

University College Dublin



Chemical Safety Manual

Rev 1. Issued February 2016

UCD Safety, Insurance, Operational Risk and Compliance

(SIRC) Office

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Revision History

- Revision 0: Dec 2006. Is an original document
- Revision 1: Feb 20163.
 - Major overall rewrite
 - Updates to classification and labelling requirements under GHS
 - Relevant legislation updates included
 - Risk assessment template updated
 - Chemical Spill Emergency Response Poster included
 - Nanoparticle safety included

1.0 Introduction

This document is intended to serve as a source of information and as a guide to those persons who work with hazardous chemical agents within University College Dublin. For the purposes of this document a hazardous chemical agent is defined as one which comes under the remit of the European Union's Regulations on the *Classification, Labelling and Packaging of Substances and Mixtures*. In simple terms what this means is that the contents of this document apply to the use of any chemical agent for which a *Safety Data Sheet* (SDS) has been produced by the manufacturer / supplier.

This document also makes reference to the requirements of Irish Chemical Safety Regulations, in particular the importance of the completion of adequate and appropriate risk assessment by persons working with chemical agents.

Further information and training for all University staff and students in chemical and laboratory safety is available from the University SIRC Office. Contact ext. 8768/8771 or email sirc@ucd.ie or refer to www.ucd.ie/sirc

2.0 Classification and Labelling of Chemical Agents

2.1 Overview

The United Nations' Globally Harmonised System on the classification and labelling of chemicals (GHS) is used across all European Union countries, including Ireland. GHS provides a basis for communicating information on chemical hazards in a uniform way, utilising a common system of chemical labelling, classifications and terminology.





The main differences between the older classification and labelling systems and the GHS system are the use of different pictorial symbols and the replacement of the older Risk and Safety Phrases with updated Hazard Phrases and Precautionary Statements.

2.2 Hazard Classification


Chemical agents are classified into various hazard classifications in accordance with their physiochemical properties, their health hazards and environment effects. Identifying and addressing the risks posed by a chemical as indicated by its classification is key to its safe use. This information is communicated on the chemicals label and within the SDS.

See Figure 1 below for details of the classification system.

Fig.1 Classification and Labelling of Chemical Agents

Hazard Symbol	Hazard Class	
 GHS01	<ul style="list-style-type: none"> Explosive Self-reactives Organic peroxides 	
 GHS02	<ul style="list-style-type: none"> Flammables Gases Flammable Aerosols Flammable Liquids Flammable Solids Pyrophorics 	<ul style="list-style-type: none"> Self- reactives Self-heating Emits Flammable gas in contact with water Organic Peroxides
 GHS03	<ul style="list-style-type: none"> Oxidising Gases Oxidising Liquids Oxidising Solids 	
 GHS04	<ul style="list-style-type: none"> Gases Under Pressure 	
 GHS05	<ul style="list-style-type: none"> Corrosive to metals Corrosive (causes severe skin burns and eye damage) Serious eye damage 	
 GHS06	<ul style="list-style-type: none"> Acute toxicity Very toxic (Fatal) Toxic 	
 GHS07	<ul style="list-style-type: none"> Acute toxicity (harmful) Skin and eye irritation Respiratory irritant 	<ul style="list-style-type: none"> Skin sensitiser Narcotic Hazardous to the ozone layer
 GHS08	<ul style="list-style-type: none"> Respiratory sensitiser Mutagen Carcinogen 	<ul style="list-style-type: none"> Reproductive toxicity Specific target organ toxicity Aspiration hazard
 GHS09	<ul style="list-style-type: none"> Hazardous to the environment Acute aquatic toxicity Chronic aquatic toxicity 	


2.2.1 Explosives

Hazard Symbol	Hazard Class
 GHS01	<ul style="list-style-type: none"> • Explosive • Self-reactives • Organic peroxides

These are chemical agents or mixtures that are capable of producing an explosive or pyrotechnic effect with substantial instantaneous release of heat and gas under the right conditions. Explosions can be initiated by heat, shock, friction, etc. Shock sensitive explosives constitute a particular risk as they can be detonated merely by moving their container. Compounds containing the functional groups azide, acetylide, diazo, nitroso, haloamine, peroxide, and ozonide may be sensitive to shock and heat.

It should be remembered that materials that are not explosive under normal conditions of use and therefore do not carry the above label can under the right circumstances generate an explosion risk, e.g. when flammable solvent vapours mix with air in the right concentrations. In some instances when incompatible chemicals are mixed together they can generate an explosive risk reaction, e.g. methanol and nitric acid. Some chemicals become an explosive risk if allowed to dry out, e.g. picric acid; 2,4, Dinitrophenol.

2.2.2 Flammables

Hazard Symbol	Hazard Class
 GHS02	<ul style="list-style-type: none"> • Flammables Gases • Flammable Aerosols • Flammable Liquids • Flammable Solids • Pyrophorics • Self Reactives • Self Heating • Emits Flammable gas in contact with water • Organic Peroxides

Flammable substances as the name suggests, ignite and burn readily. The most common class of flammables used within university laboratories are flammable liquids (organic solvents).

Flammable Liquids are classified into four categories based on flash point and initial boiling point:


- **Category 1:** Flash point < 23°C and initial boiling point ≤ 35°C
- **Category 2:** Flash point < 23°C and initial boiling point > 35°C
- **Category 3:** Flash point ≥ 23°C and initial boiling point ≤ 60.5°C
- **Category 4:** Flash point < 60.5°C and initial boiling point ≤ 93°C

Flash Point (which is the more important variable here) is defined as the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of the liquid. The lower the flash point, the easier it is to ignite the material. All flammable liquids, but particularly those in category 1 and 2, represent a very high fire risk and must be handled, stored and disposed of with extreme caution at all times.

There are two other properties of flammable liquids that must be considered when handling such chemicals.


- **Ignition / Auto-ignition Temperature:** This is the minimum temperature required to initiate or to cause self-sustained combustion independent of the heat source, i.e. 'spontaneous combustion'. A spark or flame is not necessary for ignition when a flammable vapour reaches its auto-ignition temperature.
- **Explosive / Flammability Limits:** The concentration range within air of a flammable vapour within which the application of a spark / ignition source will produce an explosion or flash. Within these ranges (*Lower Explosive / Flammability Limit* and *Upper Explosive / Flammability Limit*) the air-vapour mixture will support combustion. Below the lower level there is not enough vapour to support combustion; above the upper level there is not enough ambient oxygen to support combustion. The greater the spread of concentrations in air that a vapour will ignite the greater the risk represented by the material, especially when vapour is released during its use. Materials with a relatively low *Lower Explosive Limit* can form flammable mixtures in air at a very low concentration.

2.2.3 Oxidising

CLP Hazard Symbol	CLP Hazard Class
 GHS03	<ul style="list-style-type: none"> • Oxidising Gases • Oxidising Liquids • Oxidising Solids

Oxidising agents are chemicals that can generate an oxidation reaction. What this means is that they can readily release oxygen thus causing exothermic reactions with other materials that would normally be stable, e.g. strong nitric acid (>70%) has been known to cause spontaneous combustion of nitrile gloves following contact. Fire or explosions can be generated when strong oxidising agents come into contact with easily oxidisable compounds, such as metals, metal hydrides or organics.

2.2.4 Gases Under Pressure

CLP Hazard Symbol	CLP Hazard Class
 GHS04	<ul style="list-style-type: none"> • Gases Under Pressure

Gases held under pressure can pose a hazard in two ways:

i. Hazards from the pressurised nature of the cylinder


Because cylinders are maintained under pressure, any uncontrolled release of their contents can have catastrophic effects. Cylinders may take off at great speed, they may disintegrate, they may become extremely hot and the escaping gas may severely injure persons due to the pressure at which it is extruded.

ii. Hazards from the contents of the cylinder

The contents of the cylinder also pose a hazard to safety. Flammable gases may burn; oxidising gases may promote combustion of other materials; inert gases may displace oxygen from the


air reducing it to a level below that required to sustain human life; toxic or corrosive gases may cause severe injury; etc.

2.2.5 Corrosive

CLP Hazard Symbol	CLP Hazard Class
 GHS05	<ul style="list-style-type: none">• Corrosive to metals• Corrosive (causes severe skin burns and eye damage)• Serious eye damage

Corrosive chemicals destroy living tissue on contact. The tissue destruction occurs at the point of contact, but in the case of exposure to corrosive material through inhalation or ingestion the damage can occur within the respiratory or alimentary tracts. Corrosive materials have an ability to cause significant permanent damage to the body, especially to the eyes. The form of the agent is important, as if a material generates corrosive fumes, vapours or fine dusts then there is an increased risk of inhalation or contact with the eyes.

2.2.6 Toxic

CLP Hazard Symbol	CLP Hazard Class
 GHS06	<ul style="list-style-type: none">• Acute toxicity• Very toxic (Fatal)• Toxic

Toxic agents can cause serious damage to health if they are allowed to enter the body. Toxic agents are classified into five categories of acute toxicity by the oral, dermal or inhalation route based on the LD₅₀ (oral and dermal) or LC₅₀ (inhalation) concentration.


LD₅₀ and LC₅₀ value is the average exposure to a single dose of a chemical agent which causes at least 50% of test subjects to die.

Table 1: Acute Toxicity Hazard Categories and (approximate) LD₅₀ / LC₅₀ Values

Exposure Route	Category 1	Category 2	Category 3	Category 4	Category 5
Oral (mg/kg)	5	50	300	2000	See note 1 below
Dermal (mg/kg)	50	200	1000	2000	
Gases (ppm)	100	500	2500	5000	
Vapours (ml/l)	0.5	2.0	10	20	
Dusts and Mists (mg/l)	0.05	0.5	1.0	5	

Note 1: Substances of relatively low acute toxicity. Anticipated to have an LD₅₀ oral or dermal in the range 2000-5000mg/kg or equivalent for other routes.

2.2.7 Harmful / Irritant / Sensitiser

CLP Hazard Symbol	CLP Hazard Class
 GHS07	<ul style="list-style-type: none"> • Acute toxicity (harmful) • Skin and eye irritation • Respiratory irritant • Skin sensitiser • Narcotic • Hazardous to the ozone layer


Harmful and irritant chemical agents can cause damage to the health of persons exposed to them. They do not represent as significant a health hazard as toxic chemical. Irritant chemicals can cause inflammation of the skin or mucous membranes following any exposure.

Sensitising agents are chemical agents that are capable of causing a proportion of exposed persons to develop an allergic reaction after repeated exposure to the chemical. In some persons the allergic response can be quite severe.

Some chemicals can cause **respiratory sensitisation** following inhalation leading to asthma. Once sensitised, even minimal exposure can cause a severe allergic response.

Other chemicals can cause **skin sensitisation** following contact with the skin. Once sensitised minimal contact can cause an allergic response including severe dermatitis

2.2.8 Serious Health Hazard

CLP Hazard Symbol	CLP Hazard Class
 GHS08	<ul style="list-style-type: none"> • Respiratory sensitiser • Mutagen • Carcinogen • Reproductive toxicity • Specific target organ toxicity • Aspiration hazard

2.2.8.1 Carcinogens

Carcinogens are classed as a serious health hazard, and are assigned the hazard phrases *H350 May cause cancer* or *H351 Suspected of causing cancer*.

Carcinogens are categorised as followed:

- **Category 1A and 1B Known or Presumed Human Carcinogens:** Substances known to cause cancer in humans or presumed to be human carcinogens based on the existence of animal testing or derived from studies showing limited evidence of carcinogenicity in humans together with limited evidence of carcinogenicity in experimental animals. **Hazard Statement: H350 May cause cancer** (indicates exposure route if it is conclusively proven that the danger is not caused by any other route).
- **Category 2 Suspected Human Carcinogens:** substances that cause concern derived from limited evidence of carcinogenicity but for which available information is not sufficient to place in category 1A or 1B.

Hazard Statement: H351 Suspected of causing cancer (states route of exposure if it is conclusively proven that no other routes of exposure cause the hazard).

The use of any Category 1 or 2 carcinogens must be done under the strictest of control measures and exposure to the agent must be either eliminated or reduced to as low a level as

possible. Exposure limits are set for carcinogens which are considered to be 'safe', but zero exposure to any carcinogen must always be the ultimate aim.

Experience would dictate that many Category 2 carcinogens are reclassified over time as more information becomes available to either Category 1A or 1B carcinogens.

Given the potential serious health effects of carcinogens the use of any class of carcinogen must be justified in writing by the user with this justification kept on file. Any justification for the use of a carcinogen must be robust and based on sound scientific necessity; for example price is not an acceptable justification.

2.2.8.2 Mutagens

Mutagens are capable of producing heritable genetic defects, i.e. they can cause damage to DNA which can be passed on to future generations. Many, but not all, mutagens are also carcinogens.

Mutagens are classed as a serious health hazard, and assigned hazard phrases *H340 May cause genetic defects* or *H341 Suspected of causing genetic defects*. They are categorised as followed:

- **Category 1A and 1B:** Substances known to induce heritable mutations or to be regarded as if they induce heritable mutations in the germ cell of humans. **Hazard Statement: H340 May cause genetic defects** (states route of exposure if it is conclusively proven that no other routes of exposure cause the hazard).
- **Category 2 Mutagen:** Substances which cause concern for humans owing to the possibility that they may induce heritable mutations in the germ cells of humans.

Hazard Statement: H341 Suspected of causing genetic defects (states route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)

The use of any Category 1 or 2 mutagen must be done under the strictest of control measures where exposure to the agent is either eliminated or is reduced to as low a level as possible. Exposure limits are set for mutagens which are considered to be 'safe', but zero exposure to mutagens must always be the ultimate aim.

Experience would dictate that many Category 2 mutagens are reclassified over time as more information becomes available to either Category 1A or 1B mutagens.

Given the potential serious health effects of mutagens, the use of any class of mutagen must be justified in writing by the user with this justification kept on file. Any justification for the use of a mutagen must be robust and based on sound scientific necessity; for example price is not an acceptable justification.

Reference can also be made to classification of carcinogens and mutagens according to the International Agency for Research or Cancer ([IARC](#))

2.2.8.3 Reproductive Toxins

Reproductive Toxins can cause adverse effects on the body's reproductive system, including alterations to the reproductive organs and / or the endocrine system. Such toxins can affect both male and females. Reproductive toxins can also cause developmental toxicity in offspring.

Reproductive toxins are classed as a serious health hazard, and assigned hazard phrases *H360 May damage fertility or the unborn child* or *H361 Suspected of damaging fertility or the unborn child* or *H362 May cause harm to breast fed children*. They are categorised as followed:


- **Category 1A and 1B Known or Presumed Human Reproductive Toxicant:** Substances known to have produced an adverse effect on reproduction or on development. Classification is distinguished on the basis of whether the evidence is primarily from human data (Cat 1A) or from animal data (Cat 1B). **Hazard Statement: H360 May damage fertility or the unborn child** (states specific effect if known) (states route of exposure if it is conclusively proven that no other routes of exposure cause the hazard).
- **Category 2 Suspected Human Reproductive Toxicant:** Substances that cause concern owing to possible reproductive toxin effects but for which available information is not sufficient to place in category 1. **Hazard Statement: H361: Suspected of damaging fertility or the unborn child** (states specific effect if known) (states route of exposure if it is conclusively proven that no other routes of exposure cause the hazard).

The use of any Category 1 or 2 Reproductive Toxin must be done under the strictest of control measures where exposure to the agent is either eliminated or is reduced to as low a level as possible. Exposure limits are set for Reproductive Toxins which are considered to be 'safe', but zero exposure to Reproductive Toxins must always be the ultimate aim.

Experience would dictate that many Category 3 Reproductive Toxins / Teratogens are reclassified over time as more information becomes available to either Category 1A or 1B Reproductive Toxin.

Pregnant females must not be exposed to any workplace mutagen or reproductive toxin during the first three months of pregnancy, and any subsequent usage of such chemicals may only be done following the completion of a pregnant employee risk assessment. Contact [UCD SIRC Office](#) to arrange.

2.2.9 Danger to the Environment

CLP Hazard Symbol	CLP Hazard Class
 GHS09	<ul style="list-style-type: none">• Hazardous to the environment• Acute aquatic toxicity• Chronic aquatic toxicity

These chemicals may present a risk to one or more facet of the environment, e.g. flora, fauna, aquatic environment, etc. Their use and disposal must be carried out in such a way as to prevent any uncontrolled releases into the environment.

2.3 Hazard (H) Statements

Hazard (H) statements provide the user of a chemical with information on the hazards associated with that chemical and are usually outlined under section 2 and section 16 of the chemicals' SDS and on a chemical containers label. Hazard statements replace the older Risk (R) Phrases. A key to Hazard Phrases should be readily available in all chemical laboratories.

[See Health and Safety Authority Website](#)

2.4 Precautionary (P) Statements

Precautionary (P) Statements provide guidance to the user on how to work with that chemical safely and are outlined in section 2 of the chemicals' SDS and on a chemical containers label.

Precautionary statements replace the older Safety (S) Phrases. A key to Hazard Phrases should be readily available in all chemical laboratories.

[See Health and Safety Authority Website](#)

3.0 Classification of Chemical Agents for Transport

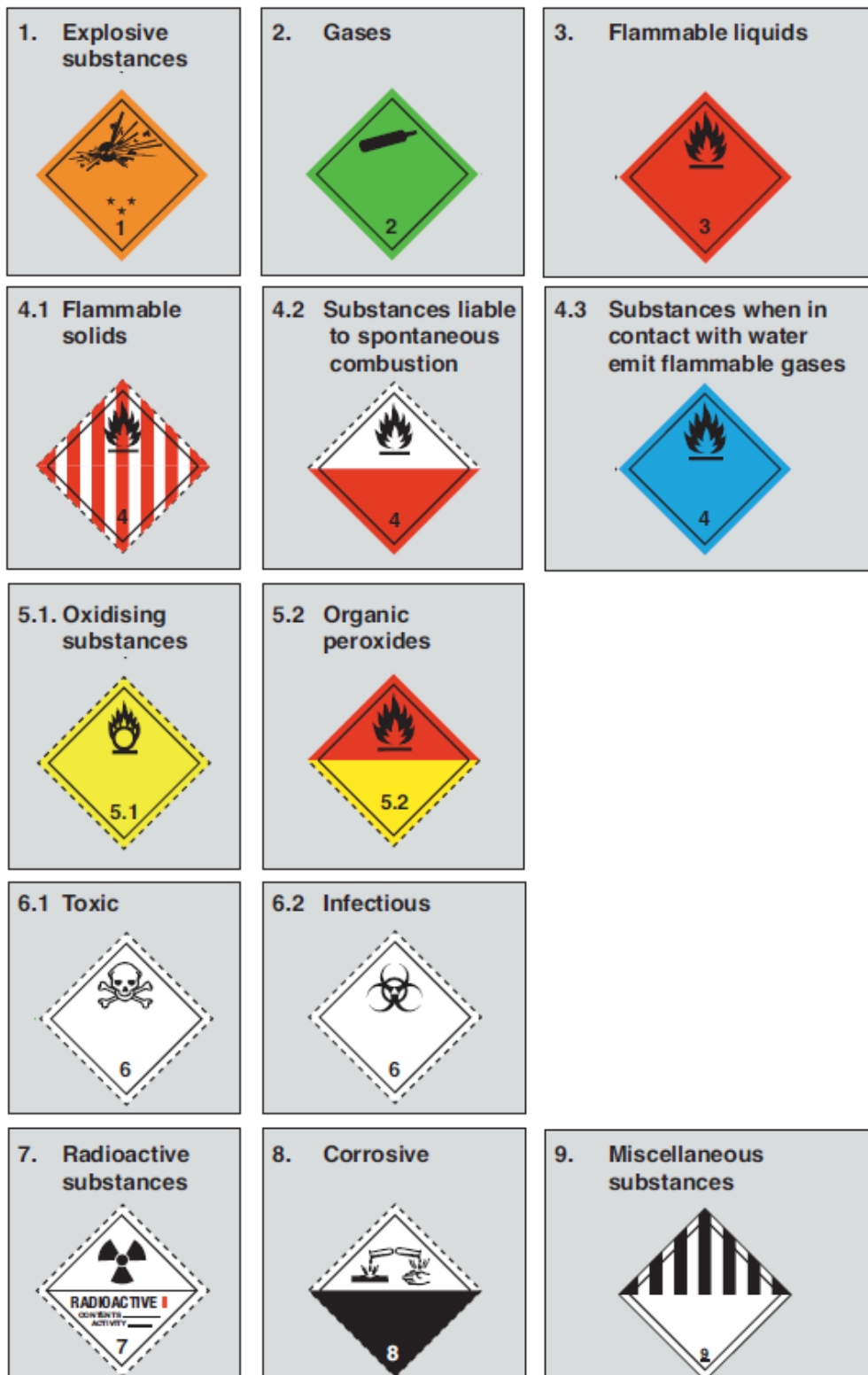
In addition to the classification of chemicals for use as outlined in section 2.0 above, there is also a separate system of classification for chemicals when they are being transported. Each transport class of chemical again has a pictorial symbol indicating its nature. These symbols are to be found on a chemical's outer transport packaging / casing. In some cases where chemicals are transported without any outer packaging over their primary container (e.g. in large drums) both user and transport classification labels may be placed on the same container. Whilst some of the pictorial symbols may be similar in appearance they do not necessarily have the same meaning as user labels and refer only to transport hazards, not the hazards exhibited by the chemicals under actual conditions of use.

The different classes applicable to hazardous materials for transport proposes are:

- Class 1 – Explosive Substances
- Class 2 - Gases
- Class 3 - Flammable liquids
- Class 4 - Other flammable hazards
 - Class 4.1 Flammable Solids
 - Class 4.2 Substances liable to spontaneous combustion
 - Class 4.3 Substances which in contact with water emit flammable gases
- Class 5 - Oxygen rich material, oxidizers and organic peroxides
 - Class 5.1 Oxidising substances
 - Class 5.2 Organic Peroxides
- Class 6 - Material affecting health, poisons and infectious substances
 - Class 6.1 Toxic Substances
 - Class 6.2 Infectious Substances
- Class 7 - Radioactive material
- Class 8 - Corrosive material
- Class 9 - Miscellaneous hazards

Each class and subclass has its own hazard warning label, which are detailed below ([adapted from HSA website](#)).

Figure 2. Transport Labels For Hazardous Materials



4.0 CAS and UN Numbers

4.1 CAS Numbers

A CAS (Chemical Abstracts Service) Registry Number is a unique number assigned to an individual chemical agent. For example [acetone and dimethyl ketone](#) have the same CAS No. (67-64-1) and so are the same substance. However it should be borne in mind that the CAS No. gives no information on the concentration of a chemical agent.

4.2 UN Numbers

United Nations (UN) Numbers are four-digit numbers used world-wide for the classification of hazardous materials during transport. The UN No's. are assigned to individual chemicals and also to mixtures of chemicals exhibiting similar properties but not necessarily the same constituents, e.g. UN1090: Acetone; UN1993 Flammable Liquid (acetone and heptane mix); UN1993 (acetone and isopropanol mix). Unlike CAS No's., UN No's. are not unique to individual chemicals and are used for transport purposes only.

5.0 Safety Data Sheets

Safety Data Sheets (SDS) are documents containing the relevant information required for the safe handling of potentially hazardous chemicals. In accordance with the REACH Regulation (EC No. 1907/2006), a safety data sheet must be provided with any hazardous chemical. Suppliers have a legal obligation to provide an SDS with any product that they may produce which falls under the classification of a hazardous agent as laid down within the relevant EU legislation (*Classification Labelling and Packaging Regulations*). When purchasing hazardous chemicals, persons should ensure that they request from the manufacturer a copy of any relevant SDS which complies with EU legislation.

Not all material encountered by persons in UCD will have an associated SDS available for consultation. This applies in particular to waste products, mixtures of chemical agents and products of chemical reactions. In such cases as much information as possible about the material in question must be obtained from the persons generating the material or in the case of mixtures the SDS for the known component parts of the mixture should be consulted.

There are 16 obligatory headings that must appear on all European SDS. It must be emphasised that this applies to SDS produced in and for the European market. Those SDS produced outside of the EU, such as in Canada or the USA follow a different set of guidelines and may not comply with European standards. Whilst the information contained within such documents is still valid chemical users must try to ensure that they consult a European SDS when handling a particular chemical.

In addition to the 'nationality' of an SDS, the age of the document is also important. SDS will have an issue date somewhere on them. It is important to ensure that recent SDS are consulted. If two conflicting SDS for the same material are encountered then the most recent must be used.

There may be differing SDS for the same chemical, if the chemical is produced by differing manufacturers. In such cases users should always try to ensure that they are referring to the SDS produced by the manufacturer of the material in question. If this is not available then SDS for the same material produced by a different manufacturer will suffice. In such cases however, users must ensure that the material in question is actually the same. Reference should be made to the materials' CAS No., their synonyms and their concentrations (See Section 2 Composition / Information on Ingredients of the SDS).

It is understood that it is impractical in some cases to hold an SDS for every chemical in use in the lab in a paper format within the lab. At a minimum, it is suggested that paper copies of SDS for the following types of chemicals be kept in the lab:

- All chemicals held in a volume over 1 litre / 1 kg
- All carcinogenic, mutagenic and tertatogenic chemicals
- All very toxic and toxic chemicals
- All chemicals utilised on a daily basis
- All chemicals whose usage is deemed to be of a moderate risk or higher following a risk assessment

In all cases ease of access to an SDS is important.

The 16 Sections present on all SDS produced for use within the European Union are:

1. Identification of substance or mixture and company
2. Composition / Information on Ingredients
3. Hazards Identification
4. First Aid Measures
5. Fire Fighting Measures
6. Accidental Release measures
7. Handling and Storage
8. Exposure Controls / Personal Protection
9. Physical and Chemical Properties
10. Stability and Reactivity
11. Toxicological Information
12. Ecological Information
13. Disposal Considerations
14. Transport Information
15. Regulatory Information
16. Other Information

This is the order in which most manufacturers produce their SDS, but as stated above the order of the sections is not binding. The detailed contents of each of the sections are discussed below.

1. Chemical Identification

This section will state the name of the material in question, as sold to you and its chemical name. It may also contain information on the manufacturer and emergency contact numbers in the case of an incident involving the material.

2. Composition / Information on Ingredients

In this section there will be further information on the nature of the material. If the material is a mixture of chemicals then the constituent parts shall be listed here, along with their relative importance in the material makeup. Other information such as the CAS Number and / or the UN number may also appear here. The molecular formulae for the material may also appear here. A useful piece of information that may also appear in this section is a list of common synonyms for the material. This section is very important as different manufacturers may use differing synonyms for the same material and it aids in identifying whether or not materials with different trade names are actually the same substance.

3. Hazards Identification

As the name implies the hazards associated with the material are detailed here. There may be a repetition of information here and in later sections detailing such items as first aid measures.

4. First Aid Measures

This section details the first aid measures to be taken following exposure to the material. This section is especially important if the person exposed to the material is taken to a hospital or to see a physician. In such cases the SDS must always accompany the patient. Users should take note as to whether or not there are any unusual first aid requirements following exposure to the material, e.g. such as the need to apply calcium gluconate gel following skin exposure to hydrofluoric acid.

5. Fire Fighting Measures

This section details the responses to be taken during a fire involving the material. Attention should be paid to the suitability of the various firefighting media for fighting a fire involving this material. Also important is whether or not the material emits noxious or dangerous fumes or products of combustion if involved in a fire, or if subjected to heating. Users of chemicals must always ensure that suitable firefighting media is available close by. This section may also

give information on the fire related stability of the material, such as its flashpoint, its explosion concentration limits, etc.

6. Accidental Release Measures

This section will detail how to respond to a leak or spill of the material and will detail the personal protective equipment (PPE) required. Particular attention must be paid to its advice on PPE, especially the material specified as suitable for use in gloves. The PPE contained within this section may also be used as a general guide for the type of PPE required when handling large volumes of a material. This section will also detail how to deal with material already spilled and will often recommend a suitable absorbent material.

7. Handling and Storage

Detailed within this section are the requirements for the safe handling and storage of the material. Again suitable PPE for handling the material may be recommended. Also detailed will be environmental conditions under which it is safe to store the material, e.g. suitable temperature ranges for storing specific materials.

8. Exposure Controls / Personal Protection

This section will contain general information on protecting oneself from exposure to the material. Suitable PPE will be detailed, as will any special requirements required for handling the material, such as the need to have safety showers nearby. It may also contain general comments such as 'keep container tightly closed at all times when not in use', etc.

9. Physical and Chemical Properties

This section will contain information on the appearance of the material and also some details on the chemical properties of the material. It will also list various characteristics of the material such as explosive limits, flammability information, etc. This information is especially important when deciding on storage areas for material or when entering areas where the material may have leaked in order to determine the risks from fire or explosion.

10. Stability and Reactivity

Within this section will be a range of information concerning the stability of the material in question and its ability to react with other materials. This section will detail if the material is likely to form peroxides or if it is potentially explosive. It will also detail incompatible materials, which may cause a serious reaction if they come into contact with the product. This

information must be consulted when handling a material to ensure that it is not going to be mixed or stored with another material that may give rise to a violent reaction. This is especially important when mixing different waste materials together into one container.

11. Toxicological Information

This section will detail the acute and chronic effects of exposure to the chemical. The acute effects of a chemical may be important in assessing whether or not exposure to a particular agent has occurred through the identification of symptoms in co-workers. A list of target organs of the material may also be listed. Again this is an important section in the treatment of exposure to the agent and must be presented to the physician providing medical treatment. This section will also give details on exposure limits for the material in question. These however have no meaning in Irish Law. For information on exposure limits users must refer to the most recent Code of Practice for the Chemical Agents Regulations (www.hsa.ie).

12. Ecological Information

This section will detail the impact the material may have on the environment if released. The information contained within this section may be relevant for example if an agent particularly toxic to aquatic organisms is to be used or handled / stored close to a drain or watercourse.

13. Disposal Considerations

This section may contain information on the means of disposing of the material, but in general will refer users to local and national laws and agencies for further advice.

14. Transport Information

This section may contain information on the means of transporting the material, but in general it will refer users to local and national laws and agencies for further advice and may advise the user to contact the manufacturer for further advice.

15. Regulatory Information

This section will contain a range of regulatory information.

16. Other Information

This section will contain other information, such as a disclaimer from the producer of the SDS.

5.1 Summary

A Safety Data Sheet (SDS) must:

- be of EU origin compliant with the new EU CLP system
- contain the 16 headings outlined above
- be specific to the chemical (not generic)
- be provided by the supplier free of charge and no later than at first delivery
- dated and any revision dates and details provided
- be readily available / accessible for all chemicals that are in use in the lab

For other groups of chemicals SDS can be accessed when required via the internet.

It is suggested that SDS for each lab / research group are held in the same location in each lab so that all persons are readily aware of their location in the event of an emergency.

6.0 Routes of Entry of Chemical Agents into the Body

Identifying the possible routes of user exposure when working with chemical agents and eliminating or reducing exposure to as low a level as possible is key to working safely with chemicals. There are five main routes by which chemical agents may enter the body. These are:

- Inhalation
- Skin Contact
- Through Damaged Skin
- Ingestion
- Trans Placental

6.1 Inhalation

This is the most important route of entry into the body for airborne substances, particularly solvent vapours. The surface area available within the lungs for the absorption of chemical agents is many times greater than that available on the skin.

The type and size of the airborne contaminant can have a significant effect on its passage through the lungs. Gases and vapours are usually carried into the deepest parts of the lungs (the alveoli), although they may be exhaled prior to absorption.

The penetration into the lungs of dusts and fumes depends on the size, density and shape of the particles:

- Particles greater than 5µm in diameter are normally trapped in the upper respiratory tract and expelled by ciliary action and mucus secretion
- Particles less than 5µm in diameter penetrate into the lungs where they may be dissolved and absorbed or phagocytosed (i.e. engulfed by the surrounding tissue)
- Very small particles which are less than 0.5 µm in diameter may be expelled

6.2 Skin Contact

Along with inhalation skin contact represents the most common route of chemical entry into the body in a laboratory setting. The outer layers of the skin act as a barrier to many chemicals but some chemicals can readily penetrate it, e.g. phenol, organic mercury compounds, etc. The lipid solubility and molecular weight of a chemical agent are important factors in determining its ability to pass directly through the skin.

6.3 Through Damaged Skin

Chemical agents can enter the body if they come into contact with damaged skin, e.g. cuts and abrasions. Chemical agents may also enter the body if the skin is damaged in the laboratory. This risk is greatly increased where sharps contaminated with chemical agents are in use.

6.4 Ingestion

Absorption of chemicals through the digestive tract via ingestion is also a potential route of exposure, but direct ingestion is considered to be unlikely in the laboratory setting. However indirect ingestion may occur if poor hygiene practices are observed.

6.5 Trans Placental

It is also possible for pregnant women exposed to chemical agents to pass that agent, or metabolites of that agent, across the placenta to their unborn child. This can lead to significant damage to the unborn foetus or embryo. The unborn child is most at risk during the first three months of development. It is not possible to assign a safe exposure limit for pregnant women to chemical agents; therefore exposure of such persons to chemical agents should be eliminated or reduced to as low a level as possible. A similar risk exists for breastfeeding mothers. Any person, staff or student, who is pregnant or is breastfeeding should not work with a chemical agent until such time as a risk assessment has been carried out. These can be arranged on a confidential basis by contacting sirc@ucd.ie

7.0 Effects of Chemical Agents on the Body

The adverse effect that a chemical can have on a person exposed to that chemical depends on a number of factors. These include:

- The nature of the chemical. Some chemicals are obviously more harmful than others dependent on their structure and makeup.
- The route of entry into the body. Different health effects can be caused by the same chemical depending on how it enters the body.
- The physical form of the chemical agent, e.g. dust, vapour, liquid, gas, etc.
- The amount absorbed. The potential toxic effect of a chemical increases as the amount exposed to increases (dose-response relationship).
- The individual concerned. Different people have different susceptibility to chemical agents dependent on their physical makeup, lifestyle, age, health, etc.
- The particular tissues and organs in which the chemical agent concerned may collect / accumulate.
- The frequency, concentration and duration of exposure.

Chemical agents can only cause harm to a living system when they come into direct contact with that system. In general the potential toxic or negative effect on a living system increases as exposure increases (dose – response relationship). All chemicals will exhibit a toxic / negative effect given a large enough dose. The potential of a chemical to do damage to a living system is therefore to a great degree dictated by the dose or amount of the chemical that comes into contact with that living system.

7.1 Adverse Effects of Chemical Exposure

7.1.1 Acute Versus Chronic Effects

The adverse effect of a chemical exposure may be acute or chronic. **Acute** effects are immediate and result usually from a single (acute) exposure to a large volume of a chemical, e.g. the immediate temporary narcotic effect of inhaling solvents. **Chronic** effects occur over a longer period of time and are usually the result of repeated (chronic) exposure to a chemical agent, e.g. development of ‘fatty liver’ from chronic exposure to carbon tetrachloride. The damage caused by chronic exposure may not become evident for many years.

7.1.2 Local versus Systemic Effects

Following exposure to a chemical agent, the adverse effect of that agent can occur at the site of the exposure (**Local Effect**) or somewhere else in the body (**Systemic Effect**). For example skin exposure to an irritant may lead to a rash at the site of exposure; whilst skin exposure to another chemical agent may lead to it being absorbed and transported around the body, affecting organs remote from the site of the initial exposure. Some substances can produce both effects, e.g. lead tetraethyl damages the skin on contact and is absorbed and transported to the central nervous system where it may cause further damage.

7.1.3 Reversible versus Irreversible Effects

In some cases the damage caused to the body's systems can be reversed, e.g. skin damage from weak acid burn, i.e. the adverse effect of the chemical is **reversible**. However some chemical agents can cause **irreversible** effects on the body where damage to one of the body's functions cannot be repaired, e.g. malignant mesothelioma caused by inhalation of asbestos fibres.

7.1.4 Cumulative Effects

Cumulative effects are characteristic of materials that tend to build up in the body as a result of numerous exposures. The effects are not seen until a critical body burden is reached. This is a typical response to heavy metal exposure.

7.1.5 Synergistic Effects

Exposure to two or more hazardous materials at the same time can give rise to a greater risk than might be expected, e.g. smoking and exposure to asbestos hugely increases the risk of developing lung cancer.

7.2 Body Responses to Chemical Exposure

7.2.1 Irritation Response

The skin and mucous membranes of the body can exhibit a range of responses following exposure to an irritant or corrosive material. This may include the inflammation of the affected area and the development of blisters or burns. Irritants can also affect the workings of the respiratory system. Acute exposure to irritants usually causes no long term damage and any damage caused is usually temporary (except where the eyes have been damaged). However chronic exposure to irritants can lead to permanent damage including dermatitis.

Long term exposure to respiratory irritants can result in the development of impaired lung function.

7.2.2 Allergic Response

An allergic response can develop when a person becomes sensitised to a particular chemical following repeated exposure to that agent. The development of respiratory sensitisation can lead to asthma like systems in affected persons which can be significant following any further exposure. Those persons who suffer from dermal sensitisation to a particular chemical can develop a severe allergic reaction following any further exposure to that agent, including permanent dermatitis.

7.2.3 Fibrogenic Response

The accumulation of some chemical agents in the lungs can lead to a fibrogenic response which can impair lung function. This type of response generally develops over years of repeated exposure to a particular type of agent, e.g. silica dust, asbestos fibres, etc.

7.2.4 Carcinogenic Response

This is one of the most severe responses (other than immediate death) to exposure to a chemical agent. A cancer is a disorder effecting cell growth and can be brought about by exposure to specific chemicals. In some cases chronic exposure is required for cancer to develop (e.g. benzene) whilst in other cases a single exposure can in theory lead to cancer (e.g. asbestos fibres). It can take decades for a cancer to develop following exposure to a cancer causing agent.

7.2.5 Mutagenic Response

A mutagenic response is one whereby exposure to a chemical leads to heritable genetic damage. Many mutagens are also carcinogens, but unlike carcinogens the damage caused by mutagens can be passed on to subsequent generations.

7.2.6 Poisonous / Toxic Response

This type of response following exposure to a chemical agent gives rise to the death or damage to body cells, organs and systems and can ultimately lead to death. The response can be instantaneous following a single acute exposure to a chemical agent (e.g. hydrogen cyanide) or can take many years to develop (e.g. carbon tetrachloride). The effects of the response can target any body tissue or system. Poisons can target the kidneys (Nephrotoxic toxins); the liver (Hepatotoxic Toxins); the central nervous system (Neurotoxic Toxins); the blood (Hematopoietic System Toxins); lung function (Pulmonary Toxins); the reproductive organs

(Reproductive Toxins); etc. Many chemical agents have 'target organs' which are those organs most susceptible to damage / poisoning by exposure to that agent.

7.2.7 Reproductive Response

Some chemical agents can have an effect on the body's reproductive system. **Reproductive Toxins** can impair fertility. **Teratogens** can damage the unborn child. **Mutagens** can damage the DNA of exposed persons creating a genetic defect that can be passed down through subsequent generations.

7.2.8 Asphyxiation Response

Some chemical agents, particularly gases and vapours, can give rise to an asphyxiation response (i.e. a reduction in oxygen uptake by the body). Asphyxiants come in two types. **Simple Asphyxiants** which displace oxygen from the air being breathed, leading to a reduction in the amount of oxygen available to the body from each inhaled breath e.g. nitrogen gas. **Chemical Asphyxiants** which reduce the body's ability to transport, absorb or use inhaled oxygen, e.g. carbon monoxide.

8.0 Exposure Limits for Chemical Agents

Every person using a chemical agent must design their working practices so as to eliminate or reduce to as low a level as possible their exposure to that agent. However, whilst minimising exposure is considered to be fundamental to the safe use of chemicals, it is not always possible to completely eliminate a users' exposure to a chemical agent. With this in mind, maximum exposure limits for a large number of chemical agents are laid down in Irish law. These limits are to be found in the *2011 Code of Practice for the Safety, Health and Welfare at Work (Chemical Agents) Regulations, 2001* which can be downloaded from the Health and Safety Authority Website www.hsa.ie

Current knowledge of a chemical and its effects on the body are used to establish an **Occupational Exposure Limit Value** (OELV) for that chemical, which is the maximum amount of that chemical that a person can be exposed to regularly throughout a working lifetime without resulting in adverse effects on the health of the exposed worker or their progeny. It should be borne in mind that these limits are under constant review as our knowledge of chemical agents expands and in general they are reducing over time as more information on the health effects of certain chemicals become available. These limits do not apply to pregnant or breastfeeding females or to any persons who may be suffering from any medical condition which may make them more susceptible to damage by a chemical agent.

Limits are given for two reference periods in the Code of Practice, an 8-hour reference period and a 15-minute reference period.

The OELV for an 8-hour reference period is the maximum amount of an airborne contaminant that can be inhaled by a person, averaged over an eight hour exposure period, e.g. if a person is exposed to a chemical agent for separate periods of 2 hours, 4 hours and 4 hours then the total exposure over those ten hours is averaged over an eight hour period and the exposure determined. Only one 8-hour reference period can be used in any 24 hour period.

The OELV for a 15-minute reference period is sometimes referred to as the *Short Term Exposure Limit* (STEL). This is the maximum amount of an airborne contaminant that can be inhaled by a person averaged over a 15 minute period, with a maximum of four such 15 minute periods in any 24 hours.

Where no specific STEL is listed, a figure three times the long term exposure value should be used.

The more hazardous the chemical the lower the exposure limits. For example, Benzene which is a Category 1 carcinogen, has an 8-hour OELV of 1ppm and has no 15-minute OELV. What this means is that for both reference periods the maximum average exposure to benzene that is permissible in law is 1ppm. When comparing two chemicals from a safety perspective it is often useful to compare their exposure limits, Toluene, which is often used as an alternative to benzene, has an 8-hour OELV of 50ppm, making it a safer alternative to benzene.

For known or suspected carcinogens and mutagens a zero exposure approach to handling the chemical should be adopted.

9.0 Storage of Chemicals

Chemicals should be stored in the laboratory in such a way that minimizes the likelihood of dangerous interactions with other chemical agents and should be segregated from incompatible materials. **Incompatible materials** are defined as likely to interact with each other so as to increase any hazard or generate a new hazard when mixed or otherwise brought into contact. An individual chemical's Safety Data Sheet must be consulted before it is stored to obtain information on its incompatibles. The web is also a good source on information in this regard. An excellent tool for assessing the possible reaction that might take place when two or more chemicals are mixed is the [Chemical Reactivity Worksheet](#) which is produced by the NOAA. This programme allows a user to input different chemicals into a reactivity matrix and it will predict the type of reaction that may be generated.

9.1 General Principles of Safe Chemical Storage

- The quantities of hazardous chemicals stored must be kept to a minimum commensurate with their usage and shelf life. Some chemicals degrade during storage and can become more hazardous. Such chemicals should be identified and managed appropriately.
- Empty containers that have previously contained hazardous chemicals should be treated as full, unless they have been cleaned.
- All packages (including those containing waste materials) must be fully labelled to allow unmistakable identification of the contents. All labels, including user generated labels, must comply with the labelling requirements as outlined in Section 2 above.
- The storage of all chemicals, including wastes, must be based on the properties and reactivity of the chemicals. Incompatible chemicals must be kept segregated from one another.
- Packages must be inspected regularly to ensure their integrity. Leaking or damaged packages must be removed to a safe area for repacking or disposal.
- Labels must be reattached or replaced, as necessary, to clearly identify the contents of a package.
- Every area, in which chemicals are stored, must have in place procedures to deal with the clean-up and safe disposal of spillages and there must be easy access to suitable spill response equipment.
- Substances which are unstable at ambient temperature must be kept in a spark proofed fridge.

- Sunlight can affect some plastic containers or the contents of some containers. Containers or chemicals that can be affected must not be stored in an area where they can be exposed to direct sunlight.
- The type and size of individual packages used in the laboratory should be chosen to minimize the quantities and handling risk. Breakable packages should be avoided. Properly labelled 'User-friendly' smaller packages for laboratory use may be filled from larger containers located elsewhere.
- Where incompatible chemicals are in the same work area, precautions should be taken to prevent their accidental mixing.
- Volatile toxic substances should be stored in a continuously run fume hood away from sources of heat or ignition.

9.2 Open Laboratory Storage of Chemicals

- The storage of chemical agents in the open laboratory should be restricted to as little material as possible. Volumes of flammable liquids, unstable solids, oxidising agents, and corrosive liquids stored in the open laboratory should not exceed what is required for one day's work.
- Where possible, the size of storage containers held in the open laboratory should be kept as small as possible.
- Chemicals kept on shelves or racks should not be stored at a height greater than 1.5m if possible.
- Shelving material used to hold chemical agents should be compatible with the goods stored, or else be suitably protected. The leakage of a chemical agent onto a shelf made from an incompatible material may generate a fire. Shelves must not be overloaded and where possible should be restrained against lateral movement.
- To assist housekeeping, chemical packages should not be kept on the floor.
- Liquid chemicals should not be stored above solids and should be stored at as low a level as possible to reduce the risk of breakages and spillage if they fall.
- Where chemicals are stored on laboratory benches, they must be kept back from the edge of the bench to minimise the risk of falling. It should not be possible to knock a chemical container to the floor by brushing up against a laboratory bench.
- Within the laboratory, incompatible chemicals should be segregated from each other so as to minimise the risk that in the event of a spillage or breakage they can come into contact with each other. The following segregation distances are suggested:

- *Incompatible Liquids*: should not be stored above each other and should be separated from each other by at least 1m
- *Incompatible Solids*: should be separated from each other by at least 50cm
- *Incompatible Liquids And Solids*: liquids should not be stored over solids and incompatible liquids and solids should be separated from each other by at least 1m

Note these distances apply where small volumes are being stored. When larger volumes of material are being stored then separation distances must be increased.

9.3 Chemical Storage Cabinets / Storage Cupboards

- Chemical Storage Cabinets are purpose built for the holding of chemical agents. To be classified as a Chemical Storage Cabinet a cabinet must meet minimum design standards. They should not be confused with non-specialised laboratory storage cupboards which are often used to hold chemical agents.
- Particular care must be taken when locating Chemical Storage Cabinets / Storage Cupboards. As a rule cabinets and cupboards must NOT:
 - be stacked upon each other
 - be located in front of doorways
 - be located under stairs or in corridors
 - hold large amounts of material– users should refer to manufacturer guidelines
- The materials used to construct Chemical Storage Cabinets / Storage Cupboards (including the shelves) must be compatible with the chemicals contained therein. In so far as is possible, all cabinets and cupboards should have in place spill trays designed to collect leaking material and prevent it being lost from the cabinet / cupboard. Shelves must not be overloaded and where possible should be restrained against lateral movement.
- All Chemical Storage Cabinets / Storage Cupboards must have warning labels affixed to the outside clearly warning persons about the nature of the contents contained therein.
- Incompatible chemicals must not be stored in the same storage cabinet / cupboard, unless measures have been taken, to prevent contact between the chemicals or the mixing of any spillages.

Whilst different types of chemicals may be stored together in the same cabinet / cupboard the following restrictions should be applied in so far as is possible:

- A storage cabinet or cupboard used to store flammable liquids should not be used for the storing of any other types of chemicals
- A storage cabinet or cupboard used to store flammable solids should not be used for the storing of any other types of chemicals
- A storage cabinet or cupboard used to store substances liable to spontaneous combustion should not be used for the storing of any other types of chemicals
- A storage cabinet or cupboard used to store substances that in contact with water emit flammable gases and it should not be used for the storing of any other types of chemicals
- A storage cabinet or cupboard used to store oxidising substances should not be used for the storing of any other types of chemicals
- A storage cabinet or cupboard used to store organic peroxides should not be used for the storing of any other types of chemicals
- The storage of corrosive substances in cabinets or cupboards must be done in a manner that will prevent contact between:
 - Acids and alkalis
 - Acids and hypochlorites
 - Acids and cyanides
 - Acids and substances that in contact with water emit flammable gases
 - Oxidizing acids and combustible materials
 - Incompatible acids.
- The opening of packages, transferring of contents, dispensing of chemicals or sampling should not be conducted in or on top of a cabinet or a cupboard for storing hazardous chemicals unless it is specifically designed for this purpose and appropriate procedures and equipment are used.

10.0 Handling Chemicals Safety

The ultimate aim when designing safe systems of work for the use of any chemical agent is to eliminate or to reduce to as low a level as possible the exposure of any person to that agent and to ensure that the agent is used in such a manner that it does not pose a risk to the user or any third party, e.g. through the generation of fire, explosion, etc. To achieve this objective there are a number of general safety rules that should be followed at all times when working with chemicals.

10.1 General Guidelines for handling all Classes of Chemicals Safely:

- When handling any chemical agent a *Safety Data Sheet* must be readily available for consultation as required. Users should make themselves aware of the properties of each chemical that they use.
- The use of every chemical agent should be subjected to a *Chemical Agents Risk Assessment*.
- No more than one day's supply of any chemical should be stored at the bench or outside of a designated storage cabinet.
- Work processes must be designed so as to minimise the amount of contaminants given off.
- Where a large amount of chemical contaminants are to be made airborne, then a process must be undertaken in a fume hood or beneath a snorkel if appropriate.
- Chemical agents must not be allowed to come into contact with the users' skin. Suitable PPE must be worn at all times. At a minimum, a lab coat, safety glasses and gloves must be worn at all times when handling any chemical agents.
- Pregnant and breastfeeding women must not work with any chemical agents unless a full risk assessment has been undertaken – contact the University SIRC Office (sirc@ucd.ie).
- Persons working with any chemical should be aware of the symptoms of exposure to that agent and cease work immediately if they develop any of the symptoms. Persons should also be vigilant for the development of such symptoms in co-workers.
- When working with flammable chemicals as many potential sources of ignition as possible must be removed from the immediate area.
- Chemicals should be stored in air tight containers.
- All chemical storage containers (including waste containers) must be clearly labelled as to their contents.
- There must be no eating or drinking in the chemical laboratory.

- Users should wash their hands following the handling of any chemical and prior to eating or drinking.
- Bottle carriers should be used for transporting glass bottles.
- When not in use, containers should have their lids replaced.
- Lone working with chemicals should be avoided unless shown to represent a low risk to the user's safety.
- When left unattended, all experiments must have an *Unattended Experiment Form* left nearby so that persons dealing with any emergency involving the experiment have details on the appropriate emergency response.
- A high standard of housekeeping must be maintained in the laboratory at all times.
- All chemical waste must be disposed of in a suitable manner.

Outlined below are further safety measures that should be taken when working with various classes of chemicals.

10.1.1 Handling Flammable Liquids / Solvents Safely

Flammable solvents are commonly used in laboratories and industrial processes. The main route of exposure to solvents is through the inhalation of vapours given off by the solvent. Most solvents are highly volatile and will readily produce vapours under normal atmospheric conditions. Short-term exposure to solvent vapours will produce a narcotic response caused by the depression of the central nervous system which is usually reversible. Long term exposure or repeated exposure to solvent vapours may cause permanent damage to the central nervous system, the liver and other organs depending on the nature of the solvent exposed to. Some solvents are known carcinogens. Symptoms of acute exposure to solvent vapours include nausea, euphoria, vomiting, headache and in high enough concentrations unconsciousness and death. Solvent exposure may also result in an inability to think clearly. Persons handling solvents should exercise vigilance in recognising these symptoms in themselves and in others. Persons may also be exposed to solvents via direct skin contact with the material. Solvents may irritate the skin, the respiratory tract and the eyes. Prolonged or repeated skin exposure can cause permanent skin damage.

Most solvents are highly flammable. The following characteristics of solvents are important when determining their fire risk:

- *Boiling Point:* This is the point at which a solvent vaporises. The lower the boiling point the greater the amount of vapour given off by a solvent under normal laboratory conditions. The ability of a solvent to produce vapour is also affected by its surface area relevant to its volume and any other materials that it may be mixed with.
- *Flash Point:* This is the lowest temperature at which the application of a flame to a solvent vapour will produce a flash.
- *Explosive / Flammability Limits:* This is the range of concentrations in air of a solvent vapour that will support combustion or within which there is a risk of an explosion on the application of an ignition source. As a rule, the greater the range the more hazardous the chemical. For example *Toluene* has an explosive range of 1-7% in air, i.e. an atmosphere that contains toluene vapours at a concentration of between 1% and 7% will explode / ignite if a flame is applied.
- *Autoignition Temperature:* This is the temperature at which a solvent's vapour in air will spontaneously catch fire while within flammability limits.
- *Vapour Density:* This is a solvent vapours density relative to air; a vapour density of less than 1 means a solvent's vapour will rise; while greater than 1 means that a solvent's vapour will sink and may collect along on the floor and in ducts and drains.

In addition to the general precautions for working with all chemicals outlined in 10.1 the following additional precautions should be taken when working with flammable liquids:

- Many individual solvents have a number of commonly used names, whilst many solvents have similar sounding names. Users must ensure that they know which particular solvent they are handling.
- No more than one day's supply of a solvent should be stored at the bench or outside of a designated flammables cabinet.
- When using solvents work processes must be designed so as to minimise the amount of vapour given off by the solvent. Solvent Winchesters should be closed when not in use and open containers used to hold solvents should have as small a surface area as possible. Users should never lean over an open solvent container.
- Where a large amount of vapour may be released then the material must be handled in a fume hood or beneath a snorkel.

- When the solvent in question is a known carcinogen then it must be handled in a fume hood.
- Solvents should not be allowed to come into contact with a users' skin. Persons handling solvents should wear appropriate gloves to prevent skin contact. The nature of the glove to be worn will be dictated by the solvent in use, as some solvents readily pass through some glove materials. The use of barrier creams must only be considered in situations where gloves cannot be worn – advice on the use of barrier creams must be obtained from the University SIRC Office (sirc@ucd.ie) before they are used. A laboratory coat and safety glasses should also be worn. Contaminated gloves must be removed immediately and disposed of. Heavily contaminated lab coats should be removed and / or laundered or disposed of.
- When a toxic or similar agent has been dissolved in a solvent particular care must be taken to prevent the solution coming into contact with the users' skin.
- Persons must not enter confined or restricted spaces where it is suspected that solvent vapours may have gathered.
- Persons working with solvents should be aware of the symptoms of solvent vapour exposure (i.e. nausea, euphoria, vomiting, headache, confusion) and cease work immediately if they develop any of the symptoms. Persons should also be vigilant for the development of such symptoms in co-workers.
- When working with solvents, as many potential sources of ignition as possible must be removed from the immediate area.
- Persons handling solvents should be aware of the potential for solvent vapours to collect in roof spaces (for solvents with a vapour density of <1) or in floor openings (for solvents with a vapour density of >1). The ability of a solvent vapour to travel far from a source and 'flash back' if it encounters an ignition source should be considered when designing work processes involving solvents.
- In so far as is practicable, solvents should be dispensed from their original containers using a purpose designed nozzle. The decanting of large volumes of solvents should be done in fume hoods or in the open air.
- Solvents should be stored in air tight containers in a flammables cabinet away from potential sources of ignition, heat and incompatible chemical agents (particularly oxidisers).
- Vessels that appear to be empty but which previously contained solvents should not be considered to be free from vapour until they have been suitably washed.

- Ignition sources should be controlled / isolated when flammable solvents are in use.
- When transferring solvents between containers consider the requirement to earth the containers to prevent a build-up of static in the liquid.
- Flammable liquids that require refrigeration must only be stored in spark proofed fridges

10.1.2 Handling Corrosives Safely

Corrosive chemicals are any solids, liquids, or gases capable of harming living tissues or causing material damage on contact. Corrosive chemicals include:

- Acids
- Bases ("caustics" or "alkalis")
- Dehydrating agents such as phosphorous pentoxide and calcium oxide
- Halogens and halogen salts such as bromine, iodine, zinc chloride, sodium hypochlorite
- Organic halides and organic acid halides such as acetyl chloride and benzyl chloroformate
- Acid anhydrides
- Some organic materials such as phenol.

Corrosive chemicals can pose a hazard by:

- *Directly attacking tissue:* Injuries to the eyes are a special concern. Caustics are particularly dangerous to the eyes.
- *Attacking materials:* Care is required when selecting materials to use with corrosive chemicals so that the equipment, including storage containers, will not be damaged by the chemicals.
- *Contributing to fire hazards:* Many acids are oxidizers that support combustion. Perchloric acid and its salts are especially reactive and may cause explosions. Nitric acid above 70% concentration also represents a significant fire risk. Some corrosives are flammable, e.g. glacial acetic acid and phenol.
- *Generating hydrogen gas:* Acids are particularly hazardous when they react with metals. Caustics can also participate in reactions that evolve hydrogen, for example when sodium hydroxide contacts aluminium, zinc or tin.
- *Possessing inherent toxicity:* Inhalation exposures to high concentrations of corrosives can cause serious lung injuries or even death if the exposure is not terminated. Acid-forming materials that are modestly soluble in water, such as nitrogen dioxide and phosgene, are

particularly hazardous because they cause delayed lung injuries that become evident a few hours to a day after the exposure occurs.

- *Generating incompatible or toxic or reactive products upon mixing.* A typical example is the mixing of cyanide or sulfide salts with strong acids, which generates potentially lethal hydrogen cyanide or hydrogen sulfide.
- Creating heat when they contact water, which can cause splatter.
- Mechanical damage to equipment aggravated by heating is also a possibility.
- Creating heat when acids and caustics mix.

In addition to the general precautions for working with all chemicals outlined in 10.1 the following additional precautions should be taken when working with corrosives:

- All corrosive compounds must be stored in a suitable manner away from incompatible materials. Acids and bases must be stored separately. It should always be assumed that corrosive liquids are incompatible with other corrosive liquids or solids unless further investigation deems otherwise.
- Liquid corrosives should be stored below eye level.
- No more than one day's supply of a corrosive material should be stored at the bench.
- When using corrosive materials work processes must be designed so as to minimise the amount of vapour or dusts released. Containers should always be closed when not in use and open containers used to hold corrosive liquids should have as small a surface area as possible. Users should never lean over a container containing corrosive liquids.
- Fuming acids must always be used in a specialist wash-down fume hood and not a standard fume hood.
- Where there is a risk that a large amount of fume or corrosive dust may be released, then the process must be undertaken in a fume hood.
- All equipment which comes into contact with a corrosive material must be resistant to that material. Particular attention must be paid to transfer lines, line joints, spill trays, reaction vessels, etc.
- The use of corrosive liquids under pressure should be avoided where practicable. Where this is not possible then the process must be undertaken in a fume hood.
- Corrosive materials must never be allowed to come into contact with a users' skin. Persons handling such materials must wear appropriate gloves to prevent skin contact. The nature of the glove to be worn will be dictated by the material in use. Neoprene and nitrile gloves

are effective against most acids and bases. Polyvinyl chloride (PVC) is also effective for most acids. Reference must be made to the material's SDS. Contaminated gloves must be removed immediately and disposed of. A lab coat and safety glasses must also be worn. If there is a risk of splashing then a face shield / goggles should be worn. Heavily contaminated lab coats should be removed and / or laundered or disposed of.

- Corrosive liquids should always be used in or over a tray made from a material resistant to the liquid which has the capacity to contain the full amount of material in use in the event of a spillage.
- The transfer of liquid corrosive compounds between containers must always be done in a fume hood over a tray.
- All containers holding corrosive compounds must be clearly labelled as such and the container material must be resistant to the nature of the corrosive contained therein.
- Always add acid to water, never water to acid.
- If handling large volumes of corrosives ensure that there is an emergency shower located nearby. There must always be a supply of clean water (from a tap or an eye wash station) nearby when handling any corrosive material.
- Dispose of all corrosive wastes through an approved specialist waste disposal contractor. Do not mix acid waste with organic waste because fire or other undesirable reactions may occur.
- Specialist spill kits containing alkali agents may be required when working with some corrosives, e.g. hydrofluoric acid.

10.1.3 Handling Toxics Safely

Toxic chemicals have the ability to cause significant damage to a users' health following exposure at relatively low doses. When handling toxic agents it is essential that the potential routes of entry into the users body are identified and measures are taken to reduce or eliminate the risk of exposure to as low as level as is possible. When carcinogens or mutagens are in use then exposure should be eliminated in so far as is possible by utilising sealed systems or other engineering controls. Users of toxic agents should be aware that when dissolved in a solvent, a toxic agent may have an increased risk of entering the body.

In addition to the general precautions for working with all chemicals outlined in 10.1 the following additional precautions should be taken when working with toxic agents:

- No more than one day's supply of a toxic material should be stored at the bench.
- Very toxic agents, carcinogens and mutagens must always be used in a fume hood or in a sealed system unless the risk of user exposure is minimal.
- Suitable personal protective equipment must be worn when working with toxic agents. In particular when working with agents which are toxic when in contact with skin, users must ensure that they select suitable gloves which are impermeable to the agent. Contaminated gloves must be removed immediately and disposed of. A lab coat and safety glasses must also be worn. If there is a risk of splashing then a face shield or goggles should be worn. Heavily contaminated lab coats should be removed and / or laundered or disposed of.
- Very toxic material should be stored in a locked cabinet when not in use.
- Activities that have the potential to generate airborne toxic contaminants must be undertaken in a fume hood or in a sealed system
- Toxic material must be stored in suitable areas away from incompatible agents. Many toxic solids emit toxic fumes when in contact with solvents, acids, alkalis or water. This should be borne in mind when mixing toxic wastes with other wastes for disposal.
- Pregnant and breastfeeding women must not work with toxic compounds unless a full risk assessment has been undertaken. This is particularly important when teratogens and mutagens are in use.

10.1.4 Handling Cyanide Compounds Safely

Cyanide compounds are commonly used in the chemical laboratory. Some cyanide compounds are extremely poisonous. Cyanides salts are solids but are often held in solution. When working with, or handling cyanide salts or cyanides in solution, poisoning may result from the inhalation of hydrogen cyanide gas or cyanide dust; from absorption through the skin or eyes following contact with cyanide salts or solutions of cyanide; or from the ingestion of cyanide salts.

Hydrogen cyanide gas is liberated from solid cyanides by the action of acids, water or even water vapour. Hydrogen cyanide has a bitter almond smell. However, a person's sense of smell cannot be relied upon as a warning signal to detect its presence, since not everyone can smell it (some 20% of adults have a hereditary inability to detect the characteristic odour).

Hydrogen cyanide gas and some cyanide salts are among the most rapidly acting of all known poisons. Even small concentrations are extremely hazardous. Any cyanide which is classified

as acute toxicity cat 1 or 2 (H300, H310, H330) must be handled with great care. Cyanide compounds which are labelled acute toxicity cat 3 (H301, H311, H331) pose less of a risk to users.

In addition to the general precautions for working with all chemicals outlined in 10.1, the following additional precautions should be taken when working with cyanide compounds:

- All cyanide compounds must be stored in a suitable manner away from incompatible materials. Extremely toxic cyanide compounds should be stored in a locked cabinet / room in so far as is possible.
- No more than one day's supply of a cyanide based material should be stored at the bench.
- When using cyanide based materials, work processes must be designed so as to minimise the amount of gases released. Containers should always be closed when not in use and open containers, used to hold liquid cyanide compounds, should have as small a surface area as possible. Users should never lean over a container containing cyanide based compounds.
- Where there is a risk that any cyanide gas may be released, then the process must be undertaken in a fume hood.
- Cyanide based materials must never be allowed to come into contact with a users' skin. Persons handling such materials must wear appropriate gloves to prevent skin contact. The nature of the glove to be worn will be dictated by the material in use. When working extremely toxic cyanide compounds two pairs of gloves should be worn, an inner pair and an outer pair. Contaminated gloves must be removed immediately and disposed of. A lab coat and safety glasses must also be worn. Heavily contaminated lab coats should be removed and / or laundered or disposed of.
- Cyanide salts must never be allowed to get wet or to come into contact with any acidic material outside of a fume hood.
- Persons must not enter confined or restricted spaces where it is suspected that cyanide gas may have gathered.
- Persons working with mercury based compounds should be aware of the symptoms of cyanide exposure (see above) and cease work immediately if they develop any of the symptoms. Persons should also be vigilant for the development of such symptoms in co-workers.
- Users of cyanide based compounds should wash their hands and face following the handling of such materials and prior to eating, drinking or smoking.

- The transfer of liquid cyanide compounds between containers must always be done in a fume hood over a tray.
- All containers holding cyanide based compounds must be clearly labelled as such.
- Small spillages of cyanide compounds should be treated with sodium hypochlorite to deactivate the cyanide – never use water to wash away a cyanide spillage.
- The need to hold a stock of amyl nitrate and / or have an oxygen therapy kit on standby, with a trained oxygen first aider, must always be assessed when working with the more toxic cyanide compounds. Contact sirc@ucd.ie for advice in this regard.

10.1.4.1 Symptoms of Cyanide Exposure

Mild Cyanide Poisoning

The onset of symptoms after exposure is very rapid. Symptoms and signs of mild cyanide poisoning include headaches, giddiness, nausea and vomiting (if the cyanide has been ingested). The person has difficulty breathing, a sense of suffocation and a feeling of general weakness with heaviness of arms and legs. Cyanide causes irritation of the nose, mouth and throat.

Severe Cyanide Poisoning

Severe cyanide poisoning may be characterised by gasping for breath and loss of consciousness. After loss of consciousness, breathing may be weak or absent. Cardiac arrest and death may result.

Antidotes to Cyanide Poisoning

In some cases the self-administration of amyl nitrate by persons exposed to cyanide may be appropriate. However amyl nitrate may lead to harm in those individuals with some forms of heart or vascular disease. If amyl nitrate is to be used as a first aid response, then the following must be adhered to:

- Amyl nitrate must only be administered where exposure to cyanide is known to have occurred. Where possible, oxygen therapy should be attempted first if time and circumstances allow.
- Only amyl nitrate ampoules in date may be used for first aid reasons.

- No more than 2-3 ampoules may be administered to an individual following exposure to cyanide.
- Ampoules must be self-administered. First aiders must not administer amyl nitrate.
- Care must be taken that ampoules are safely secured at all times. Amyl nitrate may be abused as a 'recreational' drug.
- In the event that an ampoule is used then the University SIRC Office (sirc@ucd.ie) must be informed.

In most cases of cyanide poisonings, the administering of oxygen is the preferred method of first aid.

10.1.5 Handling Hydrofluoric Acid (HF) Safely

Any persons intending to work with HF must consult the [UCD Guide to the use of Hydrofluoric Acid](#).

10.1.6 Handling Mercury and Mercuric Compounds Safely

Elemental mercury is a liquid metal which can react with many other materials to form amalgams (with other metals); mercury salts (inorganic mercury compounds) and organo-mercury compounds (compounds where carbon atoms bond directly to the mercury).

In addition to the general precautions for working with all chemicals outlined in 10.1, the following additional precautions should be taken when working with mercury or mercuric compounds:

- Users should make themselves aware of the properties of each mercury based compound that they use.
- All mercuric compounds must be stored in a suitable manner away from incompatible materials. Containers of elemental mercury should be stored over trays or be over packed / double contained. Dimethyl mercury should be stored in a locked cabinet / room in so far as is possible.
- When using mercury based materials, work processes must be designed so as to minimise the amount of vapour released. Containers should always be closed when not in use and open containers, used to hold liquid mercury compounds, should have as small a surface

area as possible. Users should never lean over a container containing mercury based compounds.

- Where there is a risk that a large amount of vapour may be released, then the process must be undertaken in a fume hood.
- Elemental mercury must not be heated unless absolutely necessary and only following a full risk assessment.
- Mercury based materials must never be allowed to come into contact with a users' skin. Persons handling such materials must wear appropriate gloves to prevent skin contact. The nature of the glove to be worn will be dictated by the material in use. When working with Dimethyl mercury two pairs of gloves should be worn, an inner pair and an outer pair. Contaminated gloves must be removed immediately and disposed of. A lab coat and safety glasses must also be worn. Heavily contaminated lab coats should be removed and / or laundered or disposed of.
- Persons must not enter confined or restricted spaces where it is suspected that mercury vapours may have gathered.
- Persons working with mercury based compounds should be aware of the symptoms of mercury exposure (i.e. metallic taste in the mouth, nausea, abdominal pain, vomiting, hand and body tremors, and emotional instability) and cease work immediately if they develop any of the symptoms. Persons should also be vigilant for the development of such symptoms in co-workers.
- Users of mercury based compounds should wash their hands and face following the handling of such materials and prior to eating, drinking or smoking.
- Elemental mercury should always be used in or over a tray which has the capacity to contain the full amount of mercury in use in the event of a spillage.
- Avoid using mercury compounds on benches with cracks where spilled material can accumulate.
- The transfer of liquid mercury compounds between containers must always be done in a fume hood over a tray.
- All containers holding mercury based compounds must be clearly labelled as such.
- All waste materials containing or contaminated with mercury compounds must be segregated from all other waste streams and disposed of through an approved specialist contractor. The recycling of elemental mercury should be considered where appropriate.

10.1.6.1 Health Hazards of Mercury and Mercuric Compounds

All forms of mercury are toxic. Mercury poisoning can result from inhalation, ingestion, and injection or absorption through the skin of a mercury containing compound. The effects from exposure to excessive levels of airborne mercury or skin contact with mercury compounds may not be noticeable for months or years. The nature of some mercuric compounds are detailed below.

Elemental Mercury

Elemental mercury poses a health hazard because it is volatile and evaporates at room temperature. Elemental mercury vapour is readily absorbed through inhalation, whilst elemental mercury can also pass through intact skin. Under conditions of high concentration of the vapour a metallic taste may be detected in the mouth along with nausea, abdominal pain and vomiting. Persons heavily exposed to elemental mercury will develop worsening tremors of the hands, shyness, insomnia and emotional instability. Mercury vapour levels can reach significant levels when the metal is heated giving rise to immediate adverse effects in exposed persons. Elemental mercury is not well absorbed by the gastrointestinal tract when ingested and is only mildly toxic from this route of exposure.

Mercury Salts

Mercury salts are both highly toxic and corrosive. Mercury compounds are highly hazardous if inhaled or if they remain on the skin for more than a short period of time. They accumulate mostly in the kidney causing renal damage.

Organo-Mercury Compounds

These compounds attack the nervous system causing tremors, impaired vision and hearing, and paralysis. These compounds can also cause birth defects. Again skin contact and inhalation are significant routes of exposure.

Dimethyl Mercury

Dimethyl mercury is a colourless sweet smelling liquid with a flashpoint of -4°C . It is an extremely toxic material which rapidly penetrates intact skin resulting in severe exposure from very minor quantities, which can be fatal. Extreme caution is required when working with this material. It is also a significant fire hazard.

10.1.6.2 Response to Mercury Spillages

In all areas where liquid mercury compounds are in use appropriate spill response equipment must be maintained nearby. Where a small amount of elemental mercury is in use, a small commercially available spill response kit is appropriate. Where a large volume of elemental mercury is in use, then a supply of sulphur should be kept nearby for treating large spillages.

- Elemental mercury will fume large quantities of vapour at room temperature and small amounts will eventually evaporate completely, so it is essential that spills are dealt with immediately.
- When spilled, mercury breaks up into small droplets so it is essential that access to the contaminated area be restricted in order to prevent the further spreading of the materials on shoes.
- If mercury spills onto a hot surface then immediately evacuate the area, as highly poisonous fumes will be given off. In the case of all mercury spills, the area should be ventilated as much as possible in order to reduce the concentration of vapour in the air.
- In a well-ventilated area small spillages of mercury do not pose a risk to safety.
- Spills should be cleaned up primarily by using mechanical means where possible, e.g. brush and pan, pipettes or a 'Mercury Collector' device. It may be necessary to first aggregate the droplets by brushing them together first before attempting to lift them from the contaminated surface.
- Where spillages occur on porous surfaces e.g. wooden benches, such techniques may not be fully effective. In such cases a 'Mercurisorb' Spill Kit or sulphur should be used to absorb any remaining mercury. It is not essential to get all the mercurisorb out from a porous surface, as mercurisorb renders the mercury non-toxic, however, every effort should be made to recover any used materials. Following the cleaning of a spill, the contaminated area should be treated with mercurisorb or with sulphur as described below as a secondary containment measure.
- In the case of larger spills such techniques may not be suitable. Large volumes of mercury will fume large amounts of toxic vapour and in these conditions the covering of the mercury is the priority. In these instances copious amounts of sulphur should be used to cover all exposed mercury. This mixture should be left for at least 24 hours before being cleared up using a brush and pan. A mercury sniffer should be used to give clearance to an area following a large scale mercury spill. If small amounts of mercury are spilled in a confined space, then it may have to be treated as a large spill as the vapours given off will accumulate in the confined space.

The University SIRC Office must be informed of any large (>100ml) spills of mercury. If it is suspected that material has been lost behind laboratory furniture or fixtures, then the [University Estate Services Office](#) must also be informed.

10.1.7 Handling Organic Peroxides Safely

Organic peroxides are a class of compounds that have unusual stability properties that make them among the most hazardous substances found in the laboratory. The lack of stability is due to the presence of an oxidation and reduction centre within the same molecule. As a class, organic peroxides are considered to be powerful explosives and are sensitive to heat, friction, impact, light, as well as to strong oxidizing and reducing agents. Peroxide forming chemicals react with oxygen even at low concentrations to form peroxy compounds. The instability of these compounds can cause auto-decomposition simply by bumping or jarring the container, or the addition of heat, light, or opening the cap. The risk associated with the peroxide increases if the peroxide crystallizes or becomes concentrated by evaporation or distillation. Peroxide crystals may form on the container plug or the threads of the cap and detonate as a result of twisting the lid. The lid of a container suspected of containing peroxides must never be opened. The older the material the greater the risk posed, as the greater the chance that peroxy compounds have formed. The risk is further increased if the container has ever been opened and exposed to the air, as this will further speed up the process.

The formation of crystals may indicate the formation of peroxides. In a glass or similar container they can be inspected for visually. In a metal container or similar where the contents are not visible peroxidation must be assumed for old materials. Crystals, which may not be visible, may also form under the lids of containers. The age and type of material must be considered when assessing whether or not crystals may have formed under the lid (see below).



The bottle on the left contains a hard crystallized peroxide formation which was formed from isopropyl ether while sitting on a shelf in a hospital laboratory.

The crystals on the right, from the same bottle, auto detonated shortly after the photo was taken.



The container on the left was located next to the other bottle on the same laboratory shelf and was safely detonated using an electric blasting cap.

The resulting detonation left a crater in the ground approximately three foot wide by one foot deep!

In addition to the general precautions for working with all chemicals outlined in 10.1, the following additional precautions should be taken when working with compounds capable of forming organic peroxides:

- A *Safety Data Sheet* must be consulted for each material in use in the lab. Hazard phrases must be closely reviewed to indicate explosive risk. A list of common chemicals that may form organic peroxides is given below.
- Materials which have the potential to form organic peroxides should be stabilised with a suitable agent.
- Chemicals that are known to become unstable after a period of time should be dated as to when they were opened and disposed of / stabilised before they become a risk. Regular testing of high risk materials for the presence of organic peroxides may be necessary.
- Containers of material that have the potential to form organic peroxide must be inspected for the presence of crystals prior to every use. If no crystals are present within the

container then the container may be handled; if crystals are found then the container must be isolated and the University SIRC Office informed. Be aware that crystals may have formed in the threads of the lid, do not open any container where there is any uncertainty about the presence of peroxides.

- In metal containers or similar where the contents are not visible peroxidation must be assumed for old materials. The age and nature of the material must be taken into account; the older the material the greater the possibility that peroxides may have formed. This is especially true if the material has ever been exposed to the atmosphere, i.e. opened. Do not take any chances; if in doubt treat suspect material as unstable.
- Do not treat empty containers which previously contained peroxide forming chemicals as safe.
- If unstable material is encountered then all work should cease and the area should be isolated.
- Suspect material must be handled gently and not exposed to excess shock or friction. Be aware that some organic peroxide forming chemicals must be stored at a reduced temperature, i.e. in a spark proof fridge. Refer to the SDS for each individual substance.

10.1.7.1 Formation of Organic Peroxides

The following materials are particularly hazardous and are capable of forming peroxides that may explode even without undergoing distillation or evaporation. Once exposed to air they become severe peroxide hazards. One of the more dangerous is isopropyl ether, which decomposes rapidly on storage so that crystals of peroxides accumulate in the threads under the cap. This condition is extremely dangerous and the container should not be opened - friction may initiate detonation. Materials discovered in this condition must not be moved. These chemicals should never be stored for longer than 3 months; after this time they should be discarded without opening or should be tested for peroxide formation. Any container that has been stored for greater than 6 months should be approached with extreme caution.

1. Divinyl acetylene (DVA)
2. Isopropyl ether (Diisopropyl ether)
3. Potassium metal
4. Potassium amide
5. Sodium amide (sodamide)
6. Vinylidene chloride (1,1-dichloroethylene)

The following materials form peroxides on concentration, so should never be allowed to dry out. They should be treated with caution if opened longer than 6 months.

1. Acetaldehyde diethyl acetal (acetal)
2. Cumene (isopropylbenzene)
3. Cyclohexene
4. Cyclopentene
5. Decalin (decahydronaphthalene)
6. Diacetylene (butadiene)
7. Dicyclopentadiene
8. Diethyl ether (ether)
9. Diethylene glycol dimethyl ether (diglyme)
10. Dioxane
11. Ethylene glycol dimethyl ether (glyme)
12. Ethylene glycol ether acetates
13. Ethylene glycol monoethers (cellosolves)
14. Furan
15. Methylacetylene
16. Methylcyclopentane
17. Methyl isobutyl ketone
18. Tetrahydrofuran (THF)
19. Tetralin (tetrahydronaphthalene)
20. Vinyl ethers

The following materials undergo peroxide initiated polymerisation and should be treated with caution if opened longer than 12 months. The risk increases if the materials are in liquid form.

1. Acrylonitrile
2. Butadiene
3. Chlorobutadiene
4. Chloroprene (2-chloro-1,3-butadiene)
5. Chlorotrifluoroethylene
6. Styrene
7. Tetrafluoroethylene
8. Vinyl acetate
9. Vinyl acetylene

10. Vinyl chloride
11. Vinyl pyridine

Common Organic Peroxide Forming Compounds

1. Acetal
2. Acetaldehyde diethyl acetal (acetal)
3. Acrylonitrile
4. Aldehydes
5. Butadiene
6. Chlorobutadiene
7. Chloroprene (2-chloro-1,3-butadiene)
8. Chlorotrifluoroethylene
9. Cumene (isopropylbenzene)
10. Cyclohexane
11. Cyclohexene
12. Cyclooctene
13. Cyclopentene
14. Decahydronaphthalene
15. Decalin (decahydronaphthalene)
16. Diacetylene (butadiene)
17. Dicyclopentadiene
18. Diethyl ether (ether)
19. Diethylene glycol
20. Diethylene glycol dimethyl ether (diglyme)
21. Diisopropyl ether (isopropyl ether)
22. Dimethyl ether
23. Dioxane
24. Divinylacetylene (DVA)
25. Ethers, especially cyclic ethers, and ethers containing primary and secondary alcohol groups.
26. Ethyl ether
27. Ethylene glycol dimethyl ether (glyme)
28. Ethylene glycol ether acetates

29. Ethylene glycol monoethers (cellosolves)
30. Furan
31. Isopropyl ether
32. Ketones, especially cyclic ketones
33. Methyl cyclopentane
34. Methyl isobutyl ketone
35. Methylacetylene
36. Methylcyclopentane
37. Methyl-isobutyl ketone
38. *p*-dioxane
39. Potassium amide
40. Potassium metal
41. Sodium amide (sodamide)
42. Styrene
43. Tetrafluoroethylene (TFE)
44. Tetrahydrofuran (THF)
45. Tetralin (tetrahydronaphthalene)
46. Vinyl acetate
47. Vinyl acetylene
48. Vinyl and vinylidene compounds
49. Vinyl chloride
50. Vinyl ethers
51. Vinyl pyridine
52. Vinylacetylene (MVA)
53. Vinylidene chloride (1,1-dichloroethylene)
54. Vinylpyridine
55. Compounds containing benzylic hydrogen atoms. Such compounds are especially susceptible to peroxide formation if the hydrogens are on tertiary carbon atoms, e.g., cumene (isopropyl benzene)
56. Compounds containing the allylic ($\text{CH}_2 = \text{CHCH}_2\text{R}$) structure, including most olefins and alkenes

10.1.7.2 Testing for the Formation of Peroxides

The formation of crystals within a container is indicative of peroxide formation; however this is not an absolute test. The following, details briefly some techniques available for testing for the presence of peroxides. These are intended as guidelines only.

The following tests will detect most (but not all) peroxy compounds and all hyperperoxides.

NOTE: These tests should not be used for testing materials potentially contaminated with inorganic peroxides (i.e., potassium).

Option 1. Add 1-3 ml of the liquid to be tested to an equal volume of acetic acid, add a few drops of 5% potassium iodide (KI) solution and shake. The appearance of a yellow to brown colour indicates the presence of peroxides.

Option 2. Addition of 1 ml of a freshly prepared 10% KI and 10 ml of an organic solution in a 25 ml glass cylinder should produce a yellow colour if peroxides are present.

Option 3. Add 0.5 ml of the liquid to be tested to a mixture of 1 ml of 10% KI solution and 0.5 ml of dilute hydrochloric acid to which a few drops of starch solution have been added just before the test. The presence of a blue-black colour within a minute indicates the presence of peroxides.

Option 4. Peroxide test strips that turn an indicative colour in the presence of peroxides. Care must be taken to follow manufacturer instructions for effective detection. In general, the strips must be air dried until the solvent evaporates and then exposed to moisture for proper operation.

From Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, 2011.

10.1.8 Handling Potentially Explosive Materials Safely

Some chemical agents used in the workplace may be at risk of generating an explosion if they are subject to certain environmental conditions or come into contact with incompatible materials. Some materials also become explosion risks if they are allowed to dry out or decompose.

Potentially explosive materials may (but not always) be labelled with an Explosive (GHS01) warning label and may exhibit one or more of the following Hazard Phrases:

- **EUH 001** Explosive when dry
- **EUH 018** In use may form flammable/explosive vapour-air mixture
- **EUH 019** May form explosive peroxide
- **EUH 044** Risk of explosion if heated under confinement
- **H200** Unstable Explosive
- **H201** Explosive; mass explosion Hazard
- **H202** Explosive; severe projection hazard
- **H203** Explosive; fire, blast or projection hazard
- **H204** Fire or projection hazard
- **H205** May mass explode in fire
- **H231** May react explosively even in the absence of air at elevated pressure and/or temperature
- **H240** Heating may cause an explosion
- **H241** Heating may cause a fire or explosion
- **H271** May cause fire or explosion; strong oxidizer
- **H280** Contains gas under pressure; may explode if heated

In addition to the general precautions for working with all chemicals outlined in 10.1 the following additional precautions should be taken when working with compounds that are potentially explosive:

- When handling any chemical agent its' *Safety Data Sheet* must be readily available for consultation to establish if the material is potentially explosive.
- All known explosive materials must be stored in a suitable manner away from incompatible materials.
- No more than one day's supply of explosive material should be stored at the bench.
- All containers holding potentially explosive materials must be clearly labelled as such.
- When potentially explosive materials are in use under environmental conditions that increase the risk from explosion then they must be held in a fume hood behind a protective screen.
- Chemicals that are known to become explosive risks when dry should be regularly inspected and where necessary wetted, e.g. picric acid.
- Chemicals that are known to become explosive after a period of time should be dated as to when they were opened and disposed of / stabilised before they become a risk.
- Keep all sources of ignition away from potentially explosive materials.

Table 2. Potentially Explosive Compounds

1-Diazo-2-naphthol-4-sulfonyl chloride	Barium styphnate
2-Diazo-1-naphthol-4-sulfonyl chloride	Bouin's Fixative
5-Mercaptotetrazol-1-acetic acid	Butyl tetryl
5-Nitrobenzotriazole	Calcium nitrate
Acetylides of heavy metals	Copper acetylide
Alkali metal dinitrophenolates (dry or containing less than 15 percent water, by mass)	Cyanuric triazide
Aluminum ophorite explosive	Cyclotetramethylenetetranitramine
Amatol	Cyclotrimethylenetrinitramine
Ammonal	Cyclotrimethylenetrinitramine
Ammonium perchlorate	Cylcotetramethylenetetranitramine
Ammonium nitrate	Deflagrating metal salts of aromatic nitro derivatives
Ammonium nitrate mixtures (containing more than 0.2 percent combustible substances)	Diazodinitrophenol (containing less than 40 percent water or a mixture of alcohol and water, by mass)
Ammonium nitrate-fuel oil mixture	Diethylene glycol dinitrate
Ammonium perchlorate	Dinitroethyleneurea
Ammonium picrate (dry or containing less than 10 percent water, by mass)	Dinitroglycerine
Ammonium salt lattice	Dinitroglycoluril (Dingu)
Azobisisobutyronitrile (AIBN)	Dinitrophenol (dry or containing less than 15 percent water, by mass)
Barium azide (dry or containing less than 50 percent water, by mass)	Dinitrophenyl hydrazine
Dinitrophenolates	Hexogen
Dinitroresorcinol (dry or containing less than 15 percent water, by mass)	Hexolite (dry or containing less than 15 percent water, by mass)
Dinitrosobenzene	Hollande's Fixative
Dinitrotoluene	Hydrazinium nitrate
Dipicryl sulfide (dry or containing less than 10 percent water, by mass)	Hydrazoic acid
Dipicryl sulfone	Lead azide (containing less than 20 percent water or a mixture of alcohol and water, by mass)

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Dipicrylamine	Lead mannite
Erythritol tetranitrate	Lead mononitroresorcinate
Fulminate of mercury	Lead picrate
Fulminating gold	Lead salts
Fulminating platinum	Lead styphnate (lead trinitroresorcinate) (containing less than 20 percent water or a mixture of alcohol and water, by mass)
Fulminating silver	Magnesium ophorite
Gelatinized nitrocellulose	Mannitol hexanitate (Nitromannite) (containing less than 40 percent water or mixture of alcohol and water, by mass)
Guanyl nitrosamino guanyl tetrazene	Mercury fulminate (containing less than 20 percent water or mixture of alcohol and water, by mass)
Guanyl nitrosamino guanylidene hydrazine	Mercury oxalate
Guanyl nitrosaminoguanilydene hydrazine (containing less than 30 percent water, by mass)	Mercury tartrate
Guanyl nitrosaminoguanilytetrazene (containing less than 30 percent water or a mixture of alcohol and water, by mass)	Mononitrotoluene
Heavy metal azides	N,N'-Dinitroso-N,N'-dimethylterephthalamide
Hexanite	N,N'-Dinitrosopentamethylenetetraamine
Hexanitrodiphenylamine (Dipicrylamine; Hexyl)	Nirtonium perchlorate
Hexanitrostilbene	Nitrated carbohydrate
Hexatonal	Nitrated glucoside
Nitrated polyhydric alcohol	Picryl chloride
Nitrocellulose (dry or containing less than 25 percent water or alcohol, by mass or plasticized with less than 18 percent plasticizing substance, by mass)	Polynitro aliphatic compounds
Nitrogen trichloride	Potassium nitroaminotetrazole
Nitrogen tri-iodide	RDX and HMX mixtures (containing less than 15 percent water, by mass or containing less than 10 percent of a suitable desensitizer, by mass)

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Nitroglycerin (containing less than 40 percent of a non-volatile water insoluble desensitizer, by mass or containing less than 90 percent alcohol, by mass)	Silver azide
Nitroglycide	Silver styphnate
Nitroglycol	Silver tetrazene
Nitroguanidine (Picrite) (dry or containing less than 20 percent water, by mass)	Sodatol
Nitroparaffins	Sodium amatol
Nitrosoguanidine	Sodium dinitro-o-cresolate (dry or containing less than 15 percent water, by mass)
Nitrostarch (dry or containing less than 20 percent water, by mass)	Sodium nitrate-potassium nitrate explosive mixture
Nitrotriazolone (NTO)	Sodium picramate (dry or containing less than 20 percent water, by mass)
Nitrourea	Sodium salts of aromatic nitro-derivatives
Octolite (Octol) (dry or containing less than 15 percent water, by mass)	Syphnic acid
Organic amine nitrates	Tetranitroaniline
Organic nitramines	Tetranitrocarbazole
Organic peroxides	Tetrazene
Pentolite (dry or containing less than 15 percent water, by mass)	Tetrazol-1-acetic acid
Picramide	Tetrytol
Picratol	Trinitroanisole
Picramic acid	Trimethylolethane
Picric acid-dry	Trimonite
Picryl flouride	Trinitroaniline (picramide)
Trinitroaphthalene	
Trinitrobenzene (dry or containing less than 30 percent water, by mass)	
Trinitrobenzenesulfonic acid	
Trinitrobenzoic acid (dry or containing less than 30 percent water, by mass)	
Trinitrocresol	
Trinitrochlorobenzene (picryl chloride)	
Trinitrofluorenone	

Trinitro-meta-cresol
Trinitronaphthalene
Trinitrophenetole
Trinitrophenol (picric acid) (dry or containing less than 30 percent water, by mass)
Trinitrophenylmethylnitramine (tetryl)
Trinitrophenolglucinol
Trinitroresorcinol
Trinitroresorcinol (styphnic acid) (dry or containing less than 20 percent water, or mixture of alcohol and water, by mass)
Trinitrotoluene (TNT) (dry or containing less than 30 percent water, by mass)
Tritonal
Urea nitrate (dry or containing less than 20 percent water, by mass)
Zirconium picramate (dry or containing less than 20 percent water, by mass)

10.1.9 Handling Compressed Gases Safely

Compressed gases pose a variety of hazards to users, but these can be broken down into three broad areas:

1. *Hazards from the pressurised nature of the cylinder*

Because cylinders are maintained under pressure any uncontrolled release of their contents can have catastrophic effects. Cylinders may take off at great speed, they may disintegrate, they may become extremely hot and the escaping gas may severely injure persons due to the pressure at which it is extruded.

2. *Hazards from the contents of the cylinder*

The contents of the cylinder also pose a hazard to safety. Flammable gases may burn; oxidising gases may promote combustion of other materials; inert gases may displace oxygen from the air reducing it to a level below that required to sustain human life; toxic or corrosive gases may cause severe injury; etc.

3. *Hazards from the size and shape of the cylinder*

Given the large size and heavy nature of many compressed gas cylinders incorrect handling of them poses a risk of manual handling injuries to handlers.

Persons working with compressed gases should implement the following general safety precautions:

10.1.9.1 Transport and Handling

- Cylinders must be handled carefully at all times. All persons handling cylinders must be trained in manual handling techniques.
- Cylinders must be transported using a suitably sized cylinder trolley. Cylinders should be properly secured in the trolley and trolleys should be pushed and not pulled.
- When manoeuvring gas cylinders into their final position a 'churning' motion must be used to safely remove the cylinders from the trolley and get them into position.
- Safety shoes and gloves must be worn when handling large compressed gas cylinders.
- If transporting gas cylinders in lifts then the following protocol should be followed:
 - Gas cylinders must not be accompanied in lift. A lift is a confined space and should leakages occur asphyxiation is possible.
 - One person should place the cylinder in the lift whilst another waits to receive it from the lift once the journey is complete.
 - There should be a clearly visible sign on the cylinder warning others not to enter the lift with the cylinder.
 - Where possible a goods lifts should be used.
- Persons must never attempt to catch a falling cylinder.
- Regulators must be removed before transporting cylinders, event for short distances.
- Cylinders must not be carried in passenger areas of vehicles. Cylinders should be carried in an open vehicle. Drivers should be aware that the transport of cylinders off the university site may be regulated by *Carriage of Dangerous Goods Regulations*. Further information is available from the University SIRC Office.

10.1.9.2 General Use

- Persons must never use compressed gases without receiving proper training.
- Always ensure that Safety Data Sheets are available for any gas in use in the laboratory.
- At a minimum; gloves, laboratory coat and safety glasses should be worn when working with compressed gases in the laboratory. Safety boots are required if moving cylinders.

- Do not locate cylinders on escape routes where they may pose a risk in an emergency situation.
- Always ensure that the regulator in use is suitable for the pressure contained within the cylinder. Check the pressure rating of the regulator and the indicated pressure within the cylinder.
- Ensure that the gas tubing is in good condition and is suitable for the gas, e.g. never use natural rubber tubing with O₂.
- Never lay cylinders on their side unless they are empty and are being stored prior to removal off site. Never lay acetylene cylinders on their side, even when empty.
- When using flammable gases remove potential sources of ignition from the laboratory wherever possible.
- Cylinders must always be securely fastened to the bench or a wall.
- Gas users must be aware of the cylinder valve thread direction to avoid damaging regulators.
- Avoid the use of PTFE tape, oils or greases to seal joints.
- Ideally, when not in use cylinders should be removed from the laboratory.
- Cylinders should not be used from the trolley when in the laboratory if possible.
- Cylinders must never be left freestanding for any length of time.
- The regulator should be closed / turned to zero before opening the cylinder valve at the spindle.
- Flammable / fuel gases such as Hydrogen or Methane must not be used or stored in the same area as Oxygen, unless separated by a distance of 3 metres or a fire-resistant wall.
- Correctly sized tools should be used when fitting regulators to ensure no damage to the fittings and a secure fit.
- During cylinder set up the Compressed Gas Set up Pre Use Safety Inspection should be undertaken (See below).
- A purpose designed leak detector fluid should be used to check for leaks around a regulator during initial set up and at regular intervals thereafter.
- Where possible toxic, flammable, corrosive and explosive gases should be used from as small a cylinder as possible in order to facilitate their positioning in fume hoods. Naked flames must not be used in areas where flammable gases are stored or used. Regulators and other fittings must be rated and suitable for the gas in use.
- Prior to introducing a flammable gas into a reaction vessel, the equipment must be purged of oxygen by evacuation or by flushing with inert gas at least three times.

- Areas in which compressed gases are in use must be adequately ventilated.
- Repairs to damaged regulators may only be undertaken by a competent service provider.
- When a cylinder is not in use the cylinder valve should be closed.
- Regulators must be serviced on a regular basis, as per the manufacturer's instructions. As a general rule an annual inspection with a five year replacement or reconditioning is recommended.
- The refilling of gas cylinders or the transfer of gases between cylinders by university personnel is prohibited.
- Cylinders must not be painted or have any of the neck markings covered or removed.
- Cylinders must not be vented or purged.
- Gas supply pipe lines from centrally located cylinders must be inspected on a regular basis for leaks.
- If necessary the use of gas alarms should be considered in areas where compressed gases are used or stored. Alarms for the detection of flammable gases or oxygen depletion alarms should be considered. Advice on same can be obtained from sirc@ucd.ie.

10.1.9.3 Storage

- Cylinders should be stored in well ventilated areas protected from the effects of weather and out of direct sunlight.
- When storing inert compressed gases an oxygen depletion assessment should be completed for the room – contact sirc@ucd.ie for advice on same.
- Full cylinders should be stored separately to empty cylinders.
- Empty cylinders should be returned to the supplier as soon as possible. Regular supplier delivery and collections should be made to ensure rapid turnover of used stock.
- The minimum number of cylinders possible should be kept in storage.
- Cylinders must be secured in an upright position.
- Gases should be segregated as outlined below.

Table 3. Common Laboratory Gases Segregation Requirements

SEPARATE	FROM	BY (MINIMUM) (METRES)
Inerts, oxidants, toxics and CO ₂	Flammables / LPG's	3*
Flammables	LPG's	3*

Toxics	Inerts, oxidants and CO ₂	1
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* or a fire resistance partition

10.1.9.4 Leak Response

- If the leak is small, attempt to close off the cylinder valve but do not endanger yourself. Eliminate all sources of ignition, ventilate and evacuate the laboratory.
- Beware of approaching a possible hydrogen leak, since the gas burns with an almost invisible flame - carry a rolled up sheet of paper in front of you to 'feel' for a flame.
- If the leak is large, evacuate the laboratory and sound the fire alarm by breaking a wall mounted red break glass unit (BGU).
- Following the large scale leakage of an asphyxiating gas *e.g.* nitrogen, argon, etc., do not re-enter the laboratory without permission.
- Be aware that gases can accumulate at floor or roof level without detection if leaks are small

10.1.9.5 Compressed Gas Set Up Pre Use Safety Inspection

1. Regulator Pre-use Safety Inspection

Remove regulator from cylinder and disconnect hoses

1. Check date coding not expired
2. Ensure that regulator is clean and free of contamination
3. Check that there is no physical damage to unit
4. Check that there is no damage or dirt in / on bullnose stem
5. Check that there is no damage or dirt in / on outlet connection
6. Check all pointers on gauges read zero
7. Ensure pressure adjusting screw turns freely
8. Ensure P.A. screw captive on regulator body

Connect Regulator to Cylinder and Open Cylinder Valve

9. Ensure inlet pressure steady (contents gauge) on cylinder
10. Do a leak test all around regulator

Close Cylinder Valve

11. Ensure inlet pressure steady

Close Needle Valve and Open Cylinder Valve, Turn P.A. Screw To 50% Of Maximum Operating Pressure (if no needle valve present go to Step 15)

12. Ensure outlet pressure gauges are steady

Close Cylinder Valve

13. Ensure all gauges are steady

14. Extend leak test up to needle valve.

2. Hose Pre-Use Safety Inspection

Free Hose

15. Check hose is clean and free of contamination

16. Ensure there are no kinks, restrictions or other damage

17. Ensure connections on both ends are undamaged

Connect Hose

18. Ensure connections on both ends are secure

Open Cylinder Valve

Open Needle Valve

19. Ensure all gauges are steady

20. Ensure all gauges are steady

21. Leak test both ends of hose

3. Gauge Pre-Use Safety Inspection

22. Ensure that all gauges are free from damage and that the protective casings or glasses are not cracked.

10.1.10 Cryogenic Safety

For information on the safe use of cryogenics please refer to the [UCD Guide To Liquid Nitrogen and Dry Ice](#) usage.

Table 4. Common Laboratory Gas Characteristics

GAS	CHARACTERISTICS	OLD CYLINDER COLOUR (BS349)	NEW CYLINDER COLOUR (EN 1089-3)	VALVE OUTLET THREAD DIRECTION*
Oxygen	<ul style="list-style-type: none"> ▪ No distinctive odour. ▪ Non toxic ▪ Does not burn but supports combustion making normally stable materials flammable. 	Black	Black with white shoulder	Right Hand
Acetylene	<ul style="list-style-type: none"> ▪ Distinctive garlic-like smell. ▪ Will ignite easily in the presence of an ignition source, e.g. spark, flame, hot surface, etc. ▪ Lighter than air therefore likely to accumulate in ceiling spaces. 	Maroon	Maroon	Left Hand
Argon	<ul style="list-style-type: none"> ▪ No distinctive odour. ▪ Non toxic ▪ Does not burn ▪ Simple asphyxiant 	Blue	Green	Right Hand
Nitrogen	<ul style="list-style-type: none"> ▪ No distinctive odour. ▪ Non toxic ▪ Does not burn ▪ Simple asphyxiant 	Grey with black shoulder	Grey with black shoulder	Right Hand
Carbon dioxide	<ul style="list-style-type: none"> ▪ No distinctive odour, but may 'sting' nose. ▪ Toxic ▪ Does not burn 	Black or black with two vertical white lines	Black or black with two vertical white lines with grey shoulder	Right Hand
Hydrogen	<ul style="list-style-type: none"> ▪ No distinctive odour ▪ Highly flammable 	Red	Red	Left Hand

* Valve outlet threads for flammable gases are screwed left-hand (anti-clockwise to tighten). Valve outlets for non-flammable gases are screwed right-hand (clockwise to tighten). All valves are opened in the same manner (opened by turning anti-clockwise, closed by turning clockwise).

11.0 Chemical Waste Disposal

It is vitally important that all waste produced by university laboratories is disposed of in a safe and legally compliant manner. Failure to dispose of waste in accordance with legal requirements can lead to the prosecution of both the university and the individual concerned.

Waste materials are divided into two basic types, hazardous and non-hazardous. The term is used to assess a material's ability to damage the environment, and is not related to its potential impact on human health, e.g. waste electronic goods are considered to be a hazardous waste, yet represent no health risk to humans. As a rule the following should be considered as hazardous wastes:

- Any material contaminated or potentially contaminated with an infectious agent (unless it has been suitably treated to eliminate the infectious agent)
- All human tissues, blood and related swabs and wipes from hospitals or laboratories
- Animal carcasses and dressings from veterinary hospitals / practices
- Microbiological cultures
- Potentially infected waste from pathology or research labs
- Most chemical wastes
- Most electrical wastes
- Contaminated sharps
- Empty unclean containers, the previous contents of which are deemed to be hazardous wastes
- All radioactive wastes

If there is any confusion as to whether a waste material is hazardous or not, an assessment of what constitutes a hazardous or non-hazardous waste must be left to a specialist.

All waste must be disposed of via a licensed contractor who is approved for the transport and disposal of the types of waste being handled. Failure to do so may leave the university at risk of prosecution.

11.1 Chemical Wastes

Almost all chemical waste is hazardous. The cost of chemical waste disposal should be considered when purchasing a chemical for use. Some chemicals are particularly expensive to dispose of, e.g. temperature sensitive compounds.

General advice for dealing with chemical wastes:

- Do not buy chemicals in bulk if you do not need to.
- Chemical waste should be disposed of promptly and on a regular basis.
- Chemical waste should not be allowed to accumulate. Research students must not leave 'waste legacies' behind them.
- Different types of chemical wastes should be segregated where the opportunity arises, e.g. do not mix halogenated with non halogenated solvents if you can avoid it; always separate mercury containing wastes from all other wastes. Do not mix chemical wastes indiscriminately, it can make disposal difficult. Do not mix incompatible wastes together.
- All chemical waste containers must be clearly labelled as to their contents; the use of expressions such as 'waste solvents' is not sufficient. Waste labels should also be renewed as appropriate as they may become torn or unreadable over time. Waste containers should also be labelled with the date of filling and the name of the producer and / or the laboratory where the waste originated if possible.
- Where appropriate similar chemicals should be bulked-up into larger containers e.g. bulk compatible waste solvents into 200l drums if possible.
- Researchers must ensure that all 'products' of research are properly labelled and their properties are fully understood and recorded
- All persons should be aware of the potential for chemical waste materials to become unstable if left for long periods, e.g. picric acid; 2,4-dinitrophenol; isopropyl ether.
- Chemical waste must always be stored in a safe manner commensurate with its properties.

Almost all chemical wastes will have to be disposed of via a licensed hazardous waste disposal operator. Some agents may be suitable for treatment on site to render them non-hazardous thus allowing them to be sent for disposal as non-hazardous wastes. The recycling of chemical wastes on site should always be considered where appropriate.

11.2 Empty Chemical Containers

Containers which have been in direct contact with chemical agents e.g. Winchesters, are considered to be a hazardous waste and must be disposed of as if they were full. However if such containers are 'triple rinsed' when empty and all warning labels are removed they may then be classed as clean and container sent for recycling / disposal. The washings generated by this process may be suitable for running down the sink or may require off-site disposal – further information is available from the *University SIRC Office*. Prior approval must be obtained before running any material down a sink.

Over packs that have not come into direct contact with a chemical agent directly can be disposed of through the non-hazardous waste route, as long as any chemical names and labels have been blanked off the pack and are unreadable.

11.3 Non Hazardous Wastes

Non-hazardous wastes are 'normal' type wastes which are not contaminated with any biological, chemical or radioactive material. Items such as paper towels, tissues, food waste, etc. which does not look like 'laboratory waste' should be sent for recycling or placed into a bin with other general wastes. It is good practice to locate bins for non-hazardous wastes outside of laboratories and to use clear plastic bags so that the contents can be easily seen and confirmed as non-hazardous prior to disposal.

Non contaminated 'laboratory type' waste, such as plastic pipettes, plastic vials, gloves, etc. whilst not hazardous waste, should be placed into a designated bin within the laboratory and disposed of using a licensed waste disposal operator who is aware of the nature of the waste. These items should not be placed into a non-hazardous waste stream as they can cause confusion if they appear at a landfill or recycling facility.

12.0 Chemical Emergency Response Procedures

12.1 Fire

There are a number of precautions that can be taken to guard against the outbreak of fire in the laboratory:

- Always conduct exothermic reactions with care.
- No more than one day's supply of any flammable material should be stored at the bench or outside of a designated flammables cabinet.
- Store all flammables in a designated flammables cabinet when not in use.
- Ensure that all chemicals are stored in such a way as to minimise the risk of incompatibles mixing.
- Great care must be taken when working with pyrophoric (air sensitive), self-reacting or chemicals which release flammable gases in contact with water.
- When working with flammables as many potential sources of ignition as possible must be removed from the immediate area.
- Flammable liquids must not be heated to a temperature greater than their flashpoints.
- Liquids should be heated in glass / Pyrex vessels only.
- Vessels to be heated over gas burners must be securely positioned on tripods or similar.
- If the heating of liquids is likely to release hazardous vapours then the process must be carried out in a fume hood.
- Flammable materials in use on the bench must be kept in covered containers and at a distance at least 30cm from any naked flames.
- Containers for flammable liquids in use on the bench when naked flames are in use must not contain more than 50ml of the liquid.
- If using a naked flame to sterilise equipment previously dipped in alcohol the excess alcohol must be allowed to run off the equipment prior to inserting it into the flame.
- Heated containers must not be handled until they are sufficiently cooled.
- Ensure that you know the location of the nearest fire extinguisher and fire alarm activation point to your working area.
- Adhere to good housekeeping practises in the laboratory and do not allow combustible materials to build up in your working area.

12.1.1 Gas burners / Naked Flame Use

- Long hair must be tied back and if possible cosmetic products (e.g. hair gels) should not be worn in the hair when working with naked flames.
- Prior to using Bunsen burners the gas tubing must be checked for damage and the ends must be securely fixed onto the gas tap and the burner inlet. Damaged tubing must be removed from service immediately.
- Lit burners must not be left unattended. They must be turned off before leaving the laboratory or moving to another area of the laboratory.
- Gas flames may not be visible in strong sunlight, if required lights should be dimmed or blinds closed to make the flame more visible.
- When not in use the flame on a Bunsen burner must be turned to the pilot (yellow) flame setting.
- Be aware that it may take a relatively long time for a gas burner to cool down when turned off. Always leave in a safe area or label appropriately to warn others in the laboratory that the unit may still be hot. Always handle Bunsen burners by the base and not the neck.
- Ensure when in use Bunsen burners are a sufficient distance from the gas supply points so that melting of the gas supply point is not possible.
- Always ensure that when in use Bunsen burners are not in a position to ignite their gas supply lines.
- Gas burners utilising gas cylinders must be fitted with an appropriately rated cylinder and fastened properly to the cylinder. Empty gas cylinders must be disposed of properly

12.1.2 Fire Response

In the event that a fire starts in the laboratory:

- Activate the fire alarm by breaking a wall mounted red fire alarm activation point before fighting the fire.
- Be aware that many chemicals give off toxic fumes under fire conditions.
- If it safe to do so and if you have been trained to do you may fight the fire.
- If your clothing catches fire, drop to the floor and roll to smother the fire. If a co-worker's clothing catches fire, knock the person to the floor and roll him or her to smother the flames. If possible cover them in a fire blanket. Use a safety shower immediately thereafter if available.
- Always use a compatible fire extinguishing media for fighting chemical fires – refer to relevant SDS. In general a dry powder fire extinguisher (red cylinder with a blue label) is the best general option for fighting chemical fires.

- Do not use water, foam or carbon dioxide to fight a chemical fire unless you are sure that these extinguishants are compatible with the chemical on fire.
- When fighting any fire always ensure that you have a safe means of exiting the laboratory – never let the fire get between you and the door.
- In the event that the fire appears to be too large to fight or gets out of control exit the area and shut all doors.
- Evacuate the building by the quickest route – follow the *Green Man Running Signs*.
- Do not use the lift.
- Report to the building fire marshals and services personnel outside of the building.
- Do not re-enter the building until told it is safe to do so.

In the event that you hear the fire alarm:

- Where safe to do so turn off all laboratory equipment (except fume hoods).
- In so far as is possible make any live experiments safe.
- Exit the area and shut all doors.
- Do not linger to gather personal belongings.
- Evacuate the building by the quickest route – follow the *Green Man Running Signs*.
- Do not use the lift.
- Report to the building fire marshals and services personnel outside of the building.
- Do not re-enter the building until told it is safe to do so.

12.2 Chemical Spills

Every building in which large amounts of chemicals are handled should have access to chemical spill kits. At a minimum such spill kits should contain:

- Absorbent booms or 'pig socks'
- Absorbent pads
- Dry absorbent material
- Brush and pan
- General purpose broad range disposable mask
- Heavy duty gloves
- Safety glasses
- Waste Bag / Empty Container

In the case of a spill or leak the following procedure should be followed:

- In the event that a chemical is spilled or is discovered to have leaked then all persons should be verbally requested to leave the affected area immediately.
- Where possible windows should be opened but all doors shut be kept closed.
- If the spilled material is flammable all possible sources of ignition, including electrical appliances should be turned off if safe to do so.
- The SDS for the chemical concerned should be consulted before dealing with the spillage and the information contained therein utilised to ensure a safe clean-up response.
- For large spills (>10 litres / kgs) contact the UCD Emergency line on 7999.
- In the event that the spillage is deemed safe to deal with a spill kit should be obtained.
- Suitable personal protective equipment should be donned by the persons dealing with the spillage. At the very least safety glasses, gloves and a lab coat should be worn. All spills must be attended by at least two persons.
- The source of the leak should be ascertained and if possible and safe to do so closed or sealed. Any damaged containers should be removed and repackaged if possible.
- In the event of liquid spills adsorbent pads or vermiculite should be spread over the spilled material until it is covered. If necessary absorbent booms should be used to prevent the spillage spreading further.
- Using a dust pan and brush the spilled material along with the absorbent material should be collected and placed into the bag / container contained within the spill kit.
- In the event of the spillage of a solid material the material should be collected using a dust pan and brush and placed into the bag / container contained within the spill kit.
- All wastes and all contaminated items generated by spillages must be disposed of in a suitable manner.
- When dealing with spillages the inhalation of large amounts of vapour should be avoided. In the event that a large amount of material is spilled then specialist assistance may be required. Respiratory protection may be required when dealing with large spillages. Persons must note that non air fed respiratory protection is not a substitute for decreased oxygen levels.
- Some chemicals require specialist responses, e.g. elemental mercury, cyanides, strong acids, etc. Reference should be made to a material's SDS before it is used in the laboratory for the first time and if required any recommended specialist spill response equipment should be sourced and held in a suitable location.

12.3 First Aid Following Chemical Exposure

The following are general guidelines for treating exposures to chemical agents. Some agents require specialist first aid responses, e.g. hydrofluoric acid, cyanides, etc. Reference should be made to a material's SDS before it is used for the first time and if required any specialist first aid equipment should be sourced and held in a suitable location and any unusual first aid responses should be noted.

Inhalation

- Following exposure to a solvent vapour affected persons should be removed from the source of exposure to fresh air.
- At no time should persons place themselves at risk when trying to remove affected persons from the source exposure.
- If breathing stops then artificial respiration should be administered – note this may not be possible if corrosive or toxic materials are on the lips or in the mouth.
- If available oxygen may also be administered.
- Any exposure which results in vomiting or unconsciousness must be referred to a medical practitioner.

Skin Contact

- Remove any contaminated clothing and wash (not scrub) the skin with soapy water.
- If required utilise an emergency shower if one is available.
- If the skin blisters or becomes reddened then seek medical advice.

Eye Contact

- Wash out eyes with copious amounts of fresh water and seek medical advice.

Ingestion

- Refer to the specific SDS. Always seek medical advice.

For further information contact the Poisons Information Centre. Telephone 01-837 9964 / 01-809 2566

If seeking medical advice after a chemical exposure, ensure that the patient has in their possession a copy of the relevant SDS.

13.0 Use and Selection of Personal Protective Equipment

Whilst the use of Personal Protective Equipment (PPE) is not a substitute for safe working practices in the laboratory it does play a key part in protecting workers against exposure to chemical agents. The selection of suitable PPE must be based upon the hazards that one is trying to protect oneself from.

13.1 Safety Glasses / Eye Protection

- Safety glasses must be worn at all times in the laboratory. Where necessary the use of a full face shield should be considered.
- Safety glasses must have integral side protection.
- Standard prescription glasses are not suitable as safety glasses.
- Contact lenses do not offer any eye protection.
- If you wear prescription glasses then they must be covered with over-glasses. Alternately prescription safety glasses should be worn.
- If damaged in any way safety glasses must be replaced
- Never leave eyewear lying about on benches where they may get damaged. Put them in safe place when not in use
- Safety glasses provide minimal protection against significant splashing; in such instances safety goggles should be worn.

13.2 Respiratory Equipment

There are two major types of respiratory protection. These are masks which 'filter' or 'absorb' airborne contaminants from the air inhaled by the wearer; and masks which provide a pumped supply of clean air to the user. In a laboratory setting respiratory protection should not be required under normal circumstances. It may however be required during spill clean-up following a leak of hazardous material. Where filter type masks are in use the filter / mask must be rated for the airborne contaminant in question, e.g. corrosive; organic; inorganic; particulate, etc. It must be remembered that filter type masks offer no protection against atmospheres with low ambient oxygen levels. Users of respiratory protection will require a 'fit test' to ensure that the mask worn is providing a seal around its edge. Respiratory protection must always be used as a last resort in handling chemical agents. The wearing of any respiratory protection in a laboratory setting must be discussed with the SIRC Office.

13.3 Laboratory Coats

Laboratory coats offer little protection against chemical hazards but they do stop contamination of the wearers' normal clothing with chemical agents. Therefore laboratory coats should be worn at all

times in the chemical laboratory. When worn, coats should be closed. Coats should be laundered on a regular basis and be disposed of when heavily contaminated.

13.4 Gloves

When handling chemical agents it is vitally important that gloves which are resistant to the chemical(s) being handled are worn. The selection of suitable gloves must be based on the information contained within the any relevant Safety Data Sheets and the nature of the exposure to the chemical agent. Gloves are very often the most important personal protective equipment that you can wear when handling chemical agents. There is no protective glove that is impermeable or resistant to all chemical agents. No one material affords protection against all chemicals. For certain chemicals there are no materials that will protect for more than a short period of time after initial contact.

The breakthrough time of gloves following exposure to a chemical agent must be considered. This is the length of time that a glove will provide protection to the wearer following contamination with a specific chemical. As a rule disposable gloves should only be worn once and disposed of after heavy or prolonged contamination. If in doubt as to a gloves suitability for a particular chemical, refer to any relevant Safety Data Sheets, and if necessary the glove manufacturer.

General guidelines on glove selection are given below.

- **Butyl Rubber:** Good for many organics, ketones, esters. Poor for aliphatic, aromatic hydrocarbons, halogenated hydrocarbons, petrol.
- **Natural (Latex) Rubber:** Good for very dilute acids and bases. Poor for organics.
- **Neoprene:** Good for acids and bases, peroxides, fuels, hydrocarbons, alcohols, phenols. Poor for halogenated and aromatic hydrocarbons.
- **PVC:** Good for acids and bases, some organics, amines, and peroxides. Poor for most organics
- **Nitrile:** Good for wide variety of solvents, oils, greases, some acids and bases.

There are also a number of specialist gloves produced by a range of manufacturers that may be suitable for particular chemical agents.

Users should note that latex gloves present a risk of irritation, allergic reaction or sensitisation which, for susceptible individuals, can be significant. The latex protein can leach out of the gloves into the user's skin, or into the glove powdering, if powdered gloves are used. This can lead to allergic skin reaction or a potentially more serious reaction if latex protein-contaminated powder is released into

the environment and breathed in. The use of any sort of latex gloves should be considered carefully, and they should only be used when no other glove is appropriate. You are strongly advised not to use powdered latex gloves.

More specific guidelines on glove selection can be obtained online or from glove manufacturers.

13.4.1 Safe Glove Removal



14.0 Controlling Chemical Exposure

14.1 Hierarchy of Chemical Control Measures

- Prohibition on chemical use.
- Replacement with a less hazardous chemical, e.g. using toluene instead of benzene.
- Limitation on use of the agent, e.g. prohibit use by undergraduates.
- Limitation on number of employees exposed, or likely to be exposed.
- The use of engineering controls, e.g. fume hoods.
- Protective measures involving the application of safe working procedures and methods, e.g. written method statements and standard operational procedures
- Collective protective measures, e.g. whole room exhaust ventilation.
- Individual protective measures where exposure cannot be avoided by other means, i.e. personal protective equipment.
- Hygiene measures
- Use of warning signs and symbols.

There are three general ways in which exposure to chemical agents can be controlled in the chemical laboratory. These are:

1. Engineering Controls
2. Personal Protective Equipment
3. Safe Systems Of Work / Administrative Controls

A combination of these controls can be used to minimise a users' exposure to a chemical agent.

14.2 Engineering Controls

14.2.1 Fume Hoods

In the chemical laboratory the chief engineering control measure that can be used to control user exposure to chemical agents is the use of fume hoods. Fume hoods isolate chemical agents in a chamber under negative pressure from which the air is actively extracted thus containing any emissions from chemicals contained therein. If used correctly fume hoods provide a significant degree of protection to the user and to persons in the laboratory.

Fume hoods should always be used when working with carcinogenic, mutagenic and high toxic agents unless there is minimal risk of worker exposure from the process concerned. Hoods should always be used where there is a likelihood that airborne contaminants will be released during a chemical process involving any chemicals unless the amount of material released is considered not to represent a risk to the safety of persons in the laboratory.

For fume hoods to work efficiently there are a number of measures that must be adhered to:

- Every fume hood must be checked on an annual basis to ensure that it is functioning correctly.
- Material held in a hood should be located towards the rear of the working surface. Materials held at the front of the working surface can reduce the efficiency of the hood.
- The sash should be kept as low as possible when the hood is in use and should be completely closed when the hood is unattended.
- Arm movements in the hood should be kept to a minimum.
- Air extracts should not be blocked or covered.
- Do not use the hood as storage cabinet.
- Minimise air flow across the front of the hood by ensuring any adjacent doors and windows are kept closed when the hood is in use and that persons do not walk in front of the hood when it is being used.
- Clean all chemical residues and spillages from the hood immediately.
- Ensure that the hood is rated for the types of chemicals and processes being carried out therein.

A standard fume hood is not designed for:

- Containing particulates
- Gas or vapours released under pressure
- Explosions
- Perchloric or fuming acids
- Micro organisms

14.2.2 Snorkels

Some university laboratories contain moveable exhaust 'snorkels' which can be positioned over chemicals to extract any fumes or vapours. Snorkels are suitable for use with low risk chemicals, but must never be used for protection against carcinogens, mutagens or very toxic materials. Advice on their usage can be obtained from sirc@ucd.ie.

14.2.3 Other Engineering Controls

In some instances other engineering controls are available to reduce exposure to chemical agents. These include the use of sealed systems and whole room ventilation. However in a normal laboratory setting the fume hood remains the standard engineering control measure

14.4 Personal Protective Equipment

Whilst the use of Personal Protective Equipment (PPE) is not a substitute for safe working practices in the laboratory it does play a key part in protecting workers against exposure to chemical agents. The selection of suitable PPE must be based upon the hazards that one is trying to protect oneself from. Using PPE doesn't eliminate the hazards posed by chemical, it only helps to reduce the risk from that chemical. Unlike engineering controls PPE does not offer protection to all persons in the laboratory, it only affords protection to the wearer. This should be borne in mind when deciding on the exposure control measures to be implemented in the busy laboratory.

The use and selection of PPE is discussed further in section 13.0 above.

14.5 Safe Systems of Work / Administrative Controls

The use of safe systems of work and administrative controls are key to ensuring that persons using chemical agents are not exposed to unsafe levels of those chemicals and that the use of chemicals does not give rise to any additional hazards in the laboratory, e.g. fire, explosion. Etc.

Safe systems of work / administrative controls include such things as:

- The prohibition on the use of high risk chemicals in the laboratory. Some chemicals may be deemed just too hazardous for use.
- The substitution of hazardous chemicals with less hazardous chemicals e.g. using toluene instead of benzene.
- Restriction on the use of high risks chemicals by certain individuals e.g. undergraduate students.
- Designing work processes so as to minimise the potential for user contact with hazardous agents.
- The restriction of processes to certain laboratories and times of the day, e.g. dedicating one lab for HF work; only allowing the use of hazardous chemicals when the laboratory is not operating at full capacity, etc.
- The use of 'wet' methods to reduce the generation of dusts.
- The use of engineering controls when required.

- The selection and use of appropriate personal protective equipment.
- Monitoring users' exposure to chemical agents if required through occupational hygiene studies and / or health surveillance.
- Monitoring health status of chemical users to identify person unsuited for working with certain chemicals and to identify persons exhibiting potentially adverse reactions to chemical exposure.
- Ensuring the preparation and testing of laboratory emergency response plans.
- The provision of appropriate equipment for the safe use of chemical agents.
- The provision of appropriate safety equipment, e.g. fire extinguishers.
- The carrying out of risk assessment for the use of all chemical agents / processes involving chemicals.
- Ensuring that all persons in the laboratory have received an appropriate level of training such that they can carry out their work without risk to their own or any other person's safety.
- Placing strict restrictions on the types of work involving chemical agents that can be carried out when persons are working alone or 'out of hours'.
- The use of *Unattended Experiment Forms* when leaving experiments unattended.
- Ensuring that the minimum amount of a chemical agents as possible is used for each process.
- Ensuring that the duration and intensity of any exposure to a chemical agent is reduced to as low a level as possible.
- Reducing the potential number of persons that could be exposed to a chemical agent to as low a level as possible.
- Ensuring that the equipment in use is not contributing to the risk from the chemical agent.
- Implementing strict hygiene and housekeeping controls in the laboratory.
- Ensuring that all chemical agents are stored and transported within the laboratory in a safe manner.
- Using warning signage when required, e.g. by warning of the presence of teratogens in a lab at the door do that pregnant females do not enter the lab unaware of the hazard contained therein.
- Strict demarcation of the working area.
- Access to Safety Data Sheets.

15.0 Safety Legislation

15.1 Individual Responsibilities Under Legislation

Regulation 80(1) of the [Safety, Health and Welfare At Work Act 2005](#) states that *'Where an offence under any of the relevant statutory provisions has been committed by an undertaking and the doing of the acts that constituted the offence has been authorised, or consented to by, or is attributable to connivance or neglect on the part of, a person, being a director, manager or other similar officer of the undertaking, or a person who purports to act in any such capacity, that person as well as the undertaking shall be guilty of an offence and shall be liable to be proceeded against and punished as if he or she were guilty of the first-mentioned offence.'* **Consequently there is a significant legal liability placed upon all managers or persons who act as managers to ensure that all operations under their control are carried out safely.**

All staff and students of the University are reminded that the failure to adhere to the statutory duties placed upon them by relevant safety legislation may be used by the enforcing authorities in the event of a prosecution.

15.2 Chemical Agents Regulations and Risk Assessment

Various regulations apply where hazardous chemical agents are present in the workplace. All employers have a duty to protect the safety of any persons who may be affected by hazardous substances whilst at work and to carry out a written **Chemical Agents Risk Assessment** for the use of said chemical agents.

The purpose of this risk assessment is to identify the hazards associated with using the chemical agent and to outline **risk reduction measures** designed to reduce the risk from the chemical to as low a level as possible.

When assessing the risk from a chemical agent consideration must be taken of:

1. Its hazardous properties.
2. Data provided by the supplier (SDS).
3. The level, type and duration of exposure.
4. The circumstances of use and the amount of material used in the workplace.

All risk assessments must be in writing and must be reviewed as and when required.

Any new activity involving hazardous chemical agents must not commence until after an assessment of the risk has been made and the control measures identified in the risk assessment have been implemented.

The legislation requires that the following be considered when identifying risk reduction measures for the use of chemical agents:

- The elimination of hazardous agents from the workplace, or where this is not possible the substitution of hazardous agents with less hazardous ones.
- The design of work processes, engineering control measures and the use of adequate equipment and materials so as to avoid or minimise the release of hazardous chemical agents into the place of work.
- The use of appropriate systems for the extraction of hazardous chemical agents at source.
- The design and organisation of safe systems of work.
- The provision of suitable and safe equipment including personal protective equipment.
- Where exposure cannot be prevented by other means the application of individual protective measures including personal protective equipment in addition to the measures specified above.
- The implementation of measures designed to reduce to a minimum the number of persons exposed or likely to be exposed to a chemical agent.
- The putting in place of appropriate hygiene measures, including washing facilities.
- Reducing the quantity of chemicals used to the minimum required for the type of work concerned.
- The putting in place suitable working procedures, including arrangements for the safe handling, storage and transport of hazardous chemical agents and wastes containing such hazardous chemical agents.
- The measurement of personal exposure to hazardous chemical agents if deemed necessary. Exposure to a chemical agent must not exceed the limits as laid down in the most recent *Code of Practice for the Chemical Agents Regulations*. Advice in this area can be obtained from the University SIRC Office.
- Avoidance of the presence of ignition sources which could give rise to fires.
- The drawing up an emergency plan to be put into effect in the event of an accident, incident or emergency related to the presence of hazardous chemical agents in the workplace.
- The provision of training and provision of information to relevant persons.
- Access to safety data sheets.
- The use of health surveillance where deemed necessary.

Under health and safety regulations all employees must cooperate with their employer and make full and proper use of any control measure, personal protective equipment or other item provided for their safety. The University considers all postgraduate students to be employees for the purposes of health and safety management and expects them to cooperate in all matters of health and safety in the University.

15.3 Carcinogen Regulations

These regulations apply to the use of carcinogens and mutagens in the workplace. As with the above regulations they require that a risk assessment be carried out on the use of carcinogens or mutagens in the workplace, i.e. **Carcinogen Risk Assessment**. In addition to the risk reduction measures outlined above for non-carcinogenic chemical agents the following additional items must be considered when carrying out a Carcinogen Risk Assessment:

- The avoidance of the use of carcinogens and mutagens when possible.
- The demarcation of risk areas and the use of adequate warning and safety signs.
- The use of sealed and clearly labelled containers for the transport and storage of carcinogens and mutagens.
- The reduction of exposure to carcinogens and mutagens to as low a level as is technically possible.

A written justification for the use of a carcinogen or a mutagen must be outlined in the risk assessment / be available in the laboratory

15.4 Pregnant Employee Regulations

All employees are strongly advised to inform their manager / supervisor when they become pregnant. Their employer, under these regulations, is then required to carry out a **Pregnant Employee Risk Assessment**. This is particularly important in situations where persons are working with hazardous materials. This requirement also applies to employees who are breastfeeding.

The function of the Pregnant Employee Risk Assessment is to ensure that the activities as carried out by the pregnant employee do not pose a risk to her own safety, her unborn child's safety or any breastfed child's safety.

Where the risk assessment carried out reveals a risk to the pregnant employee's safety or health, or any possible effect on the pregnancy or breastfeeding of an employee, and it is not practicable to ensure the safety or health of the employee through protective or preventative measures, the

employer must then adjust the working conditions or the working hours (or both) of the employee concerned so that exposure to such risk is avoided. If this is not possible, alternative suitable duties must be provided.

The risk assessment should be carried out as soon as possible after the member of staff informs the employer that she is pregnant. It is the responsibility of the Head of School / Unit to arrange for the risk assessment to be carried out by notifying the SIRC Office (email sirc@ucd.ie).

16.0 Chemical Agents Risk Assessment

The ultimate aim of a *Chemical Agents Risk Assessment* is to assess the risk from the use / presence of a chemical agent in the workplace to the health and safety of persons and to identify control measures designed to reduce the risk to as low a level as possible.

'Hazard' is defined as something with the potential to cause harm. In the case of chemical agents the chemical agent itself represents the hazard.

'Risk' is defined as the potential of the hazard (chemical agent) to cause harm under the actual circumstances of use / operation.

The assessment of the risk from any hazard / chemical agent is based on the linkage between the probability of occurrence of a negative event involving that chemical with the severity of injury or material loss resultant from that occurrence.

Risk assessments must be completed for all chemical agents in use prior to those agents being used for the first time and for all workplace activities where there is a risk of exposure to chemical agents. When carrying out the risk assessment in the case of activities involving potential exposure to several types of chemical agent then the danger presented by all hazardous agents present must be considered.

Risk assessments must be completed by a competent person. That person must have sufficient knowledge and experience to identify and classify the hazards associated with chemical agents and also how to reduce the risks from these hazards.

Risk assessments must be reviewed on a regular basis (it is recommended that *Chemical Agents Risk Assessments* are reviewed at least annually) and when changes in work practices necessitate it. Written copies of the most up to date risk assessment must be maintained in the workplace and if deemed necessary extracts should be displayed prominently in or adjacent to the areas to which they refer. All risk assessments should be dated and signed.

When conducting a risk assessment control measures for reducing the risk from chemical agents should be identified and the residual risk from the chemicals following the implementation of these control measures assessed.

Traditionally in *University College Dublin* the risk assessment matrix below (Table) has been used to assess risk from workplace hazards.

Table 7. Risk Assessment Matrix

		Severity of Outcome of Exposure		
		Slightly Harmful	Harmful	Very Harmful
Probability of Exposure	Unlikely	Trivial	Acceptable	Moderate
	Likely	Acceptable	Moderate	Substantial
	Very Likely	Moderate	Substantial	Intolerable

Probability is determined based on an assessment on how likely it is that an adverse event related to the hazard concerned will occur. Probabilities are graded as:

1. *Unlikely*: the adverse event being considered will occur only rarely.
2. *Likely*: the adverse event being considered will occur on a frequent basis
3. *Very Likely*: the adverse event being considered is almost certain to occur

Severity is based on the degree of personal injury or damage to property likely to occur in the event that the adverse event occurs. Severity of outcome is graded as:

1. *Slightly Harmful*: e.g. superficial injuries; minor cuts and bruises; nuisance and irritation; temporary discomfort; minor infection; minor material damage.
2. *Harmful*: e.g. lacerations; burns; concussion; sprains; minor fractures; dermatitis (temporary); asthma (temporary); long term discomfort; infection requiring medical treatment; significant material damage.
3. *Very Harmful*: e.g. fatality; amputation; major fracture; severe poisoning; cancer; life shortening condition / disease; deafness; head injuries; eye injuries; substantial material damage.

Risk assessments are thus **Risk Rated** graded as trivial risk, acceptable risk, moderate risk, substantial risk or intolerable risk.

- *Trivial Risk*: No further action required.
- *Acceptable Risk*: No additional risk control / reduction measures required
- *Moderate Risk*: Further risk control / reduction measures should be considered and implemented where possible. Hazards graded as Moderate Risk must be closely managed.
- *Substantial Risk*: Further risk control / reduction measures must be identified. If the risk cannot be reduced further then the hazard must be strictly managed and the frequency and duration of the hazard must be reduced to as low a level as practicable along with the number of persons exposed to the hazard.
- *Intolerable Risk*: All work must be prohibited until further control measures are implemented

16.1 Completing a Chemical Agents Risk Assessment

In order to complete either template SDS for every chemical under review along with this document should be available for consultation.

Staff and postgraduates have options when completing a risk assessment:

1. Use and amend risk assessments available from [UCD SIRC Office](#)
2. Use the chemical agents risk assessment template available from [UCD SIRC Office](#)
3. Use their own designed template / form

17.0 Contact Information and Useful Documents

[UCD SIRC Office Website](#)

[UCD Chemical Agents Risk Assessment Template](#)

[UCD Chemical Risk Assessments \(Completed\)](#)

[UCD Chemical Spill / Emergency Response Poster](#)

[UCD Liquid Nitrogen & Dry Ice Safety Guide](#)

[UCD Guide to the Safe Use of HF](#)

[UCD Gas Release Calculator](#)

Classification, Labelling and Packaging Information

[Classification, labelling and packaging legislation – I.S. 196 2015](#)

[CLP Hazard Phrases](#)

[CLP Precautionary Phrases](#)

Additional Information

[Chemical Reactivity Worksheet](#)

[International Agency for Research or Cancer \(IARC\)](#)