Chemical Storage Safety Guideline

Section 1 - Purpose and Scope

(1) This Guideline provides information about the safe storage of chemicals at The University of Queensland (UQ) and applies to:

a. UQ workers (as defined in the appendix) involved in the storage of chemicals at UQ; and
b. storage or handling systems which are bottles, packages, cylinders, drums, carboys, intermediate bulk containers (IBCs), tanks, vessels, reaction vessels, blending and mixing equipment, and associated pipework and connections.

(2) The information in this Guideline is intended to help UQ workers understand their obligations and apply the recommended procedures for bottles, packages, cylinders, drums, carboys and intermediate bulk containers (IBCs), which are the most common storage or handling systems at UQ sites, especially in laboratories, workshops and other areas where chemical containers are open.

Relevant Standards and Legislation

(3) Relevant standards and legislation include:

a. AS 1940 The storage and handling of flammable and combustible liquids;
b. AS/NZS 2243.10 Safety in Laboratories - Storage of Chemicals;
c. Work Health and Safety Act 2011;
d. Work Health and Safety Regulation 2011.

(4) This Guideline should also be read in conjunction with other UQ procedures and guidelines regarding Occupational Hygiene and Chemical Safety, including the Storage of Chemicals in Fridges, Freezers and Cold Rooms Guideline and Storage and Handling of Gas Cylinders Guideline.

Section 2 - Summary

(5) UQ Organisational Units are responsible for prioritising the safe storage of chemicals and managing risks associated with the use, handling, production, disposal and storage of hazardous chemicals – in accordance with the WHS Regulations.

(6) UQ workers should consider the following matters to support the safe storage of chemicals at UQ:

a. Identifying hazardous chemicals and knowing how to store them and other chemicals.
b. Understanding incompatibly storage issues and segregating chemicals accordingly.
c. Storing chemicals under the right conditions.
d. Minimising the potential for chemicals to become unstable, decompose or change during storage as it represents a different hazard (e.g., time-sensitive chemicals require especial precautions and monitoring, temperature control might apply).

e. Monitoring the integrity of the chemical labelling, packaging, seals and containers.
f. Minimising quantities of hazardous chemicals, commensurate with their usage and shelf life, and within the permitted storage limits.
g. Securing structures or plant used for the storage of hazardous chemicals are secured and fixed to stable foundations and measures are in place to prevent or control impact to containers, structures or plant containing hazardous chemicals.
h. Regularly reviewing chemicals held in storage and correctly disposing of those no longer required using the UQ waste procedures or via the UQ Science Store.
i. Attending required health and safety training, especially regarding chemical use, emergency response and first aid response.
j. Reporting any incidents or near misses to a Supervisor and in UQSafe.

Section 3 - Identifying for Safe Storage

(7) Hazardous chemicals and dangerous goods are a risk to the safety and health of people and the environment in the workplace. Workers need to be able to identify and avoid those risks, to avoid harmful exposure and impacting the environment. Education, induction, training, and supervision allows for the acquisition of knowledge on how to identify hazardous chemicals. Another tool available to workers are Safety Data Sheets (SDS) as they will identify the hazardous nature of a chemical. At UQ SDSs they are available through Chemwatch, or directly from manufacturers and suppliers. Refer to the Safety Data Sheets Guideline for further information.

(8) Workers need to complete risk assessments when working with chemicals and include the requirements for storage.

(9) Workers need to have clear signage on chemical storage area entry doors to identify chemical classes contained within the laboratory, workshop or area.

Section 4 - Segregation for Safe Storage

(10) Store chemicals according to their Dangerous Goods (DG) class and segregate from incompatible classes. Any secondary dangerous goods class classification must receive consideration for further segregation if reasonably practicable. There is no minimal segregation distance, provided there is sufficient control to prevent two incompatible chemicals directly mixing in the event two containers break at the same time.

> For example, acids and bases may be stored in a DG Class 8 cabinet together by storing the chemicals in separate bunded trays with sufficient capacity to prevent a leak or spill from mixing. Concentrated strong acids and concentrated strong alkalis should not be kept in the same area or cabinet unless it can be demonstrated that the risks are fully controlled.

(11) Refer to the Workplace Health and Safety Queensland Segregation Tool, for further information. Safety data sheets (SDS) available through Chemwatch also provide information on appropriate segregation and storage.

(12) The Global Harmonised System (GHS) and the DG classification differ and must be understood by the users. For example, the flammable GHS classification/pictogram covers several Dangerous Goods classes (DG 2.1, DG 3, DG 4.1, DG 4.2, DG 4.3 and DG 5.2) as shown in Table 1 (linked), which need segregation. Also refer to the national guide Safe Work Australia Classification and Labelling for Workplace Hazardous Chemicals and Appendix G of the Safe Work Australia Labelling of Workplace Hazardous Chemicals Code of Practice July 2020.

Table 1 - Comparison of GHS pictogram with ADG class ones (linked).

(13) Further clarification can be obtained from the HSW Manager or the Work Health and Safety Coordinator (WHSC) in your area, the Occupational Hygiene Advisor in the Health, Safety and Wellness Division (HSW Division), or at the Health, Safety and Wellness Division.

Section 5 - Chemicals Requiring Special Storage Conditions

(14) Store hazardous chemicals, so far as is reasonably practicable, under the right conditions to ensure their integrity. Hazardous chemicals must not become unstable, decompose or change so as to create a hazard different to the hazard originally created by the hazardous chemical, or significantly increase the risk associated with their hazardous properties.

(15) Some hazardous chemicals are inherently unstable or highly reactive or can become unstable under certain conditions. For example:

a. Substances which are unstable at ambient temperature must be kept in a controlled temperature environment set to maintain an appropriate temperature range. Reliable alternative safety measures must be provided for situations when utilities such as power, fail. Substances that can present additional hazards on heating should be clearly identified.
b. Sunlight can affect some plastic containers or the chemical contents. Containers or chemicals that are photosensitive should not be stored where they can be exposed to direct sunlight.
c. Chemicals such as hypochlorite solution and NoChromix glassware cleaner decompose to produce gaseous products and must be stored in vented cap containers. Ensure a vented cap container is used if decanted from the original manufacturer packaging. Vented cap containers must be stored in an upright position, otherwise venting of gaseous products will not take place.
d. Flammable or combustible chemicals, oxidising agents and/or the presence of other activities or materials can present significant risk of fire or explosion. Hazardous atmospheres and hazardous areas should be assessed; ignition sources must be eliminated from any hazardous areas; and auto-ignition temperatures should be considered as some hazardous chemicals may ignite spontaneously about certain temperatures.

(16) Other chemicals require restricted access and extra security controls:

a. Chemicals of Security Concern (CSC) and other controlled substances (medicines and poisons, radioisotopes, restricted carcinogens, cytotoxics, and others) must be stored away from the public and any unauthorised personnel. For example, in lockable cabinets, locked fridges/freezers or secure rooms. Refer to the Chemicals of Security Concern Procedure, and other procedures and guidelines related to Occupational Hygiene and Chemical Safety.

Aerosols

(17) Aerosol cans are classified as Class 2 Dangerous Goods, e.g., Gases. Aerosols of Divisions 2.1 Flammable gases and 2.2 Non-flammable, non-toxic gases may be stored in a store for Class 3 dangerous goods store if projectile protection is provided. Aerosol cages that comply with AS 4332: The Storage and Handling of Gases in Cylinders meet this requirement. If projectile protection cannot be provided, aerosols must be segregated from flammable liquids by 5 metres. Given this distance must be calculated from the edge of the spill catchment area, aerosols will under most circumstances need to be stored in a separate room, or in an aerosol cage as described.

Flammable and Combustible Liquids

(18) Flammable and combustible liquids must be handled and stored to minimise the fire risk. See Flammable and Combustible Liquids: Storage and Handling Procedure for further information.

Storage of Time-sensitive Chemicals

(19) Time-sensitive chemicals are those chemicals that, when stored for prolonged periods or under poor storage conditions, may develop hazards that were not present in the original formulation. There are four general categories of time-sensitive chemicals loosely based on those unsafe properties that can develop, such as:

a. peroxide formers: Oxygenated organic compounds that react with atmospheric oxygen to form explosive peroxides. Examples commonly found in laboratories include sodium amide, diethyl ether, dioxane, THF, and benzyl alcohol;
b. peroxide formers that can undergo hazardous polymerization such ethyl ether and sec-butyl alcohol;
c. materials that become shock or friction sensitive upon the evaporation of a stabilizer. Examples include azides, nitrate esters and picric acid; and
d. materials that generate significant additional hazards by undergoing slow chemical reactions, like Chloroform that reacts with air over time to form phosgene, a deadly gas with similar to new-mown hay odour, and isopropyl alcohol (2-propanol) forms peroxides very slowly.

(20) It should be noted that time-sensitive chemicals can be pure reagents or they can be commercial mixtures formulated as cleaners, adhesives and other products.

(21) All time-sensitive chemicals should be immediately marked with an expiration date upon receipt and listed on the laboratory chemical inventory to ensure timely disposal. The SDS for the chemical will state whether it is unstable under certain conditions or after a period of time in storage, and this information should be highlighted in the risk assessment. If the appearance of the chemical changes this is often a sign that the chemical should be quenched or sent for disposal.

(22) Containers should be inspected periodically, with a frequency determined by a risk assessment, to verify their condition. Signs of peroxide formation include crystal formation in the container, discoloration of liquids, or a “mossy” appearance around the cap. Peroxide test kits (strips) can also be used to determine peroxide concentration before a container is moved.

(23) If suspect materials are recognised, do not handle the container. Particularly, do not attempt to remove the cap. If explosive crystals have formed around the cap, the friction created by the unscrewing of the cap may be enough to detonate the compounds. Further advice can be obtained from an Occupational Hygiene Consultant or the local Work Health and Safety Coordinator.

(24) Refer to Table 2 (Chemical Health and Safety, Vol. No. 3, No. 5, “Review of Safety Guidelines for Peroxidizable Organic Chemicals", September/October 1996, pp. 28-36; and guides by University of California-Berkeley and Baylor University).

Table 2 – Time-Sensitive Chemical Types

A - Chemicals that form explosive levels of peroxides without concentration (3 months)[1]		
Butadiene[2] (106-99-0)	Isopropyl Ether (108-20-3)	Tetrafluoroethylene[2] (116-14-3)
Chloroprene[2] (126-99-8)	Potassium Metal (7440-09-7)	Vinylidene Chloride (75-35-4)
Divinyl Acetylene (821-08-9)	Sodium Amide (7782-92-5)	
B - Chemicals that form explosive levels of peroxides on concentration (12 months)[1]		

1,1-Dimethoxymethane (109-87-5)	Benzyl alcohol (100-51-6)	Di-n-propoxymethane (505-84-0)
1,2-Epoxy-3-isopropoxy propane (4016-14-2)	Benzyl n-butyl Ether (588-67-0)	Dioxane (123-91-1)
1,2-Dibenzyloxyethane (622-22-0)	Benzyl Ether (103-50-4)	Diethyl Ether (60-29-7)
1-Phenylethanol (98-85-1)	Benzyl Ethyl Ether (539-30-0)	Ethylene Glycol Dimethyl Ether (110-71-4)
2-Butanol (78-92-2)	Benzyl 1-naphthyl Ether (607-58-9)	Isoamyl Ether (544-01-4)
2-Hexanol (626-93-7)	Cumene (98-82-8)	Isophorone (78-59-1)
2-Methyl-1-butanol (137-32-6)	Cyclohexene (110-83-8)	Methyl Isobutyl Ketone (108-10-1)
2-Penten-1-ol (1576-95-0)	Cyclooctane (292-64-8)	Methyl Acetylene (74-99-7)
2-Phenylethanol (60-12-8)	Decahydronaphthalene (91-17-8)	Methylcyclopentane (96-37-7)
2-Propanol (67-63-0)	Diacetylene (460-12-8)	Other secondary alcohols (N/A)
4-Heptanol (589-55-9) p-	Diallyl Ether (557-40-4)	Dibenzyloxybenzene (621-91-0)
4-Methyl-2-pentanol (108-11-2)	Dicyclopentadiene (77-73-6)	p-Isopropoxypropionitrile (110-47-4)
4-Penten-1-ol (821-09-0)	Diethoxymethane (462-95-3)	Tetrahydrofuran (109-99-9)
Acetal (105-57-7)	Diethyl acetal isoamyl benzyl ether (N/A)	Tetrahydronaphthalene (119-64-2)
Acetaldehyde (75-07-0)	Diethylene Glycoldimethyl Ether (diglyme) (111-96-6)	Vinyl Ethers (N/A)
Allyl Ether (557-40-4)	Dimethoxymethane (109-87-5)	
C - Chemicals that may autopolymerize as a result of peroxide accumulation (12 months)[1,3,4]		
Acrylic Acid (79-10-7)	Methyl Methacrylate (80-62-6)	Vinyl Chloride (75-01-4)
Acrylonitrile (107-13-1)	Styrene (100-42-5)	Vinylidene chloride (75-35-4)
Butadiene[2] (106-99-0)	Tetrafluoroethylene[2] (116-14-3)	2-Vinyl Pyridine (100-69-6)
Chloroprene[2] (126-99-8)	Vinyl Acetate (108-05-4)	4-Vinyl Pyridine (100-43-6)
Chlorotrifluoroethylene (79-38-9)	Vinyl Acetylene (689-97-4)	
D - Other Time Sensitive Chemicals (varies)[5]		
Acetylene (74-86-2)	Ethylene oxide (75-21-8)	Nitrogen triiodide (13444-85-4)
Ammonium Nitrate (6484-52-2)	Germanium (7440-56-4)	Nitrogen trichloride (10025-85-1)
Ammonium Perchlorate (7790-98-9)	Hexanitrodiphenylamine (131-73-7)	Nitroglycerin (55-63-0)
Ammonium Picrate (131-74-8)	Hexanitrostilbene (20062-22-0)	Nitroglycol (628-96-6)
Calcium Nitrate (10124-37-5)	Hydrazine (302-01-2)	Nitroguanidine (556-88-7)
Chloroform (67-66-3)	Hydrazoic acid (7782-79-8)	Nitrourea (556-89-8)
Dinitrotoluene (121-14-2)	Hydrogen Compound Gases (NA)	Perchloric acid (7601-90-3)
Dinitrophenol (51-28-5)	Lead styphnate (15245-44-0)	Picric acid (88-89-1)

[1] Safe storage periods are given for an open container of each class of peroxidizable material. Unopened containers from the manufacturer have a safe storage period of 12 months.

[2] When stored in liquid form these chemicals may form explosive levels of peroxides without concentration.

When stored as a gas, these chemicals may autopolymerize as a result of peroxide accumulation.

[3] If chemical from list C is inhibited, do not store under an inert atmosphere. Oxygen is required for inhibitor to function.

[4] Uninhibited chemicals from list C have a safe storage period of 24 hours.

[5] Please refer to the SDS and manufacturers' information for more details on safe storage and shelf life.

Time-Sensitive Compressed Gas Cylinders

(25) The compressed gases listed below have a shelf-life provided by the manufacturer that must be strictly followed. Incidents involving these compounds usually relate to storage past the expiration date. For example, hydrogen fluoride (HF) and hydrogen bromide (HBr) cylinders have a shelf-life of one to two years, depending on the vendor. Over time, moisture can slowly enter the cylinder, which initiates corrosion. As the corrosion continues, HF and/or HBr slowly react with the internal metal walls of the cylinder to produce hydrogen. The walls of the cylinder weaken due to the corrosion, while at the same time the internal pressure increases due to the hydrogen generation. Ultimately, these cylinders fail and create extremely dangerous projectiles and a toxic gas release.

a. Hydrogen fluoride, Anhydrous
b. Hydrogen bromide, Anhydrous
c. Hydrogen sulfide, Anhydrous
d. Hydrogen cyanide, Anhydrous
e. Hydrogen chloride, Anhydrous.

Storage of Air-sensitive Chemicals

(26) A chemical is classed as air-sensitive if it reacts with oxygen (O_2), water, nitrogen (N_2), or carbon dioxide ($CO_{2)}$. Air-sensitive chemicals must be isolated from the atmosphere and handled in a controlled environment. Typically, under an atmosphere of nitrogen or argon. This comes in a suitably pure form from a cylinder fitted with an appropriately sized regulator. Nitrogen, less expensive, is usually the preferred gas unless the chemical(s) under study react with nitrogen.

Figure 1 - Examples of compounds that oxidize, decompose, or explode under the influence of oxygen or moisture.

Examples of Pyrophoric Compounds		**Examples of Chemicals that React Violently with Water**	
Metal alkyls and aryls	RMgX, RLi, RNa, R_3Al, R_2Zn	Metal hydrides	NaH, KH, $LiAlH_4$
Metal carbonyls	$Ni(CO)_4$, $FE(CO)_5$, $CO_2(CO)_8$	Metal amides	$NaNH_2$
Alkali metals	Na, K, Cs	Metal alkyls and aryls	RMgX, RLi, RNa, R_3Al,R_2Zn
Metal powders	Al, Co, Fe, Mg, Pd, Pt, Zn	Metals and metal powders	Al, Co, Fe, Mg, Pd, Pt, Zn
Metal hydrides	NaH, KH, $LiAlH_4$	Many main group halides	BCl_5, BF_5, $AlCl_5$, $SiCl_5$
Hydrides	B_2H_6, PH_3, AsH_3	Inorganic acid halides	$POCl_3$, $SOCl_3$
Boranes, phosphines, arsenes, etc.	R_3B, R_3P, R_3As	Low molecular weight organic acid halides and anhydrides	

The best way to keep things away from atmospheric oxygen and water is to work in a glove box, a fully enclosed bench top cabinet containing an inert atmosphere, which one could reach into with gloves. Air-sensitive chemicals can

also be stored in a dry box. There are also glove bags (AtmosBag), a poorer substitute, which you can fill with inert gas and reach into with attached gloves. Refer to Figure 2.

> Figure 2 - Glove box (left), AtmosBag (centre) and Dry box (right) (linked)

(27) Other techniques are the use of Schlenk apparatus or the Sure/Seal™ packaging system (Septum Inlet Transfer Adapter and Oxford Storage Valve Cap).

Storage of Temperature-sensitive Chemicals

(28) Many of the chemicals in storage at UQ need to be stored under relatively stable temperature and humidity regimes for best shelf life and safety. The space or plant to be used for chemical storage must be fit for purpose for the safe and secure storage of these chemicals. Take the necessary precautions to ensure that appropriate storage happens from arrival to disposal (e.g., to lower the risk of explosion).

Storage of Chemicals in Refrigerators, Freezers or Cold Rooms

(29) Where flammable substances are to be stored in refrigerators, a pharmaceutical fridge or freezer with a spark proof interior must be purchased. Refer to Storage of Chemicals in Fridges, Freezers and Cold Rooms Guideline.

(30) Controlled substances that require refrigeration will need to be secured in safes, lockable cash boxes inside fridges, freezers or cold rooms; or made secure by a lockable door or mechanism. Refer to other procedures and guidelines related to Occupational Hygiene and Chemical Safety.

Section 6 - Chemical Packaging and Labelling

(31) When storing chemicals, ensure the containers and their seals or stoppers are appropriate for the type and quantity of chemical stored. As far as is practicable, chemicals should be stored in the containers in which they are supplied and kept closed when not in use. Decanted chemicals must also be labelled appropriately during storage, refer to the Chemical Labelling Guideline.

(32) Packages should be inspected regularly, at least annually, to ensure their integrity and the labelling remains legible. Leaking or damaged packages should be removed to a safe area for repacking or disposal. Labels must be reattached or replaced, as necessary, to clearly identify the contents of the package.

Section 7 - Storage Limits

(33) AS/NZS 2243.10 Safety in Laboratories: Storage of Chemicals, states the following quantities of chemicals are permitted to be stored in a laboratory, other than in a chemical storage cabinet (e.g., open bench storage), refer to Table 3 below. These limits should be followed as closely as possible, and quantities in excess of these levels should be stored in a dedicated Dangerous Goods cabinet.

> For example, consider a laboratory containing a 2.5 L container of acetone and a 20 L drum of isopropanol, both DG Class 3 Packing Group II. Because the drum of isopropanol is > 5 L (see Table 3), it must be stored in a Dangerous Goods cabinet. The acetone may be stored in the Dangerous Goods cabinet or on a shelf or bench, as the 2.5 L container is below the 5 L container size limit.

(34) Containers must be treated as full, unless the container has been emptied, cleaned and the label removed or defaced.

(35) Any individual chemical container must be ≤25 L, even when stored in a Dangerous Goods cabinet (this includes chemical waste containers).

(36) The ventilation within a laboratory must be suitable to ensure any flammable vapours do not exceed 5% of the applicable lower explosive limit (LEL) and any toxic vapours must not exceed the relevant workplace exposure standard. This includes when chemical containers are opened for decanting or other use. Depending on the volatile nature of the chemicals in use, this may be achieved via either natural or mechanical ventilation, see Section 5 of AS/NZS 2982 for further specifications. Each laboratory must have a dedicated ventilation system not shared by other storage areas, and exhaust air must discharge outside the building.

(37) For a workshop, the ventilation must be adequate to prevent the build-up of a hazardous atmosphere.

Table 3 - Quantities of hazardous chemicals permitted to be stored in a laboratory working area outside of a Dangerous Goods Cabinet for AS2243.10.

Type of Goods	Maximum quantity per 50m^2 (kg or L)	Maximum container size (kg or L)	Notes	Conditions of storage	Alternative storage options
Class 3 (primary or subsidiary risk)	10	5	A chemical storage cabinet or cupboard used to store these liquids must not be used to store dangerous goods of any other class.	Labelled standard laboratory cupboard/cabinet or in small amounts throughout the laboratory.	AS 1940 or AS/NZS 3833
Combustible liquid	50	20		Labelled standard laboratory cupboard/cabinet or in small amounts throughout the laboratory.	AS 1940 or AS/NZS 3833
Class 4.1, 4.2, 4.3, 5.1* or 5.2	20 total, but less than 10 of any one Class	10	A chemical storage cabinet or cupboard used to store these classes dangerous goods must not be used to store dangerous goods of any other class. E.g., a cabinet or cupboard containing Class 4.1 may only contain Class 4.1 goods.	Labelled standard laboratory cupboard/cabinet or, for Classes 4.1, 4.3 and 5.1, or in small amounts throughout the laboratory.	AS 2714 or AS/NZS 3833
Class 6.1	PG I 10 Other 50	PG I 10 Other 20		Labelled standard laboratory cupboard/cabinet or in small amounts throughout the laboratory.	AS/NZS 4452 or AS/NZS 3833
Class 8	20 for liquids 50 for solids	20	Class 8 dangerous goods must be stored in a manner that will prevent reactions between: - acids and alkalis - acids and hypochlorites - acids and cyanides - oxidizing acids and combustible materials - incompatible acids	Labelled standard laboratory cupboard/cabinet or in small amounts throughout the laboratory.	AS 3780 or AS/NZS 3833

Type of Goods	Maximum quantity per 50m^2 (kg or L)	Maximum container size (kg or L)	Notes	Conditions of storage	Alternative storage options
Class 9 and aerosols	50 for liquids 100 for solids	5 for liquids 20 for solids		Labelled standard laboratory cupboard/cabinet or in small amounts throughout the laboratory.	AS/NZS 4681 or AS/NZS 3833
Hazardous chemicals, generally	N/A	5 for liquids 20 for solids		Labelled standard laboratory cupboard/cabinet or in small amounts throughout the laboratory.	
Maximum aggregate quantity	200	N/A			

* The quantities for Class 5.1 stated in the Table are the total amount of active ingredient present, rather than the actual volume or mass to allow for the very wide differences between concentrations of active ingredient in peroxides and hypochlorites that are commonly used in laboratories.

(38) At UQ we encourage best practice and strongly recommend hazardous chemicals to be always stored inside cabinets. Wherever possible, a reduction of stock should be implemented if materials cannot be safely stored in cabinets. Storage in open benches should be considered as a last resort, and always within the allowed limits.

(39) There is no limit for the storage of non-hazardous chemicals.

(40) Within a horizontal radius of 10 m, measured from any one cabinet, the aggregate storage capacity for all cabinets in that radius must not exceed 250 L or kg, including through intervening walls. Within this radius, any PG I dangerous goods from Classes 4.1, 4.2, 4.3, 5.1, 5.2 must not exceed 10kg or L for each class. An example layout is provided in Figure 3 (linked).

Figure 3 - Example layout for minimum separation distances for minor storage (linked)

Section 8 - Storage Structures

Chemical Storage in Cabinets

(41) Dangerous Goods cabinets are commonly used to store hazardous chemicals as they provide greater protection to the chemicals stored within them in an emergency situation, e.g., spills and fires. Chemical storage cabinets for the storage of dangerous goods are required where the storage quantities exceed those listed in the table above. The cabinets should comply with the design requirements of AS 1940 The storage and handling of flammable and combustible liquids, or the design criteria in the relevant standard.

(42) The following requirements apply to the storage of chemicals within cabinets at UQ:

a. Have signage indicating the class of Dangerous Goods stored within the cabinet.
b. When storing flammable substances, the contents of the cabinet must not exceed 100L. If a 250L cabinet is used for the storage, it must be de-rated to 100L. This involves removing some of the shelving and placing a sticker over the manufacturer’s capacity rating, so that it is clear that 100L is the maximum cabinet capacity.
c. All new installations of chemical storage cabinets must incorporate mechanical extraction ventilation where

highly corrosive, toxic or volatile chemicals are being stored, unless an assessment of the risk of exposure deems it not necessary. The ventilation must be to an external atmosphere (e.g., outside the building) in a manner that allows safe dispersal of vapours, fumes or dust.

d. The capacity of any chemical storage cabinet used in a laboratory to store chemicals of dangerous goods classes 4.1, 4.2, 4.3, 5.1 or 5.2 must not exceed 50L.
e. Within a radius of 10m, measured from any one cabinet, the cabinet storage capacity aggregated for all cabinets in that radius must not exceed 250L or 250kg, including no more than 10L or 10kg each of dangerous goods classes 4.1, 4.2, 4.3, 5.1 or 5.2 that are classified as PGI. The radius is measured horizontally through intervening walls, unless those walls are able to prevent the spreading of a fire of the magnitude that could be expected to result from the contents of the cabinet(s). Refer to Figure 1 above.
f. Dangerous Goods cabinets containing chemicals with a primary or subsidiary risk of Class 3, 4 or 5 must not be located within 3 m of an ignition source unless a hazardous zone assessment has been completed.
g. Have doors which are self-closing, close-fitting and held shut automatically by catches at two or more points. Where doors have a mechanism to hold them open, the mechanism will automatically release above 80°C.
h. Cabinets containing Class 5.2 Dangerous Goods must have doors with a self-closing mechanism as per Australian Standard 1940 section 4.9.2, but the cabinet door shall have a door closing mechanism that allows the door to open and pressure resulting from accelerated decomposition to be released, e.g., a magnetic lock or friction lock.
i. Dangerous Goods cabinets containing chemicals must be separated by a minimum distance of 250 mm of clear air space.
j. The spill catchment/bund of cabinets must not be used to store chemicals.
k. Where possible, store chemicals on chemically resistant spill trays within cupboards or cabinet. Refer to Figure 4 - Example of spill tray use in storage cabinets (linked).
l. Chemicals must not be opened or used on top of a Dangerous Goods cabinet.
m. Cabinets shall not be located:
    i. One above the other.
    ii. Where they can jeopardize emergency escape (minimum 3m away from emergency exits or egress points).
    iii. Under stairs or in corridors.

Figure 4 - Example of spill tray use in storage cabinets (linked).

Chemical Storage in Shelves, Racks or Cupboards

(43) Other cabinets or cupboards which do not meet the specifications of Dangerous Goods cabinets may be used to store chemicals, provided:

a. The cabinet is made of a material which is resistant to spills, leaks or vapours from the chemicals enclosed. For example, cabinets made of metal or using metal supports or shelving should not be used to store chemicals which give off corrosive vapours as the metal will corrode over time.
b. Secondary containment in the form of bunded trays is used.
c. Cabinets do not enable the build-up of hazardous atmospheres such as toxic vapours.
d. Cabinets have signage indicating the class(es) of Dangerous Goods stored within them.
e. If a cabinet is used to store volatile chemicals which present an inhalation risk, ventilation must be considered. If an individual cabinet is vented, the ventilation must be to an external atmosphere (e.g., outside the building) in a manner that allows safe dispersal of vapours, fumes or dust. Each cabinet ventilation system must be completely independent (e.g., two cabinets cannot share ducting; cabinet cannot be ducted to a fume hood

exhaust).

(44) Chemicals kept on shelves or racks are subject to the following restrictions:

a. Shelving and its fixtures must be compatible with the goods stored, or should be suitably protected from the goods (NOTE: the use of particle board is not recommended as they may fail when subjected to moisture or chemicals);
b. Secondary containment should be used to prevent spills from spreading or incompatible chemicals from mixing;
c. The maximum holding capacity of the shelving systems must not be exceeded;
d. Chemicals shall not be stored on shelves higher than 1.5m from the floor; and
e. Shelves or racks used for chemical storage should be restrained against lateral movement and must have lips on them to prevent containers being pushed through to the other side.
f. Pallets of hazardous chemicals must not be stacked on top of one another.
g. Chemical containers should not be stored on the ground.

Chemical Storage Room Requirements

(45) All chemical storage rooms must be purpose built and comply with the requirements of Section 5 of AS/NZS 2243.10 Safety in Laboratories: Storage of Chemicals. New buildings will generally have a dedicated Hazardous Area Classification (HAC) assessment covering the storage of flammable liquids, which may also apply to general laboratory areas as well. The HAC should be consulted when deciding the type and quantity of flammable liquids to store within a building.

(46) On the other hand, the storage of mixed classes of Dangerous Goods in a separate store could be:

a. A separate storeroom attached to a laboratory area.
b. A chemical storage room inside a building, where laboratory work is not undertaken in the room.
c. A chemical storage room, shed, or similar, which is outside the building.

(47) There are several Australian Standards which may be applicable to the storage of chemicals in a store separate from a laboratory, as reflected in this section. Each standard has different threshold quantities for minor storage and may include additional specific requirements for the storage area.

(48) The most appropriate set of requirements should be selected for the storage area, using Table 4 below. Once chosen, the minimum requirements for that standard must be applied in full.

Table 4 - Overview of standards which may be applied to a separate chemical storage area

Australian Standard	Overview of Requirements
AS/NZS 2243.10	This Standard is most appropriate for stores containing a wide range of hazardous chemicals but limits the total quantities of chemicals and the maximum container sizes (See Table 5). This standard has only minimal separation distances between different classes, though incompatible materials must still be segregated (e.g., through separate bunded trays).
AS/NZS 3833	This standard may offer larger allowable volumes for individual containers or for a given storage area (See Table 6), and for minor storage, has very few additional requirements pertaining to the store (e.g., ventilation, fire suppression systems). This standard may be more appropriate for stores containing moderate quantities of lower-risk (PG II-III) chemicals such as paints, solvents or hazardous chemicals with agricultural applications.

Australian Standard	Overview of Requirements
Individual DG class	Where only one Dangerous Goods class will be stored, the standard for that class may be used. AS 1940 - The storage and handling of flammable and combustible liquids AS 2714 – The storage and handling of organic peroxides AS 3780 - The storage and handling of corrosive substances AS 4326 - The storage and handling of oxidizing agents AS 4452 - The storage and handling of toxic substances AS 4681 - The storage and handling of Class 9 (miscellaneous) dangerous goods and articles AS 5026 - The storage and handling of Class 4 dangerous goods

Separate Chemical Stores Meeting AS 2243.10 Requirements

(49) In addition to the AS/NZS 2243.10 requirements for minor storage (section 3.5 and 3.6.1 to 2):

a. The store must not contain gas cylinders or cryogenic liquids.
b. Where possible the store should not contain other laboratory items such as glassware or apparatus, though the storage of other non-hazardous chemicals is permitted.
c. All internal stores should be located on the floor directly accessible from street level where possible. For stores located on any other floor of a building, a risk assessment must be conducted and documented to identify any risks posed to other floors or evacuation routes.
d. An external store must be separated from neighbouring buildings, or from site boundaries by:
    i. 3 m, if the aggregate hazardous chemicals kept in the store is ≤1000 kg or L.
    ii. 5 m, if the aggregate hazardous chemicals kept in the store is between 1000 kg or L and 4500 kg or L.
    iii. No separation distance is required if fire walls or vapour screens complying with Australian Standard 1940 are installed.
e. Any individual chemical container holding liquids must be ≤100 L. This includes chemical waste containers.
f. The aggregate maximum quantities of chemicals held in the store must not exceed Table 5.
g. The maximum quantity of chemicals in any one chemical storage cabinet must be ≤100 L or kg. There are additional limitations on the quantities of chemicals in any one cabinet for some Class 5, 6 and 8 chemicals. See Table 5 for specific limits.
h. Dangerous Goods cabinets containing chemicals must be separated by a minimum distance of 250 mm of clear air space.
i. For any Dangerous Goods cabinet containing PG I chemicals, the whole contents of that cabinet must be considered as PG I.

> For example, a 250 L flammable liquids cabinet containing a 2.5 L bottle of diethyl ether (DG Class 3 PG I) along with other Class 3 PG II and PG III totalling 100 L would not be permitted as minor storage. The presence of the PG I container in this cabinet means that the aggregate 102.5 L must all be considered PG I and this volume exceeds the allowed quantity for PG I in Table 3 of 100 L in any one cabinet.
>
> If the diethyl ether was stored in a separate 30 L flammable liquids cabinet, then these quantities would be allowed as minor storage.

Table 5 – Aggregate maximum quantities (L or kg) of classes of chemicals to be stored in a location to meet the requirements of minor storage for AS2243.10

Type of Goods	Packing Group I (kg or L)	Packing Group II and III (kg or L)	No Packing Group (kg or L)
Goods too dangerous to be transported	N/A	N/A	Risk assessment required

Type of Goods	Packing Group I (kg or L)	Packing Group II and III (kg or L)	No Packing Group (kg or L)
Class 2 aerosols (UN 1950)	N/A	100	N/A
Class 3 primary or subsidiary risk (excluding UN 3256)	200, but no more than 100 in any one cabinet	1000	N/A
Combustible liquids C1/C2	N/A	N/A	1000
Class 4.1 Class 4.2 Class 4.3 Class 5.1 Class 5.2	200 aggregate UN 3221-3240, UN 3101-3102 and UN 3111-3120 to be included in PG I *	1000 aggregate No more than 50 of Class 5.2 in any one cabinet	N/A
Class 6.1 Class 8 Class 9 (excluding elevated temperature goods) UN 3257 and 3258, and dry ice UN 1845)	500 aggregate *** No more than 100 of Classes 6.1 and 8 in any one cabinet	1000 aggregate***	N/A
UN 3256, 3257 and 3258 (elevated temperature liquid or solid) UN 1845 (dry ice)	N/A	Risk Assessment required**	N/A
Hazardous substances not otherwise classified as dangerous goods	N/A	N/A	2000
Aggregate maximum	500	200	200

* For the purpose of risk management, some dangerous goods of Class 4.1 and 5.2 have been added to Packing Group I, varying from the groupings used for ADG Code and SDS purposes.

** A risk assessment is required to determine the storage conditions, suitability and quantities. For dry ice (UN 1845), particular account shall be taken of the room size, room temperature and ventilation rates when assessing the quantity to be stored. The minor storage requirements in AS 4681 should be consulted.

*** The following Class 6.1 and Class 8 substances must be stored in Dangerous Goods cabinets (rather than bench-top, cupboard or shelf storage) in order to meet the requirements of minor storage: liquids in breakable containers >1 L capacity; liquids in non-breakable containers >5 L capacity; solids in packages >10 kg.

j. The store floor must be made of non-absorbent, non-combustible materials which are as resistant as practicable to the chemicals stored.
k. The store must contain a spill catchment mechanism (e.g., bunding of containers or a floor pit) which is sufficiently impervious to retain the spillage until clean-up measures can be taken. Where bunding under the chemical containers is used, the capacity must be at least equal to the volume of the largest container stored in the bunded area.
l. Where incompatible chemicals are stored in the same area, the spill catchment system must prevent these substances from coming into contact with one another in the event of a spill (e.g., separate bunding containers or pits for each incompatible class).
m. Similar to laboratories, the store's ventilation must be suitable to ensure any flammable vapours do not exceed 5% of the applicable lower explosive limit (LEL) and any toxic vapours must not exceed the relevant exposure standard. The needs of the ventilation system may differ depending on the volatile nature and quantity of chemicals stored, but the store must be designed with the principles of Section 4.5 of AS/NZS 1940, including:

i. A preference for mechanical ventilation over natural ventilation.
ii. Where stores are mechanically ventilated, the ventilation system must be exclusive to the room. There must be no recirculation of exhaust air, except for a cool room where a risk assessment has been conducted and control measures put in place to prevent the build-up of a hazardous atmosphere. The system must be designed such that it is at least operational whenever a person is occupying the store, if not continuously operational, and be fitted with an airflow failure warning device.
iii. Further specifications, such as the location of vents/ducting and exhausting velocities is provided in AS 1940.

n. If the store has been designated a hazardous area (e.g., potential to form an explosive atmosphere due to flammable gases, vapours, particles, etc.), it must not contain any ignition sources. See the Managing Hazardous Areas Technical Guide for more information.
o. The store must:
    i. Have an automatic fire extinguishing system which is compatible with the chemicals being stored, or
    ii. Be equipped with an alarm which will activate when the concentration of flammable or toxic vapour exceeds set limits, when there is smoke, or when heat is generated.
p. Where a sprinkler-based fire suppression system (water or foam) is installed, there must be a mechanism to contain the effluent of 20 minutes of operation within the building (but not necessarily within the store itself).
q. The store must have at least one fire extinguisher compatible with the chemicals being stored immediately outside the door to the store, with a minimum size equivalent to a 2A 60B(E) for powder-type extinguishers or a 2A 20B for foam extinguishers. Additional fire extinguishers should be considered for larger stores.
r. PPE appropriate for the chemicals stored must be available at or just inside the door of the storage area (e.g., gloves, safety glasses, lab coats).

Chemical Stores Meeting AS/NZS 3833 Minor Storage

(50) In addition to the AS/NZS 2243.10 requirements for minor storage (section 3.5 and 3.6.1 to 2):

a. The aggregate maximum quantities of chemicals held in the store must not exceed those listed in Table 6per 500 m^2 floor or ground space.
b. The store is separated from other minor stores by at least 10 m.
c. The transfer of dangerous goods from the store to the point of use must be carried out in a manner that minimizes the possibility of spillage or fire.
d. A fire extinguisher of suitable type must be installed in each minor store, located so that it is immediately accessible in an emergency along an exit route.
e. PPE such as gloves, safety glasses and lab coats must be available at or just inside the door of the storage area.

(51) Additionally, for an outdoor store:

a. the ground around the store must be kept clear of combustible vegetation or refuse to a distance ≥ 3 m.
b. the store must be separated by at least 3 m from:
    i. Any building that is not another minor chemical store, laboratory or workshop (e.g. offices, cafeterias);
    ii. Any place accessible to the general public where people are likely to congregate (e.g. public lawn areas, emergency evacuation points);
    iii. Any environmentally sensitive areas;
    iv. A ship at permanent berthing facilities;
    v. The property boundary.
c. The effluent or flow of a chemical spill or leak must be prevented from reaching any adjacent buildings or

facilities, the property boundary or any watercourse. This may be achieved using a natural ground slope or through a diversion channel, kerb, or bund.

Table 6 – Maximum quantities (L or kg) of chemicals to be stored in a location to meet the requirements of minor storage AS/NZS 3833

Type of Goods	Packing Group I (kg or L)	Packing Group II (kg or L)	Packing Group III (kg or L)	Combustible Liquids (kg or L)
Class 5.2	10 total			N/A
Total quantity of all Dangerous Goods	25	250	1000	1500

The maximum allowance of each of the groups can be stored concurrently (e.g., a store could contain 25 L of PG I plus 250 L of PG II).

Where the chemicals being stored are Class 3 Dangerous Goods of Packing Group II or III that are a suspension or solution of at least 10% non-volatile materials consistent with the definition of 'Manufactured Product' in Australian Standard 3833, the maximum storage allowance is doubled. Chemicals meeting this definition include most solvent-based paints, lacquers, and polishes.

Section 9 - Monitoring Chemical Holdings

(52) Workers must ensure they minimise the quantities of hazardous chemicals. The storage of chemicals must be monitored to facilitate periodic stocktakes to allow for update of registers and manifest, besides proper housekeeping and prompt disposal of old/expired, contaminated and decayed chemical stocks. Refer to relevant points within this Guideline, the Chemicals of Security Concern Procedure, and other procedures and guidelines related to Occupational Hygiene and Chemical Safety.

Chemical Registers

(53) An up-to-date chemical register must be maintained for all the hazardous chemicals used in the workplace and be accessible to workers and emergency services. See the Chemical Manifest Procedure and the Placarding of Chemical Storage Areas Guideline for further information.

Disposal

(54) Some hazardous chemicals may provide an expiry date on the label and SDS. Where a chemical has passed its expiry date it should not be used but be disposed according to the Environmental Management System procedures.

(55) Old/expired, unwanted, contaminated and decayed chemical stocks can be disposed as per the Chemical Waste Operating Procedure through the UQ Science Store.

Chemical Waste Storage

(56) The storage of chemical waste must follow the same procedures for safe and complaint storage as per the original chemical holdings.

Section 10 - Training

(57) Supervisors and Managers must ensure that UQ workers are aware or are made aware, by providing adequate information, training and supervision of the health hazards that the use, handling and storage of chemicals may present and be given induction and training (including refresher training) prior to using chemicals. Workers that access chemical storage areas must have received training in identifying chemical hazards, assessing risks associated with chemicals and be familiar with appropriate control measures. This includes how to accomplish safe and compliant storage of chemicals.

(58) UQ has online training available, eLearning: Chemical Safety, which is mandated for completion by all UQ workers chemical users.

Section 11 - Emergency Response

(59) The local area must consider the nature and quantity of chemicals stored to inform the appropriate emergency response, especially the plan, for any incident occurring with the stored chemicals. Workers must know how to respond to incidents that occur while storing or during storage of the chemicals, e.g., fire, breakages, spills, unwanted reactions, exposures, etc. Workers must have access to the relevant training and spill kits for the appropriate response, including access to first aid facilities, supplies, and first aid training response. Please also refer to the Chemical Spill and Response Procedure and Guideline, the Fire Safety Management and Evacuation Plan Procedure, and the Placarding of Chemical Storage Areas Guideline.

Section 12 - Incident Reporting

(60) Incidents involving chemicals during storage or while in storage (e.g., breakages, spills, unwanted reactions, exposures, etc.) must be reported by completing an incident report in UQSafe especially important is the reporting of major chemical spills and/or those that involve personnel. Incidents, including near misses, must be reported so learnings and improvements on the safe storage for chemicals can be achieved.

Section 13 - Monitoring, Review and Assurance

(61) Health, Safety and Wellness Division will review this Guideline, as required, to ensure its accuracy and relevance.

(62) Organisational Units and Supervisors should review chemical holdings and chemical storage on a regular basis, following incidents and near misses, when reviewing and updating risk assessments and after changes to processes or procedures.

Section 14 - Appendix

Relevant Standards

(63) Access to the following Standards is available via the UQ Library.

a. AS/NZ 2243.10 Safety in Laboratories: Storage of Chemicals;
b. AS 1940 The storage and handling of flammable and combustible liquids;
c. AS 2714 The storage and handling of organic peroxides;
d. AS 3780 The storage and handling of corrosive substances;

e. AS 4326 The storage and handling of oxidizing agents;
f. AS 4452 The storage and handling of toxic substances;
g. AS 4681 The storage and handling of Class 9 (miscellaneous) dangerous goods and articles;
h. AS 5026 The storage and handling of Class 4 dangerous goods;
i. AS4332 The Storage and Handling of Gases in Cylinders.

Definitions

<table>
<tr><th>Terms</th><th>Definitions</th></tr>
<tr><td>Bunding</td><td>the use of a barrier, pit or secondary containment to prevent the spread of a chemical spill or leak.</td></tr>
<tr><td>Dangerous Goods</td><td>are chemicals assigned to a Dangerous Goods (DG) class under the Australian Dangerous Goods code. A chemical’s DG class is listed in section 14 of the SDS.</td></tr>
<tr><td>Hazardous chemicals</td><td>are any substance, mixture or article that can pose a health or physical hazard to humans. They may be solids, liquids or gases. They satisfy the criteria of one or more hazard classes in the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), as modified by Schedule 6 of the WHS Regulation.

Most substances, mixtures, and articles that are dangerous goods under the Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG Code) are hazardous chemicals, except those that have only radioactive hazards (class 7 dangerous goods), infectious substances (division 6.2) and most class 9 (miscellaneous) dangerous goods.</td></tr>
<tr><td>Incompatible</td><td>Substances which, when brought in contact with one another, may react or combine in a manner that could increase the hazard of an individual substance, for example, by causing a fire, explosion, violent reaction, liberating flammable or poisonous gases; could cause the deterioration of the container or substance; could otherwise cause injury to people or endanger property.

This definition also includes substances which are declared by a relevant regulatory authority to be incompatible.</td></tr>
<tr><td>Ignition Source</td><td>A source of energy sufficient to ignite a flammable or explosive atmosphere. It may include naked flames, hot surfaces, exposed incandescent material, electrical arcs, hot particles, electrical discharge including from static electricity, chemical reactions, high intensity electromagnetic radiation including visible light or ultraviolet radiation, mechanical sparks, fixed and portable electrical equipment, portable tools or vehicles such as forklifts.</td></tr>
<tr><td>Laboratory</td><td>is any building or part of a building used or intended to be used for scientific and related work, including research, quality control, testing, teaching or analysis. This may include workshops, sheds or other areas where chemical containers are opened or handled.</td></tr>
<tr><td>Packing Group (PG)</td><td>An assigned measure of Dangerous Goods’ hazard rating. For Dangerous Goods in Classes 3, 4, 5, 6.1, 8, or 9:

<table><tr><td>Packing Group I</td><td>High danger items</td></tr><tr><td>Packing Group II</td><td>Medium danger items</td></tr><tr><td>Packing Group III</td><td>Minor danger items</td></tr></table>
Class 1, 2 and 6.2 chemicals do not use Packing Group assignations. For Class 7 chemicals, the Packing Group order is reversed.</td></tr>
<tr><td>Quenching</td><td>to terminate a reaction, to deactivate any unreacted reagents, or to destroy remaining reagents. It is a term used to describe the introduction of a material that combines with any unused reactants and effectively stops a reaction.</td></tr>
<tr><td>Safety Data Sheet (SDS)</td><td>document containing information on the health, safety and environmental aspects of a material or chemical for the purposes of storing, using and disposing of the substance in a safe way.</td></tr>
<tr><td>Segregation</td><td>Keeping incompatible goods apart from one another in one room, using a barrier or an intervening space.</td></tr>
</table>

Terms	Definitions
UQSafe	UQ online system for recording risk assessments, injuries/illness, near miss and hazard reporting and certifications.
UQ workers	for the purposes of this Guideline includes: 1. staff - continuing, fixed-term, research (contingent funded) and casual staff; 2. contractors, subcontractors and consultants; 3. visiting academics and researchers; 4. affiliates - academic title-holders, visiting academics, emeritus professors, adjunct and honorary title-holders, industry fellows and conjoint appointments; 5. higher degree by research students; and 6. volunteers and students undertaking work experience.

Status and Details

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Effective Date	22nd June 2022
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