yellow fever, and malaria. Among parasites *Plasmodium falciparum*, which causes Malaria, and *Trypanosoma cruzi*, which causes trypanosomiasis, also come under this level.

Biohazard Level 4: Viruses and bacteria that cause severe to fatal disease in humans, and for which vaccines or other treatments are *not* available, such as Bolivian and Argentine hemorrhagic fevers, Dengue hemorrhagic fever, Marburg virus, Ebola virus, hantaviruses, Lassa fever, Crimean-Congo hemorrhagic fever, and other hemorrhagic diseases. When dealing with biological hazards at this level the use of a Hazmat suit and a self-contained oxygen supply is mandatory^{xvi}.

8.1 Properties of Microorganisms

When handling biological materials, and in particular microorganisms, you should be aware of the following properties^{xvii}:

- Microorganisms can multiply very rapidly and are often extremely small and difficult to detect
- Many microorganisms can be transferred from one person to another or even from other animals to humans
- Microorganisms can enter the body by ingestion, mucous membranes such as the eye, nose, lungs and mouth, via pre-existing cuts and abrasions and by penetration with syringes, or broken glass
- Many infectious agents have long incubation periods and effects may not be seen for weeks or months
- The larger the volume that enters the body, the greater the chance of disease although some agents can cause disease even if minute quantities enter the body
- Environmental samples such as pond water may contain organisms that can lead to serious disease e.g. hepatitis A, salmonella etc and should be handled as if they contained pathogenic organisms

8.2 Types of Biohazardous Agents

There are four general classes of biohazardous agents:

- Infectious agents
- Oncogenic or cancer causing agents
- Recombinant DNA from genetic engineering
- Hazardous natural products

Of the above types of agents, infectious agents pose the greatest risk simply because they are the most common, the others are also extremely dangerous however, but are beyond the scope of this guidance toolkit.

Infectious agents

These include bacteria, fungi, viruses and parasites. A pathogen is a microorganism that can cause disease. Large doses of normally non-pathogenic organisms can also

cause disease. Therefore, it is important that all microorganisms are handled with care. People with suppressed immune systems are more susceptible to infection, than the general population. Examples include cancer patients undergoing treatment, transplant recipients and infection caused by other organisms.

Bacteria are single celled organisms which can replicate using their own genetic material and metabolic resources. Many are harmless and in fact bacteria are essential for the maintenance of life on earth.

Viruses cannot reproduce effectively outside of a host cell. They produce changes in the metabolism of host cells that may lead to death of the cell and host.

Fungi can, but are less likely to, cause disease but may cause allergies^{xviii}.

8.3 Working Safely with Microorganisms

Sterilization and Disinfection

It is essential that you are aware of sterilisation and disinfection procedures. Sterilisation is the total destruction of all living species by the use of physical or chemical means - it is an absolute term. Disinfection is the removal of organisms, generally by chemical means, of organisms which have the potential to cause infection. Not all organisms are killed and spores may remain viable.

Heat Sterilization

Heat sterilization is the most effective form of sterilisation. It works through the denaturation of proteins and is more effective in the presence of water. Autoclaves are like pressure cookers in which objects are exposed to a pressure of 1 - 2 atmosphere and temperatures of 120°C for at least 15 minutes. It is essential that steam reaches all parts of the items being treated.

Dry heat ovens require heating to 150 to 175°C for several hours to be effective. Incineration leads to the complete destruction of biological materials.

Chemical Disinfectants

Chemical disinfectants are generally selective in their action and it is important that the appropriate disinfectant is used. Generally they do not result in sterilisation. Chemical disinfectants have the further disadvantage of often being toxic - consult the material safety data sheet for further details.

While there are many types of chemical disinfectants, hypochlorite (bleach) and alcohol are more commonly used in the laboratory.

Alcohols dissolve the lipid coating on microorganisms and destroy the quaternary structure of proteins. The most effective solutions are 70 - 85% aqueous solutions.

Hypochlorite solutions are very effective even at low concentration and are not very susceptible to temperature changes. However, the disadvantages of hypochlorite are that:

- It is very corrosive, particularly to metals

- It produces toxic chlorine gas when heated
- It destroys delicate materials^{xix}

8.4 Blood Products and Body Fluids

All body fluids including blood, blood products and urine must be considered biological hazards and treated as if they were infected with pathogens - organisms capable of causing disease. Diseases that can be readily transmitted by bodily fluids include hepatitis A, hepatitis B, hepatitis C and HIV. When working with blood and bodily fluids it is important to remember the following:

- In addition to the normal laboratory practices of lab coats and safety glasses, always thoroughly wash hands with an appropriate disinfectant before leaving the laboratory and any contaminated clothing must be disinfected before removal from the laboratory
- Laboratory work surfaces must be decontaminated immediately after completion of work with 1% bleach or 70% ethanol
- All potentially contaminated materials must be sterilised by autoclaving or other agents before disposal^{xx}

8.5 Disposal of Biohazardous Wastes

- If working with any biohazardous materials, it is recommended that all waste is autoclaved and placed in the appropriate disposal containers
- If autoclaving is not an option incineration is the next best option
- In addition to the normal laboratory practices of lab coats and safety glasses, it is important to always thoroughly wash hands before leaving the laboratory, and any contaminated clothing must be disinfected before removal from the laboratory.
- Laboratory work surfaces must be decontaminated immediately after completion of work with 1% bleach or 70% ethanol
- Sharp objects such as Pasteur pipettes (eye droppers) and syringes must be placed in the appropriate containers. Pasteur pipettes should be immediately placed in a discard container with an appropriate disinfectant. Syringes must be placed in a sharps discard container. Never attempt to recap or bend disposable needles
- If there is a spill of blood after an accident, this must be treated as an infectious spill. Immediately decontaminate with 70% alcohol or 1% bleach solution
- Gloves must be worn when cleaning up spills and all contaminated materials should be disposed of as hazardous waste^{xxi}

9. RADIATION HAZARDS

Radiations that may be a hazard fall into several categories; acoustic, ultrasonic, ionising and non-ionising. It is the latter two that are the most likely sources of hazard in a modern chemical laboratory.

The general range of spectrophotometers and similar instruments have their energy beams contained within the instrument and so normally present no hazard to the user. It is only when the casing is removed from the instrument that special care may become necessary to protect the operator from the radiation.

9.1 Non-Ionising Radiations

Apart from acoustic and ultrasonic radiations, non-ionising radiations that may be harmful are electromagnetic in nature. The wavelengths involved range from around 1 nm to about 280 nm. Shorter wavelengths are progressively more dangerous, but commence falling into the category of ionising radiation.

Generally, beams of radiation that are potentially dangerous are shielded from the user, or focussed along paths that are too small for any access that may cause danger. However, the user should be aware of the potential hazard that may exist when obtaining unusual access to an instrument; e.g. when conducting repairs.

Ultra-violet (UV) radiation

This radiation is characterised in three bands:

- | | | | |
|----|---------------|------|------------------------|
| a) | 200 to 280 nm | UV-C | Short (or Far) UV |
| b) | 280 to 320 nm | UV-B | Middle (sunburning) UV |
| c) | 320 to 400 nm | UV-A | Long (or Near) UV |

UV below around 200 nm is fairly strongly absorbed by the atmosphere.

UV-B radiation is used in Organic Chemistry to promote free-radical reactions, but is usually of fairly low intensity. The full range of UV wavelengths are employed in the UV-Visible spectrophotometers, and quite intense beams may be produced. Welding arcs and quartz discharge lamps are intense sources of UV-C radiation.

The effects of UV radiation in general are tanning and burning, with long-term effects of ageing and skin cancer. Damage is similar whether a given dose is received slowly at low intensity, or rapidly from a high intensity source. **The eyes are particularly susceptible to damage**, with conjunctivitis occurring very easily, followed by inflammation of the cornea and then of the eye-lids.

When working with any UV source **do not allow any exposure to the eyes**, and minimise exposure to any part of the body. Use face-shields when UV initiation is needed for organic reactions. **Do not look directly at UV source** in spectrophotometers. Glass and many plastics are good protective shields for UV.

If a UV burn occurs, seek medical help and treat as for a normal heat burn. UV burns to the eyes usually heal in 2 to 3 days.

BEWARE CONTACT LENSES: these can become welded to the cornea.

Visible Light

Burns can occur in the eye due to the ability of the eyes to focus a beam of light to a fine point on the retina, concentrating the intensity up to 100,000 times. Concentrated light sources in a laboratory can cause retinal burns that may cause permanent damage, particularly to night vision. Cataracts can also result, especially from blue and actinic (UV-containing) light.

Intense visible light sources should be viewed only through approved dark glasses (conventional sunglasses may not be suitable). These sources may include carbon and welding arcs, high-pressure mercury, sodium and other discharge lamps, tungsten-halogen lamps and stroboscopic lamps.

In case of eye-damage from these sources, seek medical help and treat as for conjunctivitis.

Infra Red (IR) Radiation

IR is divided into three categories:-

- | | | |
|----|--------------------|-----------------|
| a) | 700 nm to 1400 nm | Near IR (IRA) |
| b) | 1400 nm to 3000 nm | Middle IR (IRB) |
| c) | 3000nm to 1mm | Far IR (IRC) |

This radiation is radiant heat, and can usually be detected before any damage is caused by the heating effect. However, the eye can be damaged without any immediate symptoms. Far IR is readily absorbed by surface tissue and causes no deep injuries. Near IR can cause cataracts. Do not let the eye near any focussed IR beam (such as in an IR spectrophotometer). In case of damage, seek medical aid and treat as a burn.

Radio-Frequency Radiation (including Microwave)

This part of the spectrum has frequencies in the range from 10 MHz to 300 GHz. However, the only likely source of damage is in the microwave region, approx. 1 to 100 GHz. Microwaves are produced in microwave ovens and Electron Spin Resonance equipment. This radiation heats biological tissue and can cause severe thermal damage. The eye is the part of the body most susceptible to damage.

Laser Radiation

A **Laser** is any device which can be made to produce or amplify electromagnetic radiation on the wavelength range from 100nm to 1mm primarily by the process of controlled stimulated emission.

Laser radiation is defined as all electromagnetic radiation emitted by a laser product between 100nm and 1mm which is produced as a result of controlled stimulated emission.

Laser beams that strike human tissues directly or are reflected onto the tissue, may be capable of inflicting varying degrees of damage. The principal concern is with damage to the retina of the eye. Skin damage is also possible with increasing laser intensities.

Eye Protection

Eye protection which is designed to provide adequate protection against specific laser radiations should be used in all hazard areas where Class 3B or Class 4 lasers are in use.

9.2 X-Rays and Other Ionising Radiations

X-ray diffraction and x-ray fluorescence equipment are high power, highly focussed beams, and as the beams are of very great intensity, the potential for damage is very high. An exposure of even 1 second to any part of the body is potentially dangerous. Although elaborate safeguards exist, take the utmost care if using this equipment.

In the event of even suspected exposure to x-rays, report the event and seek immediate medical aid. General exposure is monitored by taking blood tests, as the x-rays can diminish the white blood-cell count. Except for specific damage to major organs, there is little actual treatment that can be given - but it is essential that any damage is monitored by a doctor during the healing process.

10. Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is special gear used to protect the wearer from specific hazards of a hazardous substance. For hazardous chemicals the MSDS should specify which PPE is recommended while working with the substance. It is worth noting that PPE is a last resort protection system, it does not reduce or eliminate the hazard and protects only the wearer, not others.

10.1 Eye Protection

Serious and irreversible damage can occur when chemical substances contact the eyes in the form of splash, mists, vapours, or fumes. Injuries may also result from flying or falling objects striking the eye. Eye protection should be worn at all times in the laboratory

If prescription glasses are worn, over-glasses should be worn over them. Contact lenses are not recommended for laboratory work as some materials when splashed in the eye cause the plastic to adhere to the cornea.

Face Shields

Face shields are used when working with large volumes of hazardous materials, either for protection from splash to the face or flying particles. Face shields must be used in conjunction with safety glasses or goggles.

10.2 Laboratory Coats and Dress

When the possibility of contamination exists, protective clothing that resists physical, biological and chemical hazards should be worn over street clothes. Laboratory coats are appropriate for minor chemical splashes and solids contamination, while plastic or

rubber aprons are best for protection from corrosive or irritating liquids. Disposable outer garments (i.e., Tyvek suits) may be useful when cleaning and decontamination of reusable clothing is difficult.

Loose clothing (such as overlarge lab coats or ties), small clothing (such as shorts), torn clothing and unrestrained hair may pose a hazard in the laboratory. Only wear jewellery that either, cannot be caught in equipment or contaminated by infectious substances or chemicals, or is protected from these hazards.

Laboratory coats must be kept clean and laundered regularly (separate from normal domestic laundry).

10.3 Shoes

Closed-toed shoes should be worn at all times in buildings where chemicals are stored or used. Perforated shoes, sandals or cloth sneakers should not be worn in laboratories or where mechanical work is conducted. Such shoes offer no barrier between the laboratory worker and chemicals or broken glass.

Chemical resistant overshoes or boots may be used to avoid possible exposure to corrosive chemical or large quantities of solvents or water that might penetrate normal footwear (e.g., during spill clean-up). Leather shoes tend to absorb chemicals and may have to be discarded if contaminated with a hazardous material.

10.4 Gloves^{xxii}

Choosing the appropriate hand protection can be a challenge in a laboratory setting. Considering the fact that dermatitis or inflammation of the skin accounts for 40-45% of all work-related diseases, selecting the right glove for the job is important.

Not only can many chemicals cause skin irritation or burns, but also absorption through the skin can be a significant route of exposure to certain chemicals. Dimethyl sulfoxide (DMSO), nitrobenzene, and many solvents are examples of chemicals that can be readily absorbed through the skin into the bloodstream, where the chemical may cause harmful effects.

| Glove Material | General Uses |
|-----------------------|--|
| Butyl | Offers the highest resistance to permeation by most gases and water vapour. Especially suitable for use with esters and ketones. |
| Neoprene | Provides moderate abrasion resistance but good tensile strength and heat resistance. Compatible with many acids, caustics and oils. |
| Nitrile | Excellent general duty glove. Provides protection from a wide variety of solvents, oils, petroleum products and some corrosives. Excellent resistance to cuts, snags, punctures and abrasions. |

| | |
|----------------|---|
| PVC | Provides excellent abrasion resistance and protection from most fats, acids, and petroleum hydrocarbons. |
| PVA | Highly impermeable to gases. Excellent protection from aromatic and chlorinated solvents. Cannot be used in water or water-based solutions. |
| Viton | Exceptional resistance to chlorinated and aromatic solvents. Good resistance to cuts and abrasions. |
| Silver Shield | Resists a wide variety of toxic and hazardous chemicals. Provides the highest level of overall chemical resistance. |
| Natural rubber | Provides flexibility and resistance to a wide variety of acids, caustics, salts, detergents and alcohols. |

Other Considerations

There are several factors besides glove material to consider when selecting the appropriate glove. The amount of *dexterity* needed to perform a particular manipulation must be weighed against the glove material recommended for maximum chemical resistance. In some cases, particularly when working with delicate objects where fine dexterity is crucial, a bulky glove may actually be more of a hazard.

- Where fine dexterity is needed, consider double gloving with a less compatible material, immediately removing and replacing the outer glove if there are any signs of contamination
- Thinner, lighter gloves offer better touch sensitivity and flexibility, but may provide shorter breakthrough times. Generally, doubling the thickness of the glove quadruples the breakthrough time
- Glove *length* should be chosen based on the depth to which the arm will be immersed or where chemical splash is likely, gloves longer than 14 inches provide extra protection against splash or immersion
- Glove *size* may also be important (**One size does not fit all**), gloves which are too tight tend to cause fatigue, while gloves which are too loose will have loose finger ends which make work more difficult

10.5 Respiratory Protection

A respirator may be used when engineering controls, such as general ventilation or a fume hood, are not feasible or do not reduce the exposure of a chemical to acceptable levels.

Respiratory protection, through the use of supplied air or self-contained breathing apparatus, is required for work in oxygen deficient atmospheres. It also may be necessary during non-routine operations in which the individual is exposed briefly to high concentration of a hazardous substance (e.g., maintenance or repair activities or during spill clean-up).

11. Emergency Equipment

The emergency equipment recommended to be on standby in laboratories in case of an accident is:

- Hand-free eye-wash stations or at least eye-wash bottles
- Deluge safety showers
- Safety shields with heavy base
- Fire extinguishers (dry chemical and carbon dioxide extinguishers)
- Sand bucket
- Fire blankets
- Emergency lights
- Emergency signs and placards
- Fire detection or alarm system with pull stations
- First-aid kits
- Spill control kit (absorbent and neutralizing agents)
- Chemical storage cabinets (preferably with an explosion proof ventilation system)
- Gallon-size carrying buckets for chemical bottles
- Laboratory chemical hood (60–100 ft/minute capture velocity, vented outside)
- Ground-fault interrupter electrical outlets
- Container for broken glass and sharps
- Material Safety Data Sheets (MSDSs)
- Predetermined Emergency Action Plan

12. Occupational Health & Safety Legislation and Requirements^{xxiii}

Issues at the workplace involving hazardous substances can be complex and technical. Most countries have legislation covering hazardous substances and dangerous goods in the workplace. This legislation requires employers to provide and maintain, as far as practicable, a working environment for employees that is safe and without risks to health.

12.1 Employers Responsibilities

Control Risk

Employers must eliminate any risks associated with hazardous substances in the workplace. If it's not reasonably practicable to eliminate the risk, the employer must reduce the risk, as far as reasonably practicable, by:

- Using a less hazardous substance or a safer form of the substance
- Isolating employees from exposure, or
- Using engineering controls

Employers must review (and, where necessary, revise) risk controls if things change, if medical reports show there is a problem, or at the request of a health and safety representative. Employers have a duty to consult employees and health and safety representatives when identifying hazards and deciding on control measures.

Obtain and Provide Information on Hazardous Substances

Employers are required to:

- Provide information, instruction, training and supervision to employees to enable them to work safely and without risks to health
- Keep a register of all hazardous substances supplied to the workplace
- Obtain a current MSDS for each hazardous substance
- Make the MSDS accessible to employees
- Ensure that containers in which hazardous substances are supplied are labelled
- Identify containers of waste

Identify hazardous substances

Employers must ensure that hazardous substances contained in a work environment are identified to anyone who may be exposed to them. This may be done through signage and information training.

Conduct Atmospheric Monitoring and Health Surveillance

Employees must not be exposed to an atmospheric concentration of a hazardous substance that exceeds any relevant exposure standard. If there is uncertainty about whether the exposure standard could be exceeded, employers must carry out atmospheric monitoring, provide the results of the monitoring to employees and keep a record of the results and give the results of the monitoring to the employees involved. Employers must also provide health surveillance for employees exposed to certain hazardous substances and keep a record of the results.

12.2 Employees

The employer is required to protect employees from the risk of exposure to hazardous substances in the workplace. At the same time, employees have a general duty to take reasonable care of their own health and safety, and that of others who may be affected by their work, and to cooperate with the employer's efforts to make the workplace safe. This may include:

- Following workplace safety policies and procedures
- Using control measures provided
- Participating in any health surveillance as required
- Attending health and safety training
- Helping to identify hazards and risks

Further assistance and advice on particular OH&S issues can be found from:

- Your country's legislation
- Workplace union
- The employer
- Safety officer or technical staff

12.3 Manufacturers and Suppliers

Manufacturers, importing suppliers and suppliers have specific duties in relation to hazardous substances used at workplaces. Manufacturers or importing suppliers of a substance for use in a workplace should:

- Determine whether the substance is hazardous
- Prepare an MSDS
- Review and revise the MSDS
- Label containers of the hazardous substance
- Disclose a chemical name to a registered medical practitioner in certain circumstances

Manufacturers, importing suppliers and suppliers should provide a current MSDS to any person to whom the substance is supplied and to any employer on request. It must be supplied before the hazardous substance is used for the first time at a workplace. Suppliers must also ensure that containers of hazardous substances are labelled.

13. National Legislation

National legislation regulates many activities (storage, disposal, transport, work safety etc.) related to hazardous substances, so it is essential for Customs and Laboratory staff to know how this legislation may regulate their professional activities.

As each country has their own legislation it is not within the scope of this toolkit to provide a detailed description of all relevant legislation for each country, however it is possible to give a general overview of where to look for legislation that may regulate laboratory and Customs activities. Here are some generic legislative acts that countries should have in some form and what they may cover.

Customs Act

- Levies and taxes
- Imports and exports
- General provisions of aircraft and vessels in territorial waters
- Warehousing
- Manufacturing and bottling
- Sale of intoxicating liquors
- Duty free
- Search, seizure and arrest
- Offences and penalties

Waste Management Act

- Definitions of waste
- Powers of authorised people
- Penalties
- Waste Management Planning
- Measures to reduce production and promote recovery of waste
- Holding, collecting and movement of waste

- Recovery and disposal of waste
- General provisions regarding environmental protection

Occupational, Health and Safety Act

- Support for OHS in the workplace
- Provision of systems of work that are safe and without risk to health
- Prevention of injury and disease
- Protection of the general public’s safety and health
- Inspectors
- Regulations
- Enforcement
- Duties of employers
- Duties of employees

Environmental Protection Act

- Disposal of controlled waste on land
- Duty of care in respect to waste
- Waste Management licences
- National and local government responsibilities
- Enforcement

14. Additional Issues around Legal Export and Movement of Hazardous Waste/chemicals

Certain substances and commodities that cross borders are considered to be “environmentally sensitive” for human health or ecosystems because of their inherent hazardous qualities, some of these include banned or restricted chemicals and hazardous waste. Many of these items are controlled under multilateral environmental agreements (MEAs) and the effective monitoring and control of the transboundary movement of these substances is a key component of environmental protection and, in many some cases, national security^{xxiv}.

The four main international conventions governing the legal export and movement of hazardous waste and chemicals in the Pacific are the Basel, Waigani, Rotterdam and Stockholm Conventions. Together they cover key elements of “cradle-to-grave” management of hazardous substances by governing how they can be used, transported and disposed of^{xxv}. Table 3 below shows which conventions are used to govern the various stages in the lifecycle of hazardous substances (See Annex 1 for summaries of the four conventions and where to find further information about them).

Table 3. Hazardous substances lifecycle stages and the conventions that govern them

| New chemicals | Existing chemicals | Import/export controls | Waste management |
|----------------------|--|--|--|
| Stockholm Convention | Stockholm Convention Rotterdam Convention | Stockholm Convention Rotterdam Convention | Stockholm Convention Rotterdam Convention |

| | | | |
|--|--|--|--|
| | | Basel Convention Waigani Convention | Basel Convention Waigani Convention |
|--|--|--|--|

Customs authorities play a key role in the implementation of the Basel, Waigani, Rotterdam and Stockholm Conventions and in protecting their countries from unwanted trade of hazardous waste and hazardous chemicals. Good cooperation and coordination between Customs authorities and Designated National Authorities are essential for the effective implementation and enforcement of these Conventions. Where hazardous wastes cannot be disposed of appropriately on an island, they should be stored appropriately until they can be sent to be disposed of in another suitable country. Some common hazardous substances/materials and how they relate to these conventions are listed below.

Asbestos

Asbestos became increasingly popular among manufacturers and builders in the late 19th century because of its sound absorption, average tensile strength, and its resistance to fire, heat, electrical and chemical damage. It was commonly used as electrical insulation and in building insulation.

The inhalation of asbestos fibers can cause serious illnesses, including malignant lung cancer, mesothelioma and asbestosis (a type of pneumoconiosis). Long exposure to high concentrations of asbestos fibers is likely to cause health problems.

Asbestos is listed in the Basel, Waigani and Rotterdam Conventions as a hazardous substance so any transboundary movement of Asbestos is bound by the conditions in these conventions. All three conventions require a country that is intending to export asbestos to inform the receiving country that the export is planned prior to the shipment. This means that formal permission must be obtained to export to a particular country. Any shipments made without consent are illegal. The exporting Party must also ensure that every export shipment is clearly labelled identifying the hazardous substance. Additionally, the Basel and Waigani Conventions require Parties to ensure that the asbestos be disposed of in an environmentally sound manner in the country of destination.

E-waste

Everyday electronics such as computer screens, keyboards, televisions etc. might look harmless, but they contain potentially toxic and poisonous materials, such as lead and mercury. These chemicals can be seriously damaging to human health and the environment.

Because E-waste contains lead and mercury which are listed in the Basel, Waigani and Rotterdam Conventions as hazardous substances, any transboundary movement of E-waste is bound by the conditions in these conventions. All three conventions require a country that is intending to export e-waste to inform the receiving country that the export is planned, prior to the shipment. This means that formal permission must be obtained to export to a particular country. Any shipments made without consent are illegal. The exporting Party must also ensure that every export shipment is clearly labelled identifying the hazardous substances. Additionally, the Basel and Waigani Conventions require Parties to ensure that the e-waste be disposed of in an environmentally sound manner in the country of destination.

Used Lead Acid Batteries^{xxvi}

Lead-acid batteries contain sulphuric acid and large amounts of lead. The acid is extremely corrosive and also a good carrier for soluble lead and lead particulate. Exposure to excessive levels of lead can cause brain damage; affect children's growth; damage kidneys; impair hearing; cause vomiting, headaches, and appetite loss; and cause learning and behavioural problems.

For the movement of lead-acid batteries from any Pacific Island country to New Zealand or Australia, the Basel and Waigani Conventions require a country that is intending to export used lead acid batteries to inform the receiving country that the export is planned, prior to the shipment. This means that formal permission must be obtained to export to a particular country. Any shipments made without consent are illegal. The exporting Party must also ensure that every export shipment is clearly labelled identifying the hazardous substances.

Batteries should be held a while before packing on pallets to ensure that they are not leaking and should be strapped to pallets for transportation. Batteries prepared for export will need to be packed on wooden pallets, PLASTIC strapping (not steel, to avoid short-circuits) and pallet wrap film wrapping. Additionally, the Basel and Waigani Conventions require Parties to ensure that the lead acid batteries are disposed of or recycled in an environmentally sound manner in the country of destination.

Pesticides

Pesticides are substances or a mixture of substances intended for preventing, destroying, repelling or mitigating any pest (insects, plants etc.). Exposure to some pesticides can cause a variety of adverse health effects to humans, animals and to the environment. For this reason many pesticides and other chemicals are banned or severely restricted by the Stockholm Convention (see Table 4. in Annex I below for the list of banned or severely restricted substances in the Stockholm Convention).

Many pesticides also fall under the jurisdiction of the Rotterdam Convention which, similar to the Stockholm Convention, establishes a procedure requiring the "prior informed consent" of importing Parties to the import of the chemicals listed in the convention (see Table 5. In Annex I below for a list of the banned or severely restricted chemicals under the Rotterdam Convention). This means that formal permission must be obtained to export to a particular country. Any shipments made without consent are illegal. The exporting Party must also ensure that every export shipment is clearly labelled identifying the hazardous substances and is accompanied by a MSDS.

Additional frameworks for the Transportation of Dangerous Goods

Further recommendations on the Transport of Dangerous goods have been elaborated by the United Nations Committee of Experts on the Transport of Dangerous Goods. They are addressed to governments and international organizations concerned with the regulation of the transport of dangerous goods (including hazardous wastes). Among other aspects, the recommendations cover principles of classification and definition of classes, listing of the principal dangerous goods, general packing requirements, testing procedures, marking, labelling or placarding, and shipping documents. The main instruments regulating the international sea transport of

dangerous goods and hazardous wastes on the basis of the United Nations recommendations are as follows^{xxvii}:

Legislative Framework:

- International convention for the safety of life at Sea, 1974 (SOLAS 74)
- International convention for the prevention of pollution from ships, modified by the Protocol of 1978 relating thereto (MARPOL 73/78)

Practical Instruments:

- International Maritime Dangerous Goods Code (IMDG Code)
- Code of Safe Practice for Solid Bulk Cargoes (BC Code)
- International Code for the Construction and Equipment of Ships carrying dangerous chemicals in Bulk (IBC Code)

ANNEX I.

Summary of the Four Main International Conventions Governing the Legal Export and Movement of Waste and Hazardous Chemicals in the Pacific.

The Basel Convention

The Basel Convention on the Transboundary Movement of Hazardous Wastes and Their Disposal was adopted in March 1989. It serves as the primary international instrument governing the transboundary movement and environmental management of hazardous wastes. Its main aims are to encourage environmentally sound management of hazardous waste, to regulate international trade in hazardous waste and to reduce the generation of hazardous wastes. Environmentally sound management of wastes is described within the Basel Convention as 'taking of all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes'.

It ensures that hazardous waste must generally be treated and disposed of in its country of origin, restricting the opportunity to protect the local environment by exporting the problem.

The Convention requires every company or broker wishing to export hazardous wastes to ask the Government of the exporting State to provide prior written notification to the competent authorities in the State of import and in any transit States. The importing and transit States must then give prior written consent before any export can take place. Each approved shipment must be accompanied by a "movement document" with a detailed description of the contents and their disposal requirements, from the point at which the export begins to the point of disposal. Hazardous waste shipments made without such documents are illegal.

A waste will fall under the scope of the Convention if it is within the category of wastes listed in Annex I of the Convention (see below). The other way that a waste may fall under the scope of the Convention is if it is defined as or considered to be a hazardous waste under the laws of either the exporting country, the importing country, or and of the countries of transit.

Table 4. Materials covered under Annex I of the Basel Convention^{xxviii}

| Waste Streams | |
|--------------------------------|--|
| Y1 | Clinical wastes from medical care in hospitals, medical centres and clinics |
| Y2 | Wastes from the production and preparation of pharmaceutical products |
| Y3 | Waste pharmaceuticals, drugs and medicines |
| Y4 | Wastes from the production, formulation and use of biocides and phytopharmaceuticals |
| Y5 | Wastes from the manufacture, formulation and use of wood preserving chemicals |
| Y6 | Wastes from the production, formulation and use of organic solvents |
| Y7 | Wastes from heat treatment and tempering operations containing cyanides |
| Y8 | Waste mineral oils unfit for their originally intended use |
| Y9 | Waste oils/water, hydrocarbons/water mixtures, emulsions |
| Y10 | Y10 Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs) |
| Y11 | Waste tarry residues arising from refining, distillation and any pyrolytic treatment |
| Y12 | Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish |
| Y13 | Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives |
| Y14 | Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known |
| Y15 | Wastes of an explosive nature not subject to other legislation |
| Y16 | Wastes from production, formulation and use of photographic chemicals and processing materials |
| Y17 | Wastes resulting from surface treatment of metals and plastics |
| Y18 | Residues arising from industrial waste disposal operations |
| Wastes having as constituents: | |
| Y19 | Metal carbonyls |
| Y20 | Beryllium; beryllium compounds |
| Y21 | Hexavalent chromium compounds |
| Y22 | Copper compounds |
| Y23 | Zinc compounds |

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|-----|--|
| Y24 | Arsenic; arsenic compounds |
| Y25 | Selenium; selenium compounds |
| Y26 | Cadmium; cadmium compounds |
| Y27 | Antimony; antimony compounds |
| Y28 | Tellurium; tellurium compounds |
| Y29 | Mercury; mercury compounds |
| Y30 | Thallium; thallium compounds |
| Y31 | Lead; lead compounds |
| Y32 | Inorganic fluorine compounds excluding calcium fluoride |
| Y33 | Inorganic cyanides |
| Y34 | Acidic solutions or acids in solid form |
| Y35 | Basic solutions or bases in solid form |
| Y36 | Asbestos (dust and fibres) |
| Y37 | Organic phosphorus compounds |
| Y38 | Organic cyanides |
| Y39 | Phenols; phenol compounds including chlorophenols |
| Y40 | Ethers |
| Y41 | Halogenated organic solvents |
| Y42 | Organic solvents excluding halogenated solvents |
| Y43 | Any congener of polychlorinated dibenzo-furan |
| Y44 | Any congener of polychlorinated dibenzo-p-dioxin |
| Y45 | Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44) |

The Waigani Convention^{xxix}

The Waigani Convention is very similar to the Basel Convention in that it serves as an instrument governing the transboundary movement and environmental management of hazardous wastes but is only within the Pacific Forum region.

The main aim of the Waigani Convention is to reduce or eliminate transboundary movements of hazardous and radioactive wastes between Pacific Island Countries; minimize the production of hazardous and toxic wastes; ensure that disposal of wastes is done in an environmentally sound manner and as close to the source as possible; and to assist Pacific island countries that are Parties to the Convention in the environmentally sound management of hazardous and other wastes they generate. It also enables signatory countries to receive hazardous wastes exported from other Pacific Island countries which are not Parties to the Basel Convention. The major differences between the Waigani and Basel Convention are that:

- The Waigani Convention is administered within the Pacific Region
- It also covers radioactive wastes

- And extends to the economic exclusion zone (200 nautical miles) rather than the territorial sea (12 nautical miles)

Rotterdam Convention

The Rotterdam Convention is a global international agreement aimed at protecting human health and the environment from the potentially harmful effects of certain hazardous chemicals, including some pesticides and industrial chemicals. The Convention works by promoting shared responsibilities and cooperative efforts associated with the international trade of these chemicals and by facilitating the exchange of information about chemicals that have been banned or severely restricted in certain countries. It promotes open exchange of information through the ‘prior informed consent’ procedure and calls on exporters of hazardous chemicals to use proper labeling, include directions on safe handling, and inform purchasers of any known restrictions or bans. Parties can decide whether to allow or ban the importation of chemicals listed in the treaty, and exporting countries are obliged make sure that producers within their jurisdiction comply.

Table 5. Chemicals listed under Annex III of the Rotterdam Convention^{xxx}

| Chemical | Category |
|---|-----------------|
| 2,4,5-T and its salts and esters | Pesticide |
| Aldrin | Pesticide |
| Binapacryl | Pesticide |
| Captafol | Pesticide |
| Chlordane | Pesticide |
| Chlordimeform | Pesticide |
| Chlorobenzilate | Pesticide |
| DDT | Pesticide |
| Dieldrin | Pesticide |
| Dinitro-ortho-cresol (DNOC) and its salts (such as ammonium salt, potassium salt and sodium salt) | Pesticide |
| Dinoseb and its salts and esters | Pesticide |
| 1,2-dibromoethane (EDB) | Pesticide |
| Ethylene dichloride | Pesticide |
| Ethylene oxide | Pesticide |
| Fluoroacetamide | Pesticide |
| HCH (mixed isomers) | Pesticide |
| Heptachlor | Pesticide |
| Hexachlorobenzene | Pesticide |
| Lindane | Pesticide |
| Mercury compounds including inorganic mercury compounds, alkyl mercury compounds and alkyloxyalkyl and aryl mercury compounds | Pesticide |
| | Corrigendum |
| | Corrigendum |
| Monocrotophos | Pesticide |
| Parathion | Pesticide |

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|--|---|
| Pentachlorophenol and its salts and esters | Pesticide |
| Toxaphene | Pesticide |
| Tributyltin compounds (TBT) | Pesticide |
| Dustable powder formulations containing a combination of : Benomyl at or above 7 per cent, Carbofuran at above 10 per cent, Thiram at or above 15 per cent | Severely hazardous pesticide formulation |
| Methamidophos (Soluble liquid formulations of the substance that exceed 600 g active ingredient/l) | Severely hazardous pesticide formulation |
| Phosphamidon (Soluble liquid formulations of the substance that exceed 1000 g active ingredient/l) | Severely hazardous pesticide formulation |
| Methyl-parathion (emulsifiable concentrates (EC) at or above 19.5% active ingredient and dusts at or above 1.5% active ingredient) | Severely hazardous pesticide formulation |
| Asbestos Crocidolite Asbestos Actinolite Asbestos Anthophyllite Asbestos Amosite Asbestos Tremolite | Industrial |
| Polybrominated biphenyls (PBB) | Industrial |
| Polychlorinated biphenyls (PCB) | Industrial |
| Polychlorinated terphenyls (PCT) | Industrial |
| Tetraethyl lead | Industrial |
| Tetramethyl lead | Industrial |
| Tris (2,3-dibromopropyl) phosphate | Industrial |

Stockholm Convention^{xxxii}

The Stockholm Convention on Persistent Organic Pollutants (POPs) was adopted in 2001 in response to the urgent need for global action to protect human health and the environment from “POPs”. These are chemicals that are highly toxic, persistent, bioaccumulate and move long distances in the environment. The Convention seeks the elimination or restriction of production and use of all intentionally produced POPs (i.e. industrial chemicals and pesticides). It also seeks the continuing minimization and, where feasible, ultimate elimination of releases of unintentionally produced POPs such as dioxins and furans.

The Stockholm Convention (Article 3.2) restricts the import and export of POPs requiring that they not be transported across international boundaries without taking into account relevant international rules, standards and guidelines (Article 6.1) and prior informed consent from the country of destination.

The chemicals slated for elimination under the Stockholm Convention are listed below (the use of the pesticide DDT, although listed below, is allowed for disease vector control until safe, affordable and effective alternatives are in place).

Table 6. Chemicals listed for elimination under the Stockholm Convention

| Chemical | Category |
|---|-----------------------|
| Alpha hexachlorocyclohexane | Pesticide |
| Aldrin | Pesticide |
| Beta hexachlorocyclohexane | Pesticide |
| Captafol | Pesticide |
| Chlordane | Pesticide |
| Chlordecone | Pesticide |
| Dichlo-Diphenyl-Trichlorethane (DDT) | Pesticide |
| Dieldrin | Pesticide |
| Dioxins | Unintended by-product |
| Technical endosulfan and its related isomers | Pesticide |
| Endrin | Pesticide |
| Furans | Unintended by-product |
| Heptachlor | Pesticide |
| hexachlorobenzene (HCB) | Pesticide |
| Hexabromobiphenyl | Industrial |
| Lindane | Pesticide |
| Mirex | Pesticide |
| Pentachlorobenzene | Pesticide, Industrial |
| Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl | Industrial |
| Polychlorinated biphenyls (PCBs) | Industrial |
| Toxaphene | Pesticide |
| Tetrabromodiphenyl ether and pentabromodiphenyl ether | Industrial |

Further reading

Further information on all four of the International Conventions can be found at <http://cchandbook.ntn.org.au/>

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