



Chemical Hygiene in Laboratories

Components of a Chemical Hygiene Program



Summary

- Key definitions
- Chemical hygiene plan (CHP)
 - Requirements (OSHA)
 - Prudent practices in the laboratory (NRC)
 - School Chemistry Laboratory Safety Guide (NIOSH)

Recognizing and evaluating hazards, assessing risks, selecting appropriate practices, and performing them proficiently are essential elements of laboratory safety. The training to lay the foundation for acquiring these skills begins with the student's first experience in the laboratory.

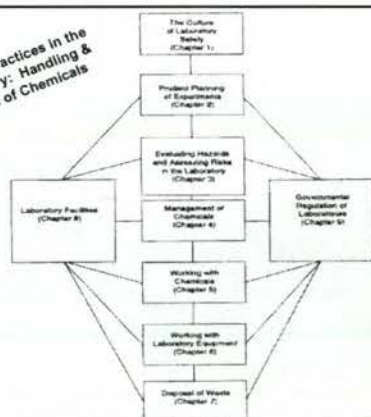
Definitions

- Chemical Hygiene Plan (CHP) – written program developed and implemented that establishes measures to protect employees from health hazards of hazardous chemicals used in a workplace.
- Chemical Hygiene Officer (CHO) – a qualified employee designated to provide technical guidance in the development and implementation of the CHP.
- Hazardous chemical – a chemical for which there is statistically significant evidence that acute or chronic health effects may occur in exposed employees.

Definitions

- Laboratory – facility where the 'laboratory use' of hazardous chemicals occurs
 - Small quantities
 - Non-production basis
- Laboratory use – handling of hazardous chemicals under the following conditions:
 - Chemical manipulations carried-out on a 'laboratory scale'
 - Multiple chemical procedures or chemicals are used
 - Procedures are not part of a production process
 - Protective laboratory practices and equipment are available and in common use to minimize potential exposure to hazardous chemicals

Prudent Practices in the Laboratory: Handling & Disposal of Chemicals



Employee Exposure Determination

Initial monitoring – if suspected exposure to regulated substance routinely exceeds the action level

- Follow provisions of the standard
- Notify employees of results within 15-days



CHP

- SOP's
- Criteria for determining control measures to minimize exposure...
- Requirement that lab hoods and other protective equipment is functioning adequately
- Provisions for employee information and training
- Medical management
- Designate a person (CHO) or committee to oversee CHP
- *Circumstances under which a laboratory operation or procedure will require prior approval*
- *Provisions for additional employee protection when handling highly hazardous chemicals*

SOP's

- General rules:
 - Accidents / spills
 - Flush eyes for 15-minutes
 - Promptly wash contaminated skin
 - Avoid eating, applying make-up, gum chewing...
 - Confine long hair
 - Appropriate lab apparel
 - Wear shoes at all times
 - Handle & store lab glassware with care
 - Do not smell or taste chemicals
 - Avoid routine exposure
 - Avoid skin contact
 - Use lab hood or work in well-ventilated area
 - No smelling, tasting...
 - Avoid use of contact lenses in lab
 - Notify of incidents, spills...

SOP's

- Lab facility design
 - general ventilation
 - 4 -12 room air changes...
 - Lab hoods
 - Other ventilated equipment (storage cabinets, canopy hoods...etc.)
 - Sinks
 - Other safety equipment (emergency eyewash & drench shower)



SOP's

- Preventive maintenance of lab (fume) hoods
 - Face velocity between 80 – 100 fpm (generally)
 - Face velocity between 100 – 120 (higher toxicity and outside influences affecting ventilation)
 - Avoid face velocity in excess of 15

Follow manufacturer recommendations



Lab Hoods

-- Performance Checks --

- Evaluate before use and on regular basis
- Verify absence of excessive turbulence
- Check continuous monitoring device on hood prior to use
- Minimize unnecessary equipment (i.e. beakers, bottles, other lab equipment, chemicals)
- Adjust sash to minimize hood face opening or to maintain appropriate face velocity
- Maintain constant

Lab Hoods

-- Factors Affecting Performance --

- Air currents outside hood
 - 30-50% of hood face velocity can interfere with containment
- Avoid placement in high-traffic areas
- Avoid placement near air diffusers
- Avoid placement near windows & doors

SOP's

Chemical procurement

- Info on proper handling, storage, and disposal
- Minimum quantity necessary (is material available within the facility)
- Maximum allowable container size...
- Proper container labeling
- Can chemical be

Receiving chemicals

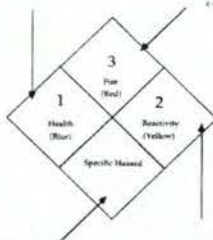
- Confine delivery to areas that can handle them
- Verification that container is intact and properly labeled
- Secure trans within the fac



- Establish procedure to follow if container leak

LABELS

HEALTH HAZARD
1: Death
2: Extreme danger
3: Hazardous
4: Highly Hazardous
5: Normal (hazard)



SPECIFIC HAZARD
Oxidizer
Acid
Alkali
Corrosive
Explosive
Flammable
Reactive

OR
ACID
ALKALI
CORROSIVE
EXPLOSIVE
FLAMMABLE
REACTIVE

FIRE HAZARD
Flash Point
1: Below 100 °F
2: Above 100 °F
3: Above 100 °F
4: Above 100 °F
5: Above 100 °F

- Also include:
- manufacturer name, address / phone #
 - hazard warnings
 - name(s) of chemicals

REACTIVITY
1: May detonate
2: Shock and heat may detonate
3: Violent chemical change
4: Unstable if heated
5: Stable

SOP's for Spill Response

-- Containment --

- Absorbent pads
- Inert absorbents such as vermiculite, clay, sand, kitty litter, and Oil Dri®
- Neutralizing agents for acid spills such as sodium carbonate and sodium bicarbonate
- Large plastic scoops and other equipment such as brooms, pails, bags, and dust pans
- Appropriate personal protective equipment, warnings, barricade tapes, and protection against slips or falls on wet floor during and after cleanup



SOP's for Spill Response

-- clean-up --

- *Materials of low flammability that are not volatile or that have low toxicity*
 - Absorption with an inert absorbent and appropriate disposal
 - PPE
 - Neutralizer
 - Sodium bisulfate - for alkalis
 - Sodium carbonate – for acids
 - Absorbents



SOP's for Spill Response

-- clean-up --

- *Flammable solvents & relative low toxicity*
 - *Eliminate ignition sources* (shut-off flames, spark producing equipment...)
 - soaked up with spill absorbent or spill pillows ASAP
 - Use non-sparking tools for clean-up
 - Prompt disposal in sealed container

SOP's for Spill Response

-- clean-up --

- *Highly toxic substances*
 - The cleanup of highly toxic substances should not be attempted alone. Other personnel should be notified of the spill, and the appropriate safety or industrial hygiene office should be contacted to obtain assistance in evaluating the hazards involved.

SOP's



• Response to Fire

- Know the locations of all fire extinguishers, what types of fires they can be used for, and how to operate them correctly
- Fire extinguisher only on incipient-stage fires
- Fires in small vessels can usually be put out by covering the vessel loosely
- Extinguish reactive metal and organometallic compound fires (e.g., magnesium, sodium, potassium, and metal hydrides) with Met-L-X® or Met-L-Kyl® extinguishers or by covering with dry sand
- drop to the floor and roll if clothing catches fire

Use the appropriate extinguisher...

A

Common materials such as paper, wood or most other combustibles

B

Flammable liquids such as gasoline, paint remover or grease

C

Electrical fires

D

Combustible metals usually found in industry

...and only for incipient stage fires!!!

SOP's

• Stockroom / storage room

- Place user's name & date received on all purchased materials (inventory control)
- Provide a definite storage place for each chemical and return the chemical to that location after each use
- Do not expose stored



SOP's

- Stockroom / storage room
 - Avoid storage on bench tops or in lab hoods
 - Separate chemicals into compatible groups* and store alphabetically within compatible groups
 - Store flammable liquids in approved flammable liquid storage cabinets



*Shelf storage Pattern – NIOSH Guide...

SOP's

- Maintain secure, accessible storage
 - Durable shelves
 - Avoid storage on top of cabinets/shelves where difficult to reach
 - Store heavy containers between knee and shoulder height



SOP's

- Stockroom / storage room
 - Use chemical storage refrigerators only for chemical storage
(No Food – Chemical Storage Only)



- Secure gas cylinders
- Segregate gas cylinder storage from other chemicals
- Don't store incompatible gases together
(i.e. Avoid flammables with reactives)
- Separate empty from full cylinders
- Considerations for



SOP's

- Housekeeping and Maintenance
 - Cleaning and maintaining work areas
 - Avoid storing materials in aisles, passageways...
 - Routine inspection and maintenance of eye wash and shower systems
- Inspections
 - maintain lab facilities & equipment in safe operating condition
 - Maintain safe work environment
 - Ensure lab procedures conducted in safe manner
 - Done bi-annually

Inspection Items

- Keep water in drain traps
- Secure plastic / rubber hose connections
- Check for inadequate or defective wiring
- Check compressed gas fittings, regulators...
- Flammables in
- Machinery safeguards
- Inspect/test emergency devices
- Keep aisles & emergency exits free of obstacles
- Other facility-specific requirements, documentation...

Criteria for Determining Control Measures

- Types of chemicals in use
- Methods of use
- Physical and chemical properties
 - Flammable
 - Corrosive
 - reactive
- Pre-experiment planning and risk assessment will determine necessary control measures
 - Ventilation (engineering controls)
 - Minimize quantities
 - Work practice controls
 - PPE

Information / Training

- Upon initial assignment
 - Prior to assignments involving new exposures
 - Refresher training as needed – determined by the employer
1. Content of the laboratory standard – 1910.1450
 2. Location / availability of the CHP
 3. Permissible or recommended exposure limits of chemicals in use
 4. signs / symptoms of exposure to hazardous chemicals used in the lab
 5. Location / availability of reference material

Information / Training

1. Methods and observations that may be used to detect exposures (i.e. Monitoring, odor and/or visual appearance of chemical when being released)
2. Physical and health hazards of chemicals in the work area
3. The measures employees can take to protect themselves from these hazards
 - Work procedures
 - Emergency procedures
 - PPE

Medical Management

- *Medical monitoring as required by regulations*
- *Routine surveillance*
 - *If routinely handling significant amounts of highly toxic chemicals*
- 1st aid trained personnel available

CHO

- Work with administrators and others to develop an effective chemical hygiene plan
- Ensure completion of appropriate inspections and annual audits
- Establish and ensure implementation of chemical hygiene practices
- Know the legal requirements of regulated chemicals
- Monitor overall procurement, storage, and use of hazardous chemicals
- Ensure adequate safeguards are available
- Training program
- Assist in planning of experiments
- Risk assessment

Planning for Experiments

Depending on the situation, this might include :

- (1) simple mental evaluation of hazards for straightforward experiments by experienced practitioners
- (2) more formal discussion of the experiment and options with experienced peers for more hazardous operations
- (3) a formal hazard review process with complete written documentation of the procedures to be employed for new, unfamiliar, or intrinsically hazardous operations.


Responsibilities

- While the experiments may be prepared and conducted by the laboratory workers, it remains the responsibility of the laboratory supervisor to determine what level of experiment planning is appropriate and to be accountable for necessary training, documentation, and compliance with regulations.

Planning for an Experiment

- Assess the risks
- Management of chemicals (acquiring & storing chemicals and equipment...)
- Identify potential hazards
- Working with laboratory equipment
- Waste disposal
- The laboratory facility
- Compliance with regulations

Assess the Risks

- Chemical Hygiene Plan (CHP)
- MSDS 
- Laboratory Chemical Safety Summary (LCSS)
- Labels
- Other references...

Assess the Risk

Toxicity

Dose  response

Duration / frequency of exposure

Risk Assessment

-- Laboratory Chemical Safety Summary --

- Identify chemicals to be used and circumstances of use
 - Will chemicals be handled repeatedly or will the experiment be done once
 - Will the experiment be conducted in an open lab, within a fume hood, or other enclosed apparatus
 - Does anyone have known sensitivities to the specific chemicals
 - Are any workers involved pregnant...
 - Is there a possibility of new/unknown chemicals being produced

Risk Assessment

-- Laboratory Chemical Safety Summary --

- Consult sources of information
 - Up-to-date MSDS if LCSS is not available
 - Labels
 - Other sources:
 - Mackison et al. (U.S. DHHS, 1981)
 - Patty's (Clayton and Clayton, 1993)
 - Assistance from industrial hygiene professionals and/or supervisors

Risk Assessment

-- Laboratory Chemical Safety Summary --

- Evaluate the type of toxicity
 - Irritant
 - Corrosive
 - Neurotoxin
 - Reproductive toxin
 - Allergen
 - Asphyxiant
 - Carcinogen
 - Organ-specific
 - Acute / chronic effects
 - Existing permissible exposure limits
 - Flammability/combustibility
 - Class I, II, & III
 - Reactivity (corrosive, oxidizer...)

Risk Assessment

-- Laboratory Chemical Safety Summary --

- Consider possible routes of exposure
 - Inhalation
 - Gases or volatile liquids
 - Dusts / aerosols
 - Contact with skin or eyes
 - Liquid that can absorb through skin
 - Ingestion
 - Dusts / aerosols
 - Ingesting food with contaminated hands



Risk Assessment

-- Laboratory Chemical Safety Summary --

- Evaluate quantitative information on toxicity
 - Determine the LD_{50} / LC_{50} for each chemical via relevant routes of exposure
 - Determine acute toxicity hazard levels of chemicals
 - Highly toxic
 - Moderate toxicity
 - Slightly toxic
 - Note permissible exposure limits for chemicals posing an inhalation hazard

Risk Assessment

-- Laboratory Chemical Safety Summary --

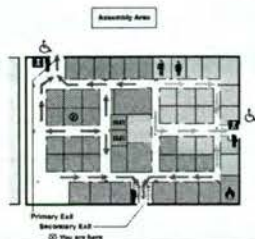
- Select appropriate procedures to minimize exposure
 - PPE
 - Chemical splash goggles / face shields
 - Gloves
 - coats
 - Work practices
 - No mouth pipetting
 - Avoid direct contact / wash hands after chemical use
 - Use lab hoods
 - Lower sash as much as possible
 - Keep work at least 6" back behind sash

Risk Assessment

-- Laboratory Chemical Safety Summary --

- Prepare for emergencies

- Note signs / symptoms
- Note appropriate measures to be taken in event of exposure or accidental release of chemical(s)



Other considerations

- Ignition sources
- Explosive hazards
- Reactive hazards
 - Acids/bases
 - Alkali metals
- Oxidants (other than oxygen)
- Specialized hazards
 - Compressed gases
 - Liquefied gases
- Dusts
- Explosive boiling (eruptive boiling)



Waste Management

- Accumulation & temporary storage at generation area
 - Labeled & closed containers
 - Up to 55 gallons hazardous
 - Up to 1 quart acutely hazardous
 - Don't store incompatible chemicals in same container
 - Transfer to central accumulation area within 3-days of exceeding quantity limits
- Central accumulation areas
 - Store up to 90-days
 - Final preparation for off-site disposal
 - Labeled containers
 - 55 gallon drums typically used to hold small containers of waste packed with absorbent material

Waste Management

- For regulatory purposes, the facility needs to keep records for on-site activities that include:

1. the quantities and identification of waste generated and shipped
2. documentation of analyses of unknown materials if required
3. manifests for waste shipping as well as verification of disposal
4. any other information required to ensure compliance and safety from long-term liability

Teacher's Responsibilities

- Routine inspections
 - Lab area
 - 1st aid / emergency equipment
- Maintenance of chemicals
 - Inventory (annual...)
 - Container labeling
 - Storage/handling/Disposal
- Recordkeeping
 - Training
- Emergency preparedness
 - Location/use of equipment
 - Evacuation plan
 - Emergency phone #'s
 - Training/drills
- Preparing for lab activities
 - Potential risk/hazards
 - Equipment prep
 - Discuss safety concerns

References

- 1910.1450 – Occupational Exposure to Hazardous Chemicals in Laboratories www.osha.gov
- Prudent Practices in the Laboratory: Handling and Disposal of Chemicals
http://www.nap.edu/catalog.php?record_id=4911#toc
- School Chemistry Laboratory Safety Guide
<http://www.cdc.gov/niosh/docs/2007-107/hygiene.html>