



Chemical Laboratory Safety

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Dr APJ Abdul Kalam



- Learning gives Creativity
- Creativity leads to thinking
- Thinking provides knowledge
- Knowledge makes us great
- (**with application**)



Simplicity
Devotion
Inspiring
Visionary

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Coverage

- Introduction
- OHS Challenges Chemical Laboratories
 - Recent Past Incidents- Gravity (Word-India)
 - Challenges

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Systematic Approach for Enhancing OHS Management In Laboratories

- Self Evaluation of Status-Gap Analysis
- Technological Approach
- Collaborative Approach
- Culture of Sustainable OHS
- Matrix of Role and Responsibility (Social-Organisational –Individual)
- Transition Towards the Objective

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Types of Laboratories

- Research – Process - QC- Chemistry- Biology- Physics-Multi-disciplinary
- Kilo Lab – Scale Ups- Pilot Plants

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16th Century Laboratory



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Laboratory work- Importance to Society

- SOCIETY NEEDS- NEW TECHNOLOGY, **NEW EXPERIMENTATION**-NEW PROCESSES- **NEW ANALYTICAL TECHNIQUES**- FACILITIES
- UN KNOWN NEW HAZARDS
- INCREASED MAGNITUDE OF HAZARDS
- NEED FOR **BETTER UNDERSTANDING**
 - **SAFETY OF EQUIPMENT / FACILITIES-**
 - **ENVIRONMENT FRIENDLY**
 - **IMPROVED SAFE PRACTICES**

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- Laboratory Researchers are often the first victims to be exposed to **new dangers**
- They may suffer **unexpected injury**
- Unless **effective control, monitoring and Supervision** are integrated into
- Design of the Research Facilities –Operations- Feedback- Objective Improvements- Increased Safety Assurance Levels

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- Every Laboratory has to identify each danger and to ensure that the working areas are technically safe and that the personnel have been trained in the appropriate safety precautions with **Facilities / Equipment / Materials / Operations**

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Worldwide- Recent Past Accidents in Chemical Laboratories

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2018, Beijing, China

- Three students were killed in a lab explosion at Jiaotong University.
- They were researching wastewater treatment

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2018, Exton, PA

- 26-year-old worker at Frontage Laboratories died as a result of exposure to potassium cyanide

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2017, Harare, Zimbabwe

- Student researcher died from burns received when a fire broke out in a microbiology lab at Premier Service Medical Investments.

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2017, Tallahassee, FL.

- Construction worker killed when a steel cap blew off a high pressure pipe on a device used to cool down one of the magnets at the National High Magnetic Field Laboratory at Florida State University.

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2016, Jurong, Singapore.

- Leeden National Oxygen chemist was killed in an explosion caused by a faulty valve on a gas cylinder.

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2015, Beijing, China

- Postdoctoral researcher died in a hydrogen explosion at Tsinghua Unive

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2015, Phnom Penh, Cambodia

- A 34-year-old science teacher was spraying a flammable gas while preparing the classroom for a lesson at the University of Health Sciences. The gas ignited, and the teacher died from smoke inhalation

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2014, San Antonio, TX.

- 50-year-old technician died at Southwest Research Institute as the result of a lab accident

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2014, Doha, Qatar

- Lab worker died from explosion in petroleum lab at TAMU-Qatar.

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2013, North Andover, MA.

- 51-year-old died from burns following a trimethyl iridium explosion in a Dow Lab (formerly Rohm and Hass).

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India- Fire in Lab-Atomic Research

- A fire broke out in a chemistry laboratory Premier Atomic Research Institute, killing two PhD students who were at work.
- Experts have ruled out any danger of radioactive radiation following accident.
- Number of analytical instruments -spectrophotometers were badly damaged.

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Lab Fire

- Nilamma, a bio-technology teacher at PG centre succumbed to burns she sustained during a practical session at the laboratory.
- Nilamma was re-arranging chemicals used in the experiment back into the cupboard when the accident took place.
- A bottle of highly combustible chemical slipped out of her hand to fall on the burner lit by her to boil chemicals used in the experiment.

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Explosive Decomposition of Azide Composition

- A chemist was isolating an organic azide (benzyltriethylammonium azide) as an intermediate in a process to synthesize a complex organic molecule
- Approximately 0.5 grams of material initially isolated -used to run analytical tests
- She scaled up the process 20 fold in order to isolate enough organic azide to continue her synthesis

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Corrosive Liquid- Splashing On Face- Blinded

- A chemist's assistant had to prepare a concentrated solution of sodium hydroxide.
- Put solid sodium hydroxide in a bottle (**first mistake**) and added the required amount of water.
- Bottle (**second mistake**) and shook it, holding the bottle on a level with her eyes (**third mistake**).
- Heat of solution created a considerable pressure in the bottle.
- The bottle broke and the hot, concentrate solution splashed over face and eyes.
- Result total blindness

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Fire & Explosion

- R&D Laboratory-4th Floor-Fire- Nitrogen / LPG cylinder Exploded
- Defective Electricals is probable cause
- Wet Riser Not available for immediate action

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Explosion at Science Lab- Killed One and Injured 3 others

- The accident happened at about 2pm at the shock waves and hypersonic lab
- Leak in a hydrogen cylinder caused the explosion
- 5th Dec 2018

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HCL HNO₃ REACTION ACCIDENT



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2018, Bengaluru, India

- 28-year old Researcher was killed in a high-pressure hydrogen cylinder explosion at Indian Institute of Science.

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Pilot Plant Fire-Research Lab

- A major fire broke out on the premises of Laboratory in evening, but it was doused within an hour
- The fire engulfed the Pilot Plan building and five fire tenders and two water tankers were deployed to douse it.

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Sink Disposal

- Left Over small quantities of Acids were disposed in sink
- After closing Lab on Friday, it was opened on Monday Morning and Lights were switched on
- There was a flash fire in lab
- Hydrogen generated with acid contact with water pipeline and got accumulated
- When lights were switched, Hydrogen in Electrical socket got ignited.

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Laboratory Accidents

- A survey of industrial accidents has shown that a very large majority of accidents is due to human factors and can, therefore, be avoided.
- The two most important causes are ignorance of precautions to be taken and disregard of safety rules.
- On the average, younger workers are more likely to have accidents.

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Chemical Laboratories

- Chemical Laboratories play a crucial role in Research, Process development, Process Control as well as in Quality control domains.
- From generic chemical information process specific information is developed and used in process optimization and safety.

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- Facility design for such safety-critical activity and Safe Operational practices, amongst certain unknowns with priority for HSE is vital
- Giving due recognition to experimentation,
- Use of specialized equipment,
- High-tech research and
- Waste management are important ingredients

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- Sometimes in the quest and anxiety for research success, safety aspects may be compromised and there are instances of destruction of facility, injuries and loss of research-findings.
- Large Number of Chemicals in small quantities

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Preamble of IS 4209

- The need for a code of safety for chemical laboratories stems from two factors
- 1. due to hazards inherent in the nature and handling of chemicals, and
- 2. due to hazards from inadequacy or handling of instrumental facilities necessary in chemical laboratories

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Issues Related to

- Electricity
- Glassware
- Machinery equipment,
- Gas, steam, water, apparatus for high/low temperature and pressure.

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- Innumerable chemicals used as reagents and solvents are
- Flammable/toxic/corrosive/poisonous, etc,
- Are **harmful/irritants to body tissues**.

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Legalities of Lab Safety- India

- Criminal Procedure Code
- Explosives Act
- Gas Cylinder Rules
- Petroleum Act – Rules
- Atomic Energy Act-Regulations (BARC)
- Municipal Corporation/ Municipality / Gram Panchayath / Industrial Clusters
- Poisons Act

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Design and Layout

- BUILDINGS EQUIPMENT
- WORKING FACILITIES
- WORKING CONDITIONS AND VENTILATION
- ENVIRONMENTAL ISSUES
- FIRE SAFETY

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Chemical Laboratory Facility

- Lab Modules (Wet)
- Instrument Lab
- Multi-storied Facilities
- Lab Benches
- Fume Cupboards

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- Wherever chemical substances are handled or processed, **Hazards are inherent**
- Chemicals
- heat, cold
- electricity
- sources of intense light
- radiating equipment

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- Responsibility and Accountability for Lab Safety
- For Training New Entrants and Ongoing Training
- Developing Laboratory Safety Culture

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Standards- Design of Lab Facility

- IS 4209-1987 Safety In Chemical Laboratories
- IS 4906-1968 'Code of safety for radiochemical laboratory' and
- IS 12035 : 1986 'Code of safety in microbiological laboratories'
- National Building Code
- American Conference of Governmental Industrial Hygienists (ACGIH).
- Industrial Ventilation: A Manual of Recommended Practice
- American Institute of Architects (AIA), Center for Advanced Technology

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- American Industrial Hygiene Association (AIHA). American National Standard for Laboratory Ventilation (ANSI/AIHA Z9.5-1992).
- American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). 1999 ASHRAE Handbook: HVAC Applications. Atlanta, GA: ASHRAE, 1999.

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- National Research Council, Committee on Prudent Practices for Handling, Storage, and Disposal of Chemicals in Laboratories.
- Prudent Practices in the Laboratory: Handling and Disposal of Chemicals. Washington, DC
- National Fire Protection Association (NFPA). NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals. Quincy, MA: NFPA, 2000

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Buildings- Types- Points

- Single storey, detached or 'linked' to other buildings.
- If multi-storey, located at ground level.
- Good access for service and emergency vehicles.
- Constructed with minimum two hours fire resistance.
- Lighting protection and earthing as necessary.

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- Internal glazing should be fire resistant, or polycarbonate
- Floor coverings should be comfortable and slip-resistant, durable and resistant to spills of water or common chemicals (especially solvents and acids).
- Flooring consisting of small units joined together, such as tiles or wood blocks, is particularly unsuitable.

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- Any spilled liquid chemicals will run down into joints and decontamination is then impossible with out taking the flooring up.
- Linoleum sheeting is being replaced by impervious PVC sheeting with welded joints and coved edges.

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- PVC is suitable for laboratories not subject to heavy solvent contamination, wheeled traffic or standing of heavy semi-portable equipment.
- For heavier duty, resin screeds, or ceramic tiles set in resin cement, may be necessary

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- Walls and floors should have smooth, impervious finishes, free from cracks that can harbour dirt and spilled chemicals.
- In some circumstances it is essential for all walls, floors and ceilings to have smooth finishes

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Preferable Layout

- Spacious arrangements in laboratories and in main storage areas.
- Separate internal store rooms for nominal stocks of materials.
- Adequate provision for cloakrooms, cleaners and hazardous waste.
- Level floors, non-slip and acid resistant surfaces.
- All rooms should have access into an escape corridor.
- **Note:** Toilets/cloakrooms should be located adjacent to final exits.

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Fire Escapes

- Atleast two means of escape in case of fire should be provide and these should be as widely separated as possible.
- Large laboratories and those in which the work is associated with a high fire risk should have a correspondingly larger number of fire exits.

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Space

- No absolute rules can be made about space requirements for laboratory work because of the great variety of work undertaken.
- Avoid Fouling with benches / equipped there on
- Between Benches, Minimum 2.4 meters free space
- 4.5sq met per person- free space approx

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- The relationship between the positions doors and benches must be carefully considered to ensure that workers will not be trapped if fire breaks out suddenly

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- A laboratory is not a haphazard collection of rooms
- A well planned and designed building, where each room has a definite function and whose arrangement relative to the others also serves a definite objective.
- Thus in the design of each room as also of the whole laboratory there has to be a proper appreciation of the purpose.

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- It is important that, in the planning of the laboratory, there should be consultation and collaboration between the architect and the engineer
- Even in old laboratories quite a lot may be achieved by minor alterations and adjustments to make them safe places for work.

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Laboratory Rooms

- The design of the laboratory will depend upon the specific needs of a particular laboratory.
- From safety point of view the bay layout is preferable to separate suite of rooms
- Moreover, every laboratory should be provided with a few minimum necessities to ensure safety in working.
- If possible, each laboratory room shall have two easily accessible exits

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- A fire escape if a second door cannot be provided.
- If a bay layout is provided for each semi-enclosed cubicle, there should be an escape arrangement from the side away from the work benches.
- The arrangement of immovable fittings should be such as to provide adequate moving space between benches.
- There should be no fittings on the floor which would hinder or obstruct free movement.

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Laboratory Furnishings

- Furnishing (curtains, etc) which will easily catch fire should be avoided.
- Fire resistance properties of materials used for these should be carefully checked.

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Design and Arrangement of Benches

- The design and arrangement of benches will naturally vary according to the function of each laboratory
- Benches should not be too deep (widely accepted width is 75 cm)
- Service line controls should be placed at the front below the bench top.
- The reagent shelves should be easily accessible and should not be unduly high.

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- The reagent shelves should be provided with beading to prevent bottles falling off due to vibrations.
- Wherever possible, flame-proof electrical fittings where large amount of solvents are handled.
- Laboratories should also be provided with adequate ventilation and efficient exhaust to prevent the build-up of the concentration of toxic flammable vapours in the atmosphere.

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Benches

- Benches should have impervious surfaces with appropriate resistance to chemicals and heat.
- Some traditional designs of laboratory benches are far from ideal, eg central shelving for stored reagents may attract dust and encourages reaching over other apparatus.

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Benches

- Flat-topped benches with rear-mounted service outlets are preferable especially where controls are fitted at the front immediately below the bench-top

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Lab Doors

- Laboratory doors should be constructed so that they are fire-resistant, but not so heavy or stiff that they are difficult to open.
- Visibility through doors is important to ensure that collisions with people or apparatus are minimised.

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Services

- 'Clean' electrical supply, with internal/external switches.
- Separate metered gas supply, with internal/external valves.
- Purpose designed vapour extraction systems to safe points.
- Space or process heating by low pressure hot water, low pressure steam or warm air.
- Electrics to be flame proof or dust proof, as necessary and include earth trips.
- Liquid waste drains to be via a chemical separator.

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- The **integration** of water, gas and electrical services and their controls with laboratory furniture needs careful consideration from the safety viewpoint,
- particularly with regard to convenient access, protection from knocks, and ease of maintenance.

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- **Sinks and drainage** system should be made of corrosion-resistant materials with precautions against blockage by discharge of gross solids, and **traps** to prevent **back-diffusion** of any volatile vapours

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- **Abuse of sinks** is one of the commonest sources of hazard in laboratories.
- Every effort should be made to **prevent the discharge to drain** of reactive chemicals, solids (including paper and glass), or water-immiscible liquids.
- Pouring quantities of flammable liquids down drains is a very hazardous practice

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- Apart from causing hazardous chemical interactions or fires, reactive and corrosive chemicals and solvents discharged to drain will probably damage the drain itself

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LAB ARRANGEMENT



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WORKING CONDITION IN LAB



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CLEAN WORK SURFACE



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LAB OCCUPATION



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Pre

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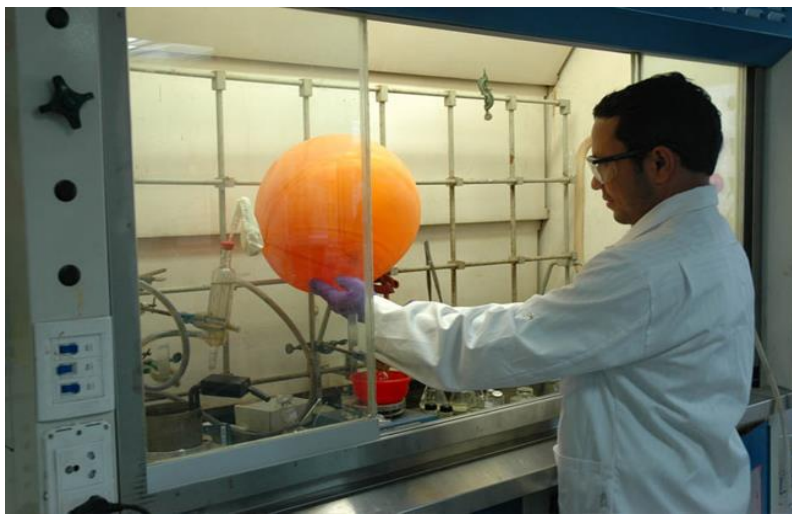
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Fume Hoods according to Chemical Risk

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Fume Cupboards

- Each laboratory should be provided with efficient fume cupboards, sufficiently large to permit complete enclosure of apparatus normally used,
- Provided with a sink for the washing of apparatus used for handling toxic materials.
- For laboratories where large number of digestions are to be carried out, a separate ante-room equipped with efficient fume cupboard may be provided.

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- The cupboard should not be too deep so that the fittings inside are easily accessible while the controls of the service connections should be provided outside.
- The fume cupboard should have corrosion-proof fittings.
- It should be provided with a light, so placed that the whole cupboard is illuminated.
- The shutter pans should be made of shatterproof or reinforced glass.

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- The front shutter should be provided with small windows so that apparatus can be manipulated through these without lifting the shutter.
- The cupboard should be so designed that there is strong upward draught even when the shutter is open and there is no chance of any fumes entering the laboratory- by having baffle at the back.

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- In rooms where work with extremely poisonous gases is done, it is advisable to have an air inlet at the bottom (balanced-draught cupboard) so arranged as to sweep everything to the exhaust.
- It is desirable to have at least one such cupboard in every chemical laboratory.
- For fume cupboard, the exhaust fan should be able to create a free velocity of 30 metres per minute at normal working height.

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- Cupboards for highly toxic materials require higher face velocities.
- Hot concentrated perchloric acid should be handled in separate fume cupboards where its vapour do not contact any organic matter.

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Service Connections

- All pipe lines in the laboratory should be differently colour coded with main valves at an easily accessible and prominently visible places so that, in an emergency
- All services to a room can be cut-off from one point.
- Sinks and drains should be made of chemically resistant materials and the drains should be properly trapped and vented.

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- A Fume Hood is an enclosed work space ventilated by an induced flow of air through the face opening intended to capture and contain gas, vapor or aerosol generated within the enclosure

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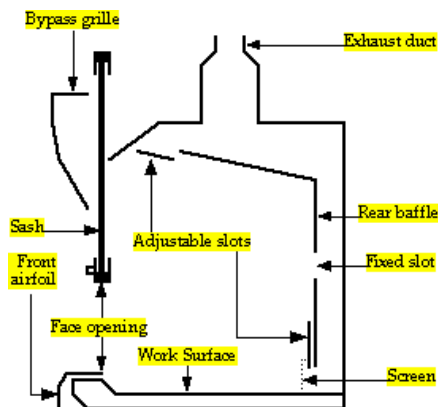


- Standard
- Bypass
- 2-position and
- Variable Air Volume

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Engineering Controls: Chemical Fume Hoods



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Fume Hood Guidelines

- Before starting an experiment, know all the physical, chemical, and toxicological properties of all the materials with which you will be working.



Fume Hood Guidelines



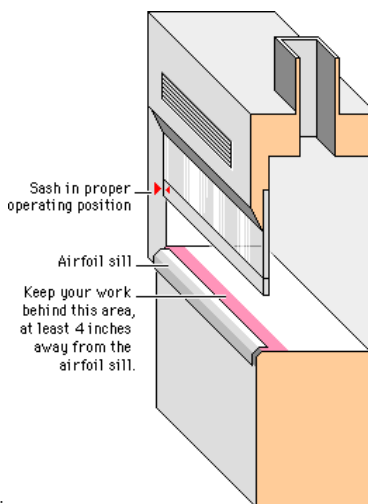
- Prior to using the hood, verify that the exhaust system is operational.

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Fume Hood Guidelines

- Work at least 4 - 6" inside hood.
- Lower the sash to the lowest practicable position.

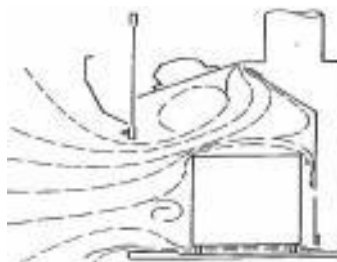


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Fume Hood Guidelines

- Keep hood surfaces clear and baffles unobstructed to allow proper airflow.



- Airflow in a fume hood is easily disrupted; do not use the fume hood for storage!

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- Flame Proof Electrical Fittings
- International Standards

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Glove Box Isolators



- weighing/transferring and manipulating gram or higher amounts
- Suitable for manufacturing activities

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97



Limitations of Isolators



- n Size of material handled
- n Bringing material in/out
- n Risk of back and shoulder strain with prolonged use
 - Must include ergonomics in design

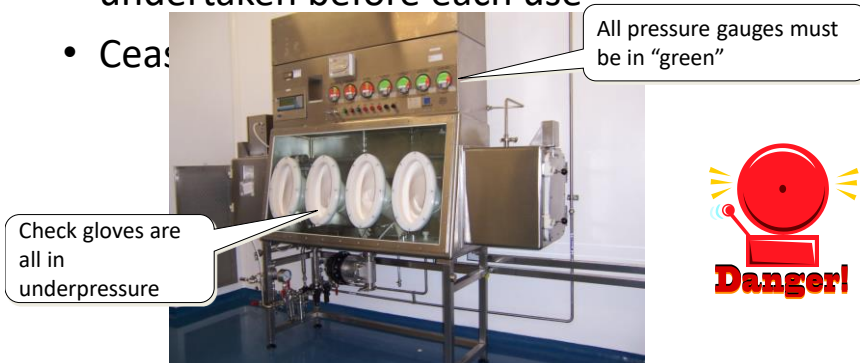
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Test before every use

- Inspection and pressurisation test must be undertaken before each use
- Ceas



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Ante-rooms

- A chemical laboratory should have, besides the actual laboratory rooms, separate rooms for :
- (a) doing pressure reactions and other hazardous operation,
- (b) overnight reactions,
- (c) chromatography, and
- (d) work involving large quantities of solvents.
- These rooms should preferably be located at the end of the main laboratories.

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Lab Ventilation

- **Supply air:**
 - 100 % treated fresh air, once through system recirculation not recommended.
 - 15 – 22 ACH
 - Controlled humidity and temperature in accordance with the type of application.
 - Double deflection grills instead of diffusers shall be used for the chemical laboratories.

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- Air intake lowers of air handling units shall be away from the stack of the fume hoods to avoid any reentry of fumes.
- **Note:** chemistry labs are 5 times energy intensive than other labs.

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- **Exhaust:**
 - Constant discharge velocity not less than 2000FPM shall be maintained.
 - Discharge stack 3 meters from the finish terrace level.
 - Scrubbers to be used according to the application

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- Exhaust ducting shall be of corrosion resistant PP/ FRP with iso-thalic resin and fire retardant coating.
- For isotope reaction SS304 ducting/blower to be used.
- For per-chloric acid SS316 short & straight ducts to be used.

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- Ducts not to be manifolded with others. the complete water sprinkling system to be used for exhaust system.
- Minimum ducting velocity shall not be less than 1200 FPM.
- Different exhaust manifold shall be planned based on the application and the building attributes.

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- Waste Management Issues
- Procedures at different levels- different applications
- Experiment Design- Safety Component
- Hazard / Risk Assessment Extrapolating Existing Data to the extent feasible
- PPE Selection – Limitation – Use - Replacement

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Glassware

- A laboratory worker should always be aware of the fact that glassware is likely to break if handled roughly.
- The importance of handling glass apparatus in the proper manner cannot be over-emphasized.
- While setting up an apparatus, it is necessary to ensure that all pieces are clamped and supported properly

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Cutting Glass Tube

- When cutting, tubing or rod, make a simple cut at the point of fracture with a triangular file or a cutter. Place a cloth over the glassware to protect the hands.
- Then, holding the tube or rod with the thumbs together, opposite the cut, bend the material towards the body.
- A clean, right-angle break will almost always be obtained, but the cloth should always be used to guard against an odd accident.

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Stores

- Where large quantities of explosive materials (but not explosives), inflammable substances, solvents or gas cylinders are to be stored
- Store should be provided with separate ante-rooms for keeping :
 - explosive materials,
 - flammable substances,
 - poisonous substances,
 - solvents in bulk,
 - gas cylinders, and
 - acids.

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- Incompatible materials are stored separately.
- Stores storing flammable solvents and chemicals should have flameproof equipment including switches
- Both the main stores and its ante-rooms should be well lighted and well ventilated with proper exhausts to prevent build-up of the concentration of toxic agents.

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- The ante-rooms should preferably be small separate blocks;
- If they have to be part of main stores building, their exit and entrance should be towards the outside of the main store rooms,
- These rooms should be well protected from heat and direct sunlight.

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Working with Chemicals

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Working with Hazardous Chemicals

- Plan Ahead
- Sound Judgement
- Assessment of Risks- No under estimation
- Safe Working Practices
- Minimise Exposure
- Secondary Containment
- Be Prepared for Possible Accidents and Emergencies

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Mistakes in Small Scale- Profit in Large Scale

Working in Chemical Labs

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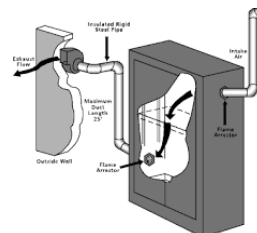


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Laboratory-Equipment.com



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First Time Experimenting

- In order to study the behaviour of new experiments, limit the size to the minimum in case of the following:
- First time experiments;
- Experiments with alkali metals, cyanides, etc;
- Halogenations, alkylations;
- Reactions involving fluorine, HF, BF₃, etc;

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- Reactions involving alkylene oxides;
- Polymerization reactions;
- Nitric acid oxidants;
- Reactions involving the use of H_2O_2 at 50 volumes or above; and
- Exothermic reactions.

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Water Reactive Chemicals

- The bench should be kept dry in the vicinity of an experiment involving alkali metals.
- Ensure that it is impossible for pieces of the metal to fall into water or oil baths during addition.

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Pressure Reactions

- Utmost care should be taken in carrying out sealed tube reactions.
- When the pressure is likely to develop, a sealed tube should never be filled up more than one-third of its volume.
- The initial runs should be done with very small quantities of reactants.
- Sealed tubes should be protected by a steel tube or a wire cage and the temperature should be raised gradually.

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- These reactions should be carried out in a separate room behind a safety screen.
- Autoclave and other pressure vessels should be set up in separate rooms and not in the general laboratory.
- The autoclaves should have safety valves in proper working conditions.

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Organic Preparative Reactions

- Special conditions must be complied with for experiments continued outside normal working hours
- Make sure the stirring gear is in good order before starting an experiment.
- Do not restart a stirrer if it has been stopped for any length of time in a heated reaction flask; allow it to cool first.
- Condenser capacity should be in excess of requirements.
- Always make provisions for rapid removal of the heating source.

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MANAGEMENT OF LABORATORY SAFETY

- By the very nature - variety, size, type and complexity of Research laboratory, it has not been possible to evolve simple generalisations on the health and safety of laboratory work.
- There is always an element of danger present in a chemical laboratory, a danger which is inherent in the day-to-day operations that the workers are engaged in.

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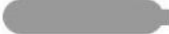


- Accident prevention should be the primary consideration of everybody in a laboratory
- Can be achieved in a laboratory only if each worker is safety conscious and inculcated safe working habits.
- Tech – Financial – Management Levels

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Industrial Gas Cylinder Colour Code

	
ACETYLENE	HELIUM
	
AIR	HYDROGEN
	
AMMONIA	NITROGEN
	
ARGON	NITROUS OXIDE
	
CARBON DIOXIDE	OXYGEN
	
CHLORINE	OXYGEN (MEDICAL)

Presente

DR. REDDY'S

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Hazards in use and Handling of Gas Cylinders

- When gas cylinders are used in work place, there could be physical or chemical hazards
- When cylinders fall from height, they may burst due to impact and the situation is very dangerous
- When cylinders valves are damaged, gases can release with great pressure
- Release of toxic or poisonous gases and asphyxiation

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Connecting and Disconnection of Gas Cylinders- Use of manifolds

- Cylinders, regulators and valves are to be compatible
- Where needed flash back arresters are to be fitted
- Do not lubricate threads of Regulator
- Avoid dust or other material on the threads of regulator and valves

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- Ensure gas tube is compatible with the gas handled
- For example, for Acetylene, Copper tube should not be used. Acetylene and Copper Can react and form Copper Acetyldehyde which is explosive.
- For high pressure application, plastic pipes should not used. Only approved MOC Pipes are to be used.
- Regularly inspect piping system.
- To increase gas flow, use of hot water or steam is prohibited by law.

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- Gas system joints can be checked with soap water
- Do not use leaking pipes, flanges or manifolds
- Un authorised persons should not handle gas system.
- Maintain cylinders in vertical position and if required can be anchored

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- In laboratory, before opening the cylinder valve check fume hood working
- Before opening the cylinder valve, warn co-workers and ensure that hose should not point individuals.
- Hose can suddenly whip, if gas is released into atmosphere suddenly

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- All fittings must be free from dust, oil or grease
- Do not force fit regulators and other parts
- For Hydrogen Service, always, use two-stage regulators
- All cylinder valves must be opened or closed slowly.
- For opening gas to flow, two or three threads is more than enough and it would facilitate easy closing if required.

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General Safety

- Server Room Safety
- Scrubbing Systems
- Vapour / Gas Detections
- Emissions to Atmosphere- Standards
- Clean Earth for Susceptible Electronic / Electric Equipment
- Drain Lines Routing

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Self Evaluation of Status-Gap Analysis

- No or Less OHS Approach
- No or less Induction from School / Academic / Industrial / Research / Contract Research Labs- Ongoing Learning from Case Histories- Sharing- **All Levels**
- Designs not matching Hazard Potential- Meeting Aesthetic Values- By Space

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- LAB LOCATIONAL / FACILITY - DESIGN ISSUES
- LAB OPERATIONAL AND MAINTENANCE ISSUES- INCLUDING **CHEMICALS SAFETY MANAGEMENT**

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- ISOLATION IMPORTANCE
- Inter Equipment Space- Separation Distances- Risks of Multi-storied Labs- Lab Space Design
- Lab Equipment OEM Safety Measures lost track off
- Health Precaution Issues

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Kilo Lab- Scale Ups- Pilot Plants

- Kilo labs and pilot plants are important tools supporting process development in Research Lab.
- Key objective is to provide for as much flexibility and agility as possible to manage a dynamic portfolio of potential products

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- While meeting environmental, health, and safety (EHS), product quality, and business requirements.
- A well-designed facility acknowledges the benefits of integrated quality and safety systems.

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Lab Wastes Management

- Every laboratory experiment generates some waste, which may include such items as
- used disposable labware
- filter media and similar materials
- No more useful chemicals
- aqueous solutions and
- hazardous chemicals.

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- The overriding principle governing the handling of waste in prudent laboratory practice is that
- *no activity should begin unless a plan for the disposal of non-hazardous and hazardous waste has been formulated.*

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- Hazardous wastes include
- discarded chemicals,
- unidentified chemicals,
- chemicals whose properties have changed with time, left-over reagents
- by-products
- Broken glass

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7 Steps in Haz Waste Mgmt

- Collecting Wastes
- Sorting
- Storing
- Marking/Labeling
- Packing
- Transporting
- Final Disposal

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Storage Area

- Full, labeled and dated containers should be brought here for storage until the next waste pickup
- Accumulation date is the date it is brought into storage area
- Containers labeled and label is facing forwards
- Containers must be clean, closed and intact
- Incompatible materials must be segregated
- There must be at least 3 feet of aisle space at all times
- The area must be free of debris and spills

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Emergency Response in Research Laboratories – Role of Individuals and Team

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How emergencies occur . . .



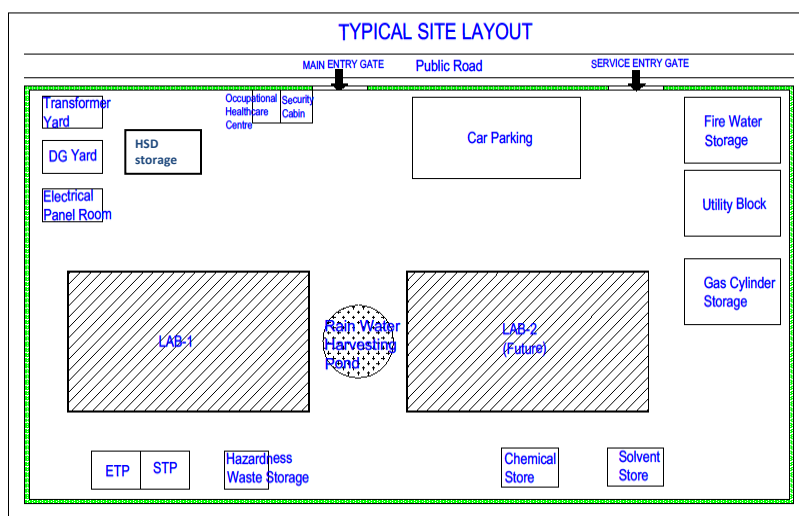
Never leave a hot plate
unattended



Safely store anhydrous hydrogen
fluoride for no more than 2 years

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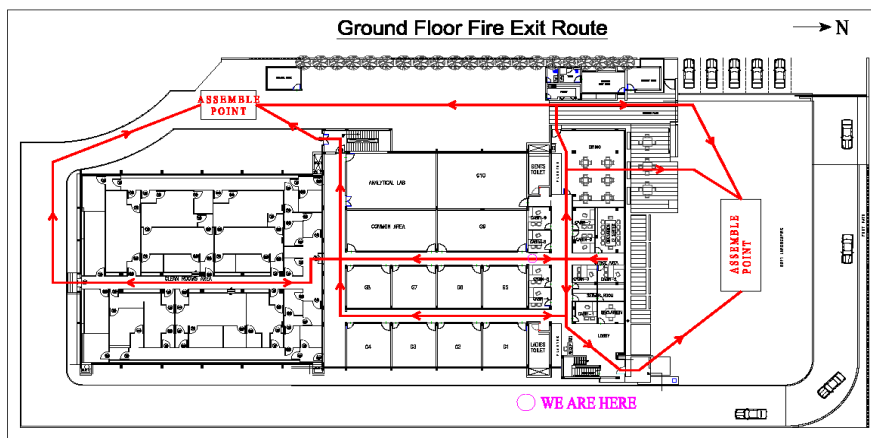
Typical Laboratory Facility Layout



Pre



Emergency escape



Selection, Use, Maintenance and Limitation of Personal Protective Equipment



Lab Working Attire

- Long hair and loose clothing or jewelry must be avoided when working in the laboratory.
- Unrestrained long hair, loose or torn clothing, and jewelry can dip into chemicals or become ensnared in equipment and moving machinery.
- Clothing and hair can catch fire.
- Sandals and open-toed shoes should never be worn in a laboratory in which hazardous chemicals are in use.

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Behaviour in Lab

- Relevant Training At All Levels
- Induction Training
- On the job training
- New Task Training
- Special Training – Equipment –OEM Requirements- Operations
- Advantage of CBT- Evaluation of Understanding and Authorisation- Competency

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Personal Behaviour

- Avoid distracting or startling other workers.
- Do not allow practical jokes and horseplay at any time.
- Use laboratory equipment only for its designated purpose.
- Do not allow visitors, including children and pets, in laboratories where hazardous substances are stored or are in use or hazardous activities are in progress. (Rats have caused Fire Accidents)

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- It is advisable to wear appropriate attire when working in Lab
- Apparel giving additional protection (e.g., non permeable laboratory aprons) is required for work with certain hazardous substances.
- Because many synthetic fabrics are flammable and can adhere to the skin, they can increase the severity of a burn.
- Therefore, cotton or HR is the preferred fabric.

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Lab OHS Performance- KPIs

- Inter-Lab OHS Performance
- Project Head
- Team Leader
- Individual Safety Performance

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Contract Terms

- Safety Responsibility to Reflect in contract
- Contract Employees- appropriate training-
periodical training
- Equipment owned by Contract / Service
Provider to meet safety standards
- Contractor Safety Performance

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Safety Awareness

- Every laboratory worker should be imparted at least a basic training on safety with regard to health and safety hazards of chemicals, and the hazards which may occur from the equipment and techniques one is likely to employ.
- No employee or laboratory worker shall commence work involving highly dangerous materials or processes without first acquainting himself with the appropriate safety practices.
-

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IS 4209



- For eliminating these causes, proper instructions are necessary
- Written rules and regulations, and safety equipment by themselves are not enough to ensure safety in laboratory.
- The first essential is to create an atmosphere of constant care and attention to even the smallest detail.

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- This cannot come by itself but should be nurtured and developed by the person in-charge, who should set an example

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Few HSE Principles Included in IS 4209

- Smoking is strictly prohibited in working areas other than those specified.
- Reporting to work in an intoxicated condition is strictly forbidden and punishable.
- All other activities detrimental in maintaining safety in the laboratory should be strictly prohibited.
- Do not work in isolation in a laboratory; a second person should be within call.
- Avoid handling or consuming food or drinks in laboratories.
- Good personal hygiene is essential.

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- Good housekeeping is considered as a backbone of laboratory safety.
- Returning equipments not in use to their proper storage place, clear labelling of chemicals, keeping laboratory floor free of obstruction and other good housekeeping practices should be strictly followed.

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- A periodic check of windows, storewells, fire appliances, first-aid boxes, etc, in the laboratory should be made.
- A suitable fire extinguisher should be located close to each laboratory.

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- Regard all substances as potential sources of hazards and handle them with care.
- Always use safety carriers for transporting glass or plastics containers with a capacity of two litres or greater.
- Incompatible chemical should never be transported together.
- They should be transported in suitable separated carriers.

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- All safety equipment shall be properly labelled and maintained regularly checked and inspected
- Allowable maximum quantities of dangerous substances, consistent with efficient operation shall be established for each laboratory and never exceeded.

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- Gas cylinders should never be dragged while transporting when standing, they should be chained to avoid their fall.
- Use proper lift (meant for carrying materials) while carrying dry ice or liquid nitrogen.
- Liquid oxygen should not be used as a substitute for liquid nitrogen.

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- Separate cans should be kept to deposit broken glass as otherwise the person cleaning the laboratory can sustain cuts from glass if mixed with waste paper, etc.
- Chemicals wastes should be disposed off by proper procedures.
- Clean up spills immediately and thoroughly. The nature of spills should be ascertained and spills treated accordingly.
- Keep all the exits free of obstructions to facilitate quick escape in an emergency.

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Emergency Information

- Keep safety information and emergency procedures prominently displayed at all times. Emergency procedures should be posted in each laboratory giving telephone numbers of:
- Antidotes
- Fire brigade,
- Ambulance,
- Supervisor/Safety coordinator, and
- Hospital.

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Sources of Information on Lab Chemicals Safety

In addition to what are referred in
Presentation

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- *Occupational Health Guidelines for Chemical Hazards, U.S*
- DHHS (NIOSH) Publication Number 81-123, 89-104
- *Chemical Safety Data Sheets*, Royal Society of Chemistry-UK
- *A Comprehensive Guide to the Hazardous Properties of Chemical Substances*, P. A. Patnaik

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- *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, ACGIH*
- *Bretherick's Handbook of Reactive Chemical Hazards*
- *Sax's Dangerous Properties of Industrial Materials*
- *Condensed Chemical Dictionary*

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- *Fire Protection Guide to Hazardous Materials- NFPA*
- *Laboratory Safety NFPA 45*
- *Patty's Industrial Hygiene and Toxicology*
- *Proctor and Hughes' Chemical Hazards of the Workplace*
- *Handbook of Toxic and Hazardous Chemicals and Carcinogens- Marshall Sittig.*

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- *Sigma-Aldrich Library of Chemical Safety Data*
- *Clinical Toxicology of Commercial Products*
- *Casarett and Doull's Toxicology*
- *Catalog of Teratogenic Agents*
- *The Laboratory Environment*
- **Prudent Practices in chemical laboratories**

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- OSHA- MSDS- ACS
- National Centre for Biotechnology
- ASHARE Standards
- NFPA 45 / NFPA 30 etc
- Lab Safety Manuals of each reputed Laboratories in USA
- NIOSH
- ILO Encyclopedia on OHS

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- European Standards
- UK Standards
- WBDG
- LCSS

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