Safety Practices in Chemistry Laboratory

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Importance of Health and Safety

- To protect your health and safety (and environment)
- To protect your colleagues' and students' health and safety

Case Study: Laboratory Fire Kills UCLA Researcher

- A 23-year-old research assistant working at UCLA who was seriously burned in a lab fire in December 2008 recently died from her injuries.
- She was trying to transfer up to 2 ounces (~50ml) of t-butyl lithium (pyrophoric chemical), which was dissolved in pentane from one sealed container to another by a 50 ml syringe.
- The barrel of the syringe was either ejected or pulled out of the syringe, causing liquid to be released.
- A flash fire set her clothing ablaze and spread second- and third-degree burns over 43% of her body.

Root Causes of the Accident

- Poor technique and improper method
  - Use a 50ml syringe to transfer~50 ml pyrophoric chemical
  - Should use a 100ml syringe
  - Should use Cannula Method for transfer of pyrophoric chemical $\geq$ 50 ml
- Lack of proper training
  - No safety training record

Root Causes of the Accident

- Lack of supervision
  - No follow up actions had been taken after received a UCLA safety inspection report with over a dozen of deficiencies
  - Solo operation in the laboratory

Root Causes of the Accident

- Poor housekeeping
  - Flammable materials and water- and air-reactive chemicals were stored improperly
- Improper use of fume hood
  - The tempered-glass vertical sash that probably was not lowered enough, otherwise, only her hands and forearms would have been burned

Root Causes of the Accident

- No proper personal protective equipment
  - Eye protection, nitrile [rubber] gloves and lab coats were not worn by laboratory personnel
  - Lab coat would have been less flammable and easier to remove than the sweater which caught on fire
- Do not familiar with emergency response equipment
  - The injured lady ran away from a nearby emergency shower instead of toward it

Contents

What To Follow?

- Chapter 509 - Occupational Health and Safety Ordinance (OHSO) and related Regulations (OHSR)
- Chapter 59 – Factories and Industrial Undertakings Ordinance and related Regulations (F&IU)

What To Follow?

- Other Legislations
  - Control of Chemicals Ordinances and Regulations [Customs & Excise Department]
  - Chemical Weapons (Convention) Ordinance [Trade and Industry Department]
  - Dangerous Goods Ordinance and Regulations [Fire Services Department]
  - Waste Disposal (Chemical Waste) (General) Regulations [Environmental Protection Department]
- Organization internal health and safety rules and regulations

Occupational Safety and Health Ordinance and Regulations

- Covers safety and health in nearly all workplaces in Hong Kong
- The OSHR is a subsidiary regulation of OSHO.
- Approved by the Legislative Council on 17 June 1997
- The Occupational Safety and Health Ordinance (OSHO) provides for safety and health protection to employees in workplaces, both industrial and non-industrial, including those working in offices, commercial premises, schools, hospitals, clinics, laboratories and other workplaces.

Duties of Employers

- Provide and maintain plant and system of work that are safe without risk to health.
- Make arrangements for ensuring safety and absence of risks to health in connection with the use, handling, storage or transport of plant or substances.
- Provide information, instruction, training and supervision as may be necessary to ensure the safety and health at work.

Duties of Employers

- Maintain workplace including the means of access to and egress from the workplace in a condition that is safe and without risk to health.
- Provide and maintain workplace and working environment that are safe and without risks to health.

Duties of Employees

- An employee must so far as reasonably practicable, take care for the safety and health of himself and of other persons who are at the workplace.
- He must also cooperate with his employer or other person so far as may be necessary to enable safety and health requirements are complied with.

Occupational Safety and Health Regulations

- Effective on 1 January 1998
  - Accident Prevention
  - Fire Precautions
  - Workplace Environments
  - Hygiene at Workplaces
  - First Aid at Workplaces
- Effective on 1 July 1998
  - Manual Handling Operations
- Effective on 24 April 2003
  - Video Display Units

Factories and Industrial Undertakings Ordinance

- The Factories and Industrial Undertakings Ordinance provides for the safety and health protection to workers in the industrial sector
- Coverage of the F&IU Ordinance
  - This ordinance applies to industrial undertakings, i.e. factories, construction sites, catering establishments, cargo and container handling undertakings, repair workshops and other industrial workplaces.
- Section 6A: General Duties of Proprietors
- Section 6B: General Duties of employees

Factories and Industrial Undertakings Ordinance

- Subsidiary Legislation
  - 30 sets of subsidiary regulations covering various aspects of hazardous work activities in industrial undertakings and other industrial workplaces
  - The subsidiary regulations prescribe detailed safety and health standards on work situations, plant and machinery, processes and substances.

Subsidiary Legislation

- F&IU (Guarding and Operation of Machinery) Regulations
- F&IU (Protection of Eyes) Regulations
- F&IU (Dangerous Substances) Regulations
- F&IU (Notification of Occupational Diseases) Regulations

F&IU (Dangerous Substances) Regulations

- Container holding dangerous substances to be labelled
  - In English and Chinese in the form prescribed by the Second Schedule
  - Can be read easily
  - Label shall be securely fixed to the container and shall stand out sharply from their background

F&IU (Dangerous Substances) Regulations

- Particulars in the label
  - The chemical name or common name of the substance
  - Classification of the substance
  - The symbol or symbols specified in respect of that classification
  - List of Particular Risks
  - List of Safety Precautions

F&IU (Dangerous Substances) Regulations

- Size of label

Capacity of container	Dimension of label
3 L or less	not less than 50mm x 75mm
> 3 L but < 50L	not less than 75mm x 100 mm
> 50L but < 500L	not less than 100mm x 150mm
> 500L	not less than 150mm x 200mm

F&IU (Dangerous Substances) Regulations

- Safety information, training and precautions
  - Safety precautions relating to dangerous substances
  - Purpose, proper use and limitations of any protective clothing or equipment provided
  - Health hazards associated with the exposure to dangerous substances
  - Make arrangement for adequate supervision to prevent dangerous substances from causing bodily injury
- Protective clothing and equipment

Control of Chemicals Ordinances and Regulations

- Specified in Schedule 1, 2 and 3 of the Control of Chemicals Ordinance, Cap. 145.
- Used for the manufacture of narcotic drugs or psychotropic substances.
- Come into operation on 1 January 1996
- 25 chemicals under 3 Schedules

Control of Chemicals Ordinances and Regulations

- Chemical under control (Schedule 1)
  - Acetic anhydride
  - Acetyl chloride
  - Acetyl bromide
- Reason
  - Acetic anhydride → Heroin

Control of Chemicals Ordinances and Regulations

- Chemical under control (Schedule 2)
  - Ephedrine, Ergotamine, Ergometrine, Pseudoephedrine, Lysergic Acid, 1-phenyl-2-propanone, N-acetylanthranilic Acid, Piperidine, Safrole, Isosafrole, Piperonal, Anthranilic Acid, Phenylacetic Acid, 3,4-methylenedioxy-phenyl-2-propanone, Potassium Permanganate, Norephedrine (with effect from 1 September 2000)
  - Reason
    - Pseudoephedrine → Methamphetamine (Ice)

DH keeps close watch on pseudoephedrine transaction

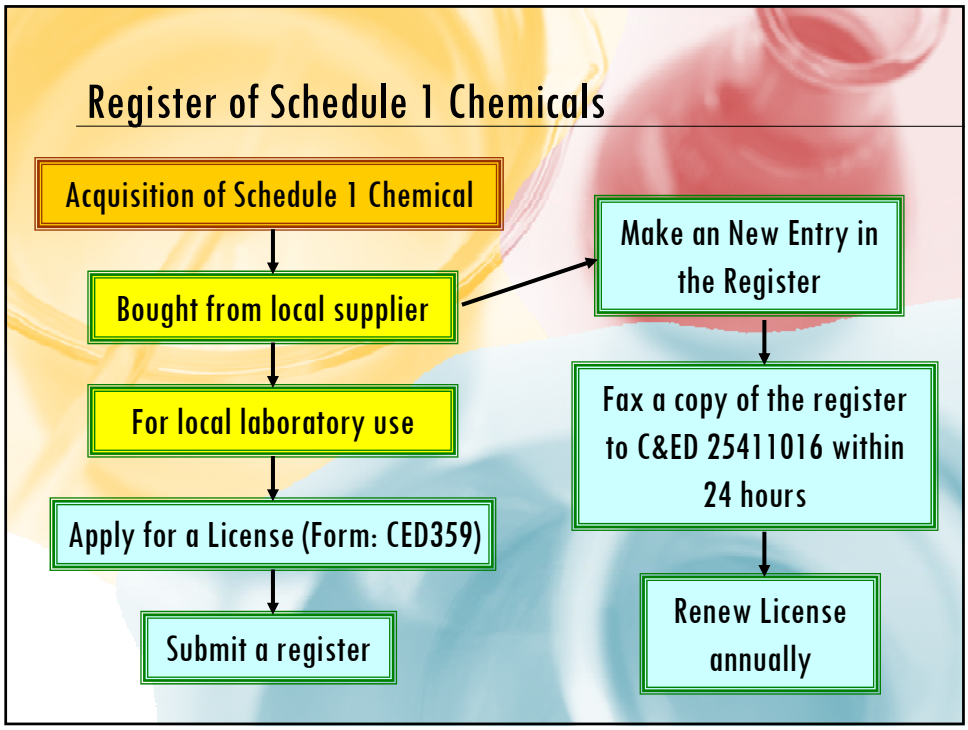
- In response to media enquiries about a news report that pseudoephedrine-containing pharmaceutical products were bought from local pharmacies for making of methamphetamine (ICE) outside Hong Kong, a spokesman for the Department of Health (DH) said the department had attached great importance to the allegation and would investigate if there were abnormal transaction of these products in local market.

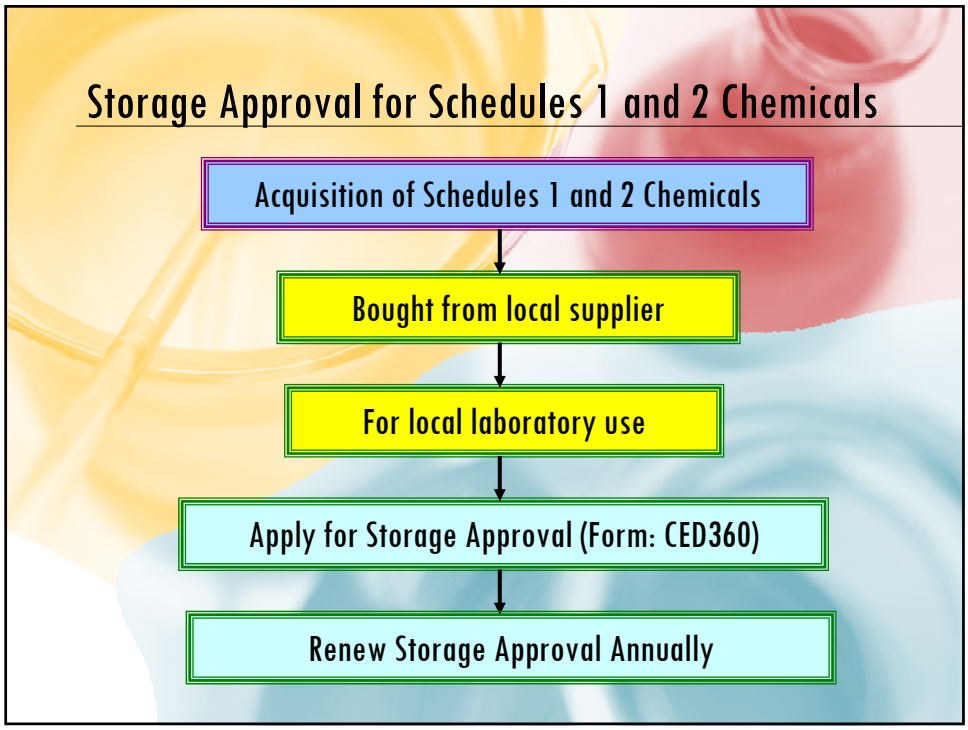
Control of Chemicals Ordinances and Regulations

- With effect from 1 June 1997, control was extended to include the salts of the chemicals stipulated on Schedules 1 and 2, whenever the existence of such salts are possible

Licence

Types of Licence required	Chemicals under Schedules		
	1	2	3
Manufacture	✓	✓	✗
Import	✓	✓	✗
Export	✓	✓	✓
Possession	✓	✗	✗
Supply or Dealing in/ with	✓	✗	✗


Register of Schedule 1 Chemicals
Acquisition of Schedule 1 Chemical
Bought from local supplier
For local laboratory use
Apply for a License (Form: CED359)
Submit a register
Make an New Entry in the Register
Fax a copy of the register to C&ED 25411016 within 24 hours
Renew License annually


Storage Approval for Schedules 1 and 2 Chemicals
Acquisition of Schedules 1 and 2 Chemicals
Bought from local supplier
For local laboratory use
Apply for Storage Approval (Form: CED360)
Renew Storage Approval Annually

Chemical Weapons (Convention) Ordinance

- Came into operation on 18 June 2004
- The purpose of the Ordinance is to enable the Chemical Weapons Convention, an international treaty that aims to prohibit the development, production, acquisition, stockpiling, retention, transfer and use of chemical weapons, to be fully implemented in the Hong Kong Special Administrative Region

Chemical Weapons (Convention) Ordinance

- In accordance with the Ordinance, users shall inform the Trade and Industry Department if it was engaged in specified activities involving Scheduled Chemicals
- Classification of Chemical Weapons
  - Schedule 1: e.g. Sarin, Ricin
  - Schedule 2: e.g. Amiton, Arsenic trichloride ($AsCl_3$)
  - Schedule 3: e.g. Hydorgen cyanide (HCN) , Phosphorus pentachloride (PCl_5)

Chemical Weapons (Convention) Ordinance

- Facilities with production and/or other specified activities exceeding the following thresholds are required to submit annual declarations under the Convention:
  - Schedule 1: where annual production exceeds 100g of Schedule 1 chemicals in the aggregate
  - Schedule 2: where production, processing and consumption exceeds : 1 kg of a chemical listed in Part A of Schedule 2 and designated with an "*" ; 100kg of a chemical listed in Part A of Schedule 2 but is not designated with an "*" ; or 1 tonne of a chemical listed in Part B of Schedule 2.
  - Schedule 3: where production exceeds 30 tonnes of a Schedule 3 chemical.

Chemical Weapons (Convention) Ordinance

- Declaration and Report
  - annual declarations on the activities of the preceding year;
  - annual declarations on the anticipated activities of the next year;
  - declarations to amend previously submitted information or additionally planned activities.

Dangerous Goods Ordinance and Regulations

- The Dangerous Goods Ordinance provides for the control on land and at sea of about 400 types of dangerous goods under ten broad categories in accordance with their inherent characteristics
- Mainly for fire protection
- Regulations on storage, transportation and packaging

Classification of Dangerous Goods

Category 1	Explosive*
Category 2	Compressed Gases
Category 3	Corrosive Substances
Category 4	Poisonous Substances
Category 5	Inflammables

*Under jurisdiction of Mining Division of Civil Engineering Department

Classification of Dangerous Goods

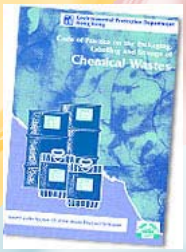
Category 6	Water Reactives
Category 7	Strong Supporters of Combustion
Category 8	Readily Combustible
Category 9	Spontaneously Combustible
Category 10	Other Dangerous Goods

Chemical Waste Regulations in HK

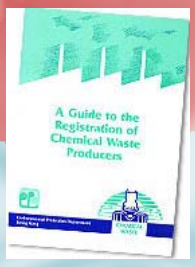
- Waste Disposal (Chemical Waste) (General) Regulations of 1992
- Set up a waste treatment facility
- Prohibition of disposal into sewer
- Registration of waste generators
- Packaging, labeling and storage of chemical waste
- Documented collection and disposal scheme

Chemical Waste Regulations in HK

A Guide to the Chemical Waste Control Scheme



Packaging, Labelling and Storage of Chemical Waste



A Guide to the Registration of Chemical Waste Producers

References: Environmental Protection Department, HKSAR

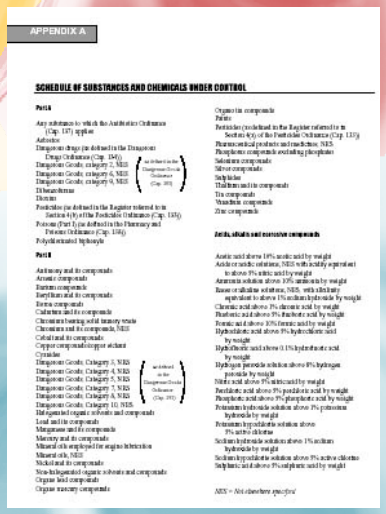
Legal Definition of Chemical Waste

- Chemical Waste is legally defined by reference to a list of substances and chemicals in Schedule 1 of the Waste Disposal (Chemical Waste) (General) Regulation enacted 18 March, 1992.

Items Not Considered to be Chemical Waste

- Dilute acids and alkalines, if % by weight is less than figures in Appendix A of "A Guide to the Chemical Waste Control Scheme", HKEPD, Sep 1992.
- Neutralized salts, not listed in App A.
- Elemental metals, not listed in App A (e.g., Copper, Iron, Tin, Zinc).
- Household chemicals used in labs.
- Apparatus rinsing water or wiping tissue.

A Guide to the Chemical Waste Control Scheme


APPENDIX A

SCHEDULE OF SUBSTANCES AND CHEMICALS UNDER CONTROL

Safety Management System

- Safety Policy
- Safety Organization
- Safety Training
- Organization Rules
- Safety Committee
- Health and Safety Inspection Program
- Job Safety Analysis (JSA)
- Accident / Incident Investigation
- Safety Promotion
- Process Control Program
- Personal Protection Program
- Health Assurance Program
- Evaluation, Selection and Control of Subcontractor
- Emergency Preparedness

Laboratory Safety Management System

- To successfully manage safety and health at work, the Labour Department has advised every school to establish an occupational safety and health management system which includes the following elements
  1. A safety and health policy statement to show the management's commitment;
  2. Organization structure of the management system, with a clear allocation of safety responsibilities;
  3. An assessment of the safety and health risks which should be updated when situations change;

Laboratory Safety Management System

4. Safety and health regulations to be observed in the workplace;
5. Education, instruction and training on occupational safety and health;
6. Emergency plans, drills and first aid arrangements,
7. A regular review of the system to ensure its effectiveness; and
8. Documentation to keep proper record and ensure continuity of activities.

Chemical Hazards in Laboratories

- Pyrophorics e.g. yellow phosphorous
- Water reactives e.g. sodium metal
- Peroxidizables e.g. ethyl ether, tetrahydrofuran
- Shock sensitives e.g. anhydrous picric acid
- Cryogens e.g. liquid nitrogen, dry ice
- Light sensitives e.g. sodium iodide

Chemical Hazards in Laboratories

- Flammables e.g. ethanol
- Asphyxiants e.g. inert gas such as nitrogen
- Corrosives e.g. sulfuric acid, sodium hydroxide
- Toxics e.g. formaldehyde, nickel compounds
- Oxidizers e.g. potassium permanganate

Flammable Substances

- Flammable substances can burn or explode when exposed to heat, spark or open flame
- The flammability of chemical liquid depends on its flash point
- Flash Point
  - —The lowest temperature at which a liquid gives off enough vapour to form an ignition mixture with air and produce a flame when a source of ignition is present

Flammable Substances

- Category 5 of Dangerous Goods (Classification) Regulation
  - Substances giving off inflammable vapours
    - C1.1 flash point below 23 °C
    - C1.2 flash point of or exceeding 23 °C but not exceeding 66 °C
    - C1.3 flash point of exceeding 66 °C

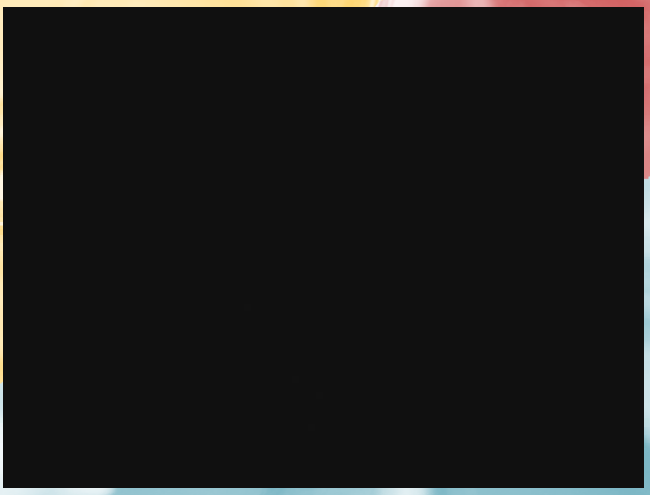
Ethanol Fire in a Biological Safety Cabinet

Phosphorus Fire

Explosive Substances

- Explosive effect or pyrotechnic effect can be caused by chemical which can burn at a very fast rate when exposed to an ignition source, and is so doing, creates violent movement of gases in the vicinity
- Explosive or flammable substances pose the danger of fire or explosion, causing damage to the body through direct burning or through inhalation of toxic fumes emitted from the fire.

Explosion of Peroxyacetone (Triacetone Triperoxide)



Source: http://exploscience.com/ChemTV_Page_5.html

Irritants

- Inflammation of tissue results from concentration far below those needed to cause corrosion
- Cause inflammation of mucous membranes with which they come in contact
- Depend on the concentration and water solubility
  - E.g. ammonia, sulphur dioxide, chlorine
- Primary irritants: cause direct irritant effects
- Secondary irritants: produce irritation but the effects are overshadowed by systemic effects

Irritants

Sensitizers

- Causes a substantial proportion of exposed people to develop an allergic reaction to skin (contact dermatitis) and respiratory tract (occupational asthma) in normal tissue after repeated exposure to the chemical
  - E.g. formaldehyde, chlorinated hydrocarbon, epoxide

Sensitizers

Corrosives

- Corrosives are chemicals which may cause visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact.
- Strong acids: Hydrochloric acid, phosphoric acid
- Strong alkalis: Sodium hydroxide, ammonia solution
- Dehydrating agents: Concentrated sulfuric acid, concentrated nitric acid
- Oxidizing agents: Perchloric acid, chromic acid

Corrosives

Oxidizers

- Substances or mixtures that give rise to highly exothermic reaction when in contact with other substances, particularly reducing agents such as flammable substances
- Oxidizing agents having oxygen in their molecules which are easily available in reaction

Fire Hazard of Oxidizers

Highly Reactive Chemical

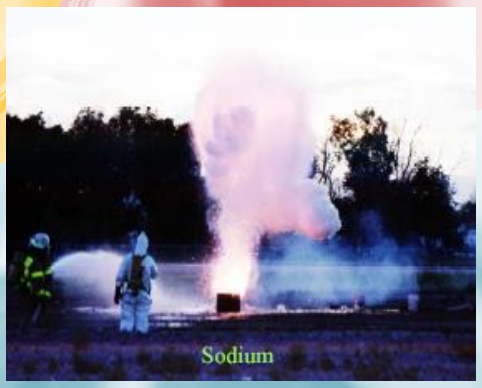
- Inherently unstable and susceptible to rapid decomposition by air, light, heat, shock, water, and certain catalyst
- Examples
  - alkali metals react violently with water
  - Formation of explosive metal acetylides by reacting acetylene with copper impurity in metal piping

Explosion of Picric Acid

Organic Peroxides

- Are extremely sensitive to light, heat, shock, sparks and other forms of accidental ignition
- Peroxide formers can form peroxide during prolonged storage and especially after exposure to the air
- E.g. ethyl ether, isopropyl ether, sodium

Inorganic Peroxides



Organic Peroxides

Peroxidizable iso-propanol

Pyrophoric Chemical

- Chemical can ignite spontaneously in air
  - A potentially more hazardous situation can occur if the gas does not burn and an explosive concentration is allowed to build up
  - E.g. Grignard reagents, metal carbonyls, alkali metals, metal powders, phosphors

Fire Hazard of Pyrophoric Chemical

Asphyxiants

- Simple asphyxiants
  - Displace the amount of oxygen in the air (reduce the oxygen concentration)
    - E.g. helium, nitrogen
- Chemical asphyxiants
  - These substances interfere with the transport of oxygen to the blood and/or the utilization of oxygen by the cells
    - E.g. Hydrogen cyanide (inhibits the cytochrome oxidase for tissue respiration)

Carcinogens

- Chemical which can cause cancer
- Do not follow dose-response curve
- Long latency period and lack of threshold
- Classification schemes of carcinogens
  - American Conference of Industrial Hygienists (ACGIH)
  - International Agency of Research on Cancer (IARC)
  - National Toxicology Program (NTP)

Classification schemes of carcinogens

- American Conference of Industrial Hygienists (ACGIH):
  - A1: confirmed human carcinogen
  - A2: suspected human carcinogen
  - A3: animal carcinogen
  - A4: not classified as a human carcinogen
  - A5: not suspected as human carcinogen
- National Toxicity Program (NTP)
  - Group 1: Known to be Human Carcinogens
  - Group 2: Reasonably Anticipated to be Human Carcinogens

Classification schemes of carcinogens

- International Agency for Research on Cancer (IARC):
  - Group 1 - Known human carcinogen
  - Group 2A -- Probable human carcinogen
  - Group 2B -- Possible human carcinogen
  - Class 3 -- Not classifiable for human carcinogenicity
  - Class 4 -- Probably not carcinogenic to humans

Mutagens

- Chemical that cause damage to the genetic materials of the host such as reacting with the nucleophilic structure of DNA
- Mutations can occur on the gene level (gene mutations) and/or chromosomal level (chromosomal mutations)
- E.g. radioisotopes, barium permanganate, methyl isocyanate, ethidium bromide

Teratogens

- Embryo toxic or fetotoxic agent that are able to produce structural damage or interfere with the metabolism of the developing fetus, usually at early stage in its development without damage to the mother or lethal effect on the fetus
- E.g. benzene, lead, nitrobenzene

General Guidelines for Storage of Chemical

- Store all hazardous chemical in a secure location, accessible only to authorized laboratory workers
- All chemical containers must be labelled with date of receipt
- Minimize quantities of chemical kept in a laboratory
- Domestic refrigerators should not be used to store flammable chemicals
- Segregate chemical physically by reactive classes and flammability
- Equip all shelves used for storing chemical with edge guards to prevent containers from sliding off the edges

General Guidelines for Storage of Chemical

General Guidelines for Handling and Transporting of Chemical

- When handling hazardous chemical, the MSDS for those chemical must be studies and recommended safety procedures adopted
- Spillage kits, clean-up equipment and appropriate personal protective equipment should be ready
- Whenever chemical are transported outside the laboratory, the container should be placed in a secondary, non-breakable container
- Carts should be used when possible
- Before moving containers, check and tighten caps, or other enclosures

Laboratory Ventilation

- General purpose of Ventilation
  - Respiration
  - Dilution of occupant generated impurities
  - Dilution of low concentration of airborne contaminants generated in the laboratory
  - Control of excess heat and humidity for thermal comfort

Ventilation Standard

- The required ventilation rate for laboratory by the Chartered Institution of Building Services Engineers (CIBSE) is:
  - Minimum → 8 L s^{-1} $person^{-1}$
  - Recommended → 12 L s^{-1} $person^{-1}$

Natural Ventilation

- Natural ventilation is a form of dilution ventilation that relies upon:
  - The natural air movement within a work environment to dilute the contaminant
  - Wind and thermal convection cause natural displacement and infiltration of air through windows, doors and other opening in the building structure

Dilution Ventilation

- Dilution of contaminated air with uncontaminated air for the purpose of controlling
  - Potential health hazard
  - Fire and explosion conditions
  - Odours and nuisance type contaminants

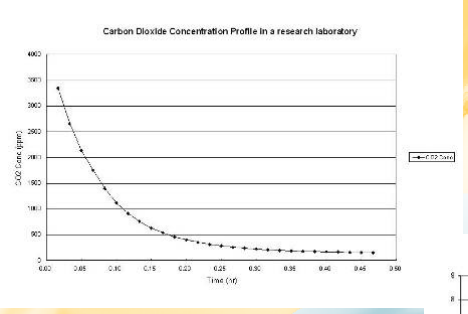
Dilution Ventilation

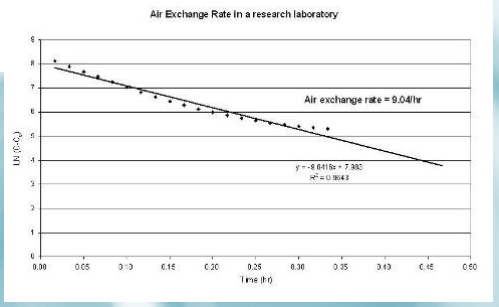
- General principles of dilution ventilation
  - Emission sources contain materials of relatively low toxicity
  - Emission sources are primarily vapors or gases, or small, respirable-size aerosol
  - The availability of clean, adequate supply of air
  - Locate supply and exhaust points to ensure air passes through contaminant generation zone
  - Emission rates of the contaminant are steady
  - Exhaust air is not re-entered into the work environment

Dilution Ventilation

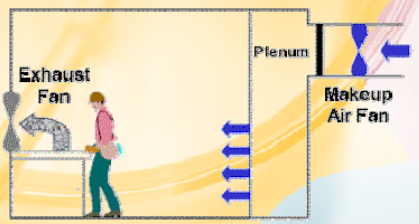
- The successful operation of dilution ventilation relies on
  - A sufficient air change rate
  - Good mixing of air in the work environment

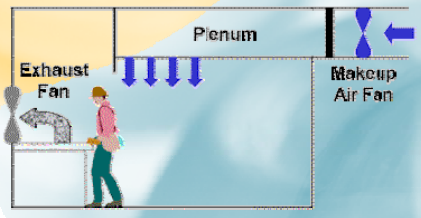
Dilution Ventilation





Dilution Ventilation

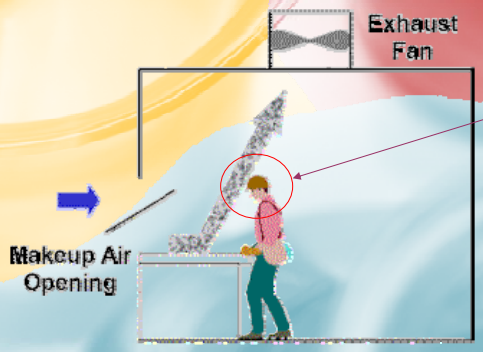




Best Air intake

Best Exhaust

Dilution Ventilation



Poor Air intake; Poor Exhaust

Local Exhaust Ventilation

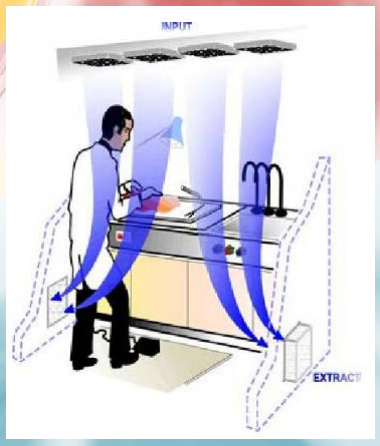
- Local exhaust ventilation systems are designed to capture the pollutant at a point as close to the source as possible
- Local exhaust is preferred to dilution because:
  - Removes contaminant from the work area
  - Handles low volume flow rates
  - Is more energy efficient

Local Exhaust Ventilation

- General principles of LEV
  - Emission sources contain materials of relatively high hazard
  - Emission materials are primarily larger-diameter particulates
  - Emissions vary over time
  - Emission sources consist of point sources
  - Employees work in the immediate vicinity of the emission source

Local Exhaust Ventilation

Poor Design

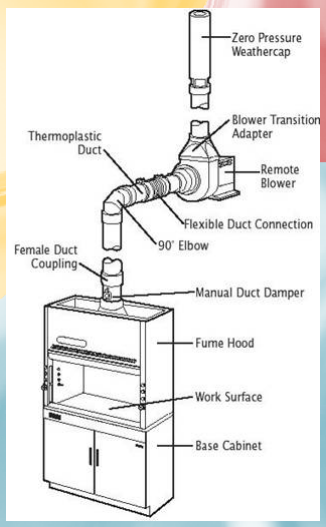


Good Design

Poor Design

Good Design

Fumehood



Fumehood

- Definition of Fumehood
  - A ventilated enclosed work space intended to capture, contain, and exhaust fumes, vapors, and particulate matter generated inside the enclosure. It consists basically of side, back, and top enclosure panel, a floor or a counter top, an access opening called the face, a sash(es) and an exhaust plenum equipped with a baffle system for air flow distribution

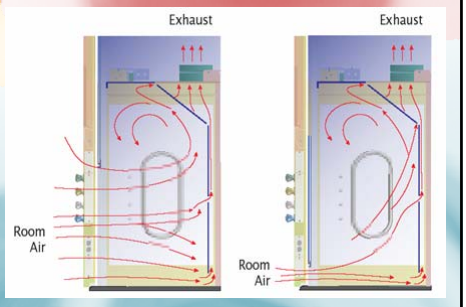
Types of fumehoods

- Standard fumehood
- Bypass fumehood
- Canopy

- Variable Air Volume (VAV) fumehood
- Radioisotope Hood
- Perchloric Acid fumehood
- Walk-in fumehood

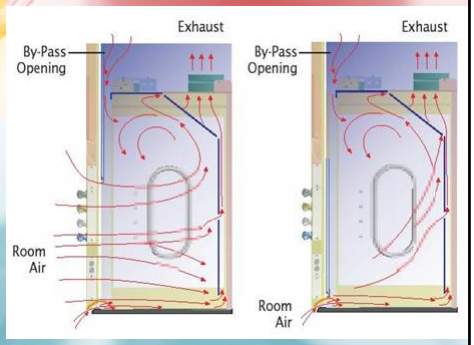
Standard Fumehood

- Features:
  - Exhaust flow is constant
  - Face velocity varies with sash opening
  - Testing is done at a specific sash opening, usually maximum
  - Face velocity is very high near closing



Bypass Fumehood

- Features:
  - Constant volume airflow with face velocity
  - With opening above and below the sash
  - Bypass open area increases as sash is closed



Basic Requirements for fumehoods

- Suitable construction materials. No grooves and joints
- Flow indicators to show normal working conditions with audible or visual alarm
- Lights providing an illuminance at work surfaces not less than 400 lux
- The fitting of the light of non-sparking or flame-proof type
- The sound pressure level (measured at the operator position in front of the sash opening) less than 65 dB(A)

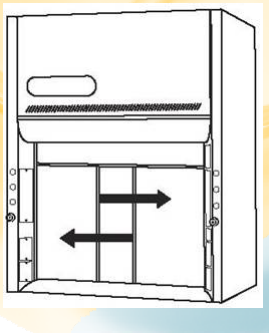
Basic Requirements for fumehoods

- An average face velocity of 0.5m/s (BS Standard: >0.3m/s)
- Fan motor situated outside the air stream and suitably protected
- The fan and its components of explosion-proof type
- The sitting of a fumehood should be carefully planned. It should not be sited such that its performance will be affected or where exit from a work space to the only escape route will necessitate passing directly in front of the fume hood.

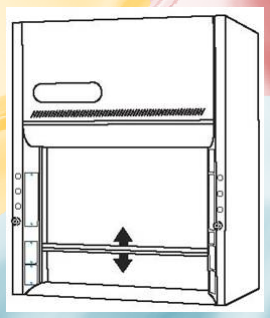
Factors affecting the performance of the fumehood

- Face velocity
- Size of face opening
- Shape and configuration of the opening surface
- Inside dimensions and location of area relative to the face area
- Size and number of exhaust ports
- Back baffle and exhaust plenum arrangement
- By pass arrangement, if applicable

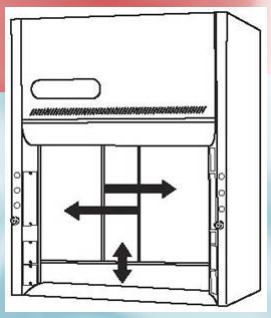
Sash(es) opening of the fumehood



Horizontal sash



Vertical sash



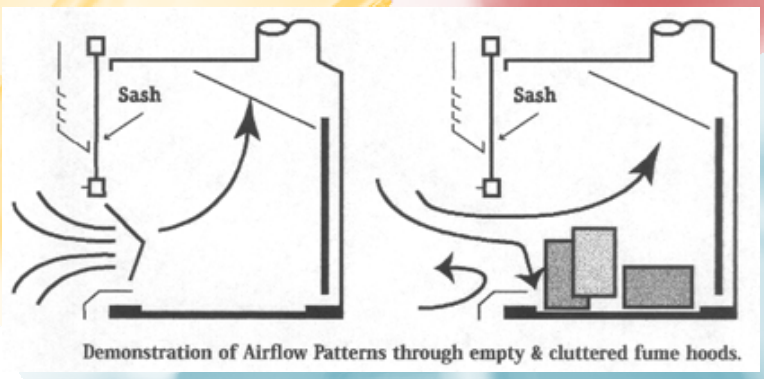
Horizontal and Vertical sash

Factors affect the effectiveness of the fumehood

- Arrangement and type of replacement supply air outlets
- Air velocities near the hood
- Openings to space outside the laboratory, including distance from doors into the laboratory
- Pedestrian traffic past the hood face
- Movements of the researcher within the hood opening
- Location, size and types of research apparatus placed in the hood
- Distance from the research apparatus to the worker's breathing zone

Work Practice Guides for Fumehoods

- Keep all containers and apparatus at least 6 inches back from the front of the hood



Demonstration of Airflow Patterns through empty & cluttered fume hoods.

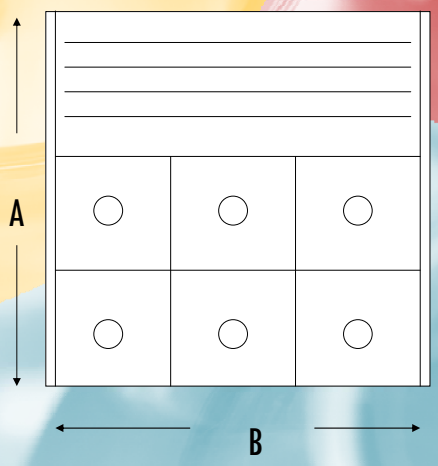
Work Practice Guides for Fumehoods

- Do not store unused chemical or apparatus inside the hood
- Conduct all operations that release significant quantities of airborne materials inside a hood
- Do not extend the head inside the hood when operations are underway
- Do not obstruct the slots or baffles in the rear of the hood
- Except for maintenance, or repair, do not remove the hood sash, horizontal sliding safety panels, airfoil sill or rear baffles

Face Velocity Test

- The Scientific Apparatus Manufacturers Association (SAMA) published in their Standard **LF 10-1980**
- **Procedures:**
  - Measure the opening size, that is, dimensions A and B.
  - Establish the grid spacing with maximum overall grid size of 12 in. x 12 in. in.
  - Take the velocity reading at the center of each grid.
  - Add the individual readings and divide by the number of readings taken; this provides the average velocity in feet per minute (fpm).
  - Multiply the average face velocity in fpm by the total area in square feet (A X B) for the volume rate in cubic feet per minute (cfm).

Face Velocity Test



Face Velocity Test

B. Face Velocity Measurement (m/s)

[ ]	[ ]	[ ]	↖ 500mm/ Sash Stop
[ ]	[ ]	[ ]	← 375 mm from working surface
[ ]	[ ]	[ ]	← 125 mm from working surface
↑ 350mmfrom left 300mm from left 250mm from left 150mm from left	↑ 1050mm from left 900mm from left 750mm from left 450mm from left	↑ 1750mm from left 1500mm from left 1250mm from left 750mm from left	2400mm 2100mm 1800mm 1200mm Hood Width

Face Velocity Test

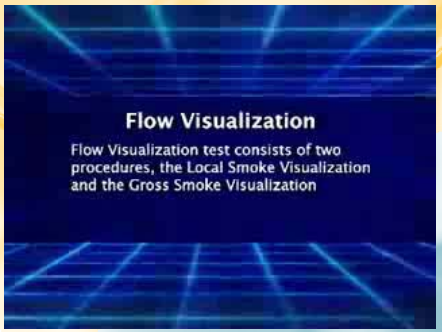
Source:
http://escoglobal.com/websites/resources/video/video.php?id=fumehood

Flow Visualization Test

Flow Visualization Test

Large Volume Flow Visualization Test

Flow Visualization Test



Sources: http://www.labconco.com/product_lit/prodlit.asp?cat20id=4 and http://escoglobal.com/websites/resources/video/video.php?id=fumehood

Chemical Incidents

- Mixing of incompatible chemical in laboratories
  - Mixing of nitric acid and organics in a closed container (formation of carbon dioxide and acid fume, and built up pressure in container causing explosion)
  - Mixing of bleach solution with acids (formation of chlorine gas)
  - Mixing of bleach solution with formaldehyde (formation of bischloromethyl ether – a confirmed carcinogen)
  - Mixing of potassium permanganate with concentrated sulfuric acid (formation of explosive manganese heptoxide)

Case study: Explosion of picric acid

Picric acid with water content less than 40% is classified as explosives

http://www.info.gov.hk/gia/general/200103/06/0306213.htm

Case Study: Solvent Fire

- Flame/Ethanol Sterilization Fires in a biological safety cabinet

Source: Laboratory Safety Incidents: Explosions; AIHA Laboratory Health and Safety committee

Case Study: Oxidizer Solvent Explosion

- Oxidizer Solvent Explosion
  - A corrosive storage cabinet under a chemical hood in a University undergraduate laboratory was the site of an early morning explosion

Mixing of nitric acid with organics in a closed container

Source: Laboratory Safety Incidents: Explosions; AIHA Laboratory Health and Safety committee

Case Study: Chemical waste container explosion

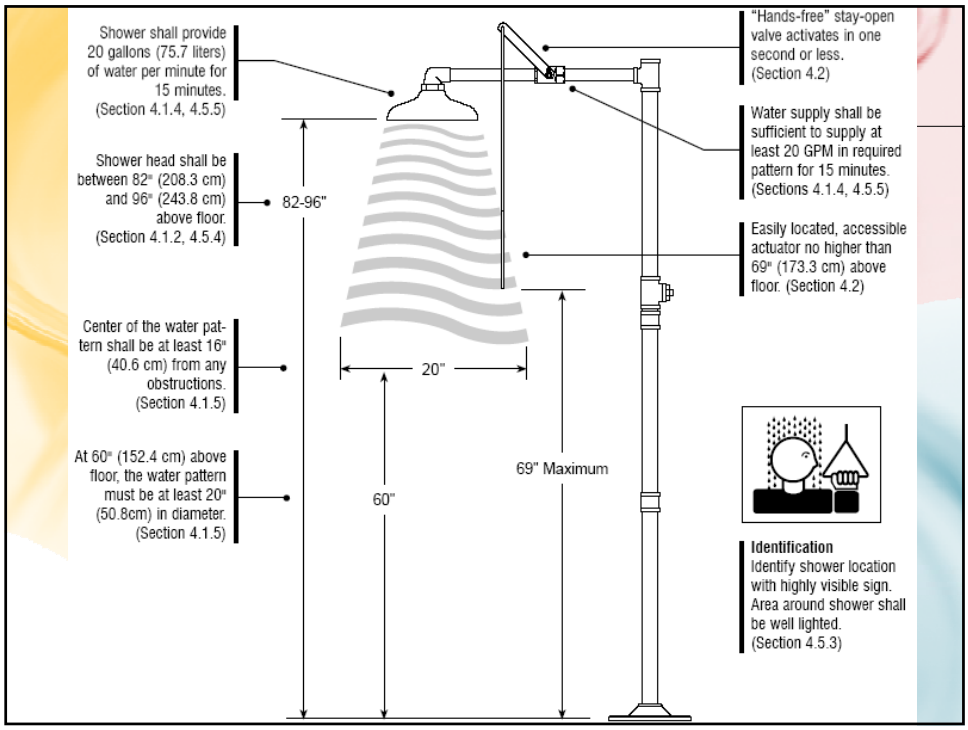
Case Study: Chemical waste container explosion

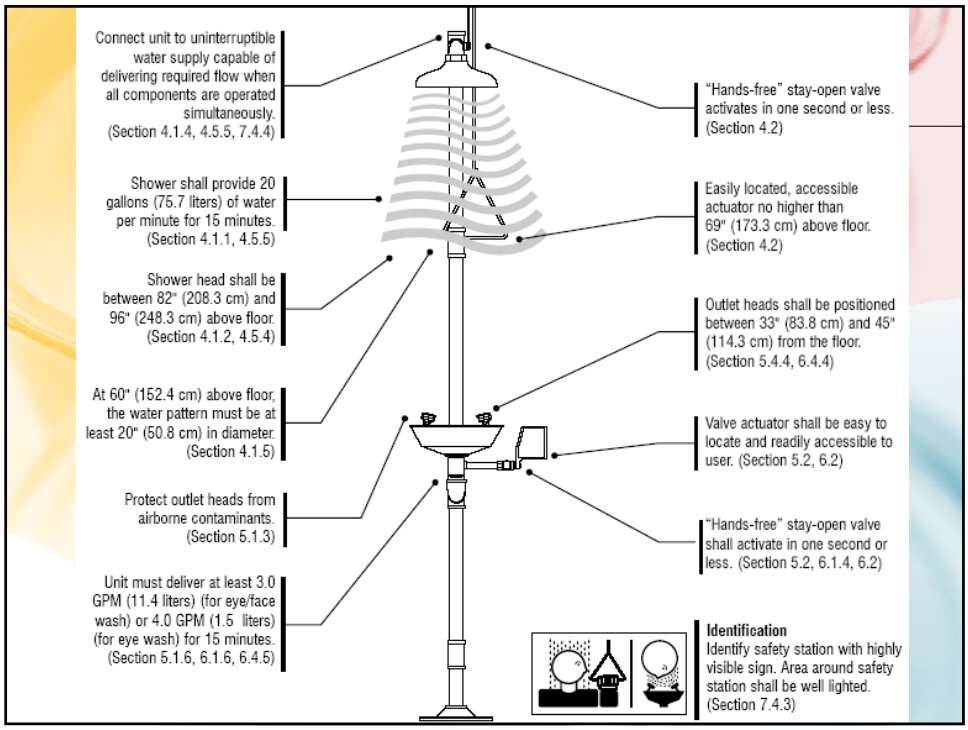
Case Study: Chemical waste container explosion

Emergency Showers and Eye Washes

Emergency Showers

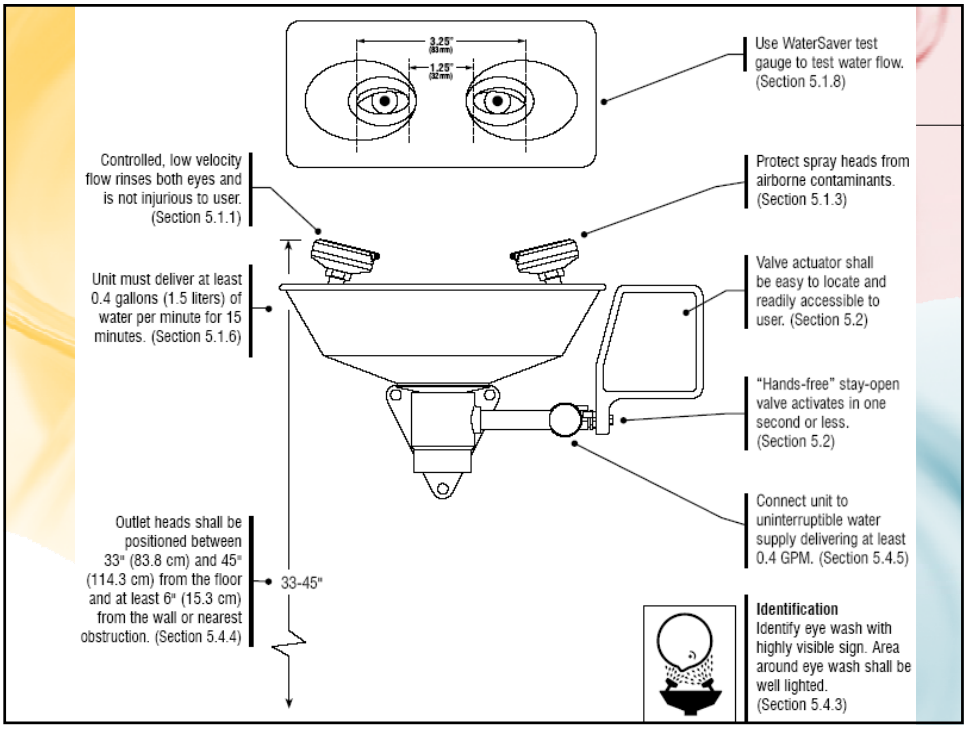
- Require for work environments that may expose employees to harmful chemicals
- Location
  - Within 10 seconds and 100 feet of the working area
  - Located on the same level as the hazard (no stairs, step or ramps)
- Valve
  - The stay-open valve activate in 1 second or less


Shower shall provide 20 gallons (75.7 liters) of water per minute for 15 minutes. (Section 4.1.4, 4.5.5)
Shower head shall be between 82" (208.3 cm) and 96" (243.8 cm) above floor. (Section 4.1.2, 4.5.4)
82-96"
Center of the water pattern shall be at least 16" (40.6 cm) from any obstructions. (Section 4.1.5)
20"
At 60" (152.4 cm) above floor, the water pattern must be at least 20" (50.8cm) in diameter. (Section 4.1.5)
60"
69" Maximum
"Hands-free" stay-open valve activates in one second or less. (Section 4.2)
Water supply shall be sufficient to supply at least 20 GPM in required pattern for 15 minutes. (Sections 4.1.4, 4.5.5)
Easily located, accessible actuator no higher than 69" (173.3 cm) above floor. (Section 4.2)
Identification
Identify shower location with highly visible sign. Area around shower shall be well lighted. (Section 4.5.3)


Connect unit to uninterruptible water supply capable of delivering required flow when all components are operated simultaneously. (Section 4.1.4, 4.5.5, 7.4.4)
Shower shall provide 20 gallons (75.7 liters) of water per minute for 15 minutes. (Section 4.1.1, 4.5.5)
Shower head shall be between 82" (208.3 cm) and 96" (248.3 cm) above floor. (Section 4.1.2, 4.5.4)
At 60" (152.4 cm) above floor, the water pattern must be at least 20" (50.8 cm) in diameter. (Section 4.1.5)
Protect outlet heads from airborne contaminants. (Section 5.1.3)
Unit must deliver at least 3.0 GPM (11.4 liters) (for eye/face wash) or 4.0 GPM (1.5 liters) (for eye wash) for 15 minutes. (Section 5.1.6, 6.1.6, 6.4.5)
"Hands-free" stay-open valve activates in one second or less. (Section 4.2)
Easily located, accessible actuator no higher than 69" (173.3 cm) above floor. (Section 4.2)
Outlet heads shall be positioned between 33" (83.8 cm) and 45" (114.3 cm) from the floor. (Section 5.4.4, 6.4.4)
Valve actuator shall be easy to locate and readily accessible to user. (Section 5.2, 6.2)
"Hands-free" stay-open valve shall activate in one second or less. (Section 5.2, 6.1.4, 6.2)
Identification
Identify safety station with highly visible sign. Area around safety station shall be well lighted. (Section 7.4.3)

Eye/Face Washes

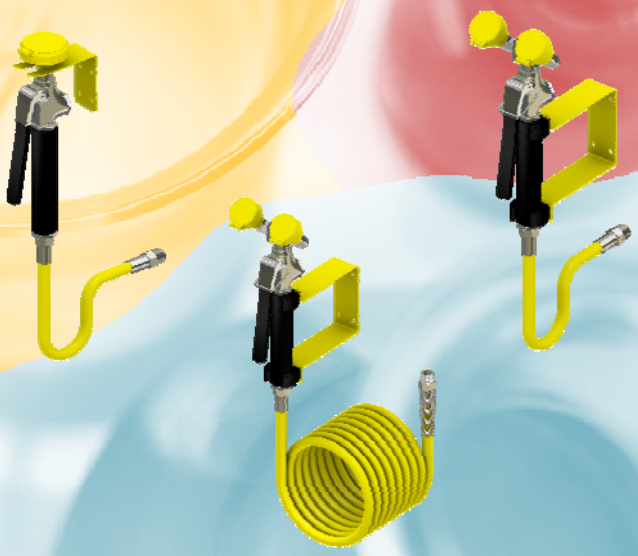
- Location
  - Within 10 seconds and 100 feet of the working area
  - Located on the same level as the hazard (no stairs, step or ramps)



Drench Hose / Eyewash Units

- A flexible hose connected to a water supply and used to irrigate and flush eyes, face and body areas

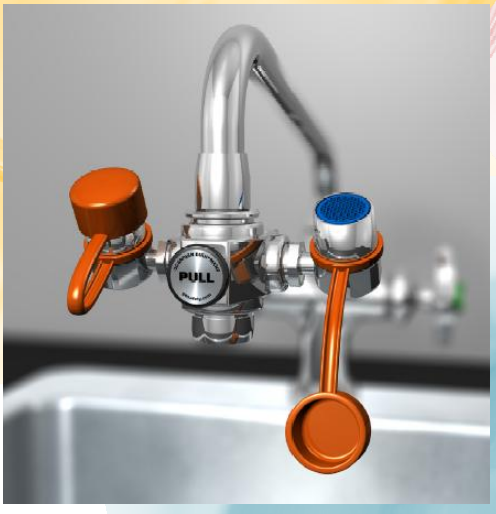
Eye Washes / Drench Hose Units



Faucet-Mounted Eyewash

- Faucet-mounted eyewashes require two motions to operate (turn on water, pull knob to activate eyewash flow).
- A supplementary eye wash that supports emergency showers and eye washes etc

Faucet-Mounted Eyewash



Personal Eye Wash

- A supplementary eye wash that supports emergency showers and eye washes etc
- Can provide immediate flushing when they are located near the workstations
- Cannot be a substitute of emergency showers and eye washes

Training

- Training
  - Teachers should instruct all students in the location and proper use of emergency showers and eyewashes
  - All students who might be exposed to a chemical splash shall be trained in the use of the equipment
  - Students should hold the eyelids open and rolling the eyeballs so flushing fluid will flow on all surfaces of the eye and under the eyelid

Maintenance and Inspection

- Maintenance
  - Activate emergency showers at least weekly
- Inspection
  - Emergency showers / eye washes should be inspected annually

Emergency Response

Definition

- Emergency
  - A sudden unforeseen thing or event needing prompt action
  - Examples:
    - Fire
    - Explosion
    - Accident
    - Heart attack
    - Gas Leak
    - Bomb threat
    - Chemical Spill

Emergency Responses

- Emergency Responses for Hazardous Substances Incidents
  - Raise the alarm
  - Notify responsible teacher or dial 999
    - Describe the location of the emergency
    - The type and extent of the emergency
    - Your name and telephone number

Emergency Responses

- Identify products
  - Determine types of hazard posed by the hazardous substances referring to
    - Hazard class labels
    - Storage containers
    - Packages
    - MSDS

Emergency Responses

Assess the situation

- Is there a fire
- Is there a spill or leak? How large is it?
- Is containment necessary?
- Where outside facilities are involved?
- Who and what is at risk?
- How significant is the risk?
- Is public protection necessary?
- What can be done safely right away?

Emergency Responses

- Secure the area
- Be there to meet the emergency services
- Approach with care
  - Only emergency responders should approach the scene
  - Approach from upwind to keep from coming in contact with vapors
- Respond

Spills in the Laboratories

- Laboratory's Emergency Plans should include:
  - Spill management
  - Emergency response strategies
- Laboratory workers should be trained in the emergency response procedures

Material Safety Data Sheet

- MSDS include information on
  - How to minimize the impact of a spill
  - How to response to and handle small to medium spills

Spill Kits

- Spill kits may include
  - Personal protective equipment
    - Protective clothing
    - Chemical resistant gloves and boots
    - Safety glasses or a face shields
    - Appropriate respiratory protection
  - Material with which to contain a spill
  - Material with which to absorb a spill

Spill Kits

- Spill kits may include
  - Warning signs and barriers
  - Appropriate container in which to store waste materials
  - Reagents necessary for decontamination procedures

Spill Kits

Chemical Spill

- Major Spill
  - > 1 litre concentration solution
    - Evacuate the area and contact emergency service for assistance
- Minor Spill
  - < 1 litre concentration solution
    - Proceed decontamination

Chemical Spill – Acid and Base

- Neutralization
  - Contain the spill by placing non-combustible material such as sand around the perimeter of the spill and then carefully apply the neutralizing agent
  - During neutralization, be aware of the production of excessive heat or hazardous fumes

Chemical Spill – Acid and Base

- For acid spill:
  - use lime, soda ash, calcium carbonate, sodium bicarbonate or limestone
- For alkali spill:
  - use dilute solution of hydrochloric acid or acetic acid

Chemical Spill – Aqueous cyanides, phenols and other organic substances

- Oxidation
  - The reaction may be hazardous and should be proceeded by trained personnel
  - Sodium hypochlorite and calcium hypochlorite oxidizing agents are used to treat spills of cyanide, nitrile, amine and phenolic compounds
  - Hydrogen peroxide is used to treat spills of sulphides, mercaptans, amines, phenols and cyanides
  - Potassium permanganate can be used to treat spills of aldehydes, mercaptans and phenols

Chemical Spill – Heavy Metal Solution

- Reduction
  - The reaction may be hazardous and should be proceeded by trained personnel
  - Ferrous sulphate and sulphite compounds are reducing reagents which are used to treat spills of chromate compounds
  - Sodium bisulphite and calcium sulphite are used to treat spills of hypochlorite solutions
  - Sodium borohydride is used to treat spills of heavy metal solutions

Chemical Spill – Liquid Chemical Spill

- Absorption
  - it is important that the absorbent used is compatible with substance to be absorbed
  - there are many specialised commercial chemical absorbent kits available
  - dry sand is suitable as containment and as an absorbent for most of the spills occurring in the lab

Mercury Spill

- For minor spill that involves a few small droplets – pick up by wet toweling, adhesive tape or by vacuum pump
- For major spill – need assistance from trained emergency personnel
- Wear proper personal protective equipment
- Provide sufficient ventilation (shut down air conditioners and open windows)
- Apply sorbents or spill control materials
- Consolidate the droplets using scraper and the resulting pool of mercury removed with a special vacuum pump

Survey of Mercury Droplets

1. Use a high intensity halogen light to detect the presence of mercury droplets or powder
2. Apply of a Sodium Sulfide solution to the contaminated area. Discoloration in the form of dark reddish brown stain will indicate the presence of mercury

Mercury Spill Kits

Commercial mercury cleanup kits and sponges are also very useful

Mercury Spill Kit Chemistry (Amalgamation)

- Ingredient: Zinc and Citric Acid
- Use powdered zinc with the addition of approximately 5% w/w citric acid, to speed up the amalgamation of the mercury

$$Zn + Hg \rightarrow Zn\text{-}Hg$$

Mercury Spill Kit Chemistry (Insolubilization)

- Ingredient: Sodium Thiosulphate and EDTA
- Colloidal sulphur can be created in the acid by the addition of sodium thiosulphate. The reaction to form colloidal sulphur is as follows:

$$H_2SO_4 + Na_2S_2O_3 \rightarrow S + Na_2SO_4 + H2O$$

$$Hg + S \rightarrow HgS$$

- The sulphur will react with the mercury to form crystalline mercury sulphide (HgS)

Thank you