

Safe Storage of Hazardous and Dangerous Substances in Stockrooms, Workshops and Laboratories

1. Introduction:

This guidance is for those responsible for the storage of hazardous and dangerous substances. If you seek guidance on risk assessing the use of hazardous or dangerous substances, please refer to the [Control of Substances Hazardous to Health \(COSHH\)](#) or the [Dangerous Substances and Explosive Atmospheres \(DSEAR\) Assessment Guidance](#).

The correct storage of hazardous and dangerous substances is critical to ensure the health and safety of all who may be directly or indirectly exposed. Poor storage practices can result in fire/explosion and the production of toxic vapours through the reactions of incompatible substances.

All substances should be stored in such a manner as to prevent incompatible substances from being accidentally mixed together in the event of the breakage of one or more containers in the storage area, or to prevent the formation and build-up of reactive vapours. The correct storage requirements of substances within storage areas / stock rooms, workshops and laboratories can sometimes be complex. However, the purpose of correct storage practices is to maintain control over the substances so that they can be both stored and retrieved safely.

It is best practice to consider the "whole-life-cycle" of a hazardous or dangerous substance prior to it being delivered to the campus. This will include:

1. What storage facilities are required and are they currently available?
2. Methods of delivery and receipt onto campus.
3. Methods of uplift and delivery to specific storage facilities.
4. How will risks be managed whilst it is present and used on campus?
5. How it will be disposed of or collected for disposal?

The principle source of information aiding the understanding of substance incompatibilities and recommended storage requirements is the Safety Data Sheet (SDS). Suppliers of hazardous substances are legally required to make the SDS available to customers. In many cases these are free to access online, prior to ordering the substance.

Safe storage of substances can be achieved by arranging the substances to provide separation based on their chemical properties. This requires planning and will involve, an inventory list, accurate labelling, an appreciation of chemical incompatibilities and a range of suitable containers and storage facilities.

The reasons for proper chemical storage are:

1. Providing for effective management of substances
2. Lessening the risk of fire
3. Preventing accidental mixing in emergencies
4. Minimising exposure to corrosive and toxic substances

5. Complying with relevant statutory security obligations

Accidents resulting from poor chemical storage techniques are preventable and Appendix 1 lists some common examples of improper storage practices to avoid.

2. Storage According to Hazard Class and Incompatibility

The risk associated with incompatible substances accidentally coming into contact must be avoided wherever substances are handled or stored. When incompatible substances react, the generation of energy may be violent, potentially resulting in fire and explosion. Reaction products may also release toxic vapours capable of affecting nearby personnel.

Non-hazardous vapours may also be harmful if given off in a great enough volume to displace the oxygen in an enclosed area, thus creating an oxygen deficient environment. These situations should be avoided or assessed where risks remain. (Please contact the Occupational Health and Environmental Safety (OHES) team for advice on oxygen depletion).

A typical substance storage practice is that of simply storing substances in alphabetical order on shelves. This often results in incompatible substances being stored together e.g. alphabetical arrangement could result in hydrogen peroxide (a strong oxidizer) being stored next to hydrazine (a very strong reducer). Substances should not be stored alphabetically unless they have first been separated into their hazard classes.

There are no absolute rules on how many classes of substances should be segregated. The degree of segregation will depend upon the risk and reasonable practicality. However, isolation of substances into the basic hazard classes will eliminate most accidental adverse reactions that may occur due to breakages or leakages in storage areas.

In general, substances should only be stored with compatible substances according to the categories outlined in Appendix 3.

Common storage problems can lead to mixing incompatible substances. The most serious of these is the storage of inorganic acids (especially oxidizing acids) with flammable substances. However, organic acids tend to be flammable and if so, should be stored as such i.e. glacial acetic acid.

See Appendix 2 for examples of substances stored by hazard class; Appendix 3 for examples of common chemical incompatibilities and; Appendix 4 for a suggested best practice storage scheme.

2.1 Combustible liquids / solvents and halogenated solvents:

Many organic and inorganic substances are combustible, that is they can be ignited and will then burn in air. This group of combustible substances are separated into 3 sub-categories to highlight the level of risk. These sub-categories are Flammable,

Extremely Flammable – Flashpoint less than 23°C and a boiling point lower or equal to 35°C

Highly Flammable – Flashpoint less than 23°C and a boiling point greater than 35°C

Flammable – Flashpoint equal to or greater than 23°C and less than or equal to 60°C

Highly Flammable and Extremely Flammable. The sub-category that a combustible substance is assigned to is based on a combination of its flashpoint and boiling point.

Appendix 5 provides a list of well known substances and their flashpoints, boiling points and Auto-Ignition Temperature. The auto-ignition temperature of a substance is the lowest temperature at which it spontaneously ignites in normal atmosphere without an external source of ignition, such as a flame or spark. This is also an important characteristic to consider when thinking about how to safely store the substance.

The United Nations Globally Harmonised System (GHS) of classification and labelling uses the following label to indicate if a substance is flammable:



Do NOT store Combustibles with the following:

- **Oxidizing agents** such as chlorates, nitrates, perchlorates, permanganates, and peroxides. They usually do not combust on their own but provide the oxygen to accelerate the combustion rate of other substances
- **Corrosive substances** (acids or bases that destructively attack organic and non-organic substances. Common acids include sulfuric acid, acetic acid, and nitric acid. Common alkalis (bases) include ammonium hydroxide, calcium oxide (slaked lime) and sodium hydroxide (lye).
- **Substances susceptible to spontaneous heating and/or explosions.** Hydrogen peroxide contacting combustible substances can result in spontaneous combustion. Picric acid can be explosive if dry (sensitive to shock and friction when dry)
- **Substances that react with air or moisture to create heat** (water-reactive substances react with water to release flammable hydrogen gas). Concentrated sulfuric acid is a corrosive that can react violently with water, giving off heat and toxic fume.

Avoid storing flammables in direct sunlight or near other heat sources; eliminate all sources of ignition (heat, sparks, or open flames). Keep the area dry and cool. Use explosion-proof refrigerators designed for chemical storage when substances require extra cool temperatures. Most flammable vapours are heavier than air and will settle low to the ground where they are free to do so. Provide adequate ventilation to prevent the accumulation of large amounts of vapour.

Liquids with a flashpoint in the range 32°C to 55°C will not normally produce a flammable atmosphere when stored at an ambient temperature below 32°C. They can produce flammable atmospheres if heated or if released as a mist or spray and will ignite and burn readily if exposed to fire from another source. It is preferable for these

higher flashpoint liquids to be stored either in the open air or in a safe of fire resisting store.

Note: The flashpoint of a multi-component system will vary depending upon the composition and solubility of the individual components. For instance, the flashpoint of pure ethanol is 13°C, but making a 10% solution of ethanol in water will raise this to 47.5°C. However, adding water to an immiscible solvent will not change its flashpoint. It should be remembered that flash points can be determined by different methods and quoted values may vary by a few degrees (see Appendix 5).

2.2 Oxidisers

Oxidisers (e.g. hydrogen peroxide, ammonium persulfate) are corrosive and irritating and must be stored to avoid contact with incompatible substances such as flammable and combustible liquids, greases and other substances that could react with the oxidiser or catalyse its decomposition. Liquid oxidizers, such as ammonium persulfate and hydrogen peroxide, react with nearly everything. They may potentially cause explosions, and must be double contained (i.e., the primary container must be kept inside a canister, tray, or tub) since fires may be initiated by the action of oxidizing agents on organic substances. This includes organic packaging substance e.g. paper and cardboard which should be excluded from the area where oxidisers are stored or used.

The United Nations Globally Harmonised System (GHS) of classification and labelling uses the following label to indicate if a substance is an oxidiser:



- Store in a cool, dry place (some may require refrigeration – consult the SDS)
- Keep away from combustible and flammable substances
- Keep away from reducing agents such as zinc, alkali metals, and formic acid
- Store in a labelled ventilated corrosive storage cabinet / cupboard where possible

2.3 Acids

Contact of a concentrated oxidizing acid with a flammable substance can result in a fire or an explosion. Organic acids are combustible substances and many of them are combustible liquids.

The United Nations Globally Harmonised System (GHS) of classification and labelling uses the following label to indicate if a substance is corrosive:



2.4 Acids, Inorganic

Inorganic mineral acids (e.g. nitric, sulfuric, phosphoric, chromic, hydrochloric and perchloric acids)

- If possible, store in a labelled ventilated corrosive storage cabinet, separated from flammable and combustible substances. If ventilated cabinets are not available other control measures should be considered to limit the creation of a hazardous/corrosive atmosphere. Other control measures may include storing the acid into a secondary container (See Figure 2: [safepak](#) or [nalgene](#)) or instructing all acid users to ensure that the lids of the containers fitted securely.
- Segregate acids from reactive metals such as sodium, potassium, magnesium, etc
- Segregate acids from substances which could generate toxic or flammable gases upon contact, such as sodium cyanide, iron sulphide, calcium carbide, etc.
- Segregate acids from bases
- Perchloric acid presents special hazards - carefully isolate it from acetic anhydride, bismuth and its alloys, alcohol, paper, wood, oil, ether, grease, and sulfuric acid

Take special precautions to keep Perchloric acid away from acetic acid i.e., oxidizable substances and dehydrating agents.

Hydrofluoric acid (HF) is uniquely hazardous and must be stored with extreme care and only handled by competent trained persons. It should be isolated i.e. stored in a separate acid resistant cabinet away from all other substances.

2.5 Acids, Organic

Organic acids (e.g. acetic, butyric, formic, trifluoroacetic and mercaptopropionic acids) can safely be stored with flammable and combustible liquids, but they should generally not be stored with oxidizing mineral acids, which could react more or less violently with organic acids.

- Store separately from oxidizing mineral acids
- Store in a ventilated corrosive storage cabinet if possible
- Can be stored with organic solvents unless otherwise noted on the Safety Data Sheet
- Take special precautions to keep acetic acid away from Perchloric acid

Remember: All acids must be segregated from any substances which could generate toxic or flammable gases upon contact (e.g. cyanide salts, metal sulfides, calcium carbide) and reactive metals (e.g. sodium, potassium, magnesium).

2.6 Alkalis (Bases)

Alkalis / bases (e.g. sodium hydroxide, ammonium hydroxide, gluteraldehyde) are corrosive or irritating. Those that are liquid in large glass containers, such as ammonium hydroxide, should be stored in a separate cabinet or area.

The United Nations Globally Harmonised System (GHS) of classification and labelling uses the following labels to indicate if a substance is corrosive or/and irritating respectively:



- Segregate bases from acids, metals, explosives, organic peroxides and easily ignitable substances
- Store in tubs or trays in a labelled cabinet / cupboard where possible

2.7 Air/Water Reactives

This section also includes combustible solids (e.g. sodium and potassium metals, lithium aluminium hydride, metal hydrides, butyl lithium).

Water Reactive substances react violently with water releasing heat and in some cases explosive by-products. Of chief concern are the alkali metals e.g. sodium and potassium.

All alkali metals react vigorously (i.e. exothermically) with water to form the hydroxide, liberating hydrogen gas. The heat generated from the reaction can ignite the hydrogen resulting in an explosion. The rate of reaction increases as the atomic weight increases. Alkali metals can also react with oxygen, acids, halogenated hydrocarbons and carbon dioxide.

- Store all metals in the container provided by the manufacturer.
- Store in a cool, dry environment, away from light and free from extremes of temperature and humidity and away from any water source.
- Store alkali metals under mineral oil or in an inert atmosphere. Note: Lithium reacts with nitrogen.
- Make certain that a L2 D-metal fire extinguisher is available when a significant amount of flammable metal is available (for use on flammable metal fires only).
- Use secondary containment.
- May be stored with dry solids.
- Certain compounds require the container headspace to be purged with inert gas after use.
- Consider the use of drying agents and desiccators where appropriate.

Pyrophoric substances are substances / substances which will react with the air to ignite when exposed, e.g., white phosphorus

- Store in a cool, dry place making provisions for an airtight seal

2.8 Peroxide forming substances

This group includes the following:

- Ethers and acetals. Especially dangerous are cyclic ethers (e.g. Tetrahydrofuran and dioxane) and ethers derived from primary and secondary alcohols, particularly diisopropyl ether. Ethers having an aromatic group bonded to the oxygen generally do not peroxidize under normal conditions.
- Benzylic hydrogen containing compounds, especially tertiary hydrogens, (e.g. cumene, tetralin).

- Allylic hydrogen containing compounds ($\text{CH}_2=\text{CHCH}_2\text{R}$), including most alkenes (e.g. cyclohexene, cyclooctene).
- Ketones, especially cyclic ketones.
- Dienes and vinylacetylenes (e.g. divinylacetylene, butadiene).
- Paraffinic and alkylaromatic hydrocarbons with tertiary hydrogens (e.g. decalin, methylcyclopentane).
- Vinyl and vinylidene compounds (e.g., vinyl acetate, vinylidene chloride).
- Aldehydes (particularly anhydrous acetaldehyde); ketones with an alpha- hydrogen (methyl isobutyl ketone); ureas, amides, lactams.
- Potassium metal (actually forms the yellow superoxide KO_2) and alkali metal amides such as sodium amide.

Peroxide forming compounds should be:

- Stored in airtight containers in a dark, cool, and dry place
- Containers must be labelled with receiving, opening, and disposal dates
- Periodically tested for the presence of peroxides
- Where possible, container headspace should be purged with an inert gas

The chemical incompatibilities discussed above are by no means exhaustive. As a result, it is important for laboratory personnel to thoroughly research the properties of the substances they are using. SDSs have sections on chemical incompatibility. The container's label should also provide storage guidelines.

2.9 Poisons

Poisons in this sense are defined as a substance that causes injury, illness, or death, especially by chemical means. There are numerous types of poisons, including:

- inorganic poisons (e.g. mercury, heavy metals and their salts),
- organic poisons (e.g. phenol, sodium azide, pharmacological drugs*) and
- Schedule 1 poisons (controlled under the Pharmacy and Poisons Act and subject to the Poisons List Order).

The United Nations Globally Harmonised System (GHS) of classification and labelling uses the following labels to indicate if a substance is an acute or chronic poison:



Toxic substances that are acid-sensitive, such as cyanides and sulphides, should be stored in a separate location from acids or protected from contact with acids. Store poisons and toxic substances according to the nature of the chemical using appropriate security where necessary e.g. locked cabinets with strict key controls.

Volatile poisons e.g. poisons, toxics, and carcinogens, such as carbon tetrachloride, chloroform, dimethylformamide, dimethyl sulfate, formamide, formaldehyde, halothane, mercaptoethanol, methylene chloride, and phenol should be:

- Stored in a ventilated cabinet and may be stored with flammable liquids if bases are not present

Non-volatile liquid poisons e.g. acrylamide solutions, coomassie blue stain, diethylpyrocarbonate, diisopropyl fluorophosphate, uncured epoxy resins, ethidium bromide, triethanolamine should be:

- Stored in a normal cabinet, preventing contact with other substances and may be stored with non-hazardous liquids, such as buffer or salt solutions
- Double contained if quantities greater than one litre

* the storage of certain substances are subject to control under The Misuse of Drugs Regulations and the Drug Precursor Regulations and may be required to be kept secure under lock and key

2.10 Dry solids

All hazardous and non-hazardous powders, should be stored separately from the above categories on open shelves or in either a normal or ventilated cabinet as appropriate. Where space is limited, dry solids may be stored above compatible liquids / solutions. If properly double contained, dry solids can be stored with metal hydrides

Solid picric acid or picric sulfonic acid may be stored with dry solids, but should be checked regularly for dryness. When completely dry, picric acid is explosive and may detonate upon shock or friction.

2.11 Compressed gases (e.g. oxygen, nitrogen, hydrogen, and acetylene)

We should seek to restrict the number of compressed gas cylinders stored indoors to a minimum working quantity and each cylinder should not greatly exceed a volume appropriate for the intended work. Any additional cylinders over this quantity should be stored in an external gas store.

The United Nations Globally Harmonised System (GHS) of classification and labelling uses the following label to indicate a compressed gas is present:



Storage of cylinders should:

- Allow for easy identification of a cylinder's contents, including if it is empty or full and their associated hazards.
- Allow for the desired cylinder to be accessed without the risk of others toppling over.
- Be secure at all times; they should be properly restrained against the wall, securely clamped to a bench, or in trolleys designed for this purpose.
- Be away from areas vulnerable to impact, e.g. under shelves, behind doors.
- Be segregated from incompatible gases in accordance with the current British Compressed Gas Association codes or practice (advice available from OHES).

- Be held externally in cases of acutely toxic and toxic gases, or in ventilated gas cabinets or fume cupboards; minimising the cylinder size as far as is reasonably practicable.
- Provide protection from external heat sources that may adversely affect their mechanical integrity. Do not store next to radiators or other heat sources.

Oxygen presents a unique hazard in a number of ways. It will support an existing fire to burn and can cause more vigorous combustion. It can cause ignition of substances not normally considered flammable and it can cause grease or oil to spontaneously ignite.

It is recommended that the RGU notice board label system is implemented where cylinders are present. The primary function of this system is to advise the Fire Services of the presence of gases and cylinders in the event of a fire.

Example of a label used for an 'L' size cylinder of Helium:



3 General Storage Guidelines

Section 2 above has considered the specifics of storing certain categories of hazardous and dangerous substances. Section 3 considers hazardous and dangerous substances as a single category and the best practice that should be implemented for all substances.

1. Limit the amount of substances stored to the minimum required, making use of external storage locations for larger stocks. Stored substances in Laboratories and Workshops should be kept to a working minimum.
2. Storerooms, cupboards and bins should be marked to indicate their contents e.g. Highly Flammable, Acids, Oxidisers, etc.
3. Identify a designated storage place for each chemical, not on the workbench.
4. In all storage areas, avoid exposure of substances to heat or direct sunlight. This may lead to the deterioration of storage containers as well as the degradation of the substances.
5. Individual chemical containers should be "date stamped" upon bringing into the laboratory/workshop and "date stamped" when first opened.
6. Individual containers should be clearly marked to indicate their contents and the degree of flammability, toxicity, etc.
7. Where appropriate, store all hazardous liquid substances in drip trays or secondary containers that are chemically resistant. 'Photographic trays' can provide good containment for some substances (see Figures 1 and 2 below), others may require different plastics (solvent resistant), metal (stainless steel) or even glass
8. Ensure that caps and lids on all chemical containers are tightly closed to prevent evaporation of contents

9. The storage of substances above head height must be minimised to reduce the risk of spillage when being removed or replaced - particularly important with large or glass containers
10. Ensure all shelving is suitable and secure – consider the implications of a shelf failing
11. A system of stock rotation should be employed so that the oldest containers are removed from store first
12. If date-marked, substances must be used or disposed of by the 'use by' or 'disposal date', as guidelines for storage as appropriate
13. Avoid storing substances on bench tops except for those being currently used
14. Label all containers (including squeeze bottles and Nalgene bottles) to which hazardous substances are transferred with the identity of the substance and its hazards. NB. Be aware that squeeze bottles and Nalgene bottles have varying resistances to different substances
15. Evaluate/test stored substances that can form peroxides for crystal formation, deterioration, and integrity (see advice from [Sigma-Aldrich](#))
16. Use approved corrosive storage cabinets (constructed of chemically resistant components) for storing acids and bases. These should ideally be connected to exhaust ventilation
17. Wherever possible, all corrosives should be stored in sealed, air-impermeable containers. Therefore, containers with tight-fitting caps are necessary and containers with loose fitting lids or glass stoppers should not be used
18. Use flammable storage cabinets, containers or bins to store flammable liquids (see Figure 3)
19. All stored containers should be periodically inspected to ensure the packaging is in good condition and there are no leaks. If a leak is found, the container should be removed to a safe place and its contents transferred safely to another container
20. Refrigerators used for storing substances must be appropriately labelled
21. Drip trays or fridge boxes should be used to prevent substances stored in refrigerators from being accidentally broken and to contain any spills (cardboard boxes are not suitable)
22. Refrigerators and freezers must be regularly defrosted to prevent the build-up of ice (see Figure 4)

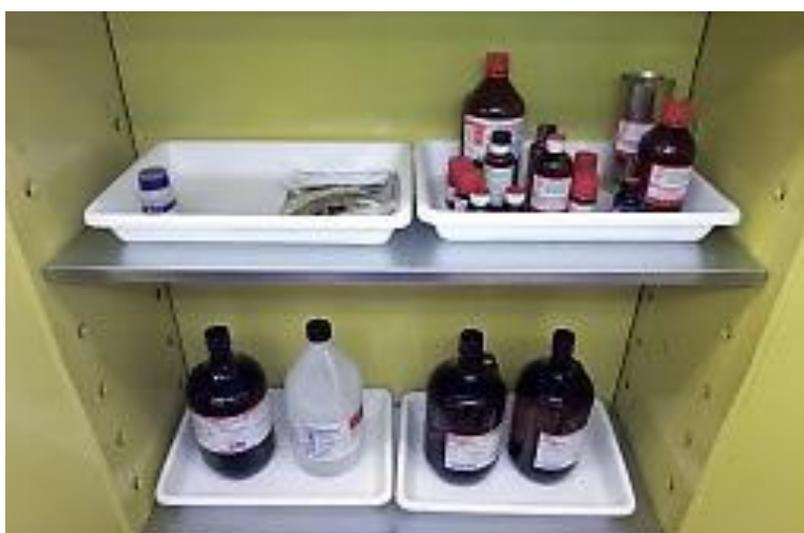


Figure 1 – Bottles stored in drip trays within flammables cabinet



Figure 2 – Bottles stored in drip trays within ventilated acids cabinet including example of chemically resistant secondary containment (BDH / VWR Safepak bottom right)



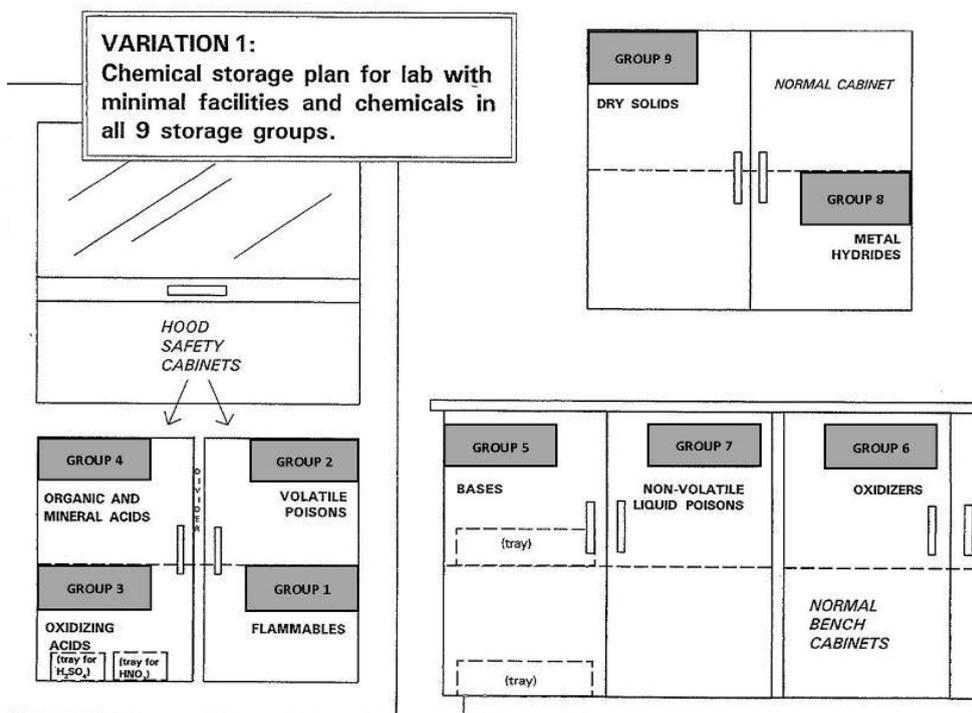
Figure 3 – Flammable substance storage – bins, cans and cabinets



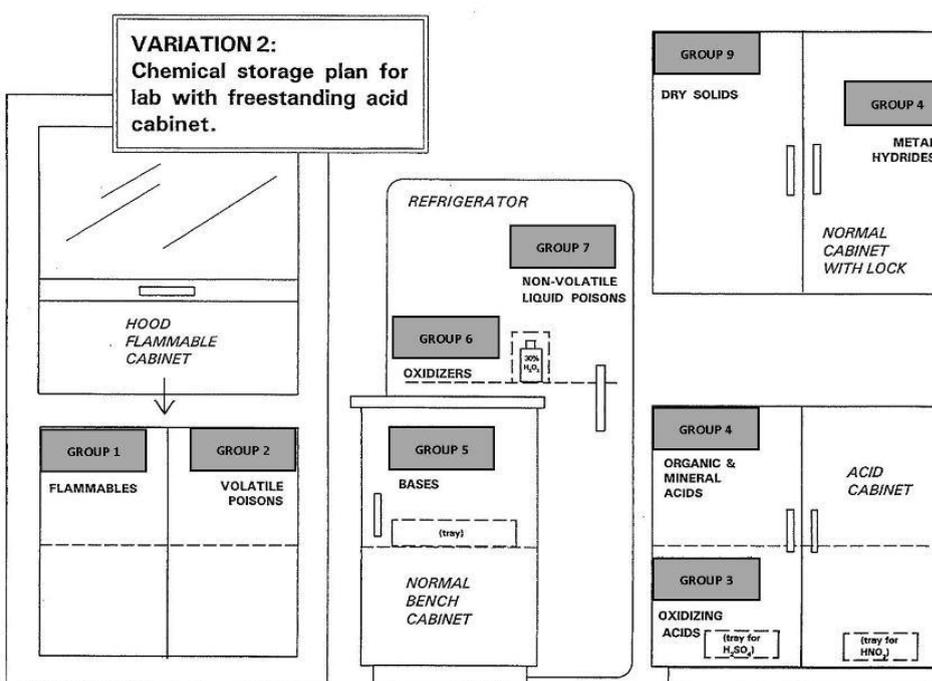
Figure 4 – Poor refrigerator storage practices
NB. The substances stored in the bottom drawer are frozen solid

4 Chemical Storage Plan

One way to support working in line with this guidance is to develop a Chemical Storage Plan. The plan should take into account all the substances in use within the laboratory/workshop, the chemical categories, the information provided in their SDS and the storage facilities available. Below are 2 examples of a chemical storage plan to aid development.



Chemical storage plan for lab with minimal facilities and substances in all 9 storage groups.



Chemical storage plan for lab with freestanding acid cabinet.

5 Inspection of Stored Substances

Chemical storage areas should be inspected at least annually and any unwanted or expired substances must be removed and safely disposed of via the School/ Department's Hazardous Waste Disposal Service. During this inspection, the list of substances present in the laboratory should be updated or verified and the date and name of the inspector recorded.

In lower risk areas storing small stocks of hazardous substances, the inspection of stocks should still be undertaken, although for ease this could be achieved via the standard workplace inspection process as defined in the [RGU Active Monitoring Procedure](#) and recorded through the [Inspection of Low Hazard Area Proforma](#).

Although the deterioration of a specific compound in storage cannot be predicted in detail, generalizations can often be made about the reaction characteristics of groups of compounds. Some general conclusions about the stability of classes of substances can be reached, and corresponding storage time spans can be identified. Visual inspection of stored substances is important in the disposal decision.

Substances showing any of the indications listed below should be sent for disposal:

- Slightly cloudy liquids which were once clear
- Darkening or change in colour
- Caking of anhydrous substances indicating uptake of water
- Existence of solids in liquids or liquids in solids
- Distinct layers forming in liquids
- Pressure build-up in containers
- Evidence of reaction with water
- Corrosion or damage to the container
- Missing or damaged (i.e., illegible) labels
- Old substances of unknown origin e.g. research substances

A suggested chemical storage checklist can be found in Appendix 6.

6 Emergency Procedures

Emergency procedures are required to respond to events involving or affecting chemical stocks. Emergencies can include small and large spills, gas releases, fires and floods.

The SDS provides information on emergency responses, i.e. the appropriate protective equipment when managing a spill, the correct extinguisher in the event of a fire, or measures to take in event of a gas release. For substances in use or created as part of an activity, the SDS will help users to define and document emergency procedures within the activity's [COSHH Assessment](#) or [DSEAR Assessment](#).

There may be no immediately identifiable COSHH or DSEAR assessment record documenting such procedures in a simple storage scenario with no associated usage or activity stimulating the assessment. In these circumstances, consideration should be made as to whether an SDS or existing procedures (such as Emergency Evacuation Information) provides sufficiently detailed emergency response information, or

whether further procedures should be documented, i.e. a spill recovery plan, or gas detection procedures.

It is also important to consider the competence required to use equipment and manage an emergency. This could involve providing staff, likely to be required to manage a spill, with training. Or, in the event of a high severity emergency, regularly drilling an emergency response to allow employees to practice managing such a situation.

7 Substances of Special Interest

There are specific substances that should be notified to the Occupational Health and Environmental Safety team at the time of potential procurement. The reasons for notification are:

- a legal requirement to inform authorities of the substance's use or presence
- the uniquely hazardous nature of the substance requiring equally unique control measures to mitigate exposure and harm.

Relevant substances are listed in Appendix 6: OHES Notifiable Substances.

Appendices:

Appendix 1 - Common Examples of Improper Storage Practices

- substances are stored in alphabetical order by name without consideration of incompatibilities
- substances are stored according to poorly chosen categories e.g. all acids are stored together, all organics are stored together
- substances are stored in fume cupboards
- substances are stored on shelves above average eye-level / head height
- Shelves are overcrowded and containers and bottles of liquid are stood on top of other containers
- substances are left out on benches rather than returned to their appropriate storage area after use
- substances are stored in direct sunlight causing degradation of both the substances and the plastic packaging
- inventory control is poor or non-existent: many containers are not identified with the date of receipt, date of opening or the person responsible for the chemical (in shared facilities)
- containers have no label or the label is illegible
- containers are reused but not relabelled
- flammable solvents are stored in domestic fridges which have not had all ignition sources removed
- unused and unwanted substances are stored away in cabinets rather than disposed of (see Appendix 2 – Suggested storage time limits)

Appendix 2 - Suggested storage time limits

For common peroxidizable compounds
MOST DANGEROUS: Discard after 3 months.
Peroxide formation hazard during storage.

- Di-vinyl acetylene
- Ether
- Isopropyl
- Potassium metal
- Sodium amide
- Vinylidene chloride

DANGEROUS: Discard after one year.
Peroxide formation hazard during storage and on concentration (i.e. distillation) of compound.

- | | |
|----------------------------|----------------------------------|
| • 1-Phenylethanol | • Decahydronaphthalene(decalin) |
| • 2-Cyclohexen-1-ol | • Diacetylene |
| • 2-Hexanol | • Dicyclopentadiene |
| • 2-Pentanol | • Diethyl ether |
| • 3-Methyl-1-butanol | • Diglyme |
| • 4-Heptanol | • Dioxane |
| • 4-Methyl-2-pentanol | • Ethylene glycol dimethyl ether |
| • 4-Penten-1-ol | • Ethylene glycol ether acetates |
| • Acetal | • Furan |
| • Acetaldehyde | • Methyl acetylene |
| • Benzyl Alcohol | • Methyl isobutyl ketone |
| • Chlorofluoroethylene | • Methylcyclopentane |
| • Cumene | • Sec. Alcohols |
| • Cumene(isopropylbenzene) | • Tetrahydrofuran |
| • Cyclohexene | • Tetrahydronaphthalene |
| • Cyclopentene | • Vinyl ethers |

DANGEROUS: Discard after one year.
Peroxide formation causes initiation of hazardous polymerization.

- | | |
|---------------------------|-----------------------|
| • Acrylic acid | • Styrene |
| • Acrylonitrile | • Tetrafluoroethylene |
| • Butadiene | • Vinyl acetate |
| • Chloroprene | • Vinyl acetylene |
| • Chlorotrifluoroethylene | • Vinyl chloride |
| • Methyl methacrylate | • Vinyl pyridine |

Safety advice:

1. Do not purchase these compounds in quantities greater than can be used in the specified storage time period.
2. Ethers should be stored in the dark and under nitrogen if possible.
3. Always check for the presence of peroxides before distilling any peroxide former.
4. Consult safety references before working with peroxidizable compounds.

Appendix 3 – Substance Categories and Compatibility Chart

		1	2a	2b	3	4	5a	5b	5c	6
		Flammable Liquids	Acids, Inorganic	Acids, Organic	Alkalis (Bases)	Oxidizers	Poisons, Inorganic	Poisons, Organic	Schedule 1 Poisons	Air / Water Reactives
1	Flammable Liquids	✓	X	✓	X	X	X	✓	X	X
2a	Acids, Inorganic	X	✓	X	X	✓	X	X	X	X
2b	Acids, Organic	✓	X	✓	X	X	X	X	X	X
3	Alkalis (Bases)	X	X	X	✓	✓	✓	X	X	X
4	Oxidizers	X	✓	X	✓	✓	✓	X	X	X
5a	Poisons, Inorganic	X	X	X	✓	✓	✓	X	X	X
5b	Poisons, Organic	✓	X	X	X	X	X	✓	X	X
5c	Schedule 1 Poisons	X	X	X	X	X	X	X	✓	X
6	Air / Water Reactives	X	X	X	X	X	X	X	X	✓

X Not Compatible – Do Not Store Together
 ✓ Possibly Compatible – Consult SDS

Appendix 4 – Suggested Best Practice Storage Scheme

	<p>Flammable liquids:</p> <p>Risk Phrase: R10, R11, R12</p> <p>Hazard Phrase: H224, H225, H226, H227</p>	<p>Do not store anything else in the cupboard except substances that are non-hazardous AND have been packaged in non-combustible containers, e.g. glass.</p>
	<p>Combustible solids:</p> <p>Risk Phrase: R17, R18</p> <p>Hazard Phrase: H228,</p>	<p>Keep segregated from everything else – INCLUDING flammable liquids.</p>
	<p>Toxic substances:</p> <p>Risk Phrase: R23, R24, R25, R26, R27, R28, R39, R45, R46, R48, R49, R60, R61</p> <p>Hazard Phrase: H300, H310, H330, H301, H311, H331, H302, H312, H332, H303, H313, H333</p>	<p>Do not routinely store anything alongside these except non-hazardous substances.</p>
	<p>Corrosive substances:</p> <p>Risk Phrase: R34, R35</p> <p>Hazard Phrase: H314, H315, H316, H318</p>	<p>Avoid keeping incompatible substances such as acids & alkalis together.</p>
	<p>Oxidizing substances:</p> <p>Risk Phrase: R7, R8, R9</p> <p>Hazard Phrase: H270, H271, H272</p>	<p>Keep entirely segregated from all other classes.</p>



Organic peroxides:

Risk Phrase:

R 7

(May have different warning symbols)

Hazard Phrase:

H240, H241, H242

Keep segregated from everything else.

Appendix 5 – Examples of Flash Points, Boiling Points and Auto-ignition temps

Chemical	Flash Point (°C)	Boiling Point (°C)	Auto-ignition temp (°C)
Acetaldehyde	-38	21	175
Acetic Acid	43	118	426
Acetone	-19	57	465
Acetonitrile	6	82	524
Acrylonitrile	0	77	481
Benzene	-11	80	561
1-Butanol	35	118	343
2-Butanol	24	99	406
Carbon disulfide	-30	46	90
Cyclohexane	-18	82	245
1,2-Dichloroethane	13	83	413
Diesel fuels (several grades)	52 to 96	246 to 388	177 to 285
Diethylamine	-26	55	312
Diethyl ether	-45	34.6	160
Diisopropyl ether (DIPE)	-28	69	443
1,4 Dioxane	12	101	180
Ethanol	13	79	363
70% Ethanol	17	79	363
Ethyl acetate	-4	77	427
Ethyl formate	-20	53	440
Hexane	-23	68	234
Kerosene/Paraffin oil (several	35 to 72	150 to 300	220
Methanol	11	65	464
Piperidine	16	106	320
Petrol/Gasoline (several grades)	< -45	38 to 205	246 to 280
Propan-2-ol (iso-propyl alcohol)	12	83	465
Pyridine	20	115	482
Tetrahydrofuran	-14	66	321
Toluene	4	111	535
1,1,1-Trichloroethane	'none'	74	536
Trichloroethylene (Trike)	'none'	87	410
Triethylamine	-17	89	230
Vinyl acetate	-8	72	402
White Spirit (several grades)	21 to > 55	130 to 220	230 to 240

Appendix 6 – Chemical Storage Checklist

Taking stock of current storage conditions and procedures is the first step in managing a safe chemical storeroom. The following example checklist was developed to help assess safety in the storeroom. The checklist format not only facilitates a systematic assessment of storage and housekeeping conditions, but also identifies general and specific areas of concern. The completed checklist serves as a record of needed improvements. An affirmative answer to each item indicates a satisfactory storage condition.

YES	NO	N/A	STORAGE AREAS
			Storage rooms are properly marked or identified.
			Storage rooms are secured whenever not in use and are available only to authorised personnel.
			Storage areas are well illuminated.
			Storage areas are well ventilated.
			Aisles in the storage area are free from obstruction.
			Ladders with handrails are available where needed.
			SHELF STORAGE
			Large bottles and containers are stored on shelves near the floor.
			Containers of substances are stored below eye level.
			Where possible shelves have raised edges or rim guards to prevent the accidental dislodging of containers.
			Reagent bottles or containers do not protrude over the shelf edges.
			Enough space is available so that substances are not overcrowded.
			Empty bottles are removed from shelves.
			Shelves are level and stable. Shelving units are securely fastened to wall or floor.
			Shelves are clean-free of dust and chemical contamination.
			STORAGE CONTAINERS
			Storage containers are inspected periodically for rust, corrosion, or leakage.
			Damaged containers are removed or repaired immediately.
			Substances are kept in airtight bottles, not in beakers or open vessels.
			Stoppers form an airtight seal with containers.
			Stoppers are easily removed from bottles or containers.
			LABELLING OF CHEMICAL CONTAINERS

			All containers are clearly labelled as to contents.
			Labels are readable and free of encrustation or contamination.
			Labels are firmly attached to containers.
			Chemical containers are labelled with the appropriate hazard warning (e.g. poison, corrosive, etc).
			All container labels include both date of receipt and group name.
YES	NO	N/A	STORAGE AREAS
			HOUSEKEEPING
			Cleanliness and order are maintained in the storage areas at all times.
			Unlabelled, contaminated, or undesirable substances are discarded properly.
			Substances in storage cabinets and on shelves are inspected for decomposition on a regular basis.
			Unused substances are never returned to stock bottles.
			Packing substances and empty cartons are removed at once from the area.
			Waste receptacles are properly marked and easily located.
			Separate disposal containers are available for broken glass.
			EMERGENCY PREPAREDNESS
			Equipment and supplies for cleaning up spills are readily available.
			Fire extinguishers are immediately accessible.
			Fire extinguishers are periodically inspected and maintained.
			CHEMICAL STORAGE
			Substances are not exposed to direct sunlight or localised heat.
			Containers of corrosive substances are stored in trays large enough to contain spillage or leakage.
			Substances are stored by, reactive class (e.g. flammables with flammables, oxidizers with oxidizers).

			Incompatible substances are physically segregated from each other during storage.
			1. Acids
			Large bottles of acids are stored in acid cabinets.
			Oxidizing acids are segregated from organic acids and flammable and combustible substances.
			Acids are separated from caustics and from active metals such as sodium, magnesium, and potassium.
			Acids are segregated from substances that can generate toxic gases on contact, such as sodium cyanide and iron sulphide.
			Bottle carriers are used for transporting acid bottles.
			Absorbents or acid neutralizers are available for acid spills.
			2. Caustics
			Caustics are stored away from acids.
			Solutions of inorganic hydroxides are stored in polyethylene containers.
			Absorbents or caustic neutralizers are available for spills.
YES	NO	N/A	
			3. Flammables
			Flammables are kept away from any source of ignition: flames, heat or sparks.
			Approved refrigerators are used for storing highly volatile flammable liquids.
			Bonding and grounding wires are used where flammables are stored and dispensed.
			Absorbents are available for leaks or spills.
			4. Peroxide-Forming substances
			Peroxide-forming substances are stored in airtight containers in a dark, cool, and dry place.
			Peroxide-forming substances are properly disposed of before the date of expected peroxide formation.
			Suspicion of peroxide contamination is immediately evaluated by use of safe procedures.
			Substances are labelled with date received, date opened, and disposal date.
			5. Water-Reactive substances
			Substances are kept in a cool and dry place.
			In case of fire, a Class D fire extinguisher is used.
			6. Oxidizers

			Oxidizers are stored away from flammable, combustible, and reducing agents (e.g. zinc, alkaline metals).
			7. Toxic Compounds
			Toxic compounds are stored according to the nature of the chemical, with appropriate security employed where necessary.

Appendix 6: OHES Notifiable Substances

Substance Group	Example	CAS registry if applicable	Reason For Notification
A - Toxics			
O-Alkyl ($\leq C_{10}$, incl. cycloalkyl) alkyl (Me, Et, n-Pr or i-Pr)-phosphonofluoridates	Sarin: O-Isopropyl methylphosphonofluoridate	(107-44-8)	CWC – Schedule 1
	Soman: O-Pinacolyl methylphosphonofluoridate	(96-64-0)	CWC – Schedule 1
O-Alkyl ($\leq C_{10}$, incl. cycloalkyl) N,N-dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidocyanidates	Tabun: O-Ethyl N,N-dimethyl phosphoramidocyanidate	(77-81-6)	CWC – Schedule 1
O-Alkyl (H or $\leq C_{10}$, incl. cycloalkyl) S-2-dialkyl (Me, Et, n-Pr or i-Pr)-aminoethyl alkyl (Me, Et, n-Pr or i-Pr) phosphonothiolates and corresponding alkylated or protonated salts	VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate	(50782-69-9)	CWC – Schedule 1
Sulphur mustards	2 - Chloroethylchloromethylsulphide	(2625-76-5)	CWC – Schedule 1
	Bis(2-chloroethylthio)methane	(505-60-2)	CWC – Schedule 1
	Mustard gas: Bis(2-chloroethyl)sulphide	(63869-13-6)	CWC – Schedule 1
	Sesquimustard: 1,2-Bis(2-chloroethylthio)ethane	(3563-36-8)	CWC – Schedule 1
	1,3-Bis(2-chloroethylthio)-n-propane	(63905-10-2)	CWC – Schedule 1
	1,4-Bis(2-chloroethylthio)-n-butane	(142868-93-7)	CWC – Schedule 1
	1,5-Bis(2-chloroethylthio)-n-pentane	(142868-94-8)	CWC – Schedule 1
	Bis(2-chloroethylthiomethyl)ether	(63918-90-1)	CWC – Schedule 1
	O-Mustard: Bis(2-chloroethylthioethyl)ether	(63918-89-8)	CWC – Schedule 1
	Lewisites:	Lewisite 1: 2-Chlorovinylchloroarsine	(541-25-3)
Lewisite 2: Bis(2-chlorovinyl)chloroarsine		(40334-69-8)	CWC – Schedule 1
Lewisite 3: Tris(2-chlorovinyl)arsine		(40334-70-1)	CWC – Schedule 1

Nitrogen mustards:	HN1: Bis(2-chloroethyl)ethylamine	(538-07-8)	CWC – Schedule 1
	HN2: Bis(2-chloroethyl)methylamine	(51-75-2)	CWC – Schedule 1
	HN3: Tris(2-chloroethyl)amine	(555-77-1)	CWC – Schedule 1
Saxitoxin		(35523-89-8)	CWC – Schedule 1
Ricin		(9009-86-3)	CWC – Schedule 1
B - Precursors			
Alkyl (Me, Et, n-Pr or i-Pr) phosphonyldifluorides	DF: Methylphosphonyldifluoride	(676-99-3)	CWC – Schedule 1
O-Alkyl (H or ≤C ₁₀ , incl. cycloalkyl) O-2-dialkyl (Me, Et, n-Pr or i-Pr)-aminoethyl alkyl (Me, Et, n-Pr or i-Pr) phosphonites and corresponding alkylated or protonated salts	QL: O-Ethyl O-2-diisopropylaminoethyl methylphosphonite	(57856-11-8)	CWC – Schedule 1
Chlorosarin: O-Isopropyl methylphosphonochloridate		(1445-76-7)	CWC – Schedule 1
Chlorosoman: O-Pinacolyl methylphosphonochloridate		(7040-57-5)	CWC – Schedule 1
A - Toxics			
Amiton: O,O-Diethyl S-[2-(diethylamino)ethyl] Phosphorothiolate and corresponding alkylated or protonated salts		(78-53-5)	CWC – Schedule 2
PFIB: 1,1,3,3,3-Pentafluoro-2-(trifluoromethyl)-1-propene		(382-21-8)	CWC – Schedule 2
BZ: 3-Quinuclidinyl benzilate (*)		(6581-06-2)	CWC – Schedule 2
B - Precursors			
Chemicals, except for those listed in Schedule 1, containing a phosphorus atom to which is bonded one methyl, ethyl or propyl (normal or iso) group but not further carbon atoms, Exemption: Fonofos: O-Ethyl S-phenyl ethylphosphonothiolothionate	Methylphosphonyl dichloride	(676-97-1)	CWC – Schedule 2
Dimethyl methylphosphonate		(756-79-6)	CWC – Schedule 2

N,N-Dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidic dihalides			CWC – Schedule 2
Dialkyl (Me, Et, n-Pr or i-Pr) N,N-dialkyl (Me, Et, n-Pr or i-Pr) - phosphoramidates			CWC – Schedule 2
Arsenic trichloride		(7784-34-1)	CWC – Schedule 2
2,2-Diphenyl-2-hydroxyacetic acid		(76-93-7)	CWC – Schedule 2
Quinuclidin-3-ol		(1619-34-7)	CWC – Schedule 2
N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethyl-2-chlorides and corresponding protonated salts			CWC – Schedule 2
N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethane-2-ols and corresponding protonated salts Exemptions: N,N-Dimethylaminoethanol and corresponding protonated salts N,N-Diethylaminoethanol and corresponding protonated salts			CWC – Schedule 2
N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethane-2-thiols and corresponding protonated salts			CWC – Schedule 2
Thiodiglycol: Bis(2-hydroxyethyl)sulfide		(111-48-8)	CWC – Schedule 2
Pinacolyl alcohol: 3,3-Dimethylbutan-2-ol		(464-07-3)	CWC – Schedule 2
A – Toxics			
Phosgene: Carbonyl dichloride		(75-44-5)	CWC – Schedule 3
Cyanogen chloride		(506-77-4)	CWC – Schedule 3
Hydrogen cyanide		(74-90-8)	CWC – Schedule 3
Chloropicrin: Trichloronitromethane		(76-06-2)	CWC – Schedule 3
B - Precursors			
Phosphorus trichloride		(7719-12-2)	CWC – Schedule 3
Phosphorus pentachloride		(10026-13-8)	CWC – Schedule 3
Trimethyl phosphite		(121-45-9)	CWC – Schedule 3
Triethyl phosphite		(122-52-1)	CWC – Schedule 3
Dimethyl phosphite		(868-85-9)	CWC – Schedule 3
Diethyl phosphite		(762-04-9)	CWC – Schedule 3

Sulfur monochloride		(10025-67-9)	CWC – Schedule 3
Sulfur dichloride		(10545-99-0)	CWC – Schedule 3
Thionyl chloride		(7719-09-7)	CWC – Schedule 3
Ethyldiethanolamine		(139-87-7)	CWC – Schedule 3
Methyldiethanolamine		(105-59-9)	CWC – Schedule 3
Triethanolamine		(102-71-6)	CWC – Schedule 3
Substances which shall not be made available to members of the general public on their own, or in mixtures or substances including them, except if the concentration is equal to or lower than the limit values set out below			
Hydrogen peroxide ($\geq 13\%$ w/w)		(7722-84-1)	Marketing and use of explosives precursors – Annex 1
Nitromethane ($\geq 30\%$ w/w)		(75-52-5)	Marketing and use of explosives precursors – Annex 1
Nitric acid ($\geq 3\%$ w/w)		(7697-37-2)	Marketing and use of explosives precursors – Annex 1
Potassium chlorate ($\geq 40\%$ w/w)		(3811-04-9)	Marketing and use of explosives precursors – Annex 1
Potassium perchlorate ($\geq 40\%$ w/w)		(7778-74-7)	Marketing and use of explosives precursors – Annex 1
Sodium chlorate ($\geq 40\%$ w/w)		(7775-09-9)	Marketing and use of explosives precursors – Annex 1
Sodium perchlorate ($\geq 40\%$ w/w)		(7601-89-0)	Marketing and use of explosives precursors – Annex 1
Substances on their own or in mixtures or in substances for which suspicious transactions shall be reported			
Hexamine		(100-97-0)	Marketing and use of explosives precursors – Annex 2

Sulphuric acid		(7664-93-9)	Marketing and use of explosives precursors – Annex 2
Acetone		(67-64-1)	Marketing and use of explosives precursors – Annex 2
Potassium nitrate		(7757-79-1)	Marketing and use of explosives precursors – Annex 2
Sodium nitrate		(7631-99-4)	Marketing and use of explosives precursors – Annex 2
Calcium nitrate		(10124-37-5)	Marketing and use of explosives precursors – Annex 2
Calcium ammonium nitrate		(15245-12-2)	Marketing and use of explosives precursors – Annex 2
Ammonium nitrate [in concentration of 16 % by weight of nitrogen in relation to ammonium nitrate or higher]		(6484-52-2)	Marketing and use of explosives precursors – Annex 2
1-phenyl-2-propanone (BMK)		(103-79-7)	Drugs Precursor – Category 1
3-4 Methyleneedioxy-Phenylpropan-2-one (PMK)		(4676-39-5)	Drugs Precursor – Category 1
Alpha-phenylacetoacetonitrile (APAAN)		(4468-48-8)	Drugs Precursor – Category 1
Chloroephedrine			Drugs Precursor – Category 1
Chloropseudoephedrine			Drugs Precursor – Category 1
Ephedrine			Drugs Precursor – Category 1

Ergometrine			Drugs Precursor – Category 1
Ergotamine			Drugs Precursor – Category 1
Isosafrole			Drugs Precursor – Category 1
Lysergic Acid			Drugs Precursor – Category 1
N-acetylanthranilic Acid			Drugs Precursor – Category 1
Norephedrine			Drugs Precursor – Category 1
Piperonal			Drugs Precursor – Category 1
Pseudoephedrine			Drugs Precursor – Category 1
Safrole			Drugs Precursor – Category 1
Acetic Anhydride			Drugs Precursor – Category 2A
Phenylacetic Acid			Drugs Precursor – Category 2B
Potassium Permanganate			Drugs Precursor – Category 2B
Anthranilic Acid			Drugs Precursor – Category 2B
Piperidine			Drugs Precursor – Category 2B
Acetone			Drugs Precursor – Category 3
Ethyl Ether			Drugs Precursor – Category 3
Hydrochloric Acid			Drugs Precursor – Category 3

Methyl Ethyl Ketone (MEK)			Drugs Precursor – Category 3
Sulphuric Acid			Drugs Precursor – Category 3
Toluene			Drugs Precursor – Category 3
Uniquely Hazardous Substances			
Substances assigned H300: Fatal if swallowed	Hydrofluoric Acid	(7664-39-3)	Uniquely Hazardous
	Uranyl acetate dihydrate	(6159-44-0)	Uniquely Hazardous
	Mercuric Chloride	(7487-94-7)	Uniquely Hazardous
Substances assigned H310: Fatal in contact with Skin	Mercury (II) Sulphate	(7783-35-9)	Uniquely Hazardous
	Vitamin D3, 25-Hydroxy-	(19356-17-3)	Uniquely Hazardous
	Hydrofluoric Acid	(7664-39-3)	Uniquely Hazardous
Substances assigned H330: Fatal if inhaled	Selenium hexafluoride	(007783-79-1)	Uniquely Hazardous
	Acetic Anhydride	(108-24-7)	Uniquely Hazardous
	Hydrofluoric Acid	(7664-39-3)	Uniquely Hazardous
Substances which contains one or more radionuclides whose activity cannot be disregarded for the purposes of radiation protection.	Uranium Tetrafluoride	(10049-14-6)	Uniquely Hazardous
	Caesium-137	(10045-97-3)	Uniquely Hazardous
	Cadmium-109	(7440-43-9)	Uniquely Hazardous