

PLANNING & RISK ASSESSMENT

MODULE 1 – CHEMICAL SAFETY TRAINING

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1. INTRODUCTION

Hazardous chemicals can potentially cause injury or illness if not handled properly. It is an important part of managing risk to plan and assess the risks associated with activities using hazardous chemicals. A systematic approach to manage risk is also a key requirement of WHS legislation.

2. PURPOSE

This document provides guidance in identifying hazards and assessing the risk when using hazardous chemicals. It has been developed in support of the [University's Chemical Safety standards](#) and as a resource for module 1 of the online chemical safety training. All staff and students are encouraged to use this document when seeking information on the risk assessment process for activities using hazardous chemicals.

3. IDENTIFY HAZARDS

3.1 University chemical standards

The [University's Chemical Safety Standards](#) outline minimum performance requirements for working with hazardous chemicals. These include a requirement to carry out risk assessments for activities involving hazardous chemicals.

A basic risk assessment for an activity involving chemicals involves:

- **Reviewing the chemical safety data sheets (SDS)** to identify the health & physicochemical hazards.
- **Considering the proposed work processes or tasks** including the quantities and concentrations of the chemicals used, the equipment, work environment and the people involved.
- Identifying possible routes of exposure and the likelihood of exposure.
- Considering the likelihood of a dangerous reaction, fire, or explosion occurring during the work process.
- **Implement risk controls** to reduce the risk of exposure.

Part A Identify Chemical Hazards

How will you find information about the physicochemical and health hazards associated with the chemicals you are using?

Hazard information is provided on **chemical labels** and in **Safety Data Sheets (SDS)**.

On a label you will see

- Pictograms
- Signal words
- Hazard and
- Precautionary statements.

3.2 Understanding GHS classification

The table below (Table 1) shows information for a 37% formaldehyde solution taken from the SDS. Chemicals are classified and labelled in accordance with the Globally Harmonised System for the Classification and labelling of chemicals (GHS).






Hazard class	Category	Pictogram	Signal word	Hazard statement
Acute Toxicity: Oral	Category 3		Danger	Toxic if swallowed
Acute Toxicity: Skin	Category 3			Toxic if in contact with skin
Acute Toxicity: Inhalation	Category 3			Toxic if inhaled
Skin Corrosion/Irritation	Category 1C			Causes severe skin burns and eye damage
Skin Sensitization	Category 1			May cause an allergic skin reaction
Carcinogenicity	Category 2			Suspected of causing cancer
Specific Target Organ Systemic Toxicity (Single Exposure)	Category 2			May cause damage to organs

Table 1: GHS Hazards of 37% formaldehyde

3.2.1 GHS Terminology

Term	Definition
Hazard class	<p>The hazard class describes the nature of the physicochemical or health hazard. The GHS specifies criteria for classifying chemicals into a number of hazard classes, e.g. flammable liquids, acute toxicity, gases under pressure, carcinogenicity.</p> <p>If a chemical meets the criteria for one or more class, it is classified as a hazardous chemical. It is not uncommon for a single chemical to be allocated to multiple hazard classes, e.g. a chemical can be a flammable liquid and pose an acute toxic hazard.</p>
Category	<p>The category can indicate the severity of the hazard within a hazard class. For example, with a flammable liquid, the lower the number the more severe the hazard.</p>
Pictogram	<p>There are eight hazard pictograms in the GHS that are used to represent all physicochemical and health hazards. A single pictogram can be used to represent multiple hazard classes.</p> <p>The primary hazard is not always obvious at a glance, so don't rely only on the pictograms alone. You MUST also read the hazard statements.</p> <div data-bbox="783 987 1278 1312" data-label="Diagram"> </div>
Signal word	<p>There are two signal words used on GHS labels. DANGER indicates a higher level of severity to WARNING</p> <p>The signal word on a label provides an indication of the overall severity of the chemical hazards.</p> <div data-bbox="874 1442 1321 1783" data-label="Image"> </div>
Hazard Statement	<p>Hazard statements communicate the nature of the hazard in everyday language. There is a specific hazard statement for each category within each hazard class.</p>

Term	Definition
Precautionary statement	Precautionary statements recommend measures to avoid or minimise the risk of incident or injury. Precautionary statements relate to prevention, response, storage and disposal.

Table 2: GHS terminology

Further information on the GHS is provided in the [Introduction to GHS](#) guideline and the [SafeWork NSW GHS poster](#).

3.3 What information do I get from a Safety Data Sheet (SDS)?

Suppliers are required to provide a SDS for every chemical they supply.

SDS must be:

- Written in English
- Presented in a standard format
- Reviewed at least every 5 years

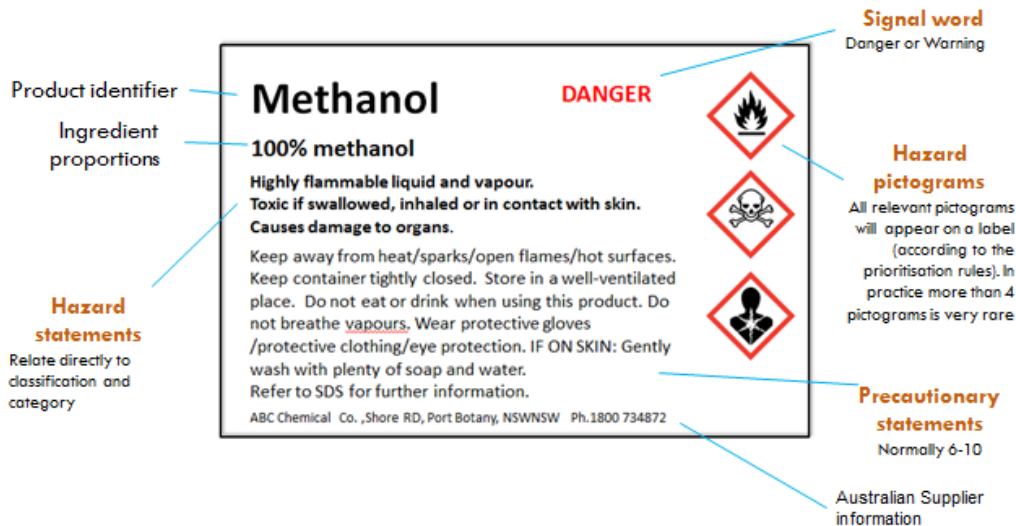
In the workplace, everyone who works with chemicals must have access to the relevant SDS. Many suppliers provide access to current SDS via their web sites. SDS can also be accessed from [ChemAlert](#). Always check that you are use the current SDS for the correct chemical.

Standard information in a Safety Data Sheet

Identification: Product identifier and chemical identity
 Hazards identification
 Composition / information on ingredients
 First aid measures
 Fire-fighting measures
 Accidental release measures
 Handling and storage
 Exposure controls and Personal protection
 Physical and chemical properties
 Stability and reactivity
 Toxicological information
 Ecological information
 Disposal considerations
 Transport information
 Regulatory information
 Any other relevant information

3.4 What information can I get from a chemical label?

Hazard information is available on the label. Always read the label in conjunction with the SDS to ensure all chemical hazards are identified.



Product identifier
Methanol

Ingredient proportions
100% methanol

Hazard statements
Relate directly to classification and category
Highly flammable liquid and vapour.
Toxic if swallowed, inhaled or in contact with skin.
Causes damage to organs.

Signal word
Danger or Warning
DANGER

Hazard pictograms
All relevant pictograms will appear on a label (according to the prioritisation rules). In practice more than 4 pictograms is very rare

Precautionary statements
Normally 6-10
Keep away from heat/sparks/open flames/hot surfaces. Keep container tightly closed. Store in a well-ventilated place. Do not eat or drink when using this product. Do not breathe vapours. Wear protective gloves /protective clothing/eye protection. IF ON SKIN: Gently wash with plenty of soap and water. Refer to SDS for further information.

Australian Supplier information
ABC Chemical Co., Shore RD, Port Botany, NSWNSW Ph.1800 734872

3.5 About physicochemical hazards

Some chemicals have physicochemical or chemical properties that pose a risk to workers other than an adverse health effect.

Chemicals with physicochemical hazards can be:

- Explosive,
- Flammable,
- Corrosive,
- Oxidising,
- Stored under pressure
- Highly reactive.



Inappropriate handling or use of chemical with physicochemical hazards can result in **immediate** and severe **consequences**.


The table below shows the categories and hazard statements for **flammable liquids**. These are determined by **flashpoint** and **boiling point limits**. Chemicals with a very low flashpoint and boiling point are classified as flammable.

Flammable liquids		
Category	Hazard statement	Intrinsic property
1	Extremely flammable liquid and vapour	Flash Point < 23 C, Boiling Point ≤ 35 C e.g. <i>Ether</i>
2	Highly flammable liquid and vapour	Flash Point < 23 C, Boiling Point > 35 C e.g. <i>Acetone</i>
3	Flammable liquid and vapour	Flash Point ≥ 23 C, Boiling Point ≤ 60 C e.g. <i>Xylene.</i>
4	Combustible liquid	Flash Point > 60 C, Boiling Point ≤ 93 C e.g. <i>Diesel</i>

Table 3: GHS hazard statements and physical properties of flammable liquids

The GHS pictogram and hazard classes for physicochemical hazards are listed in Table 4.

Pictogram	Hazard Class	Explanation
	Explosives	Explosives are chemicals or manufactured articles that pose a mass explosion, blast or projection hazard. You need to be licensed to work with explosives. Contact Safety Health and Wellbeing for more information.
	Self-reactive substances and mixtures	The explosive pictogram is also used for some self-reactive substances and organic peroxides that may explode or catch fire if heated.
	Organic peroxides	
	Flammable Gases	Flammable gases will sustain fire in air (at standard temperature and pressure) if an ignition source is applied and the gas is present in the correct concentration. Examples of flammable gases used at the university include hydrogen, acetylene, carbon monoxide, liquefied petroleum gas (LPG) and natural gas.

Pictogram	Hazard Class	Explanation
	Flammable Liquids	<p>The flammability of a liquid is defined by flash point and boiling point. A liquid is considered to be flammable if its flash point is less than or equal to 93°C.</p> <p>Common examples of flammable liquids include diethyl ether, ethanol, acetone, methanol and xylene.</p>
	Flammable Solids	<p>Flammable solids are readily combustible and may cause or contribute to fire.</p> <p>Examples of common flammable solids include paraformaldehyde, magnesium and sulphur.</p>
	Flammable Aerosols	<p>Flammable aerosols are materials that are held in dispensers where they can be ejected in a propellant. If the aerosol contains a flammable gas, liquid or solid it is considered a flammable aerosol.</p>
	Pyrophoric solids	<p>Pyrophoric materials can catch fire spontaneously when they come in contact with air. This can happen when only small amounts are used, with no external ignition source. Ignition may be delayed by up to five minutes.</p> <p>Common pyrophoric solids include alkali metals (e.g. lithium, sodium, and potassium), finely divided metals (e.g. aluminium, magnesium) and metal hydrides (sodium hydride, lithium aluminium hydride).</p>
	Pyrophoric liquids	<p>Examples of pyrophoric liquids include alkyl lithium reagents (e.g. tert-butyl lithium), boranes, grignard reagents, alkylated metals (e.g. trimethylaluminium) or non-metal alkyls (e.g. tetramethylsilane, tributylphosphine).</p>
	Self-heating substances and mixtures	<p>Self-heating substances can also catch fire if exposed to air or stored in large volumes, but these take much longer to heat up and ignite (e.g. hours or days).</p>
	Substances and mixtures which in contact with water emit flammable gases	<p>Substances which emit flammable gases after contact with water include alkali metals (e.g. sodium, potassium), metal hydrides (e.g. sodium hydride, lithium hydride), complex metal hydrides (e.g. sodium aluminium hydride) and calcium carbide. In many cases, extremely flammable hydrogen gas is generated by the reaction.</p>



Pictogram	Hazard Class	Explanation
	Oxidising gases	<p>Oxidising gases contribute oxygen to a reaction, which can cause or intensify the combustion of other material.</p> <p>Oxygen is an oxidising gas. It is not itself flammable, but it is a fire hazard.</p>
	Oxidising liquids and solids	<p>Oxidising liquids and solids are often highly reactive. They are not themselves combustible or flammable, but can contribute oxygen to a reaction, which can cause or contribute to the combustion of other materials.</p> <p>Examples include bromine, bromates, chlorates, chromates, dichromates, hypochlorites, nitrates, nitric acid, nitrites, perchlorates, perchloric acid, periodates, permanganates, peroxides and persulphates.</p>
	Gases under pressure	<p>Many gases are stored under pressure. This hazard class applies to gases stored at pressures greater than 200 KPa at 20°C, and gases that are liquefied or liquefied and refrigerated.</p> <p>Common hazards include:</p> <ul style="list-style-type: none"> • The potential for the uncontrolled release of gas at high pressures • The release of a large volume of gas resulting in the displacement of air creating a potentially low oxygen or toxic environment • Cryogenic burns.




Table 4: GHS pictograms and hazard classes for chemicals with physicochemical hazards




3.6 Health hazards explained




Some chemicals have the potential to cause adverse health effects as a result of direct contact or exposure. Exposure is most commonly through inhalation, skin contact or ingestion.

Health effects can be:

- **Acute** (short term) - e.g. headaches, nausea and vomiting or skin irritation
- **Chronic** (long term) - e.g. sensitisation, asthma, dermatitis, infertility or cancer.

Pictogram	Hazard Class	Explanation
	Acute toxicity (oral, dermal or inhalation)	<p>Acute toxicity refers to the health effects that occur within minutes or hours of a single exposure.</p> <p>The toxicity of a chemical is often determined by animal testing and expressed as a LD₅₀ (oral, dermal) or LC₅₀ (inhalation) value. You will notice these values SDSs.</p> <p>LD₅₀ means, Lethal Dose 50%, i.e. the minimum amount of the chemical required to cause death in 50% of a population of test animals.</p> <p>Many chemicals have acute toxic effect. Some examples of chemicals with severe acute toxicity hazards include:</p> <ul style="list-style-type: none"> • Osmium tetroxide • Sodium azide • Arsenic • Potassium cyanide • Carbon monoxide
	Carcinogenicity	<p>Chemicals that may cause or are suspected of causing cancer are called carcinogens. The appearance of cancer may be delayed or appear after long term exposure.</p> <p>In addition to the GHS categories, valuable information is provided by the International Agency for Research on Cancer (IARC). The IARC classify carcinogens as definitely, probably, possibly carcinogenic to humans and also not classifiable or probably not carcinogenic.</p> <p>Examples of carcinogens used in the University include:</p> <ul style="list-style-type: none"> • Benzene • 1,4-cyclohexadiene • Cadmium and nickel salts • Formaldehyde • Dichloromethane
	Germ cell mutagenicity	<p>A germ cell mutation acts to cause a permanent change in the amount or structure of the genetic material in a cell. Offspring produced by the altered code will carry this mutation and pass it along to their offspring. In other words, the mutation is inheritable.</p> <p>Examples of germ cell mutagens include:</p> <ul style="list-style-type: none"> • Potassium dichromate • Ethidium bromide • Mercuric chloride • Phenol • Phenolphthalein

Pictogram	Hazard Class	Explanation
	Reproductive toxicity	<p>Chemicals that have reproductive hazards can affect sexual function, fertility of the development of the unborn child.</p> <p>Teratogens specifically affect the growth and development of the foetus, and are of particular concern to women who may be in the early stages of a pregnancy.</p> <p>Chemicals which might be passed from mother to child during breastfeeding are also identified.</p> <p>Examples of reproductive toxins include:</p> <ul style="list-style-type: none"> • Carbon monoxide • Mercury • Chloroform • Thalidomide
	<p>Specific target organ toxicity (STOT)</p> <p>Single exposure</p> <p>Repeated exposure</p>	<p>Chemicals with Specific Target Organ Toxicity (STOT) hazards may target, accumulate or impair specific organs, even at low doses. Generally, the main organs susceptible are:</p> <ul style="list-style-type: none"> • Liver • Kidneys • Brain • Bone and bone marrow • Thyroid • Fatty tissues • Nerve cells <p>Like acutely toxic chemicals, STOT chemicals can have adverse effects on the body at relatively low doses.</p> <p>Examples of STOT chemicals include:</p> <ul style="list-style-type: none"> • Mercury • Xylene • Methyl ethyl ketone
	Aspiration toxicity	<p>Aspiration hazards can enter the trachea and lower respiratory system as either a liquid or solid, either directly from the mouth or nose, or indirectly from vomiting.</p> <p>Aspiration toxicity can result in chemical pneumonia, varying degrees of pulmonary injury, or even death.</p> <p>Examples of chemicals with aspiration toxicity include</p> <ul style="list-style-type: none"> • Petroleum ether • Xylene • Some chlorinated hydrocarbons

Pictogram	Hazard Class	Explanation
	Respiratory and skin sensitisers	<p>Respiratory sensitisers are chemicals that may cause allergies, asthma symptoms or breathing difficulties if inhaled or allergic skin reactions if exposed by skin absorption.</p> <p>Symptoms can occur on first exposure to the substance or after a long period of regular exposure. Not all people will react to a sensitiser in the same way.</p> <p>Once sensitised, debilitating respiratory attacks or extreme skin reaction can be triggered by very small exposures.</p> <p>Common respiratory sensitisers which may be encountered in the laboratory include:</p> <ul style="list-style-type: none"> • Trypsin • Isocyanates • Chromium (VI) compounds • Cobalt and nickel compounds <p>Common skin sensitisers include:</p> <ul style="list-style-type: none"> • Formaldehyde • Potassium dichromate • Trypsin • Latex in disposable gloves
	Serious eye damage	<p>Some chemicals can permanently damage or destroy living tissue in the eye and severely impair vision.</p> <p>Examples of chemicals that can cause serious eye damage include:</p> <ul style="list-style-type: none"> • Alkalis - sodium hydroxide, potassium hydroxide, ammonium hydroxide. • Inorganic acids – hydrochloric acid, sulphuric acid, phosphoric acid • Organic acids - acetic acid and formic acid • Oxidising acids – nitric acid, perchloric and chromic acid.
	Skin corrosion	<p>Skin corrosion is irreversible damage to the skin through the epidermis and into the dermis. Symptoms such as ulcers, bleeding and blistering are obvious within 4 hrs. After 14 days there may be skin scarring, discolouration and lesions.</p> <p>An example of a common chemical that poses a significant risk of skin corrosion is nitric acid.</p>










Pictogram	Hazard Class	Explanation
	Irritant	<p>The exclamation mark is used to represent lower severity health hazards.</p> <p>The table below shows how the exclamation mark is used for some of the hazard classes.</p>
		<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Acute toxicity</p> <p>Fatal or toxic if swallowed, in contact with skin or inhaled.</p> </div> <div style="text-align: center;">  <p>Acute toxicity</p> <p>Harmful if swallowed, in contact with skin or inhaled.</p> </div> </div>
		<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Causes severe skin burns and eye damage</p> </div> <div style="text-align: center;">  <p>Causes skin irritation</p> <p>Causes eye irritation</p> </div> </div>
		<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Specific target organ toxicity</p> <p>Causes or may cause damage to organs</p> </div> <div style="text-align: center;">  <p>May cause respiratory irritation</p> <p>May cause drowsiness or dizziness</p> </div> </div>
		<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Respiratory sensitizer</p> </div> <div style="text-align: center;">  <p>Skin sensitizer</p> </div> </div>

Table 5: GHS pictograms and hazard classes for chemicals with physicochemical hazards

Part B Identifying task related hazards

The University's risk management procedures require that five key risk factors be considered whenever assessing the risk associated with a specific activity. These include the:

1. **Nature of the hazard/s** (in this case the chemicals);
2. **Work environment** where the activity will be carried out;
3. **Physical activities** required to complete the task;
4. Psychological demands of the task; and
5. The characteristics of the **individual workers** involved.

It is important to think about the process from start to finish. Use the questions on the next page to help you identify hazards.

3.7 Assessing task related hazards

Nature of the hazard



- What chemicals are being used and how are they classified?
- What quantities and concentrations will be used?
- What techniques and equipment are involved?
- Is there the risk of a dangerous reaction, high temperature or high pressure?
- Will new chemicals be synthesized or hazardous waste generated?

Work environment



- Is the work area clean and organised?
- Is there a fume cupboard available for the work? If so, is working correctly?
- Is it likely that the workers will be distracted or bumped into while doing high risk work?
- Is there someone around to help if something goes wrong



Physical activities

- Is the task or activity physically demanding?
- Are any of the tasks repetitive?
- Are you required to work in an awkward posture?



Psychological demands

- Does the task require extended periods of concentration?
- Are their demanding timeframes?
- Are the workers supported?



Individual workers involved

- Who will undertake the activity?
- Have the workers been trained in the planned activity?
- Will other people be affected by this activity? If so, who and how?

3.8 Examples of task related hazards

Activity	What could go wrong?
Transporting and handling 2.5 L glass bottles of solvent and acid (Winchesters) 	<ul style="list-style-type: none"> • Drop or knock over the bottle • Glass bottle cold break resulting in a reasonably large chemical spill on the bench or floor • Spill could result in a chemical exposure or release of flammable vapour
Pouring and measuring concentrated solutions/chemicals 	<ul style="list-style-type: none"> • Release of vapour • Inhalation of vapour • Minor hazardous chemical spills • Splash on skin or in eyes
Using laboratory glassware 	<ul style="list-style-type: none"> • Cuts broken glassware • Cracked glassware could break resulting in a spill • Dirty glassware could be contaminated with other chemicals affecting the purity of the solution being prepared or in extreme cases resulting in an unexpected chemical reaction.
Working in a busy laboratory with other workers 	<ul style="list-style-type: none"> • Other workers can be exposed to the hazards associated with your tasks (and vice versa) • Being interrupted and unable to focus on important tasks • Being bumped when carryout important or hazardous steps
Working in a fume cupboard 	<ul style="list-style-type: none"> • Fume cupboard not working properly • Too much equipment in the cupboard affecting the air flow • Insufficient room to setup properly
Handling flammable liquids 	<ul style="list-style-type: none"> • Release of flammable vapour • Possible ignition of flammable vapour from ignition sources within the laboratory, e.g. heating mantles, hot plate/stirrers, vacuum pumps, fridges etc.

Handling concentrated acids



- Splash on skin resulting in burns
- Splash in eyes resulting in serious eye damage
- Reaction with other chemicals

4. ASSESS THE RISK

4.1 About risk assessment

The terms 'hazard' and 'risk' are often used in ways that can be confusing, so what exactly do we mean when we use these terms?

- A **hazard** is anything that has the *potential* to cause harm (or other adverse effects).
- **Risk** is a qualitative measure of the *likelihood* and *potential consequences* of injury or harm occurring when exposed to a hazard.

The assessment of risk associated with physicochemical hazards is quite different to the assessment of the risks associated with health hazards.

When assessing risk associated with **physicochemical hazards** we are essentially looking at the interaction between the chemical and the conditions that might result in a dangerous incident. For example, the interaction between flammable vapour and an ignition source, the reaction of one chemical with another, or the sudden release of gas in a confined space.

When assessing the risk associated with **health hazards** we are looking at the interaction between the chemical and the people using the chemical. How they might be exposed to the chemical while carrying out a specific task or activity, and if exposed what the impact of that exposure might be.

4.2 Assessing physicochemical hazards

When assessing the risks associated with a task or activity involving chemicals it is important to always consider the possibility of:

- Fire and explosion
- Dangerous chemical reactions
- Build up and/or sudden release of pressure
- Asphyxiation

4.2.1 Fire and explosion

Fire and explosion can result in catastrophic consequences. The three primary elements required for a fire are:

- Fuel - a flammable liquid or gas, or other combustible material
- Oxygen – usually just the oxygen in the air
- Ignition – a source of energy sufficient to cause ignition.



At the most basic level we need to know which chemicals have fire hazards and what types of ignition sources are present in the work area. Managing the risk of fire and explosion is essentially about separating flammable material from potential ignition sources. But like all things, unfortunately it is not that simple. To really assess the risk we need to understand the physical and chemical properties of the chemicals involved, the activities being carried out and the conditions that increase the likelihood of ignition.

As an example, heating a flammable liquid will generate an increased volume of flammable vapour. The vapour from most flammable liquids is denser than air, so when released will often settle at low level. If that vapour is present in the air in a concentration above the lower explosive limit (LEL) and below the upper explosive limit (UEL), and the vapour/air mixture comes in contact with a hot surface with a temperature above the auto ignition temperature of the chemical, the vapour will be ignited.

While the vapour from most flammable liquids is heavier than air and will accumulate at low level, the density of flammable gases varies greatly. For example, hydrogen gas is very light and is most likely to be ignited by an ignition sources located above the source of release.

Ignition sources can include anything with an open flame or anything that produces sparks or heat. This includes all sorts of electrical equipment commonly used at the University.

4.2.2 Dangerous chemical reactions

Some chemicals are unstable under specific conditions, e.g. at particular temperatures. Other chemicals are incompatible with other chemicals and can cause dangerous reactions including fire, explosion, and the generation of excess heat or gas, a build-up of pressure or the release of toxic or flammable by products. In order to assess the risk you need to understand the conditions that will be present during the specific task or activity.

4.2.3 Build-up and/or sudden release of pressure

We have just learnt that some chemical reactions can result in a build-up of pressure. This could result in a closed vessel pressurising and in some cases exploding causing projectiles.

In other situations, processes may be intentionally carried out under pressure or vacuum, e.g. to force a liquid through a filter. In these situations it is important to understand the pressure limits of the equipment you are using and where possible use pressure relief devices to prevent a dangerous build-up of pressure that may cause explosion or implosion.

Gas cylinders often store gases at high pressures which pose significant risks if there is a sudden release of gas. If exposed to elevated temperatures, cylinders can potentially over pressurise.

4.2.4 Asphyxiation

Asphyxia is a condition that occurs where there is a lack of oxygen. Cryogenic liquids and compressed gasses expand significantly when released. This process can push the air out of a room and lower the overall concentration of oxygen in the air. Too little oxygen in the air we breathe can cause fatigue and death.

4.3 Assessing health hazards

Chemicals with health hazards are only a risk to our health if we are exposed. To assess the risk associated with a specific task or activity we must understand the:

- Possibly routes of exposure
- Potential dose
- Exposure standards (where they exist)

4.3.1 Routes of exposure

Chemicals can enter our body via a number of mechanisms, usually referred to as the routes of exposure. These include:

Inhalation

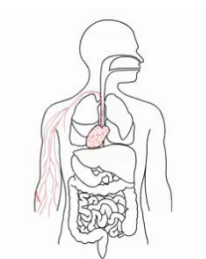


This is the most common and direct way for a chemical to enter your body. Vapours, mists and fumes from chemicals, as well as dusts and gases, can be inhaled.

Chemicals can directly enter the bloodstream via the lungs. In some cases they can deposit toxins in organs and fat tissue.

- **Vapours** can be released from organic solvents such as chloroform or toluene.
- **Fumes** are released from concentrated acids or heated metals.
- **Mists** are formed by gases that condense into small liquid droplets in the air or alternatively from the splashing or atomizing of a liquid.
- **Gases** if released from a compressed gas cylinder will be readily inhaled.
- **Fibres** such as asbestos are able to be inhaled deep into the lungs.
- **Dusts** generated by some mechanical or abrasive activity or fine particles, such as silica.

Absorption

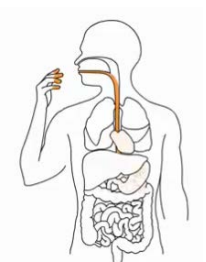


Some chemicals can be absorbed through the skin or through the mucus membranes of your eyes, nose or mouth.

The skin generally provides a good barrier, but some chemicals can readily pass through the skin. Direct contact of a chemical with the skin is the second most common way a chemical can enter the body.

Acids and alkalis can destroy the protective barrier in your skin. Exposure to some solvents and other chemicals can cause dermatitis type conditions that damage skin that allow other hazardous substances to enter your body.

Ingestion



Poor laboratory hygiene and housekeeping practices are the primary cause of the accidental ingestion of chemicals. Examples of poor practice include:

- Not regularly cleaning up or decontaminating the work area
- Touching nose or mouth during work
- Not removing and disposing of gloves immediately after use
- Not washing hands prior to leaving the laboratory.

While uncommon, accidental injection can occur.

Injection



Cut and puncture injuries with contaminated sharps (e.g. scalpel blades, pasture pipettes and other glassware) also fit into this category.

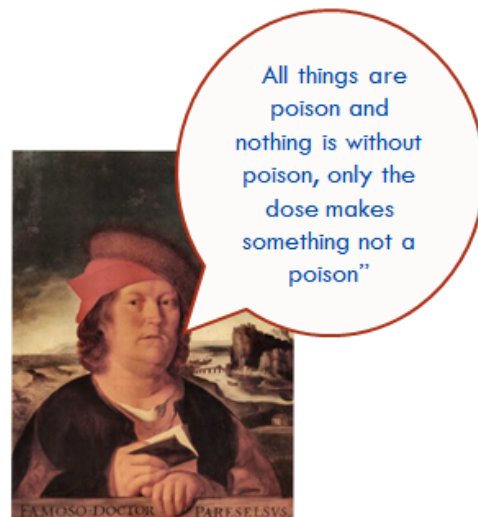
Injection can also occur if pressurised fluids and other materials penetrate the skin. This is also not common, but the consequences can be very serious.

4.3.2 Factors influencing health effects

a) Potential Dose

The chemical dose received is a function of many factors including:

- **concentration** of the chemical
- **frequency** of exposure (how often)
- **duration** of the exposure (for how long)
- **routes of exposure**, e.g. inhalation of a vapour as opposed to absorption of a liquid through the skin.



Paracelsus (1493-1541)
Swiss physician and alchemist

b) Exposure standards

Exposure standards have been established for some chemicals. An exposure standard is defined as:

*An **airborne** concentration of a particular substance in the workers breathing zone, exposure to which, according to current knowledge, should not cause adverse health effects or discomfort to nearly all workers.*

Exposure standards are usually expressed as a Time Weighted Average (TWA). This is the concentration of the chemical that most people can be exposed to for 8 hours per day, 5 days per week without experiencing any negative health effects (refer Table 6).

Chemical	TWA (ppm)
ethanol	1000
acetone	500
methanol	200
dichloromethane	50
chloroform	2
formaldehyde	1
carbon dioxide	5000
ammonia	25

Table 6: TWA exposure standard for several common chemicals

c) Other factors that influence the potential health effects

Other factors that influence the potential health effects include the target organs affected and the rate of biological metabolism and the elimination pathways for a chemical, e.g. some will be metabolised and eliminated, while others will accumulate in the body.

It is also important to note that we are all different and will respond differently to chemical exposures. Some people are more susceptible to negative health effects than others.

4.4 Conditions that may increase risk of injury or illness

Common conditions that influence the risk of a dangerous incident or negative health effect occurring when working with chemicals include:

- Concentration** Pure chemicals and high concentration solutions and mixture may be extremely hazardous, while dilute solutions and mixtures of the same chemical may be non-hazardous.
- Volume** Working with larger volumes has the potential to more significant dangerous incidents and/or increased exposure to health hazards.
- Temperature** High temperatures can affect the volatility and stability of a chemical. Chemicals can release high volumes of vapour or react quicker at higher temperatures.
- Pressure** High and low pressure can affect both chemicals and equipment. Glass vessels placed under low pressure can implode and high pressure can explode. The uncontrolled release of gases stored under pressure can result in dangerous incidents, and toxic or low oxygen environments.
- Physical form** Gases and vapour are difficult to control. Liquids are more difficult to clean up than solids. Working with powders is more likely to result in exposure via inhalation than dealing with tablets or pellets.

5. ELIMINATE OR CONTROL THE RISK

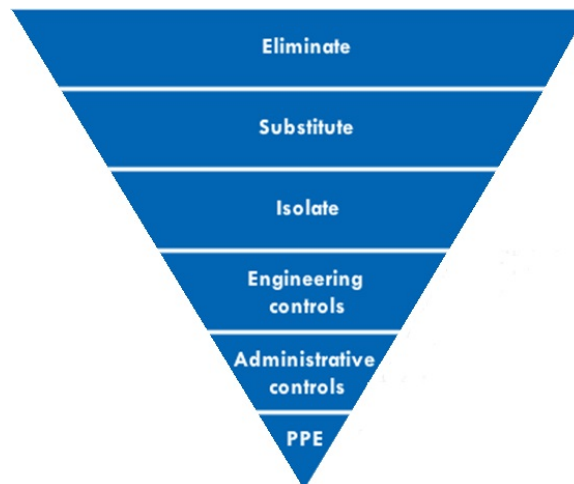
5.1 Eliminate the risk

Risks to health and safety must be eliminated whenever reasonably practicable.

Where it is not possible to eliminate the risk, suitable risk controls must be chosen with reference to the hierarchy of risk controls.

5.2 Hierarchy of risk controls

Essentially, some risk controls are more effective than others. The hierarchy of risk controls identifies a number of categories of risk controls. Those at the top of the hierarchy are considered to be the most effective.



Eliminate the task or hazard

This is the ultimate risk control and must always be considered. Ask yourself if you really need to carry out the activity? If so. Why?
Example: Consider outsourcing hazardous tasks and activities to external specialists.

Substitute- use a safe alternative

This is particularly relevant when working with chemicals. Ask yourself if a less hazardous chemical can be used, or if a safer method is possible?

Isolate the hazard from the people

Isolation involves separating people from the chemicals or hazards by distance or barriers to prevent exposure.

Examples: Restrict high risk work to a specific area and prevent unauthorised access. Use physical barriers to separate incompatible chemicals.

Engineering controls

Using a fume cupboard is a good example of an engineering control.

Another example is a solenoid valve that turns off the gas supply when a gas leak is detected.

Scientific equipment is often designed with specific engineering controls, e.g. pressure relief valves.

Administrative controls

These controls are dependent on people behaving in a specific way to minimise the risk of incident, injury or illness, e.g. to read a sign or follow a procedure.

Examples: Establishment of safe work procedures, provision of information, training and supervision, and signage.

PPE - personal protective equipment

This is the lowest level of risk control, but is often used in combination with other higher level risk controls.

5.4 Risk controls and the SDS

Remember - there is information about recommended risk controls on chemical labels and in the SDS.

Precautionary statements for a flammable liquid	
Prevention	Keep away from sparks and open flames. No smoking
Response	In case of fire: Use powder for extinction
Storage	Store in a well-ventilated placed
Disposal	Dispose of contents/container in accordance with local regulations

Table 7: GHS precautionary labels

6. REVIEWING THE RISK

6.1 Using the risk matrix

It is important to apply a risk based approach to our work. Risk is a qualitative measure of the **likelihood** and potential **consequence** of a dangerous incident, injury or illness occurring. We use the risk matrix to ensure a consistent approach to the allocation of risk levels associated with University work. To use the risk matrix you need to:

1. Think about what could go wrong and determine where those potential consequences sit on the scale from **not significant** (e.g. minor injuries not requiring medical treatment) right through to **severe** (e.g. a potential fatality)

 **MODERATE**

2. Next you need to make a subjective judgement about how likely that particular dangerous incident, injury or illness is to occur on the likelihood scale from **rare** (e.g. could happen, but probably never will) right through to **almost certain**

UNLIKELY

		Potential Consequences					
		L6	L5	L4	L3	L2	
		Minor injuries or discomfort. No medical treatment or measureable physical effects.	Injuries or illness requiring medical treatment. Temporary impairment.	Injuries or illness requiring hospital admission.	Injury or illness resulting in permanent impairment.	Fatality	
		Not Significant	Minor	Moderate	Major	Severe	
Likelihood	Expected to occur regularly under normal circumstances	Almost Certain	Medium	High	Very High	Very High	Very High
	Expected to occur at some time	Likely	Medium	High	High	Very High	Very High
	May occur at some time	Possible	Low	Medium	High	High	Very High
	Not likely to occur in normal circumstances	Unlikely	Low	Low	Medium	Medium	High
	Could happen, but probably never will	Rare	Low	Low	Low	Low	Medium

3. The combination of potential consequences and likelihood determines the risk rating. **MEDIUM RISK**

6.2 Inherent, current & residual risk

In most cases the application of risk controls will reduce the level of risk by reducing the likelihood of a particular consequence occurring. In some cases, additional risk controls can also reduce the severity of the potential consequences.

- **Inherent risk** refers to the level of risk associated with an activity or situation without any risk controls.
- **Current risk** is the risk associated with the activity or situation taking into account the existing risk controls.
- **Residual risk** is the level of risk associated with the activity after additional risk controls have been applied.

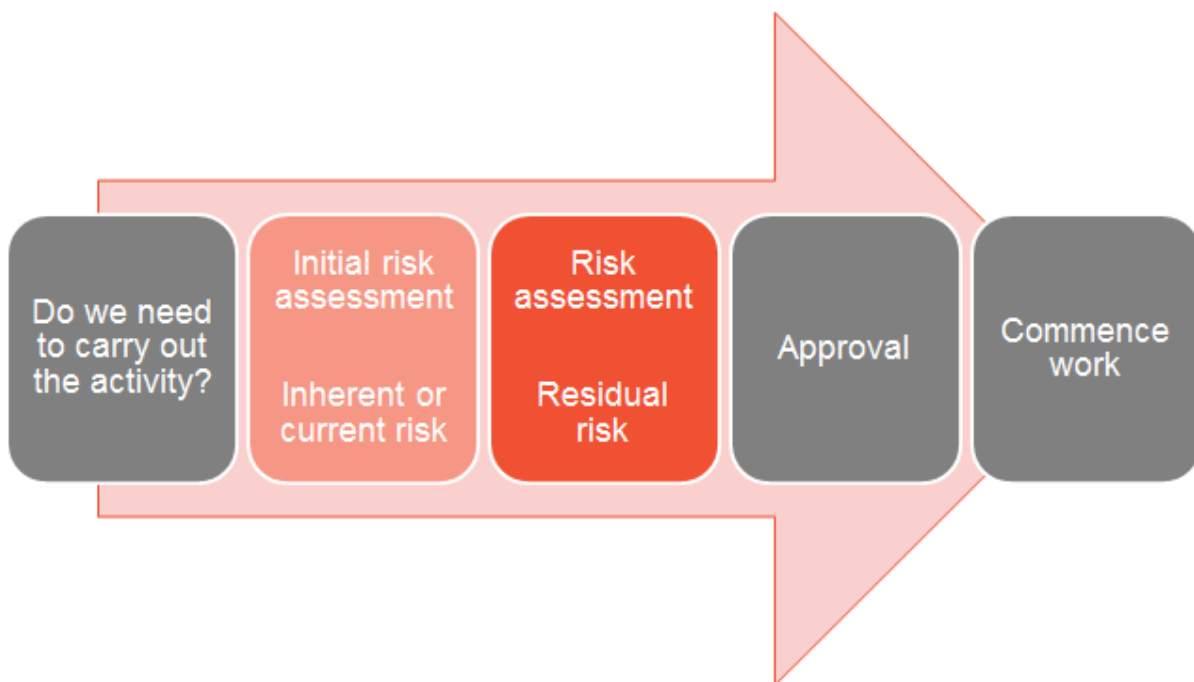
It is important to note that the current risk rating applies until the planned additional risk controls have been fully implemented. Refer Table 8 for an example risk assessment.

Task/activity	Hazards	What could go wrong?	Existing risk controls	Inherent risk rating	Risk controls	Residual risk rating
Flash column chromatography with 70% petroleum ether and 30% acetone	<p>Petroleum ether (Cat. 1) and acetone (Cat. 2) flammable liquids</p> <p>Dry silica has fine particles that can be easily inhaled</p> <p>Using glassware under pressure (nitrogen)</p> <p>Using compressed nitrogen gas (under high pressure)</p> <p>Samples and solvents may be toxic or irritant</p>	<p>Ignition of flammable vapours resulting in fire</p> <p>Solvent spillage when loading column or if column fails</p> <p>Inhalation of silica dust causing damage to lungs</p> <p>Glassware could crack or explode under pressure resulting in projectile glass</p> <p>Uncontrolled nitrogen leak resulting in a low risk environment</p> <p>Exposure to toxic material</p>	PPE including laboratory coat, safety glasses and disposable nitrile gloves	HIGH	<p>Separate work from ignition sources.</p> <p>Carry out work in a fume cupboard - pull fume cupboard sash down to lowest practical working position while the column is under pressure.</p> <p>Gradually apply nitrogen pressure and do not over-pressurise column.</p> <p>Turn off nitrogen supply when finished.</p> <p>Check glassware (columns, sample and collection vials, adapters) for integrity, cracks, chips prior to use. Replace if faulty.</p> <p>Use disposable P2 respirator when handling silica powder</p>	MEDIUM

Table 7: GHS precautionary labels

6.3 Risk based workflow

The risk associated with an activity should influence the actions we take. We refer to this as a risk based workflow.



<p>Hazardous tasks and activities must be avoided or eliminated whenever possible.</p>	<p>If it is necessary to carry out the task or activity, a simple initial risk assessment must be carried out to determine the inherent or current risk.</p>	<p>If the initial risk assessment indicated that the current risk level is 'high' or 'very high' a more detailed risk assessment is required.</p> <p>The detailed risk assessment must be documented and include the specific hazards, potential harm, the existing and proposed risk controls and an assessment of residual risk.</p>	<p>The residual risk rating of a particular task or activity drives the approval process.</p> <p>University supervisors can approve work with a 'low' or 'medium' residual risk rating, but must seek the approval of senior managers prior to commencement any work with a 'high' or 'very high' residual risk rating.</p>
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6.4 Reviewing risk assessments

The risk controls adopted for any task or activity should be monitored regularly to validate their effectiveness, but as a minimum risk assessments must be reviewed annually or whenever there is an incident, a significant change to the work process or new information about a specific hazard or activity.

Initial risk assessment	Action	Documented risk assessment	Action	Timeframe	Approval
Inherent risk rating		Residual risk rating			
LOW	Local requirements	LOW	Validate risk controls	Annually	Supervisor
MEDIUM	Local requirements	MEDIUM	Validate risk controls	Annually	Supervisor
HIGH	Prepare documented risk assessment	HIGH	Review available risk controls Review risk/benefit	Act immediately	HOS/HOA
VERY HIGH	Prepare documented risk assessment	VERY HIGH	Stop work Review available risk controls Review risk/benefit	Act immediately	Dean/Director

Table 8: Risk assessment review

7. REVIEW AND EVALUATION

Performance standards and the associated procedures and guidelines will be reviewed by Safety Health & Wellbeing at least once every two years to identify and implement opportunities for improvement.

8. REFERENCES

1. NSW Work Health and Safety Regulation, 2017.
2. Code of Practice, Managing risk of hazardous chemicals in the workplace, July 2014, SafeWork NSW.
3. Code of Practice, Labelling of workplace hazardous chemicals, April 2016, SafeWork NSW

Acknowledgements					
Related Documents		WHS_CHE_STD_1_Chemical_Safety_Standard			
Version Control	Date released	Author/s	Custodian	Approved by	Amendment
1.0	20/5/2017	WHS Specialist (Chemical), Manager, WHS Services	Manager, Work Health & Safety Services	Director, Safety Health & Wellbeing	Original

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