LTAV
Laboratory Technicians' Association of Victoria
By Lab Technicians for Lab Technicians

ABN 96 439 156 002

# Laboratory Environment Policy

**Background** Members have expressed a great deal of confusion about what the minimum standards for the physical storage of chemicals should be, and in relation to the physical environment of teaching and preparation laboratories.

Problems have been seen with instances of inadequate provision of approved chemical storage cabinets, a separate chemical storage area, technicians being required to work in the same space that chemicals are stored in. The problems of inadequate storage. Problems with lighting and ventilation, and of security and access

The responses to these issues range from "guidelines and standards are advice only" and "we do not have the money to do better".

The response from Workcover Victoria is that the Australian and New Zealand standards represent best practice and their view is that a workplace must be at least that safe

**Policy:**

1. The minimum standard for the design and construction is that outlined in AS/NZS 2982:2010 "Laboratory Design and Construction.
2. The minimum standard for the operation and maintenance of laboratories, including chemical stores, preparation laboratories and teaching laboratories, shall be that described in AS/NZS 2243, "Safety in the Laboratory" as amended from time to time.
3. The standards mentioned in 2 and 3 above are considered a minimum standard, the preferred standard is outlined in Bennedetti, Clark, Eckardt and Edwards, LTAV 2002 updated 2003, "LABCON 2003 Laboratory Design Session", attached here as APPENDIX A
4. The Laboratory Technicians' Association of Victoria (inc) does not consider that lack of funding is an acceptable excuse for expecting our members to work in substandard and potentially dangerous environments

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# APPENDIX A

# LABCON 2003 LAB DESIGN SESSION ©

First presented by LTB STAV 2002 Safety Information Officers Simon Benedetti, Margot Clark, Glenn Eckardt, Jill Edwards. Monash University, Clayton. December 5th & 6t 2002

Reviewed and revised by Margot Clark for presentation at VIEU School Officers' Conference, August 27t 2003
This paper was first written to accompany the Laboratory Design session at LABCON 2002., represented with some revisions at the VIEU School Officers' Conference 2003, and again at LABCON 2003.



The information in this document was correct at the time of publication, some references have been updated since then, and all care should be taken to ensure that the application of this document is consistent with current standards and legislation

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The session was offered in response to many requests from Victorian school Laboratory Staff, Science coordinators and teaching staff for information on Lab design.

The material offers suggestions for the interpretation and implementation of the many statutory Regulations, Codes of Practice, and relevant Australian and other industry Standards that apply to laboratory design in Victorian schools, in order to improve the safety and functionality of school laboratory resources.

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# 1 Project Brief

## 1.1 Definition of laboratories

School science classroom laboratories and the preparation area are included in the definition of laboratory given in AS 2982.1:1997 Laboratory design and Construction. "- any building or part of a building used or intended to be used for scientific or technical work which may be hazardous, including research, quality control, testing, teaching or analysis. Such work may include the use of chemicals including Dangerous Goods, pathogens and harmful radiation, or processes including electrical or mechanical work that could also be hazardous. The laboratory includes such support areas as instrument and preparation areas, laboratory stores and any offices ancillary to the laboratory."

## 1.2 Determining Appropriate usage and resources

Whenever science laboratory facilities are planned, whether a new building, conversion from some other usage, major renovations, or cyclic maintenance, the first step is to determine how the facility will be used.

- What type of laboratory, and curriculum features are required; e.g junior level science, preparation labs, teaching and laboratory staff work areas, senior chemistry, biology, physics?
- What degree of flexibility is required in the usage of the various areas; e.g. will the physics classroom need to be used for other classes as well.
- How many staff and students will be accommodated? Include some provision for an increase during the building phase.
- What equipment, furniture, utilities, materials and processes will be used?
- What hazards do these present?
- What are the cleaning and waste disposal requirements?
- Can the building be extended in the future if needs increase?
- Unless these issues have been included in the planning, the facilities when completed may not be able to meet your needs.

## 1.3 Siting the building

When choosing the site of the laboratory building, or the location of the laboratory within a building, there are a number of factors to be considered.

- The need to isolate other sensitive areas from laboratory hazards, e.g. food storage or preparation areas.
- Control of unauthorised access.
- Access and facilities for handling hazardous substances, bulky equipment.
- Supply of utilities such as gas and water.
- Access for emergency services.
- Increased fire risk.
- • Disposal of hazardous wastes. Access for materials and equipment is important in planning and siting the laboratory. Factors to be considered include:

- The size of openings and aisle ways for access to equipment. Trolleys, tubs and boxes of equipment are difficult to manoeuvre through narrow spaces.

- Avoidance of steps in paths used for access. Ramps for trolleys can be installed in place of steps.

- Ready access for vehicles for the delivery of goods and services. Where possible internal roadways within the school should allow direct access to the science labs. Delivery of bulky items, and visiting lab technology presentations need direct access.

### 1.3.1 Sunlight protection

Optimum orientation of the building with respect to the sun can have a number of positive effects on light and climate control. While natural light is preferable to artificial light in laboratories whenever possible, the size and position of the windows can be problematic. AS2243.1.2.1.4, & 2243.10, and AS2982.1.2.2 discuss the need for protection against sunlight. Windows should be designed and located to avoid direct sunlight onto workbenches and storage shelves. Laboratory materials, plastics, and equipment may deteriorate in direct sunlight or heat. Glass containers of liquids such as reagent bottles can act as lenses and magnify the intensity of the incident light. South-facing windows will admit light but suffer little direct sunlight or heat. North or West facing windows should be avoided if possible. East-facing windows will admit very bright sunlight in the mornings especially during winter months when the sun is low in the sky. (See also the section on Lighting below.)

### 1.3.2 Relationship between classrooms and prep room

Direct access between the preparation laboratory and the science classrooms is preferable to facilitate efficient transport of equipment and materials to and from classes, and ready communication between teachers and laboratory staff. If the arrangement of the classrooms does not allow connecting doors, then the classrooms and preparation lab should be as close as possible along a connecting corridor or space. This will minimise the need to transport potentially hazardous materials or heavy equipment through high traffic areas. If some science classrooms are located far way or in another building then an additional preparation lab should be provided nearby to service these rooms.

The preparation laboratory should have a separate access / egress route that does not require travel through a classroom. Laboratory staff have chemical and equipment purchases to bring in, equipment and materials to distribute, laboratory wastes to remove, and duties in other areas that can require them to move in and out several times during a work day. This is very distracting to a class in progress, and may expose students and other staff to hazards. In the event of fire or a chemical accident in the preparation lab the lab staff must have a quick direct evacuation route to safety. Travel through a crowded classroom does not provide a quick exit.

### 1.3.3 Access and Egress – The 'Ins' and 'Outs'

Previous editions of AS2243.1: 1997 included detailed descriptions of the number, siting, spacing and opening of doorways in laboratories. The Standard was amended in 1999, and the Building Code of Australia (BCA) now describes the minimum conditions required for access and egress.

Under the BCA Section D2.20 and D2.21 the following provisions are mandatory for doorways that are deemed required exits or form part of a required exit, or in the path of travel to a required exit. (A required exit is one that has been so deemed to satisfy the access and egress requirements of the BCA.)

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Swinging doors in rooms less than 200$m^2$ that are the only exit from the room must be fitted with a device to hold the door open. Otherwise they must swing in the direction of egress.

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- Doorways must unobstructed and the doors must not impede the path or direction of egress to or through a required exit
- • The latch on an exit door should be a level or 'panic bar' type. The door lock must be openable from the inside without a key. The door should not be lockable against egress. The following details are taken from the pre-1997 AS2243.1. They are NOT mandatory. However, they are still considered best practice to ensure that, in the event of fire, chemical spill or other emergency, escape from the area is swift, direct, and not impeded by classroom activities, or effect of the fire or emergency.

- Laboratories and classrooms should have at least two separate means of egress; at least one opening directly to the outside or a corridor that has external egress. The other may open into another room with an exit to the outside or corridor that has an external egress.

- Small laboratories sub-compartments, such as chemical storeroom, may have only one access door provided that the distance of travel to the door from any point in the room does not exceed 7 metres.
- • Where there are two or more doors the distance between them should be at least
- 12.5 metres, or 20% of the perimeter of the room (whichever is the lesser) i.e. for a classroom 10 *11 metres the distance between the two exits doors should be at least 8.5 metres.
- The doors should have a glazed vision panel. In a fire door this panel must not compromise the fire rating.
- The egress doors should open in the direction of egress, and should be recessed so that it does not impede traffic in the corridor.

### 1.3.4 Upstairs vs downstairs

According to AS 2982.1 Appendix A, laboratories should be located separately in an environment appropriate to their functions. They should not be mixed with non-laboratory functions. Proximity to the laboratory area may expose other areas to the same risks. Chemical storage areas should have at least one access door at ground level.

In a multi-level building, Science laboratory facilities should be located on the ground level. Science labs on upper levels will have increased costs of installing utilities such as drainage, water, gas, and expose the lower levels to the risk of chemical spills. Access for fire fighting and other emergency services is more difficult on the upper level, as is delivery of goods and services.

If the science laboratories must be located upstairs then spill containment should be provided to prevent spilled chemicals, or water overflow from running into the areas on lower floors. A goods or trolley lift should be installed for movement of equipment and materials between levels.

# 2 Chemical storage

## 2.1 Regulations

In Victoria, the Dangerous Goods (Storage and Handling) Regulations 2000 provides for the safe storage and handling of dangerous goods,. Victorian Workcover Authority has published an associated Code of Practice for the Storage and Handling of Dangerous Goods to assist with compliance with the regulations. The parts of this regulatory package that are most relevant to school science departments are : Part 3 of the Regulations, duties of manufacturers and suppliers (other than retail suppliers), to

- Determine whether or not the goods are dangerous goods, and ensure that an appropriate Class, and Packing group is assigned.
- Ensure that the are goods packaged in a sound condition, and labelled to indicate the nature of the dangerous goods contained.
- Prepare and supply a current Material Safety Data Sheet (MSDS) to the occupier of premises where the goods are stored and handled.

Part 4 of the Regulations, Duties of the Occupier to
- Ensure consultation, information, training and supervision for workers,
- Undertake hazard identification, risk assessment and control of risks associated with the dangerous goods,
- Ensure that current MSDS are maintained for all dangerous goods
- Provide adequate facilities to respond to an emergency, e.g. fire or spillage,
- Maintain a manifest and /or register of dangerous goods, and provide appropriate placarding as required according to the quantities of dangerous goods held.

Part 5 of the Code of Practice 'Minor Storages of Dangerous Goods' that applies to premises where quantities of dangerous goods stored are less than the 'Placarding quantities' listed in Schedule 2 of the regulations.

If the risk associated with the Dangerous Goods cannot be eliminated, then means to control the risk must be implemented, including suitable, safe storage facilities. The Code of Practice for the Storage and Handling of Dangerous Goods references several Australian Standards that provide details safe storage and handling of various classes of dangerous goods. These Standards form part of the Code of Practice and have the same status in law as the Code of Practice. Neither the provisions of the Code nor the Standards are mandatory, but, where they are relevant to a duty under the Regulations, compliance with the provisions of the Standard is regarded as compliance with the relevant duty under the Regulations. Below is a list of Standards most relevant to secondary school science laboratories that are referenced in the Code of Practice:

- AS 2243 (all parts) Safety in Laboratories,
- AS 2430 Classification of hazardous areas,
- AS/NZS 3833 The storage and handling of mixed classes of dangerous goods in packages and intermediate bulk containers,
- AS1940 The storage and handling of flammable and combustible liquids,
- AS 4326 The storage and handling of oxidising agents,
- AS/NZS 4452 The storage and handling of toxic substances,
- AS 3780 The storage and handling of corrosive substances,

- AS/NZS 2982.1 Laboratory design and Construction – General requirements.
- BCA The Building Code of Australia
- AS/NZS 3000 Australian/New Zealand Wiring rules
- AS/NZS 1841 parts 1-7 Portable fire extinguishers
- AS 1851.1 Maintenance of fire Protection equipment
- AS 2444 Portable fire extinguishers and fire blankets – Selection and location

## 2.2 Quantities

The provisions of the Code of Practice and the different Standards for safe storage of Dangerous Goods vary according to the quantity of goods stored. A large quantity presents a higher risk than a small quantity. The Standards and the Code of Practice allow lower levels of protection for 'Minor' quantities. The following table is taken from Schedule 2 of the Regulations, and shows the minimum quantities of mixed Dangerous Classes of Dangerous Goods that require specific Placarding. The Code of Practice states that quantities of goods under the Placarding quantity are classified as 'Minor Storage'. These quantities are very generous for school secondary science facilities.

## 2.3 Design and construction features

There are features of chemical storage areas than apply regardless of the quantity stored. (AS3833.2)

- The store shall be secure from unauthorised access.
- The store shall be located so that it doesn't hinder escape from the area in the event of fire. Clear access to the area should be maintained at all times.
- The store shall be away from any heating or ignition sources[1]. AS1940 and AS4326 require a minimum of 3 metres between storage of flammable liquids, or oxidising agents and any ignition source.
- The store shall be provided with adequate natural or mechanical ventilation (see section on ventilation).

| Dangerous goods class | Packing group | Placarding quantity |
|---|---|---|
| 3, 4.1, 4.2, 4.3, 5.1, 5.2, 6.1, or 8 | I | 50 kg or L |
| | II | 500kg or L |
| | III | 2000kg or L |

[1] AS3833.1.4.21 "A source of energy sufficient to ignite flammable or explosive atmosphere, and which may include naked flames, hot surfaces, exposed incandescent material, electrical welding arcs, mechanical or static sparks, hot particles, electrical discharge, and electrical or mechanical equipment not approved for use in hazardous areas."

 

- Storage areas, shelves and fittings shall be constructed from materials that are resistant to attack from the goods stored. Powder-coated metals will be scratched by the chemical containers and may suffer corrosion. Particle board may absorb moisture unless it has resistant coating. The supporting structure must be able to hold the maximum capacity of the chemical packages. The shelving should be designed so that residues cannot build up, and spillage can be easily seen and cleaned up.
- The width of the aisle between shelves or racks should be a minimum 1200mm.
- Liquids should be stored below packages of solids, and powders, not more than 1 metre from the floor. Glass bottles should be at the lower levels. Containers of liquids should stand in spill trays.
- Containers with capacity of more than 1 kg or 1L should not be stored on shelves higher than 1.5 metres.
- Spill retention measures shall prevent spilled materials from entering the waste water system.
- Environmental conditions such as sunlight, ambient temperature, or humidity shall not cause deterioration or decomposition of the goods stored.
- Lighting should be sufficient to provide safe working conditions; including clear visibility of package markings and labels, and other signs or notices. (see section below on Lighting).
- Goods that are incompatible, or react dangerously together, or produce hazardous reaction products shall be segregated. (See Segregation, below)

Schools are strongly encouraged to reduce their stores of Dangerous goods so that they fall into the Minor storage classification. If that is not possible then the requirements for fire protections, segregation and ventilation are more stringent, and difficult and expensive to achieve. See also Cupboards 4.2.1 below.

## 2.4 Segregation

The following table of information is taken from information in Section 9.1.3 Australian Dangerous Goods Code 6th ed. The grey shading shows where classes of goods are incompatible and must be segregated by an impervious barrier or distance.

In the case of Goods that may evolve Dangerous vapours, an impervious barrier is required to preventing the passage of vapours from one place to the other. Such barriers can be made from a wide range of materials such as metal sheeting, galvanised or Colorbond sheeting or any type of sheeting that generally has good durability, and is non-combustible material. Chemical storage cabinets are commercially available to meet the criteria for a range of different Dangerous goods classes. Until recently these cabinets have been made from double-walled, sheet steel, but there are now cabinets for Class 8 Corrosives that are made from corrosion – resistant plastic. Victorian Workcover Authority guidelines allow a minimum distance of 1metre between Australian Standards-compliant chemical storage cabinets.

### 2.4.1 Some features of approved Chemical storage cabinets

Different sizes, different types for different classes

Flammables AS1940

- can store class 3, 4.1, 4.3 together, not 4.2. (check for incompatibilities within those classes)
- Double-wall 40mm sheet steel, 150mm deep bund at the bottom, shelves perforated for air movement, self-closing door, close fitting, latch at least 2 points, structural components resistant to failure up to 850C.
- Located at least 3m from ignition source, not near exits, may not impede emergency escape.
- Venting, not essential for fire protection, only to disperse toxic fumes, must not compromise structural integrity or fire rating, must have flash-arrestor provided, double-wall flue pipe, extractor fans not necessary, must have means for permanent closure. Better to eliminate source of fumes through good housekeeping or reduce quantities.
- Secure against unauthorised access, either in a secured area, or lockable

cabinets Corrosives AS3780

- Constructed from corrosion-proof material, or lined as such; self-closing, close fitting door latched at least two points, Secured against unauthorised entry, (either supervised or locked), 150mm bund to hold at least 25% of stored volume. Vented shelves for air movement. Away from sources of heat, away from exits.

Toxics AS/NZS4452

- Construction and design as for flammables except must be lockable, specific venting provisions when required.

Oxidising agents

- Design and construction similar to flammables EXCEPT
- Must be vented, NOT lockable, door catches must self-release if pressure inside cabinet builds up.
- Door catches and hinges must NOT be plastic or zinc die castings
- Cannot not store class 5.1 and 5.2 or other incompatibles together.

Minor quantities of liquid Dangerous goods or goods in solid or powder form that do not present a risk from hazardous vapours can be also stored in approved cabinets. However, if they are held in other cupboards or open shelves, the minimum distance between incompatibles, required by the Code of Practice is 1.5 metres. Compatible goods can be stored in the intervening spaces.

| CLASS | 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | If class 3 is nitro methane | | | |
| 4.1 | | | | | | | | | |
| 4.2 | | | | | | | | | |
| 4.3 | | | | | | | | | |
| 5.1 | | | | | | | | | If class 9 is a fire risk. |
| 5.2 | | | | | | | | | |
| 6.1 | | | | | | | | Acids from cyanides | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | Strong acids from strong alkalis | |



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## 2.5 Layout

According to AS3833, a chemical storage area for packages can be a room attached to the external wall of a building, a room within a building, or storage cabinets, cupboards or shelves within the preparation laboratory. AS2982.10 prohibits the storage of flammable liquids, or substances evolving hazardous vapours within any school teaching laboratory.

The allocation of sufficient space for a separate chemical storeroom is important for best practice in laboratory safety. If the chemicals are stored in cabinets, or cupboards within the wider laboratory work area, then the security, fire protection, and ventilation facilities must provide for the entire area. Chemical vapours collect despite the best laboratory housekeeping. Any staff working in the area will be continually exposed to any chemical contamination of the air. The mechanical ventilation required to ensure clean air will affect the heating and cooling requirements of the room. A chemical leak or spill cannot be isolated and corrected so effectively if it occurs in the laboratory area rather than a dedicated store area.

Chemical storerooms are best built without windows. Solid walls provide better protection against heat and sunlight, improve the fire rating of the room, and offer better security against break-in and theft or vandalism.

# 3 Ventilation issues

The provision of ventilation in laboratory and chemical storage areas is best addressed at the planning stage of a new facility or at the renovation stage of an existing area. The design of a ventilation system and its components requires engineering expertise and must follow the established principles in order to operate satisfactorily. In general, the following points need to be observed:

- Air supplied to working areas should not be contaminated by unhealthy impurities
- Recycling cleaned air to work areas should not be considered if it contains contaminant material
- When air is exhausted, adequate provision needs to be made for the supply of replacement air, either by permanent inlets or by mechanical means. Unless this is done problems may arise with opening or closing doors, reversal of or reduced flow in the naturally ventilated flues, downdraughts and reduced efficiency of propeller fans.
- Components of a ventilation system include fans, ducts, air cleaners, inlet and outlet grills, sensors and controllers.

## 3.1 Natural versus mechanical ventilation

### 3.1.1 Natural ventilation

Natural ventilation is ventilation by natural airflow through fixed ventilators, doors or openable windows due to thermal or pressure gradients (as per 1.3.33 AS/NZS 2982.1). The following points should be taken into account when installing natural ventilation:

- Vents need to be placed at both floor level and near the ceiling so that fresh air flows in top vent and the dangerous vapours flow out the bottom vent
- A minimum of $1m^2$ of vent area must be provided for each 50m and the siting of vents needs to ensure effective airflow
- Air must be vented to the outside, not to another internal space or to a floor or ceiling cavity
- Vents must be located away from any external ignition sources

### 3.1.2 Mechanical ventilation

Mechanical ventilation is defined as the distribution of venting air by the use of exhaust fans or other physical air-moving devices (as per 1.3.32 AS/NZS 2982.1). Mechanical or dilution ventilation usually involves the use of large exhaust fans in the walls or roof of a building or room. Opening doors or windows can be used as dilution ventilation, but this is not always a reliable method since air movement is not controlled. Cooling fans are also sometimes used as a method of ventilation but fans usually blow the contaminant around the work area without effectively. The following points should be taken into account when installing mechanical ventilation:

- Inlet and outlet vents should be located on opposite sides of the store at low levels to provide laminar airflow across the floor as far as practicable
- Where both inlet and exhaust are mechanically assisted, capacities and rates should be adjusted to ensure that the pressure inside the store or room never exceeds outside
- Ensure that there is adequate make-up air to replace the exhausted air
- Ensure that the re-circulated air doesn't mix with air to supply non laboratory areas
- Ensure that the minimum air supply rate as indicated in AS 1668.2 is provided

Advantages of mechanical ventilation:

- Lower equipment and installation costs
- Requires less maintenance
- Effective control for low toxicity chemicals
- • Best ventilation for small dispersed contaminant sources or mobile sources Disadvantages of mechanical ventilation:

- Does not completely remove contaminants
- Cannot be used for highly toxic chemicals
- Ineffective for large amounts of gases or vapours

### 3.1.3 Local exhaust ventilation

Local exhaust ventilation's main advantage is that it captures air contaminants at or near to its source. It operates on the principle that air moves from an area of high air pressure to an area of low air pressure. A fan that draws or sucks air through the ventilation system creates the difference in low pressure.  Examples of local exhaust ventilation include fume cupboards, glove boxes, slot hoods, elephant trunks, and canopy hoods. A local exhaust system has five major components:

- The Hood Hoods come in a variety of designs. Choose the one most suitable for the processes used in the laboratory or room. The hood should be designed to have sufficient capacity to prevent the escape of contaminants into the work area.
- The Ducts. Ducts carry the contaminants from their source to an outlet point. Air velocity in the ducting must be high enough to prevent contaminants settling in the system, but not so high that it causes vibration and noise problems. Extraction ducting should not be linked to multiple items of plant if there is any likelihood of fire spreading through ducting
- The fan. The fan is the heart of the system, creating movement of air to shift the contaminants. Centrifugal fans are generally best for high pressures and axial fans are best for low pressure/high volume applications
- Filters .Filtering equipment captures contaminants in the extracted air and lets clean air continue through.
- Discharge stack The stack releases exhaust gas into the air. It must be high enough to avoid gas reentering the workplace and make sure contaminant levels on the ground are within clean air standards. Stacks should be at least three metres above the highest roof or adjacent building and away from air inlets.

The exhaust system should be resistant to attack by vapours, mists and dusts that are being exhausted

Advantages of local exhaust ventilation:

- Captures contaminant at source and removes from workplace
- Only choice for highly toxic airborne chemicals
- Can handle all types of contaminants including dusts and metal fumes
- • Requires small amount of make-up air Disadvantages of local exhaust ventilation:
- High cost for design, installation and equipment
- Requires regular cleaning, inspection and maintenance.

## 3.2 Safe oxygen level

The purpose of ventilation is to produce and maintain a safe working atmosphere in laboratory and storage and handling areas.

"A safe working atmosphere", as defined by the Code of Practice for Storage and Handling of Dangerous Goods, "is one in which:

- There is a safe level of oxygen for breathing;
- Hazardous gases, vapours, mists, fumes and dusts are within relevant exposure standards;
- The concentration of flammable gases, vapours, mists, fumes and dusts is always below 5% of the lower explosion limit and
- The build-up of heat and extremes of temperature is avoided.

## 3.3 Chemical storage areas

Ventilation of storage areas is required to be adequate in order to prevent the generation of a flammable or harmful atmosphere. Many dangerous goods vapours are heavier than air and venting should be provided to prevent the build up of dangerous vapours. This can be achieved by the introduction or re-circulation of air by natural, forced or mechanical means. The level and type of ventilation depends on the nature of the goods and whether they are being stored or used. Any ventilation system should be exclusive to the particular room, space or building. The Standard for individual dangerous goods classes, in most cases, provides additional information on the design of suitable natural ventilation systems. In the absence of a specific classification, the provisions of, AS 1940 are the minimum requirement.

Where vents are provided for chemical storage cabinets and laboratory cupboards they should be vented to the open air outside the building.

## 3.4 Laboratory areas

Laboratory areas, including preparation room/s should be provided with mechanical ventilation or suitable natural ventilation. In addition, these areas usually require local exhaust ventilation in the form of a fume cupboard for the preparation of hazardous gases, vapours etc. In the instance of supply of a fume cupboard a suitable fire extinguisher should be available in close proximity to it. Fume cupboards should be located, installed and maintained according to AS 2243.8. In some cases the provision of a slot hood, as a means of local exhaust ventilation, may be more suitable (in either the preparation room and /or in the laboratory for use with specific pieces of instrumentation) due to factors such as restriction of space or low frequency of handling hazardous substances. Local exhaust systems installed for laboratory ventilation must comply with AS 1668.2, the relevant building regulations and Section 5.6 AS 2982.1.

## 3.5 Classrooms

Dilution ventilation is the most common way of dealing with exposure to chemicals and other contaminants in science laboratories. Dilution ventilation involves providing measured amounts of supply and exhaust-air and is suitable for controlling vapours from organic liquids of low toxicity. Laboratories installed with a mechanical ventilation system should conform to Section 5.4 AS 2982.1

Natural ventilation may be adequate for some laboratories/classrooms, take into consideration the type of experiments/activities and that may be conducted in the room or space and the additional requirements, as per AS 2982.1 Section 5.3 “Laboratories may be naturally ventilated provided that -

- Ventilation openings have an openable area not less than 10% of the floor area, are provided in each laboratory, located to ensure cross-ventilation to provide adequate air exchange;
- Laboratory processes and instrumentation do not require temperature and humidity control beyond that achievable by this method;
- Unfiltered ventilation air will not degrade applicable laboratory processes;
- Fume cupboards and other devices relying on a uniform face velocity for containment are not exposed to draughts which will degrade their performance;
- Natural ventilation is not used as the primary method for the contaminant dilution or control and
- Laboratory ventilation is physically segregated from any adjacent non-laboratory area. Partioning between laboratory and non-laboratory areas shall not have any ventilation openings other than an openable access door or doors.”

## 3.6 Air sources, effect on fume cupboards performance

When positioning a fume cupboard it is important to take into account:

- The traffic flow
- The location of other fume cupboards, air extraction and/or air-conditioning outlets
- Obstacles such as benches, walls, doors
- Access for maintenance and service work
- Ensure that the air-conditioning supply outlets are not adjacent to the fume cupboard and that the fume cupboard is positioned away from doorways to ensure that exit paths are not blocked. This will also ensure the

efficiency of operation of the unit.

## 3.7 Climate control effects, thermal comfort

Laboratories should be supplied with a permanent form of heating where the temperature consistently falls below 20$^{0}$C during work hours. In the instance of flammable or combustible vapours being present the heating equipment provided should be as an indirect means. Where the high temperatures in the laboratory may give rise to identifiable potential hazards, cooling should be provided. Any provided heating or cooling system should be designed to maintain a temperature of 22$^{0}$C plus or minus 2$^{0}$C throughout the laboratory.

# 4 Fittings and fixtures,

## 4.1 Safety and emergency resources

### 4.1.1 Safety showers/Eye wash facilities

See under water utilities

### 4.1.2 Fire extinguishers

Fire extinguishers should be provided in all laboratory areas as well as adjacent to chemical storage areas, electrical switchboards and installed fume cupboards. Fire extinguishers should be of the type and size appropriate to the work carried out in the laboratory. They should be located and installed in the room in accordance with AS 2444 and maintained in accordance with AS 1851.1.

### 4.1.3 Fire blankets

Fire blankets should be available in laboratories for the small fires and be located and installed in accordance with AS 2444. They should be in accordance with AS/NZS 3504.

### 4.1.4 Telephone

A telephone should be available in laboratory areas for emergency and general business calls. A list of emergency phone numbers (ambulance, fire brigade, nearest hospital, police, poison information centre etc) should be next to the phone.

### 4.1.5 First aid cabinets

Approved first aid cabinets should be provided in laboratory areas. Should consider the nature of the hazards, the frequency and type of accidents/incidents, the first aid procedure and number of trained first aid personnel in the school.

### 4.1.6 Reticulated services

#### 4.1.6.1 Gas isolating valves

In every science laboratory that is provided with gas, a lockable isolating valve should be located on or adjacent to the teacher's bench. Isolating valve should be clearly labelled. (as per Section 10.1 AS/NZS 2982.1)

#### 4.1.6.2 Electrical services

The general-purpose power outlets for student use in science laboratories should be provided with a push button emergency master control. The reset should be key operated. This device should be clearly labelled and located near the teacher's bench, adjacent to the gas mains. (as per Section 10.3 AS/NZS 2982.1)

#### 4.1.6.3 Water

Science laboratories should be provided with a master control for cutting off of water.

## 4.2 General Storage areas

Adequate storage space is often overlooked when science classrooms and laboratories are planned. The provision of storage space will influence the efficient use of laboratory resources. If workbenches and floor areas must be used for storage space then work practices and movement within the laboratory will be compromised.

Equipment that is common to all science curriculum areas should be stored centrally so that it can be distributed to different classrooms when required. Specialised equipment that is used in only one area can be stored in that area.

### 4.2.1 Cupboards, shelves.

Under bench cupboards and shelves at the back of the workbench are a common way to store laboratory supplies and reagents. However these not the most ergonomically sound storage systems. Reaching across bench for items and reagent bottles can lead to accidents. Bending down to access goods in deep under bench cupboards is also hazardous.

Full height wall storage cabinets are preferable. However, The height of any storage cabinet or cupboards should not exceed 2200mm, and the top shelf should not exceed 1700mm. The depth of storage cupboards should be not more than 500mm. Access to the rear of the shelves deeper than 500mm is difficult, especially for low shelves and under bench cupboards.

Small items including, chemicals and reagents should be stored on narrow shelving to avoid the need to stack the containers and bottles behind each other. ‘Compactus’ storage units are unsuitable for laboratory equipment or chemicals. They may be ideal for documents and office supplies but the moving shelf units can break glass bottles and damage delicate equipment. The powder coating on the metal shelves is easily scratched, and the shelves will deteriorate in contact with chemicals. The ‘compact’ design of the units means that segregation of incompatible chemicals may not be achieved when the unit is closed, and adequate natural or mechanical ventilation is not possible.

Closed cupboards are preferred to reduce the build-up of dust on the stored items. Open shelving should be avoided except for short-term storage of items that are used frequently.

A storage system of floor-to-ceiling racks and polypropylene tubs that slide on and off is common in schools. It has the advantage of being inexpensive and very adaptable to changing needs. There are also disadvantages that should be considered before installing this system.

- The tops racks are too high to access safety without a ladder.
- The tubs when full may be too heavy to handle at that height.
- The contents of the upper level tubs cannot be seen without a ladder.
- The lower levels require deep bending to access the tubs, and handling of heavy items from floor level.
- Items can fall out of the tubs when they are being moved in or out if they are overfilled.
- • The tubs can collect dust unless they are covered. This tub and rack system can work very well if some principles of ergonomic storage are followed.

- Install the racks only between shoulder and hip height.

- Limit the amount stored in each tub to reduce the weight to be handled.
- Do not load items over the top edge of the tub.
- Label each tub clearly to identify the contents.
- Use the covers that are designed for the tubs.

# 4.3 Surfaces and work areas

## 4.3.1 Walls

Walls in all labs, chemical storerooms, and science classrooms areas must be finished with materials or surface coatings that are:

- impervious,
- resistant to chemicals used in the laboratory,
- smooth,
- easy to clean.

Porous surfaces will allow moisture, chemicals and biological contaminants from vapours or splashed liquids to be absorbed. They may cause deterioration of the surface. Similarly, textured surfaces have minute indentations that may harbour chemical particles and micro-organisms. These surfaces are not easily cleaned or disinfected. The residues can release hazardous vapours in the air, and add to chemical contamination. The surface finish must be resistant to reaction with any chemicals, such as vapours, or acids or solvents that may be splashed or spilled. The walls of most school classrooms and preparation labs will be plasterboard, fibrocement sheet, or other composite fibreboards. Although these don't seem to meet the criteria listed above, their resilience can be improved if the sheets are securely joined, and properly prepared and coated with a good quality paint with a satin or semi gloss, washable finish. Although, full gloss finishes are easy to wash they can create unwanted glare and reflections. Any contaminants must be washed away immediately to prevent damage to the surface. Graffiti and scuffmarks from shoes will also be easier to remove from a washable surface.

Specialist wet areas in the preparation lab may have a ceramic tiled finish. However the cement-based grouting between the tiles will be subject deterioration by chemicals unless specially formulated to resist it. Any grouted finish will deteriorate over time, and may need to be repaired or replaced during the life of the tiles.

### 4.3.2 Ceilings

AS2982 1.2.5 describes the required ceiling finishes as rigid, smooth-faced, nonabsorbent material such as fibrous plaster, fibrous cement, or cement render. The ceiling should be painted with washable semi gloss paint. The paint should be light in colour to maximise light diffusion in the room. Use of white or light colours can improve the lighting in the room and reduce the quantity, or the wattage of the artificial lights required.

Acoustic ceiling tiles are common in school classrooms. They made from a composite, fibrous material and usually have a smooth finish on the exposed face. They may not be impervious or resistant to damage from an chemical accident, or slow deterioration by contact and absorption of chemical or biological contaminants. They should be inspected regularly for physical or chemical damage, and replaced as required.

Older classrooms, including 'portables' pre –1985 may have asbestos material in these acoustic tiles. If they contain asbestos and are crumbling or friable, i.e. fibres are becoming detached, they must be assessed by a competent authority, and removed by a licensed asbestos removal contractor.

### 4.3.3 Floors

Choice of suitable floor covering for the science classroom and laboratory areas will affect the safety and comfort of students and staff.

AS2982.1 lists a number of features for safe flooring, including:
- Impervious
- Resistant to the chemicals used in the laboratory.
- Smooth
- Slip resistant
- Easy to clean

The recommended floor covering is smooth sheet vinyl that is made for laboratory use, and pre-finished with polyurethane for durability and resistance. It must be laid, joined and finished strictly in accordance with manufacturers' specifications. When laid it should be taken 150mm up the walls. It should be laid with a minimum number of joints. The joints must be welded. An approved cushioning or underlay will may also improve the comfort of the occupier who is standing on it all day, and attenuate noise up to 25d(B)A.

Slip resistance is achieved by maintaining the surface finish according to specifications. Do not apply a polish, or buff the surface with mechanical polishers or scrubbers. The polish will collect dirt, and a highly polished surface will be more slippery., especially when wet. Cleaners should be instructed in the recommended maintenance regime.

A coarsely-textured surface may be slip resistant, such as the rubber flooring with raised circular 'buttons' that is designed for wet areas. However, the uneven surface will be unstable for tables, chairs, or stools; and be difficult to wheel trolleys across.

Slip resistant 'safety-flooring' is available for laboratory applications such as mortuaries that must be washed down frequently. This flooring has a fine abrasive component right through it that will collect dirt from shoes, as well as chemicals and bacteria, and requires daily mechanical scrubbing for adequate cleaning.

The floor covering should be a light to medium tone with only a subtle pattern if any. Lighter colours add to diffusion of light through the room. Dark colours and bold patterns may hide some dirt and graffiti but they will also mask chemical spills, and make broken glass and other items dropped in the floor harder to see.

### 4.3.4 Benches

Secondary school science laboratories are unique because, unlike industry, research and University student laboratories, they usually combine the practical laboratory area with a theory or lecture space. This combination means that some of the safety features will be compromised unless careful planning is done.

The preparation laboratory layout is often affected by limited space and the need for direct access to the classrooms. AS 2982.1 lists a number of features of work benchtops, and width of spaces between benches or other freestanding furniture or equipment.

#### 4.3.4.1 Spacing

The minimum required spacing between laboratory benches is as follows.

- Where the worker stands at a bench on one side of an aisle opposite a wall or other fixtures, with no through traffic - Minimum distance of 1020mm
- Where the worker stands at a bench on one side of an aisle opposite a wall or other fixtures, with some through traffic - Minimum distance of 1200mm
- Where the workers stand at benches on both sides of an aisle with no through traffic - Minimum distance of 1350mm
- Where the workers stand at benches on both sides of an aisle with some through traffic - Minimum distance of 1800mm.

#### 4.3.4.2 Bench top finishes

The bench top finish must be:

- Smooth (free from irregularities.)
- Impervious
- Resistant to the chemicals used in the laboratory
- Scratch resistant
- Easy to clean
- Glare protected.
- Free from joints so far as possible. Joints must be sealed to prevent seepage of spills into the space beneath. Where ends of the bench meet and end wall the bench top finish shall continue up the wall to form a splash-back.

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There are many bench top materials and coatings that can meet these criteria, but they must have a smooth, matt finish with little or no pattern in a light to medium tone. Textured and patterned surfaces may be suitable for household kitchens but not for laboratories. Textured surfaces harbour dirt, chemical residues and bacteria. A textured, hard surface is more slippery than a smooth one. A glass flask or beaker will slide more easily on a textured surface. The contact surface area between the bench and flat-bottomed glassware is less for a textured surface. This means less friction between them. The diagram below shows an exaggerated cross section of a textured bench top with a piece of flat-bottomed equipment standing on it, and the same equipment on a smooth matt surface.

Dark colours, and patterned surfaces may not show dirt and damage so much as plain ones, but they will also mask chemical spills, and make pieces of broken glass and small items hard to find.

Suitable bench top finishes include:

- Good quality laminate over composite fibreboard with minimal joints that are well sealed. This will be resistant to most chemicals, and to scratching I will suffer damage from aggressive solvents, concentrated acids, and hot equipment and naked flames. It is not easily repaired in patches so the entire bench top may need to be replaced.
- ‘Marblo’ solid surface sheeting. It uses a jointing material that colour matches the sheeting, It conceals the joints and can repair scratches holes or cracks. It is easily cleaned with a detergent or mild household abrasive.
- ‘Trespa TopLab Plus’, a compact laminate that is hardwearing and chemical resistant. It is designed specifically for laboratories. It is also repairable.

Unsuitable materials for general applications are:

- Stainless steel. It is very hard, and cold to the touch. Glassware dropped on this will break more easily. It is not resistant to common laboratory chemicals. Dilute acids and alkalis, and some metal salt solutions will leave corroded areas. It will conduct electricity, so that practical activities involving electric circuits will need an insulating mat. They are easily scratched, and difficult to keep looking clean.

- Sheet vinyl. Some school laboratories, especially science 'portables' often have benches finished with a vinyl sheet similar to the floor covering. This is not heat or scratch resistant. The polyurethane finish will soon degrade and the surface will deteriorate in contact with aggressive solvents or concentrated acids. Heat and chemical attack will evolve toxic vinyl chloride fumes. Vinyl is difficult to clean. Abrasive cleaners and graffiti remover will damage the surface. Damaged areas must be removed and replaced.

## 4.3.4.3 Work bench areas

Laboratory work covers many different tasks. The optimum layout and height of benches will vary with the task. Work with chemicals is safer when standing so that the effect of spills is minimised. Student workbenches should be designed for standing tasks. The optimum height of a bench top for work while standing is 900mm. This is for an average adult. Classroom used exclusively for younger students may have slightly lower bench heights.

The workbenches may have under bench cupboards, or drawer units. The supports for these cupboards should not be covered by a 'kick board'. Spilled water or chemicals may run under the kickboard and collect underneath, unseen, causing damage and contamination. The space under the cupboards should be left open to make cleaning easier.

There should also be an area of the preparation room workbench that has free space underneath for knee room while sitting. Laboratory tasks like writing labels, soldering or repairing equipment require close access, for which the worker must to sit down. The worker can sit on a high stool at the 900mm bench., or at a lower bench designed for seated tasks. The optimum range for the height of a bench for seated tasks is 700750mm.

For administrative or other desk-based tasks, Laboratory staff must have a separate 'write-up' area within, or close to the laboratory space but partitioned to isolate them from noise and chemical contamination. Laboratory records, references, telephone, and desktop computer can be kept here. Each laboratory worker should have his or her own workstation, although they may share the telephone and computer. Non-laboratory activities such as food storage, preparation, or consumption must not be permitted in the laboratory, or science classroom.

## 4.3.4.4 Classroom configurations

The configuration of benches in the science classroom will depend on the size and shape of the rooms. The following diagrams, Fig A, B, C & D, show four commonly used science classroom arrangements for a room that is approximately 110 $m^2$. Each of them has merits and disadvantages that are detailed below. The diagrams are not drawn to scale.

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Figure A below shows a science room typical of the 1960s design that combined the writing and 'theory' teaching areas with the practical workbenches. These benches are crowded with books during practical classes; that are easily contaminated with spilled water and chemicals. During the teaching periods student are tempted to 'play' with the gas and water utilities, and use the long troughs as waste paper bins. One advantage of this design is that students do not need to move from their allocated space to perform the practical activity and then write it up. It also requires less space.

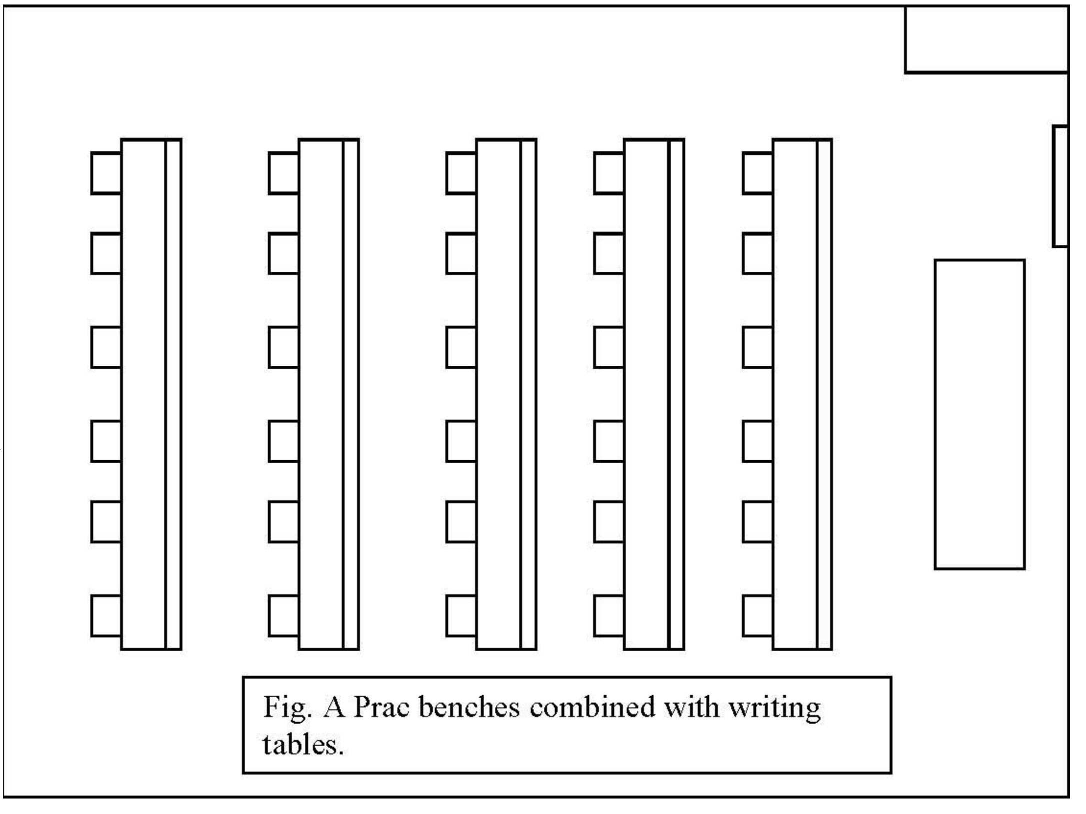

Fig. A Prac benches combined with writing tables.

AS2982.1.2.7 9 (c.) requires a minimum of 1200mm between the work benches.

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Fig B below shows more recent arrangement of peninsula benches on opposite sides of the room, with the writing space in the centre. This design separates the hazards of a practical activity from the writing area. The student benches are well spaced to allow easier supervision by the teacher. Work at the benches is not interrupted by through traffic, and students are not distracted by equipment during a theory class.

A disadvantage is that students need to move between the practical and theory areas during class.

This is the arrangement preferred by many laboratory designers.

AS2982.1.2.7 9 (c.) requires a minimum of 1350mm between the work benches, and 1000 between the edge of the writing area and the work benches.

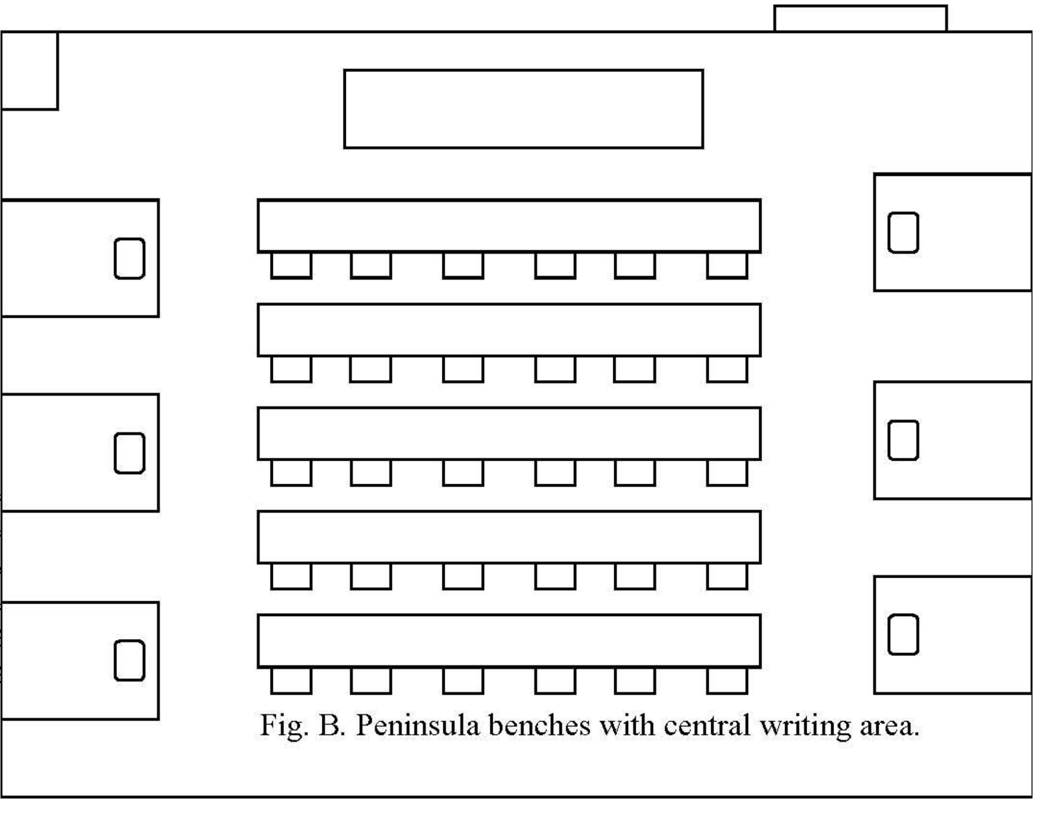


Fig. B. Peninsula benches with central writing area.

Fig C below shows another traditional arrangement, with perimeter benches on three sides of the room, and a writing, theory area in the centre. This design can be accommodated in a smaller room than B. It also isolates the hazards of the practical activity from the theory or writing area. Supervision of the practical area is more difficult because the students are elbow-to-elbow, with their backs to the teacher. Students need to move between the work bench and writing area during the class.

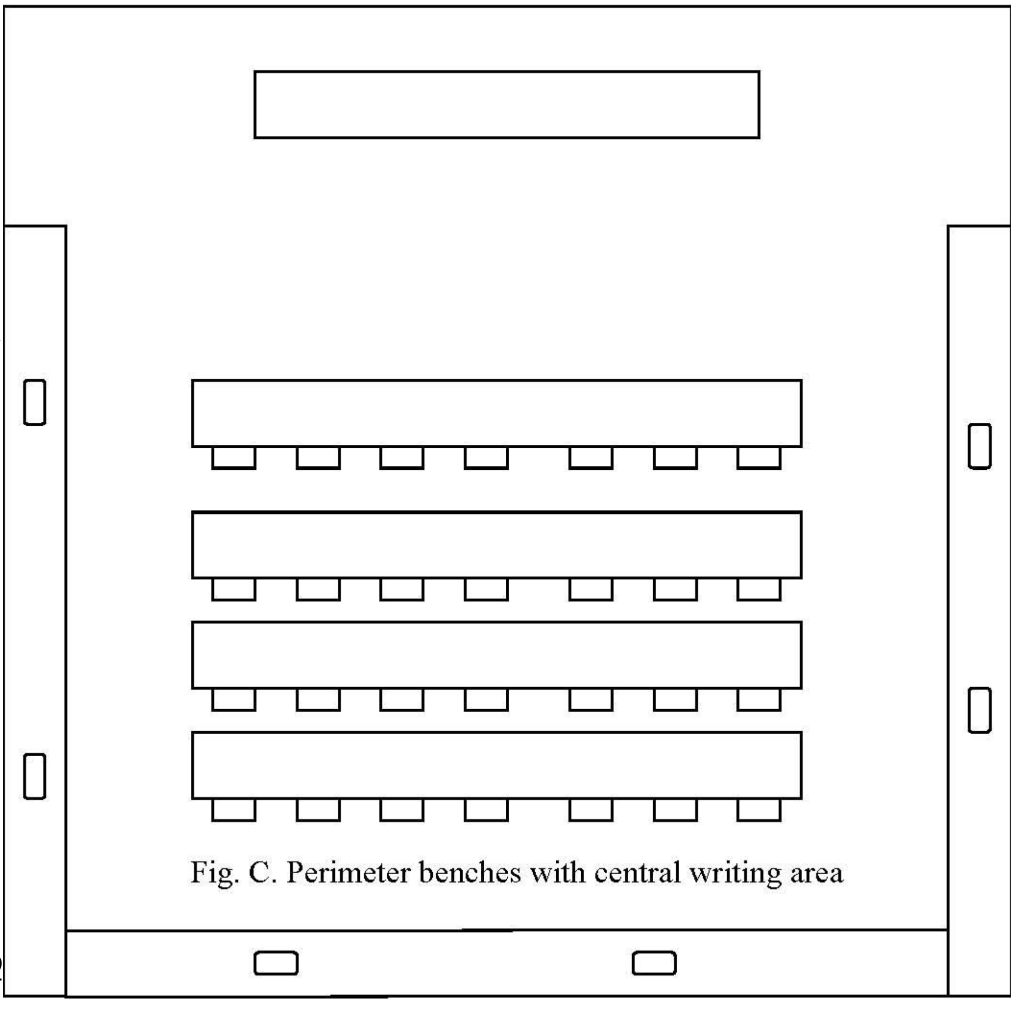


Fig. C. Perimeter benches with central writing area

AS2982.1.2.7 9 (c.) requires a minimum of 1200mm between the work benches, and the edge of the writing area.

Fig D below shows a recent arrangement of island benches on one side of the room, and the writing or theory teaching area on the other.

This design requires more space for the practical area than the other designs because the distance between the workbenches must also allow for through traffic as student move back and forth between the tables and their workstation.

It has the advantage of separating the practical and theory areas very effectively.

AS2982.1.2.7 9 (c.) requires a minimum of 1350mm between the workbenches, and the 1000 between edge of the writing area and the end of the workbenches, and 1200mm between the workbenches and the walls.

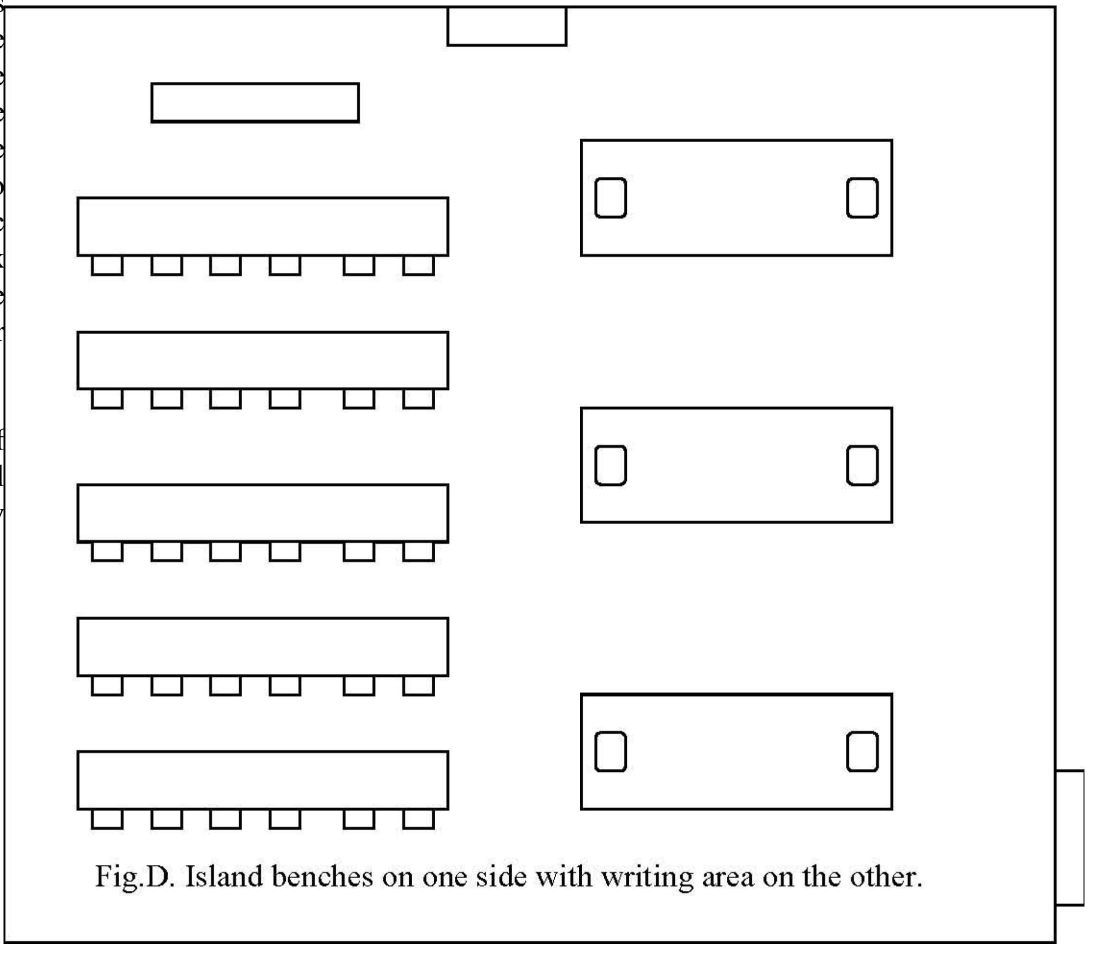


Fig.D. Island benches on one side with writing area on the other.

## 4.4 Utilities

### 4.4.1 Water Utilities

#### 4.4.1.1 Emergency eye/face wash and safety shower stations

Due to the nature of science, science laboratories and preparation rooms are among the most hazardous instructional areas in the school. The design of the science classroom/laboratory and preparation rooms should promote safety, comfort, health and ease of maintenance. AS 2982, Section 10 states that " When designing secondary school laboratories, the tendency for young students to panic in an emergency should be kept in mind." Therefore, when designing a laboratory and preparation room, it is important to keep in mind the hazardous nature of chemicals and procedures in an environment where there is limited knowledge about the consequences of certain experiments. Under regulations stated in AS 2982 section 6, it is required by law to provide safety showers and emergency eye/face wash facilities in each laboratory area where hazardous substances are used.

Most if not all secondary level science laboratories and preparation rooms require engineering controls such as eye/face washes and showers. This is dictated by direct contact or exposure to hazardous chemical products, which can harm eyes or other body surfaces. Emergency eye/face washers and safety showers deliver water to the user so that the contaminants can be flushed from the eyes, face and body. Although safety goggles provide protection from the eyes when worn properly, they do not provide protection from other areas of the face from harmful chemicals. There are regulations regarding emergency safety equipment. AS 2982, Section 6 provides the regulations in which standards have to be in place for laboratory and preparation rooms. The standards addresses engineering control to protect the users eyes and body parts from chemical exposure implications. Once the emergency eye/face wash and safety showers stations have been properly installed, staff and students and must receive professional development on the proper use of equipment.

Plumbing connections must be installed according to Building Standards in your relevant state. The American National Standards Institute (ANSI) has developed standards concerning emergency equipment. Under AS 2982 Section 6 regulations, schools are recommended that they should use standard ANSI Z358.1 as a guideline for the correct design, installation, use and performance of all emergency safety equipment. There are many styles and designs of eye/face washes and safety showers, ranging from those that are pedestal, deck or countertop mounted to those that are recessed into the wall. Some designs allow the water flow to begin when the user steps on a floor plate, whilst others require that the user push a hand plate. In a classroom situation, the controls are open to accidental or mischievous misuse, so selection of the location and type of control are important. Whichever apparatus the school decides to use, the following criteria should be observed:

- Emergency eye/face wash and shower stations must be installed in science laboratory and preparation rooms where hazardous chemicals are used.
- Each station must be no more than 10 metres (AS2982.1.6.2) from any position in the laboratory or preparation room, and the path to the station must be unobstructed.
- The emergency eye/face wash and shower stations must be capable of providing up to 12 litres of water for 15 minutes (ANSI Z358.1). Protective covers should be provided to stop airborne contamination from entering the spray heads.
- The valve handle, which starts the flow of water, must be large enough for the user to locate and operate easily, preferably without using the hands. Once activated,

the water must flow at least at 30 PSI (ANSI Z358.1). Eyewashes must provide water at a low velocity so that they will not cause injury to eyes.

- There must be a 'hands free' valve on the station that stays open and provides a continuous flow of water.
- Safety signs identifying the emergency eye/face wash and safety shower stations must be in a highly visible place so that students and teachers can locate them easily. Teachers and students must be instructed on the location and proper use of the eye/face wash and safety shower.
- Each eye/face wash and safety shower station should be inspected weekly and activated by allowing the water to flow for at least 5 minutes to remove mineral and biological contaminants that may be found in the water lines

NOTE It is important to note that hand-held drench hoses and gravity fed eyewashes can provide additional protection for students and teachers. However, they are not meant to replace emergency eye/face wash and safety showers, which are required in all chemistry rooms. AS2243.1.2.6 allows a hand-held spray in place of a fixed safety shower The drench hose line must be long enough to reach an injured person who is in a prone position, or reach areas of the face and body inaccessible to the fixed stream of water from an eyewash or emergency shower. Gravity fed eyewashes are only acceptable where reticulated water isn't available, such as an outdoor location like a building site, or as part of a First Aid equipment on a field trip such as camp. They are then only to be used if filled with fresh clean water each day and the bottles are kept cool.

### 4.4.1.2 Sink and Sink Units

Science classrooms and preparation rooms must be furnished with fixtures that provide a safe and effective learning and working environment. There are many types of examples of sinks and sink accessories, which are available and are only limited by the usage that is required of them. Sinks that are used for cleaning equipment and washing hands should provide hot and cold water. These sinks are usually located around the perimeter of the laboratory room. Trough sinks that are found in island benches for student experimental uses are designed for light cleanup, distillation apparatus, and Venturi-type vacuum pumps, and usually only provide cold water. There should be at least one sink for every four students and depending on the curriculum being taught, the sinks may be located at the students' workstation. Preparation rooms require hot and cold water and the sinks are large enough to embody a multitude of equipment of varying sizes. Separate sinks with hot and cold water should be provided for hand washing.

Sinks are usually composed of one of four materials: stainless steel, solid epoxy resins, fibreglass or glazed ceramic. The curriculum taught in the laboratory should determine the composition of the sink. For example, an acid resistant, solid epoxy resin should be selected for chemistry laboratories.

Again, just as there are many types of sinks available, there are also many types of faucets available for use. Faucets can be manufactured from a variety of metals that resist corrosion from chemicals used in chemistry investigations. The style and type of faucet is important to the functioning it will have in the laboratory and preparation room.

Whilst there are no regulations that cover the types of sinks and faucets to be used, there are Building Regulations relevant to your state, which cover the proper installation of this equipment. These regulations include positioning of the wet areas and the compliance of the types of sink and arrangements. The sinks and fittings must be compatible with the intended usage.

Before installing sinks and sundry items such as faucets, there should be questions worth considering. These include:

- What will be the purpose and use of each type of sink?
- Where should the sinks be located in the room?
- Will the sink also serve as locations for eye/face wash drenching hoses?
- Should all sinks be composed of the same material?
- What style of faucet is needed for each classroom and preparation room?
- Which faucets have protective coatings added to make them corrosion resistant?
- How many faucets should provide both hot and cold water?

### 4.4.1.3 Pollution prevention and Waste minimization

Pollution prevention and waste minimization are terms that refer to practices that reduce or eliminate the amount and/or toxicity of pollutants, which could enter the waste stream and released into the environment.

### 4.4.1.4 Water discharges

As a convenient way to dispose of chemical laboratory waste, sink drains can be very tempting. Disposal of most types of chemicals in this manner should be discouraged, however, since it may result in fire, chemical reactions, and corrosion within the plumbing system. In addition, drain disposal of chemicals may cause pH upsets and other environmental problems at the wastewater treatment plant. If carefully controlled, some wastes e.g., acidic or basic wastes, can be neutralized before it is safely discharged via the sewer. This may be the most desirable disposal method because it minimizes the wastes sent off site. Federal, State and local Water Authorities regulations stipulate which are acceptable and prohibited pollutants for discharge. In most states, it is acceptable to neutralize acidic and caustic solutions and then dispose of the neutralized solution down the drain if it has no other hazardous characteristics. A neutralized solution should have a final pH value of between 6 and 9. Check with your local water authorities first, if you are unsure about disposing of chemicals down the drain and to make sure that the pH range meets their requirements.

Most chemical waste cannot be disposed of down the sewer. The following is a representative lists of a few chemicals which cannot be disposed of with this method, and require collection and disposal from a certified chemical disposal company. The list is not exhaustive and it is recommended that the MSDS be used as a guide:

- Flammable solvents such as acetone, methanol, ethanol, propanol, hexane
- Acids and bases not neutralized such as hydrochloric acid, sulfuric acid, nitric acid, ammonium hydroxide and sodium hydroxide
- • Heavy metal solutions such as solutions of copper, silver, zinc and lead The improper disposal of chemical waste into the laboratory sinks can have the following adverse effects:

- The disposal of volatile solvents can cause annoying odour problems throughout the building as the vapours escape through the sink drains. Reaction with other substances can emit other hazardous vapours.

- Corrosive wastes can dissolve and erode the plumbing connections decreasing their effective life span.

- Water downstream may be adversely affected by the improper disposal of metals and toxic chemicals into the sewer system

- Workmen working inside sewage system may be exposed to dangerous chemical vapours and potentially flammable or explosive environments

#### 4.4.1.4.1 Neutralization tanks

Although many schools are equipped with neutralization tanks in wastewater lines, problems can result in their usage. For example, the limestone chip bed is commonly used as a passive in-line acid neutralization system. In theory, these systems should work but they often do not in practice because (1) they are flow-dependant and (2) the system maintenance, such as cleaning, are often neglected. In addition, limestone, which is effective in neutralizing acid discharges, is not helpful in neutralizing caustic solutions. In general, it is not wise to rely on this system until it's effectiveness has been proven and can be monitored. Pollutants capable of releasing fumes or vapours in sufficient quantities to detrimentally affect the safety of the teachers, students and technicians may build up if the system is not maintained. After obtaining recommendations from an OHS&E consultant the following guidelines were noted " That there be regular flushing with tap water, at least weekly, is a requirement. A plumbing contractor is required to replace and recharge the marble chips when they are down to 70% of their initial volume."

## 4.4.2 Electricity

### 4.4.2.1 Electrical Safety Guidelines

Electricity is potentially very hazardous if proper care is not taken. In addition to posing a direct risk of fatality and serious injury, it can serve as a trigger for a chain reaction of events leading to more injuries and death. Within a school, there are wide variations in the conditions under which electrical appliances are kept and used. Some conditions may be particularly corrosive e.g., in a fume cupboard, and other conditions may be far less demanding e.g., preparation room office areas. Some equipment is more at risk because it is moved regularly e.g., vacuum cleaners and power packs. This can be a cause of plug and lead strains. The sheer number of items of portable electrical equipment in a school together with the turnover of new or redundant pieces means that some system is required to match the period of testing to the demands on the equipment.

The management of electrical safety should be designed to provide protection from:
- Electric shock arising from:
- Exposed contacts
- Damaged insulation on equipment or extension leads
- Wet conditions in the area of equipment

Risk of fire arising from:
- Heating equipment
- Overloaded circuits
- Loose connections
- Short circuits
- Inappropriate electrical equipment in hazardous atmospheres

As stated in AS 2982 Section 4, all electrical installations must comply with the requirements of the relevant statutory authority. In Victoria, this is the Office of the Chief Electrical Inspector (OCEI), who administers the Electricity Industry Act, 1993, the Electrical Safety Act 1998, the Electrical Safety (Installation) regulations 1999 and the regulations relevant to each Act. Compliance with AS 3000-2000 Electrical installations- Building Structures and Premises and other related Australian Standards, are required, when building a new premises.

Only, competent persons may carry out all work on electrical installations and electrical equipment circuits, which exceed 50 V A.C. or 120 V D.C. Electrical workers who have been certified by the electrical Licensing Board in an electrical trade, or persons who have been granted restricted certificates of competency are considered competent persons. The scope of work that holders of restricted certificates of competency can be permitted to perform is dependant on their level of certification. The safety inspection and testing of electrical equipment are based on AS/NZS 37602000. This standard states that "in order to manage the risk to health and safety to users present by the use of plug in electrical, the equipment must be inspected, tested and tagged at a regular basis."

As mentioned previously, electrical testing can be performed by a ‘competent’ person,
i.e. “who the person in charge of the premises ensures has acquired through training, qualification, experience or a combination of these, these knowledge and skill enabling that person to perform the task required correctly”, i.e., either:

- a qualified electrical tradesperson or
- a person holding a restricted certificate of competency trained to use a Portable Appliance Tester (PAT).

A PAT is an electronic instrument that automatically tests equipment plugged into it.

Testing is performed to detect electrical faults as well as damage, wear or other conditions which might render it unsafe

Equipment identified as faulty is removed from usage. A "DANGER- DO NOT USE" tag attached and then should be sent to be repaired or disposed

Equipment that has passed the testing is tagged to show the date of the testing and the date it is due for retesting. Equipment types are divided into groups depending on the risk assessment associated with the equipment. Each risk group are tested at different intervals according to the equipment, though visual testing should be performed by the electrical appliance operator each time the equipment is used. The items to check for visual inspection are:

To ensure the equipment is free from obvious external damage Ensure there are no component defects such as connectors, plugs or socket outlets damage The electrical supply cords and inner cords are not exposed, external sheaths not cut, abraded or damaged Flexible cords are anchored effectively

The requirements for inspecting and testing electrical equipment vary for different work situations. The testing intervals for testing corded electrical equipment are set out below. For most of the electrical equipment used in schools the requirements for inspection, testing and tagging are described in AS/NZS 3760-2001, In-service Safety Inspection and Testing of Electrical Equipment. In most cases, the equipment will need testing every twelve months. If the school has Residual Current Devices (RCD's) they will generally need regular testing of the push button by the user at least every three months.

### 4.4.2.2 Testing intervals for portable electrical equipment:

AS3760 requires 12 month testing for Class I and II equipment in laboratory and educational establishments, 5 years for low risk office environments, and immediately after repair or service that affects the electrical safety or purchase of second hand equipment. Below is a table that designates testing intervals for equipment types . NOTE: This table was adapted from AS3760:2001 Table 2.

| | Type of environment and/or equipment | INTERVAL BETWEEN INSPECTION AND TESTS | | | | | | Cord extension Sets and EPOD | Residu |
|---|---|---|---|---|---|---|---|---|---|
| | | Class of equipment | | | | | | | |
| Specific | | Class 1 (protectively earthed) | Class II (double insulated) | Push button test by user | | Operating time RCD tester | | | |
| | | | | Portable | Fixed | Portable | Fixed | | |
| | Laboratories, health care, educational establishments, tea rooms, office kitchens | 12 months | 12 months | 3 months or before use whichever is longer | 6 months | 2 years | 2 years | 12 months | |
| | Office environment: Where the equipment or supply flexible cord is subject to flexing in normal use OR is open to abuse OR is in a hostile environment | 12 months | 12 months | 3 months | 6 months | 2 years | 2 years | 12 months | |
| | Office environment: Where the equipment or supply flexible cord is NOT subject to flexing in normal use AND is NOT open to abuse AND is NOT in a hostile environment | 5 years | 5 years | 3 months | 6 months | 2 years | 2 years | 5 years | |

requirements and recommended practices relating to electrical safety and electrical equipment in laboratories are specified in AS2243.7. These requirement include:



Laboratory Technicians' Association of Victoria
89 Burwood Road
Suite 150
Hawthorn, Victoria, 3122

#### 4.4.2.2.1 Testing of new equipment

Many electrical appliances are imported from overseas and on several occasions the wiring arrangements and colours used have been found different to those required by Australian Standards. In some cases, incorrect wiring of new appliances has led to dangerous electrical situations. This emphasizes the need for qualified personnel to carry out the initial wiring and to test and tag new equipment before it is put into use. Qualified staff at the point of sale generally carries out the testing of new equipment for laboratory apparatus, therefore it is recommended that staff ensure the equipment is certified to Australian Standards.

#### 4.4.2.2.2 Multi-outlet power boards and double adapters

The use of double adapters and multi-outlet power boards can be unsafe because of the potential for overloading and inadequate protection of circuits. Whilst the use of double adapters and multi-outlet power are not forbidden by legislation, they should not be used. Double adapters are particularly prone to the connections working loose with the resultant potential for overheating or contact with live terminals. In addition, where multi-outlet power boards are not secured they are very vulnerable to damage and have been frequently found covered with water or conductive solutions in laboratories. It is recognised that at times, it will be necessary to use electrical socket outlet adapters. It is preferable to install sufficient general-purpose outlets for all of the equipment in the workplace when designing the laboratory and preparation area.

#### 4.4.2.2.3 Electrical extension leads

It is important to ensure that all electrical extension leads are in good condition before they are used. In addition to periodic testing, users should check before each use to see whether the lead has a current test tag, whether the plug and socket are properly secured to the cord and that there are no cuts or tears in the outer insulation. Significant amounts of heat can be generated by electrical leads, which may lead to fires. The coiling of leads or placing them under mats or rugs exacerbates the heating effect. When using extension leads, ensure that they are fully extended, not covered and not placed where they could be a tripping hazard e.g., across aisles or trafficable areas.

#### 4.4.2.2.4 Electrical equipment in hazardous atmospheres

The risk associated with electrical installations in hazardous atmospheres created by flammable gases, vapours from flammable liquids or combustible dusts should be carefully considered when designing laboratory and preparation areas. Standard electrical switches, lights and other equipment may act as ignition sources for solvents used in laboratory benches or in fume cupboards. Electrical appliances either should be specially designed with Australian Standards approval, or should be excluded from hazardous locations. To determine if an installation is in a hazardous location reference should be made to AS 2430-Parts 1 and 3 Classification of Hazardous Areas.

#### 4.4.2.2.4.1 Heating equipment

Electrical heating appliances are a common source of fires. Equipment with exposed heating elements that come into combustible materials should not be used. Where possible appliances should have thermostat controls and thermal overload protection. Thermostats should be of a type that shut the equipment off when they fail.

#### 4.4.2.2.4.2 Special circuit protection

Contact with mains voltage can lead to severe electric shock or electrocution. Since relatively small currents through the body can prove fatal, conventional circuit breakers and fuses do not protect against this hazard. Special circuit protection such as residual current devices (RCD’s) or isolation transformers is required for specific electrical equipment in laboratory and preparation areas. Appropriate advice should be obtained before designing new facilities or installing equipment in existing points. Correct selection of the type of earth leakage protection is also important to avoid an unacceptable level of circuit tripping by the devices. Requirements for RCD's specific to various applications are given in AS 3000-1986.

### 4.4.2.2.5 What is a Residual Current Device (RCD)?

An RCD is an electrical safety device specially designed to immediately switch electricity off when electricity " leaking" to earth is detected at a level harmful to a person using electrical equipment. An RCD offers a high level of personal protection from electric shock. Circuit breakers and fuses provide equipment and installation protection and operate only in response to an electrical overload or short circuit. Short circuit current flow to earth via the equipment’s earthing system causes the circuit breaker to trip, or fuse to blow, disconnecting the electricity from a faulty circuit.

However, if the electrical resistance in the earth fault current path is too high to allow the circuit breaker to trip, electricity can continue to flow to earth for an extended time. RCD's detect a very much lower level of electricity flowing to the earth and immediately switch the electricity off. RCD's are designed to operate within 10 to 50 milliseconds and to disconnect the electricity supply when they sense harmful leakage. The sensitivity and speed of disconnection are such that any earth leakage will be detected and automatically switched off before it can cause injury or damage. There are three types of RCD's, switchboard mounted, powerboard mounted (GPO) type, and plug in type (portable). Portable RCD's are plugged into a fixed socket. A non-portable RCD installed at the switchboard is the best option in most situations as it protects all the wiring and appliances plugged into the circuit. However regulations stated in AS 3000-1986, provides the option of providing non-portable RCD's to be built into fixed sockets.

### 4.4.2.2.6 General Power Outlets

Whilst there are no standards that recommend the amount of power outlets required in the laboratory and preparation rooms, the positioning and location are stipulated by regulations set out in AS2430. In general, it is preferable to install sufficient general-purpose outlets for all of the equipment in the workplace when designing the laboratory and preparation area. When installing general power outlets AS2430 requires that, they are located at a minimum of 300mm above a bench height, and away from possible wet areas. It is also required that power outlets should be fitted with RCD protection, and if they are unprotected they are to be prominently labeled **'Outlet Not R.C protected.'** The electrical power to all general power outlets which are provided in a laboratory area for student use, is to be supplied through an emergency/master control circuit operated by a labeled push button, with a manually operated manual reset as stipulated by regulations set out in AS/NZS 2982 Section 10.3. It is also required that the reset button be located near the teacher's/demonstration bench adjacent to the gas isolating valves.

### 4.4.3 Lighting

### 4.4.3.1 Lighting and Controls

Daylighting forms the cornerstone of sustainable, high performance design for schools. Affecting the occupants on both conscious and subconscious levels, it provides light to see the environment and to do work, a natural rhythm that determines the cycles of days and seasons, and biological stimulation for hormones that regulate body systems and moods. In addition, it offers opportunities for natural ventilation and tremendous energy savings in electrically lit interiors.

Performing visual tasks is a central component of the learning process for students, teachers and teachers assistants. A high performance school should provide a rich visual environment — one that enhances, rather than hinders, learning and teaching — by carefully integrating natural and electric lighting strategies; by balancing the quantity and quality of light in each room and by controlling or eliminating glare. When properly designed, daylighting systems can also substantially reduce operating costs. The first step is decreasing the need for electric lighting. As an added benefit, waste heat from the lighting system is reduced, lowering demands on the school's cooling equipment. The design team must work together using the principles of integrated design to maximize the effectiveness of daylighting systems, and the building occupants need to be educated about how the systems work. Lighting options range from no-cost and low-cost choices to sophisticated state of the art systems. It is important to communicate daylighting goals clearly with the design team, and find a solution that fits the budget. Classroom laboratory and preparation room lighting levels should always be in accordance to standards set out for laboratory and preparation room design. The recommended levels are discussed and set out in AS 1680.1. The standard sets out levels of lighting which are adequate for the specific tasks that are to be carried out. The list below is only a small sample of the recommendations of the Australian Standard. Many retail locations have lux levels over 1000.

| Lux | Area |
|---|---|
| | |
| 40 Lux | Corridors |
| | Passageways |
| 80 Lux | Warehouses involving search & retreval tasks |
| | Stairs |
| 160 Lux | Entrance halls |
| | Foyers |
| | Waiting Rooms |
| | Canteens |
| | Machine shop general work bench |
| 240 Lux | Counters |
| | |

AS1680.2.4:1997 table E1 gives minimum Lux levels

The following six principles should provide fundamental guidance in designing lighting in laboratory and preparation rooms in schools:

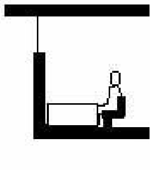
**Prevent direct sunlight penetration.** Direct beam sunlight is an extremely strong source of light. It is so bright, and so hot, that it can create great visual and thermal discomfort. Direct sunlight can deteriorate some plastics, and might be magnified through glass containers such as curved reagent bottles, which would then reflect the sunbeam into other directions, including your eyes. Refer to standards AS2243.1-10 AND AS2982.1 for more notes on the discomfort direct sun light. Daylight, on the other hand, which comes from the blue sky, from clouds, or from diffused or reflected sunlight, is much more gentle and can efficiently provide excellent illumination without the negative impacts of direct sunlight. Good daylighting design typically relies on maximizing the use of gentle, diffuse daylight, and minimizing the penetration of direct beam sunlight. In general, sunlight should only be allowed to enter a space in small quantities, as dappled light, and only in areas where people are not required to do work.

**Provide gentle, uniform illumination.** Daylight is most successful when it provides gentle, even illumination throughout a space. Evenly diffused daylight will provide the most energy savings and the best visual quality. Achieving this balanced diffuse daylight throughout a space is one of the greatest achievements of a good daylight design. The arrangement of reflective surfaces that help to distribute the light are just as important as the arrangement of daylight openings for providing gentle, uniform llumination. Whenever possible, place daylight apertures next to a sloped or perpendicular surface so the daylight washes either a ceiling or a wall plane, and is reflected deeper into the space. Examples of openings that provide illumination at varying degrees include:

High Sidelighting —Clerestory (Windows)

Recommendation

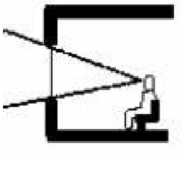
Use high clerestories in perimeter walls to increase daylight delivery deeper in classrooms, offices, libraries, multipurpose rooms, preparation rooms, and administrative areas.

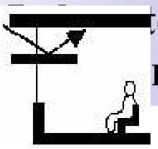


View Windows

Recommendation

Provide access to exterior views through view windows for all interior spaces where students or staff will be working for extended periods of time. High Sidelighting —Clerestory with Light Shelf or Louvers





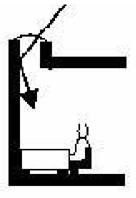


Recommendation Use light shelves or louvers with high clerestory glazing in perimeter walls to improve daylight distribution, block direct sun penetration, and minimize glare in classrooms, offices, libraries, multipurpose rooms, gymnasiums, and administrative areas.

Classroom Daylighting —Wall Wash Toplighting

Recommendation Use wall wash toplighting for interior classroom walls to balance daylight from window walls, brighten interior classrooms, and make them seem more spacious.

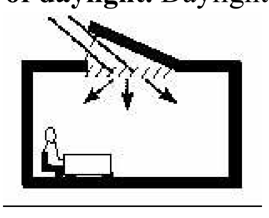
Central Toplighting



Recommendation Use central top lighting in single-story classrooms to provide high levels of even, balanced daylight across the entire room. It is essential to recognize that walls and ceilings are part of the daylighting design. For greatest efficiency and visual comfort, they should be painted white, or a light color that has a high light reflectance value.

**Avoid glare.** Excessively high contrast causes glare. Direct glare is the presence of a bright surface (for example, bright diffusing glazing or direct view of the sun) in the field of view that causes discomfort or loss in visual performance. This can have negative effects on student and staff performance.

**Provide control of daylight.** Daylight is highly variable throughout the day and the year, requiring careful design to provide adequate illumination for the maximum number of hours while contributing the least amount possible to the cooling load.



Teachers should have easy access to controls for shades or blinds to adjust light levels as needed throughout the day. These systems should be reliable, easy, and economic to clean and repair. Manually operated controls are slightly less convenient but also less expensive and less likely to need repair.

**Integrate with electric lighting design.** The daylight and the electric light systems should be designed together so they complement each other to create high quality lighting. This requires an understanding of how both systems deliver light to the space. The electric lighting should be circuited and controlled to coincide with the patterns of daylight in the space, so that the lights can be turned off in areas where daylight is abundant and left on where it is deficient. Controls can be either manual or automatic. Automatic controls use a small photo sensor that monitors light levels in the space. Manual controls are substantially less expensive, but need to be convenient and well labelled to ensure their use. Automatic controls guarantee savings, but are more expensive and must have overrides so the teacher can darken the room for audio/visual use.

**Plan the layout of interior space**s. Successful daylighting designs must include careful consideration of interior space planning. Since daylighting illuminance can vary considerably within the space, especially with side lighting, it is important to locate work areas where there is appropriate daylighting. Perhaps more importantly, visual tasks (especially the teaching wall) should be located to reduce the probability of discomfort or disability glare. In general, work areas should be oriented so that daylighting is available from the side or from above. Facing a window may introduce direct glare into the visual field, while facing away from a window may produce shadows or reflected glare.

Install High Performance Lighting and Controls Electric lighting is one of the major energy uses in schools. Enormous energy savings are possible using efficient equipment, effective controls, and careful design. Using less electric lighting reduces a major source of heat gain, thus saving air-conditioning energy, increasing the potential for natural ventilation, and reducing the space's radiant temperature (improving thermal comfort). Electric lighting design also strongly affects visual performance and visual comfort, by maintaining adequate, appropriate illumination and by controlling reflectance and glare. Finally, visual, accessible light and power meters can educate students and faculty about how lighting systems and energy controls work. Lighting in laboratory and preparation rooms should provide a visual environment that enhances the working process for students, teachers and teachers assistants, which can occur only if people can perform their visual tasks quickly and comfortably.

### 4.4.3.2 Integration with Daylight

Properly controlled daylight promotes comfort and productivity. To achieve energy savings, electric lights must be turned off (either manually or automatically) when sufficient daylight is available. Many teachers and students are quite conscientious in manually turning off the lights when not needed, but automatic systems tend to result in greater energy savings over the long run. The first and most important step in integrating electric lighting with daylighting is to make sure that the electric lights are circuited so they can be logically switched off or dimmed in proportion to the presence of daylight in the room. This generally means that the electric lights should be circuited in lines parallel to the daylighting contours in the space. The areas of the room with the most daylight, the space adjacent to windows or skylights for example, should be turned off or dimmed first. A good rule of thumb for daylighting integration: control electric lights with a minimum of three separate circuits in daylighted spaces. The electric lighting should be designed to provide balanced and sufficient illumination under nighttime conditions, but it should also be circuited to supplement partial daylight when needed on dark days.

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The lighting designer should thoroughly understand the patterns of daylight illumination expected during different times of the day and year, so that the electric lighting design can supplement the daylight, filling in darker areas of the room or highlighting a wall when needed. The choices of switching versus dimming, and manual versus automatic photosensor controls, are partly a cost issues, but also operational issues. Questions and Issues of lighting design are discussed in the following paragraphs.

### 4.4.3.3 Visual Comfort

- Are the basic daylighting and electric lighting designs being developed so that they provide illumination as uniformly as possible, using task or accent lighting as appropriate to meet specific needs?
- What tools have been used to model the interactions of both these systems in terms of their impacts on
- visual comfort?
- Is individual lighting designs being developed for individual room types?
- Do the designs vary, even within room type, depending on the amount of daylight the room will receive?
- Is the potential for glare being analyzed, and are the lighting/daylighting systems being designed to
- minimize it?
- Are the color and texture of wall, floor, and ceiling surfaces being taken into account in terms of their interaction with the lighting and their combined impact on the visual environment?
- Have direct/indirect lighting fixtures been selected for general illumination in classrooms and preparation rooms?
- What shading strategies (internal and external) have been selected?
- Has the potential for glare been analyzed, and have the lighting/daylighting systems been designed to minimize it?
- Will the control systems perform as expected during both active and quiet classroom activities?

### 4.4.3.4 Day lighting

- What strategies are being considered to control unwanted heat gain and glare?
- What basic strategies are being considered for bringing daylight into the school, particularly the
- classrooms?
- What tools are being used to analyze the impact of any daylighting strategies on the electric lighting system, and on visual comfort and energy use?
- What are the preliminary results of these analyses?
- Are the classrooms receiving as much daylight as possible, while avoiding glare and unwanted heat gain?
- What types of glazing have been selected (for windows, skylights, and/or roof monitors) and why are they more energy and cost effective than alternatives?
- How will the daylighting and electric lighting systems interact?
- What analyses has been done to optimize these interactions?

## 4.4.3.5 High Performance Electric Lighting

- What electric lighting system is being proposed for the school and, in particular, for the classrooms and preparation rooms?
- What are its energy and visual performance benefits?
- How does it interact with the daylighting strategies being used?
- How are these interactions being analyzed and optimized?

### 4.4.3.5.1 Horizontal Illumination

Too often, schools are designed with excessively high horizontal light levels. Many published school lighting design parameters remain based on antiquated standards calling for excessively high horizontal illuminance. Too often, this results in poor lighting quality, reduced visual performance, wasted lighting energy, and high energy and maintenance costs. The recommended horizontal illuminance level for most typical classroom and office reading tasks is 160 Lux. Some classroom and preparatory room tasks may justify up to 600 Lux for intricate work, where close examination is needed, so choosing between 160 and 600 Lux is an excellent compromise. Better lighting designs don't stop with horizontal illuminance levels, but also focus on lighting quality issues such as uniformity, vertical illuminance, and glare avoidance.

### 4.4.3.5.2 Vertical Illumination

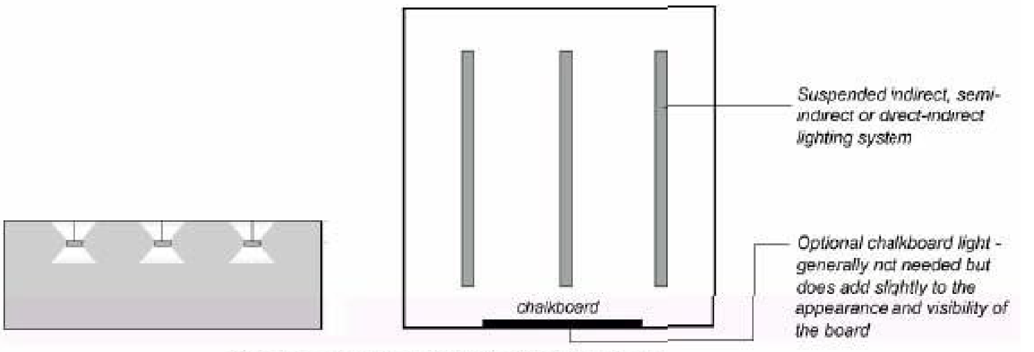
Achieving adequate vertical illumination is one of the more critical design issues in school lighting. With the exception of desktop reading, nearly all school visual tasks are "heads-up" type activities requiring proper vertical illuminance. In addition, much of the perception of what comprises lighting quality is strongly influenced by vertical illumination. For example, proper wall illumination is a critical factor in obtaining lighting uniformity in classrooms. In addition, good vertical illumination is important for promoting the important school activity of social communication.

### 4.4.3.5.3 Glare Control

Light sources that are too bright create uncomfortable glare. In extreme cases, direct or reflected glare can also impair visual performance by reducing task visibility. Glare causes eye fatigue by forcing the eye to work much harder. All sources of light, including daylight, must be carefully controlled to avoid causing discomfort or disabling glare. Common glare problems in classrooms include uncomfortable direct glare from overhead sources, reflected glare from computer screens and whiteboards, and direct glare from uncontrolled windows or skylights.

### 4.4.3.5.4 Lighting Uniformity

For the most part, illuminate laboratory and preparation room spaces as uniformly as possible, avoiding shadows or sharp patterns of light and dark. Large differences between light and dark spaces forces the eye to constantly adapt to differing light levels and contributes to fatigue. The standard lighting fixture historically used in classrooms (recessed or surface-mounted parabolic fixtures) should be avoided in most spaces. By blocking light from reaching the upper portion of the wall and ceiling, they create a shadowy, cave-like environment. The best method of maximizing uniformity is to make a concerted effort to light vertical surfaces and, where possible, the ceiling. Using light-colored, diffuse surface materials also serves to optimize lighting uniformity. Below is a typical design for a classroom where there is consideration for the type of lighting positioning.




Classroom Pendant Mounted Lighting Desig

This classroom design uses three rows of suspended fluorescent luminaires. This same lighting design can be used for recessed luminaires

### 4.4.3.6 Lighting Control Flexibility

Lighting controls should be designed for flexibility to accommodate the varying nature of many school spaces. In addition to saving energy, multiple level switching or separate circuiting of light fixtures enables selection of different light levels to respond to changing requirements or amounts of natural daylight. Control flexibility increases energy efficiency by encouraging only the use of lights that is needed for the activity at hand. Lighting control systems must be easy to understand and operate. Non-intuitive control interfaces are likely to be ignored at best, and disabled in more extreme cases. Control flexibility is especially important in classrooms, which typically must accommodate lighting levels for a variety of conditions and activities. It is especially critical that teachers have the ability to override any automatic dimming and/or occupancy sensor controls, so that they can switch the lights off manually when necessary.

#### 4.4.3.6.1 Integration with Daylight

To achieve its benefits, daylight must be properly controlled. Integrating electric light with daylight is one of the more challenging aspects of school lighting design. At a minimum, luminaires should be circuited to match how daylight enters the space. In other words, luminaires closest to windows or skylights should be circuited separately from other lights in the space. This promotes daylighting's potential energy savings by allowing some or all of the electric lighting to be turned off during the day. To maximize energy savings, consider the additional flexibility of dimming ballasts with manual or automatic dimmers.

### 4.4.3.7 Light Sources

A variety of light sources are available for schools. Light source selection critically affects building space appearance, visual performance, and comfort. This section outlines the different types of sources available to the designer, describing each technology type and providing appropriate application examples.

#### 4.4.3.7.1 Incandescent and Halogen Lamps

Incandescent lamps represent the oldest of electric lighting technologies. Advantages of incandescent technology include point source control, high color performance, instant starting, and easy and inexpensive dimming. Disadvantages range from low efficacy and short lamp life to high maintenance costs. Incandescent sources should not be used in new schools except in very limited and special accent lighting circumstances. Examples might include dimming applications where color performance, beam control, and/or dramatic effect is critical. In most of these cases, halogen sources, which offer longer life, better point source control, and crisper color performance, are superior to standard incandescent lamps. The most efficient halogen technology is "infrared reflecting" or "IR", which should be used whenever possible.

#### 4.4.3.7.2 Fluorescent Lamps

Fluorescent lamps can and should be used to light nearly all types of laboratory and preparation spaces. They offer long life, high efficacy, good color performance, and low operating and maintenance costs. Fluorescent lamps are typically straight or bent tubes, which limit their use somewhat. Dimming fluorescent lamps require special electronic ballasts that cost more than standard high frequency ballasts.

AS4024.1 Safeguarding of Machinery, Clause 6.18 states that" Fluorescent lighting may be used us a local lighting source on a machine provided that any stroboscopic effects do not conceal a hazard, create a distraction or cause annoyance." Clause 11.7 warns that the stroboscopic effect of moving machinery must be considered when selecting lighting. It is possible that fluorescent lighting may create a strobe effect, especially when taken from the same phase of a 3-phase power supply. The normal practice by electrical contractors to avoid this effect is to have some of the lights wired to one phase, some to the second phase and others to the third. In this way they don't flicker all at the same time. If taken from a single-phase power supply, there is unlikely to be a problem.

As part of the risk assessment, you need to determine whether there is a strobe effect occurring. If there is a problem, it may be overcome by the methods mentioned above, or by changing the types of lights, e.g., incandescent or sodium vapour. You should talk to a competent electrician or lighting engineer to get specific guidance for your situation.

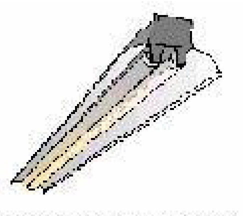
## 4.4.3.7.3 Luminaires

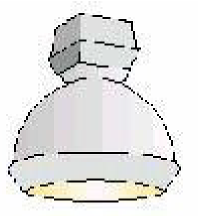
Luminaires (light fixtures) generally consist of lamps, lamp holders or sockets, ballasts or transformers (where applicable), reflectors to direct light into the task area, and/or shielding or diffusing media to reduce glare and distribute the light uniformly. There is an enormous variety of luminaire configurations. This section briefly outlines some of the more important types for laboratory and preparation room design.

Examples of types of Luminaires:

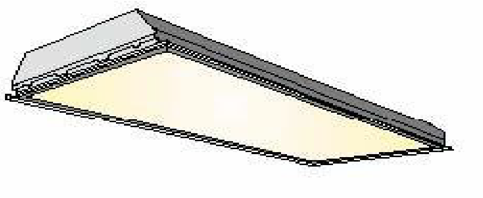
**4.4.3.7.3.1 Recessed Luminaires**

Recessed luminaires represent a large segment of the overall luminaire market. There are two basic variations:


Hooded Industrial Fluorescent Luminaire


Low-bay HID Luminaire


Modern lens recessed troffer


surface troffer

Lay-in troffers recess into an acoustical tile ceiling. The most common types measure 0.6m x 1.2m or 0.6m x 0.6m. With the use of a special flange, they can also be recessed into gypsum board ceilings. They typically consist of a housing, reflector, mounting hardware, lamps, ballast, and a lens or other shielding or diffusing media, such as parabolic louvers. Their primary use is as a direct general light source. They are among the least expensive of light fixtures available. Their primary advantages are their low cost and their ability to produce high levels of uniform horizontal light. They are generally less effective than other types of luminaires at producing the high wall and ceiling illumination levels that are important for visual comfort. This is particularly true of the parabolic troffer.

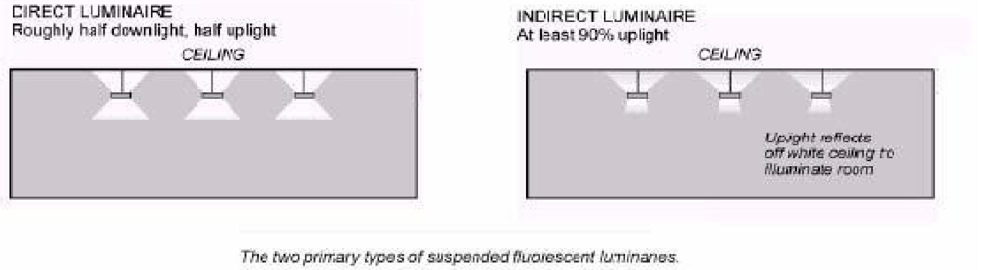
Down lights can also be recessed into t-bar or hard ceilings. They are relatively compact luminaires used for wall washing, accent lighting, and supplemental general or task illumination, as well as for lower levels of ambient illumination. They use incandescent, compact fluorescent or HID sources. Specific luminaire components vary depending on application.

Other types: A relatively recent addition to the recessed luminaire family is a modified version of the standard troffer that indirectly reflects light into the space. These are marketed as “indirect troffers”, and their intent is to soften the distribution pattern of a direct distribution luminaire without losing the benefit of lighting uniformity. However, in many cases the surface brightness of the exposed reflector is actually higher than that of a standard troffer. Use them with caution, and do not use them in larger building spaces such as classrooms and open offices.

#### 4.4.3.7.3.2 Suspended Classroom Luminaires

Suspended indirect or direct/indirect luminaires are the preferred luminaires for lighting classrooms. Some people dislike the “cloudy day” effect produced by 100% indirect luminaires, and prefer some direct illumination. However, luminaires with too much of a direct component can produce shadows, glare or reduced uniformity. Fortunately, luminaire optical system options allow the designer to determine the amount of indirect and/or direct illumination. By using the ceiling to distribute light into the room, indirect and direct/indirect fixtures efficiently produce soft, uniform illumination throughout the space. and to avoid ceiling “hot spots.”

High-end suspended classroom luminaires are constructed of extruded aluminium and cost significantly more; however, steel luminaires are available at prices comparable to recessed troffers, particularly when installation labour costs are factored in. Luminaires can usually be specified to include transparent dust covers, which prevent dirt and refuse (spit balls, paper airplanes, etc.) from accumulating inside the fixture, thereby blocking light and increasing required maintenance.




The two primary types of suspended fluorescent luminaires.

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**4.4.3.7.3.3 Specialty Luminaires**

Several specialty luminaires are available for specific school lighting applications. These include specialty wall wash luminaires to illuminate blackboards, task lighting luminaires to supplement general illumination such as specific tasks in the preparation room. Blackboard lights provide supplemental vertical illumination on the teaching wall. Specially designed recessed or surface-mounted linear fluorescent luminaires provide high levels of uniform illumination when mounted in continuous rows over the vertical surface. Specialty task lighting luminaires are important in areas such as preparation areas where ambient illumination levels are kept relatively low. Portable or furniture-mounted task lights can provide supplemental illumination for certain paper tasks and other visual work requiring higher illumination levels. Usually these luminaires employ compact fluorescent or halogen lamps and include local switches or dimmers to allow the user some flexibility.

## 4.4.3.8 General Application Notes for Lighting Controls

Lighting control strategies are most successful when people can easily understand their operating characteristics. Another critical factor is the proper commissioning of lighting control systems so that they operate according to design intent. Finally, regularly scheduled maintenance of control equipment will improve the long-term success of the system. Poorly designed, commissioned or maintained automatic lighting controls can actually increase lighting energy use, and cause user

dissatisfaction. For optimising lighting control performance, consider the following rules of thumb when designing lighting control systems:

Provide control interfaces that are easy to understand and operate by laboratory users. Always commission automatic lighting controls after installation to ensure compliance with design intent. Involve the lighting control equipment manufacturer in the specification, installation and commissioning of lighting controls. Provide detailed maintenance procedures for all specified controls.

# 5 REFERENCES

AS 1668 The use of Mechanical Ventilation and Air-conditioning in Buildings, Part 2: Mechanical Ventilation for Acceptable Indoor- Air Quality
AS 1940 The Storage and Handling of Flammable and Combustible Liquids
AS 2243 Safety in Laboratories, Part 1-10:
AS 2982 Laboratory design and construction, Part 1: General requirements
Haski, Roberta; Cardilini, G and Bartolo, William. CCH Laboratory safety Manual: CCH Australia Ltd, 2002
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