Annual CNAM & JQI Lab Safety Training

Presented by Karen Kelley & Bill Guffey
May 30, 2017
Today’s Presentation

- Incidents and Emergencies Refresher
- Safety Culture
- Laboratory Safety with Focus on Controls
- Fire Safety
- What’s New in Lab Safety
Incidents & Emergencies
Incidents and Emergencies

How to report emergencies

- Call 301-405-3333 from a cell phone
- Call #3333 from Verizon Wireless, Sprint, Nextel and AT&T (This does not work for other carriers!)
- Call 911 from UMD landlines
- Use emergency phones
  - Blue light phones outside
  - Yellow phones in some buildings
Incidents and Emergencies

- Chemical in Eye
  - Rinse eye at eyewash for 15 minutes holding eyes open
  - Go to Health Center
  - Call for ambulance after hours
  - Report exposure to instructor, stockroom and/or PI

Test eyewashes once a week!
Incidents and Emergencies

Chemical on Skin
- Rinse for 15 minutes
- Remove contaminated clothing
- Go to Health Center
- Call for ambulance after hours if corrosive chemical
- Report exposure to instructor, stockroom and/or PI
Incidents and Emergencies

Seek medical attention:

- Eye contact with chemical
- Significant chemical exposure
- Chemical exposure that results in symptoms
  - Inhalation of any substance that causes coughing
  - Burning or severe irritation
- Electric shock
- Laser injury
Which spills require outside assistance?

- 500 ml of ethyl ether spilled on the floor
- 500 ml of 2-mercaptoethanol on the floor
- 20 ml of toluene on the floor
- 1 liter of an unknown chemical
- 10 mg of an acutely toxic powder spilled on a lab bench
- 5 gallons of ethanol on the floor
Chemical Spill

- All spills should be cleaned up in a timely fashion
- Assess the spill to determine proper response:
  - Call 911 if it is an emergency situation
  - Contact ESSR for assistance if it is not an emergency
    - 5-3960 from 8-5
    - 5-3555 off hours and let dispatch know you need to contact ESSR
    - 301-314-2000 spill number
When can lab personnel clean up a chemical spill?

- Chemical(s) involved in the spill are known
- Small quantity, low hazard
- Spill kit contents are compatible with the spill
- Spill kit contents is sufficient for the spill
- You have been trained to clean up spills
- You have the appropriate PPE to clean up the spill
Chemical Spill

ő Cleaning up small spill
  ü Use spill kit
  ü Wear gloves and other PPE
  ü Dispose of clean-up materials as hazardous waste
  ü Notify PI
Chemical Spill

- Large or hazardous spill
  - Get everyone out of lab
  - Assist anyone that is injured
  - Close door as you leave
  - Call 301-405-3333 from cell phone or 911 from a UMD landline and give as much information as possible
Fire

- Evacuate lab
- Close sash if the fire is in fume hood if safe to do so
- Close door as you leave
- Evacuate building immediately
- Activate alarm as you leave if it is not already sounding
- Call 911 or 301-405-3333
- Gather at an appointed meeting spot outside the building and account for students
- Do not re-enter until told it is safe to do so (Fire Dept and ESSR)
Safety Culture
Postdoc Thea Ekins-Coward lost her right arm in explosion.

Combing hydrogen (70%), oxygen (20%) and carbon dioxide (10%) from high pressure cylinders into low pressure tank.

Digital pressure gauge acted as path to ground for static charge.

Exploded when she pressed “off” button on gauge.
University of Hawaii

Investigation findings:
- No pressure relief valve
- No safety barricades
- No electrical bonding and grounding
- Tank designed for dry air only
- Digital pressure gauge not intrinsically safe
- Stainless steel ball valve can create static charge
- No gas monitor
Investigation findings:

- Gap in laboratory safety inspections
- Chemical hygiene plan deficiencies
- Safety training lacking
- Lack of formal hazard identification and risk assessment training
- No management of change
- Infrastructure inappropriate
- Near miss event did not stop work from proceeding
- Safety rules not enforced (gloves to prevent static charge transfer)
APLU and Other Safety Culture Reports

- Reports address these issues
- University is moving ahead with APLU Task Force

CSB
May, 2010

ACS
March, 2012

NAS
July, 2014

APLU
April, 2016
Oversight Gaps

- No committee to look at high hazard chemical or physical processes
- Granting agencies don’t typically look at safety
  - DOD requires facility safety plan
  - DOE COE grants will require detailed research safety plan
Laboratory Safety with a Focus on Controls
Hierarchy of Controls

Most Effective

1. Elimination
2. Substitution
3. Engineering Controls
4. Administrative Controls
5. Personal Protective Equipment

Least Effective
Elimination

- Most effective
- Not always feasible due to research needs, but it should be considered whenever possible
- Easy example is to dispose of hazardous chemicals that are no longer used or are expired
Substitution

- Substitution is next most effective means of control
- Also not always be feasible due to research needs, but should be considered whenever possible
### Substitution

Both carbon tetrachloride and cyclohexane have hazards associated with them. The following sections of the Safety Data Sheets (SDS) show the hazards of each chemical:

<table>
<thead>
<tr>
<th>Carbon Tetrachloride</th>
<th>Cyclohexane</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2.2 GHS Label Elements</strong></td>
<td><strong>2.2 GHS Label Elements</strong></td>
</tr>
<tr>
<td>Pictogram</td>
<td>Pictogram</td>
</tr>
<tr>
<td><strong>Signal Word</strong></td>
<td><strong>Signal Word</strong></td>
</tr>
<tr>
<td><strong>Hazard Statement(s)</strong></td>
<td><strong>Hazard Statement(s)</strong></td>
</tr>
<tr>
<td>H301 + H311 + H331</td>
<td>H225</td>
</tr>
<tr>
<td><strong>Toxic if swallowed, in contact with skin or if inhaled.</strong></td>
<td>Highly flammable liquid and vapor.</td>
</tr>
<tr>
<td>H317</td>
<td>May be <strong>fatal if swallowed</strong> and enters airways.</td>
</tr>
<tr>
<td>May cause <strong>allergic skin reaction</strong></td>
<td>Causes <strong>skin irritation</strong>.</td>
</tr>
<tr>
<td>H352</td>
<td>May cause <strong>drowsiness or dizziness</strong>.</td>
</tr>
<tr>
<td>Suspected of causing <strong>cancer</strong></td>
<td>Very toxic to aquatic life.</td>
</tr>
<tr>
<td>H372</td>
<td></td>
</tr>
<tr>
<td>Causes <strong>damage to organs</strong> (liver, kidney) through prolonged or repeated exposure if inhaled.</td>
<td></td>
</tr>
<tr>
<td><strong>2.3 Hazards Not Otherwise Classified (HNOC) or Not Covered by GHS</strong></td>
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</tr>
<tr>
<td>Rapidly absorbed through skin.</td>
<td>None.</td>
</tr>
</tbody>
</table>


Engineering Controls

- Isolate people from the hazard.
- Built into the design of the laboratory, equipment, or the process.
Minimize exposures through work practices

Include safe work procedures, training, good housekeeping, signage, and alarms
Personal Protective Equipment

- Last line of defense and should not be used as a substitute for more effective controls
- PPE only protects the user, it does not remove the hazard from the laboratory and it does not protect others in the area who are not wearing PPE

Most Effective

Personal Protective Equipment

Least Effective
Engineering Controls

Most Effective

Least Effective
Ventilation

Two types of ventilation in laboratories:
- Local exhaust ventilation
- General exhaust ventilation
Fume Hoods

- Most common LEV in laboratories
- Primary control when working with volatile hazardous chemicals

Air enters the hood through the sash and is exhausted through a slot or slots at the back of the hood into the laboratory exhaust ductwork.
Fume Hood Face Velocity

- Most hoods on campus have a face velocity of approximately 100 fpm.
- If face velocity is too high or too low, contaminants may not be contained.
CV Fume Hoods

- Exhaust same amount of air regardless of sash height
- As sash raised and lowered, the face velocity changes
- Physics Building

Proper sash height. Face velocity at safe level.

Sash is too high. Face velocity may be too low.

Sash is too low. Face velocity may be too high.
VAV Fume Hoods

- Vary the air flow to maintain a constant face velocity regardless of the sash height.

Physical Sciences Complex

Face velocity at safe level at any sash height. Lowering or closing the sash conserves energy!
There are two ways fume hood performance is monitored:

- Fume hoods are equipped with a monitoring device that continuously measures the air flow.
- Fume hoods are tested annually to ensure they are working properly.
Fume Hood Monitoring Devices
Fume Hood Testing

- Face (Inflow) Velocity
- Test Date
- Proper Sash Height
Fume Hood Testing

- If fume hood does not pass, a notice will be placed on the sash
- ESSR will place a work order for the repair
- Notice will be removed when the fume hood is repaired
- Never use a fume hood that is not working properly
Fume Hood Repair

FMS Number: FHX-0737

To Report Problems Call Work Control 301-405-2222
Reference the FHX-### on the hood.

Fume Hood Number
Phone Number
Fume Hood Safe Work Practices

Limitations of fume hoods:

- **Do not** use a fume hood for biological materials
- **Do not** use a fume hood for pyrophoric chemicals or highly toxic materials
- **Do not** use a fume hood for processes that generate large amounts of particulate
- **Do not** use conventional hood for perchloric acid or acid digestion
Verify the fume hood is working properly:

- Check the monitor to make sure the fume hood is not in alarm
- Check that air is flowing into the hood
Fume Hood Safe Work Practices

Work as close to the center of the hood as possible, and work at least 6 inches back from the sash opening.
Fume Hood Safe Work Practices

- Position large equipment to the side when possible.
- Place equipment on blocks to prevent it from blocking the back slot and ensuring proper airflow.
Fume Hood Safe Work Practices

- Close the sash when fume hood is not being used or when there is an unattended experiment in the hood.

- For unattended experiments, place a notice on the sash with emergency contact information and hazard information.
Fume Hood Safe Work Practices

Do not overload the hood or use the hood for storage.
Fume Hood Safe Work Practices

Do not store gas cylinders larger than a lecture bottle in a fume hood.
Fume Hood Safe Work Practices

Wear appropriate PPE while working in a fume hood.
Fume Hood Safe Work Practices

Know how to respond to emergencies in a fume hood:

- Clean up chemical spills in the fume hood promptly
- If there is a fire in a fume hood, close the sash if it is safe to do so, evacuate the lab, and report the fire immediately to the UMD Police Department
Ventilated Gas Cabinets

- All gases with NFPA health rating of 3 or 4 or a health rating of 2 with no warning properties required to be stored in ventilated enclosure
- Gases larger than lecture bottle must be stored in ventilated gas cabinet
Canopy Hoods

- Canopy hoods typically used to exhaust heat
- Canopy hoods not appropriate for hazardous materials and processes
Snorkel Hoods

- Snorkel hoods susceptible to cross drafts and must be positioned close to the source of contaminants
- Use for lower hazard contaminants
  - Benchtop soldering or other heating processes
  - Ventilate benchtop equipment such as gas chromatographs
Glove Boxes

- Provide a leak-tight environment to perform work under vacuum or in an inert atmosphere
- Use for work with pyrophoric materials or highly toxic materials
General Laboratory Exhaust

- Provide dilution for contaminants that are not captured by LEV, such as chemical spills
- Maintain negative pressure
  - Keep door to your lab closed
Controls for Chemical Storage

- All Class I flammable liquids and Class II combustible liquids must be stored in a flammable liquids storage cabinet when not in use
  - Flash point < 140°F
Controls for Chemical Storage

Three types of refrigerators and freezers:

- Household grade
- Flammable materials storage
- Explosion proof
Controls for Chemical Storage

Compressed gas cylinders must be secured from falling at all times, whether they are empty or full.
Risk Assessment

Risk assessment should be performed for any new hazardous operation or when changes are made to existing hazardous operation.

- Identify hazards
- Evaluate risks associated with the hazards
- Determine ways to eliminate or control the hazard
Hazard Identification

- Health hazards associated with chemicals
- Routes of exposure
- Physical and reactive hazards associated with chemicals
- Process hazards
Hazard Identification

Health hazards associated with chemicals
- Irritant or sensitizer
- Corrosive
- Acute toxin
- Carcinogen or potential carcinogen
- Reproductive or developmental toxin
- Other systemic toxin

Routes of exposure
- Inhalation
- Skin/eye contact
- Skin absorption
- Injection
- Ingestion
Hazard Identification

- **Physical** and **reactive** hazards associated with chemicals
  - Flammable/Explosive
  - Strong oxidizer
  - Air or water reactive
  - Form unstable peroxides
  - Shock or friction sensitive

- **Process** hazards
  - Pressure
  - Temperature
  - Removal of inhibitor
  - Vacuum
  - Electricity
Risk Assessment

- Identify circumstances of use, handling and storage
- Evaluate hazards posed by chemical changes over course of experiment
- Plan for Emergencies
Risk Assessment

- Identify circumstances of use, handling and storage
  - Quantity
  - Concentration
  - Frequency of use
  - Experiment location
  - Storage location

- Evaluate hazards posed by chemical changes over course of experiment
  - Pressure changes
  - Heat generation
  - Reaction products
  - Gas production
  - Rates of reaction
Risk Assessment

- Identify controls
- Anticipate what could go wrong
  - “What if?”
- When planning for emergencies, consider:
  - Emergencies associated with the experiment (spill, explosion, unexpected reaction, fire)
  - Emergencies associated with the building (fire, loss of utilities, unexpected building closure)
  - Emergencies associated with the campus (unexpected campus closure)
Safe Work Procedures

Safe work procedures should be incorporated into the laboratory’s standard operating procedures (SOPs): A summary of the hazards

- Safe handling and storage procedures
- Controls needed (fume hood, shielding, etc.)
- Required personal protective equipment
- Waste procedures
- Emergency procedures
Laboratory Specific Training

- Training on hazards and safety controls specific to each research laboratory

- Three levels of training:
  - Orientation checklist
  - Proficiency in standard lab techniques
  - Proficiency in higher hazard operations

- To be reviewed by the PI or laboratory supervisor with all laboratory personnel:
  - When researchers/technicians/visitors first enter the lab
  - Whenever a change in hazards or safety controls warrants new training
  - After accidents/incidents
Chemical Segregation and Storage

Segregate chemicals according to their hazard class:

- Flammables
- Acids (Corrosive)
- Bases (Corrosive)
- Oxidizers
- Pyrophorics
- Water Reactives

Do not store chemicals alphabetically, except within hazard class.
Corrosives Storage

- Segregate acids and bases
- Do not store corrosives with flammables or in a flammable liquids cabinet
- Segregate oxidizing acids, such as nitric and chromic acids, from organic acids and flammables
- Segregate acids from chemicals that can generate toxic gases, such as sodium cyanide
- Avoid storing corrosives in metal cabinets
- Store corrosives below eye level
Flammable Liquids Storage

- Store flammable liquids in an approved storage cabinet or refrigerator
- Segregate flammable liquids from oxidizers, acids, and bases.
- Store away from heat or source of ignition

Proper storage of flammable liquids.

Improper storage of flammable liquids outside of an approved cabinet.
Oxidizers

- Segregate oxidizers from flammables, organic solvents, and combustible materials, such as paper and wood.
- Segregate oxidizers from reducing agents, such as alkaline metals and formic acid.
General Chemical Storage Guidelines

- Store chemicals in a cool, dry location away from direct sunlight
- Store chemicals in cabinets that can contain spills or in bins
- Segregate liquid and solid chemicals or store solids above liquids
- Do not store chemicals on the floor
- Do not overcrowd chemical storage areas
General Chemical Storage Guidelines

Inspect chemical storage areas on a regular basis for signs of chemical or container deterioration.

Contact ESSR for assistance in disposing of chemicals that have deteriorated or may have become unstable.
Laboratory Housekeeping

Good laboratory housekeeping minimizes exposures and accidents.
Signage and Postings

EMERGENCY RESPONSE GUIDE

General Emergency Procedures  9-1-1 or 301.405.3333
Fire  9-1-1 or 301.405.3333
Radioactive Material  Minor Spill: 301.314.2000  Major Spill: 9-1-1 or 301.405.3333
Chemical  Minor Spill: 301.314.2000  Major Spill: 9-1-1 or 301.405.3333
Biological  Minor Spill: 301.314.2000  Major Spill: 9-1-1 or 301.405.3333
Personal Injury  9-1-1 or 301.405.3333
Laboratory Specific Instructions  9-1-1 or 301.405.3333
Personal Protective Equipment

Most Effective

Least Effective
Personal Protective Equipment

- PPE is selected by PI based on the specific hazards and tasks being performed in lab
- At a minimum, when working with hazardous materials, you should wear:
  - Lab coat
  - Gloves
  - Eye protection
  - Proper laboratory attire (long pants, closed toe shoes)
Eye Protection

- Safety glasses
  - Risk of splash is low
  - Materials being used cannot burn or damage the eye
  - Impact protection required

- Splash goggles
  - Splash risk
  - Working with chemicals that can burn or injure the eye
Gloves

- Disposable nitrile gloves
  - Protect from accidental splashes.

- Chemical protective gloves
  - Provide protection for specific chemicals
  - May be required for higher hazard chemicals or when hand contact is expected
  - Contact ESSR for assistance in selecting chemical protective gloves
Other specialty gloves may be needed for specific hazards or tasks in your lab.

- Insulated gloves for working with cryogenic liquids.
- Insulated gloves for working with hot objects.
- Cut resistant gloves for handling sharp objects.
- Flame resistant glove liners for working with pyrophorics. (Chemical resistant gloves can catch fire.)
Face Protection

Face protection is needed when:

- Working with cryogenic liquids
- Working with UV light
- There is a risk of splash from chemicals that can injure the skin (corrosives)
- There is a risk of injury to the face from flying objects or particulate
Different types of lab coats provide different levels of protection:

<table>
<thead>
<tr>
<th>Material</th>
<th>Splash Resistance</th>
<th>Flame Resistance</th>
<th>Use and Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester/Cotton Blends</td>
<td>Yes</td>
<td>No</td>
<td>May provide better protection from corrosives than cotton. Do not use with flammable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>liquids, pyrophorics, or open flame.</td>
</tr>
<tr>
<td>100% Cotton</td>
<td>No</td>
<td>No</td>
<td>Appropriate for labs with light flammable liquids or open flame use.</td>
</tr>
<tr>
<td>100% Cotton with Flame Retardant</td>
<td>No</td>
<td>Yes</td>
<td>Appropriate for labs with significant flammable liquids or open flame use.</td>
</tr>
<tr>
<td>Nomex</td>
<td>Yes</td>
<td>Yes</td>
<td>Appropriate for labs working with pyrophorics.</td>
</tr>
</tbody>
</table>
Respiratory Protection

- Engineering controls, such as local exhaust ventilation, should always be used to protect from inhalation of hazardous materials.
- If you feel you need to wear a respirator in your laboratory, contact ESSR.
Voluntary Respirator Use

- N95 respirators for nuisance dust
- Requires training on the correct use and limitations of an N95 per OSHA regulations

[OSHA Appendix D]
Laboratory Waste
Laboratory Waste

University of Maryland
Hazardous Waste
Satellite Accumulation Storage Area

IMPORTANT INFORMATION

HAZARDOUS WASTE containers must be closed with a leakproof lid at all times except when adding or removing hazardous waste.

HAZARDOUS WASTE containers must have a University of Maryland Hazardous Waste tag (purchased from the Chemistry Stores or General Stores) attached with the chemical constituents and percentages.

HAZARDOUS WASTE may only be accumulated at or near any point of generation and must be under the control of the operator.

HAZARDOUS WASTE may be accumulated up to 55 gallons of non-acute hazardous waste or 1 quart of acute hazardous waste (P-listed).

HAZARDOUS WASTE that is incompatible must be separated using secondary containment tanks.

HAZARDOUS WASTE containers may not be opened or handled in a manner which may cause it to leak and hazardous waste must be stored in proper containers.

HAZARDOUS WASTE Satellite Accumulation Storage Areas must be free of spills and leaking containers.

All UM personnel with waste management responsibilities must complete the On-Line Hazardous Waste Generator Training.

For further information call Environmental Safety extension 53960 or visit our web site at http://www.des.umd.edu
Laboratory Waste
Fire Safety

Bill Guffey
Deputy Fire Marshal
PSC Problems

- Designed as business occupancy with low hazard labs
- Only 10 labs were designed for chemical usage
- Laboratories not being used for designed use
- Fifty labs located below grade
- Improper ventilation for laboratories using chemicals (recirculating ventilation, non-negative pressure)
- Class 1 flammable liquids not permitted below grade
PSC Restrictions

- Ten basement labs designed for hazardous materials use
  - Maximum quantity 15 liters per room
  - Maximum container size 500 ml
  - Flammable liquids must be stored in approved flammable liquids cabinets
  - Flammable gases greater than 6 cubic feet must be stored in ventilated gas cabinets
PSC Restrictions

- Rooms not designed for hazardous materials (recirculated air, not negatively pressurized)
  - Maximum quantity of flammable liquids 500 ml
  - Use or storage of hazardous materials requires review and approval (toxic, flammable, oxidizers, explosives, etc.) before bring in building
  - Small quantities of low toxicity materials consistent with office use permitted.
PSC Restrictions

- Compressed gases and cryogenic fluids must be used in areas with proper ventilation or oxygen monitoring system.
- Inert gases permitted only cylinders necessary for operation and one spare per each cylinder in use.
- Hazardous gases have severe restrictions require review and approval before use.
What do we do?

- Engineering (New construction and renovations)
- Code Enforcement Inspections (Existing Buildings)
- Public Education
- Code Consultations
- Fire/Arson Investigations
**Type of Lab Inspections**

- Unannounced
- Normally conducted annually
- Complaint investigations
- When requested by lab personnel, FM, or ESSR
- Joint inspections with Research Safety Group
Lab Inspections

Based on State Fire Code (NFPA1 and NFPA 101) local amendments and referenced standards

- NFPA 45, *Fire Safety in Laboratories Using Chemicals*
- NFPA 30, *Flammable and Combustible Liquids Code*
- NFPA 55, *Compressed Gas Standard*
- Other referenced standards (over 100 NFPA standards, ANSI, ASRA, ASTM, CGA, US Government, etc.)

www.nafpa.org
Lab Inspections

- Obstructed egress
- Emergency lighting and exit signs
- Fire protection systems
- Fire extinguishers
- Fire resistance construction (fire doors, fire walls, and floors)
- Electrical hazards (extension cords, exposed wires, etc.)
Lab Inspections

- Compressed gas storage
- Toxic gas storage
- Flammable liquid storage
- Chemical storage (incompatible chemicals, not used or stored in accordance with SDS)
- Lab ventilation (room and fume hoods)
- MAQ’s of hazardous materials
Improper lammable liquids storage

Improper storage of flammable liquids
Flammables stored in refrigerator not designed for flammable storage
Incompatible chemical storage
Open container of pyrophoric chemicals
Obstructed fire exit
Improper toxic gas storage
Obstructed fire alarm strobe light
Exposed electrical wiring
(fire and shock hazard)
Misuse of extension cords
Extension cord not protected from damage
Incompatible gases
(flammable and oxidizing)
Inspection Findings

- Written Notice to PI.
- Normally 30 days to correct, less time if a serious hazard.
- Follow-up inspection is conducted.
- Referred to chair if not corrected
- Conducts second reinspection
- May close lab and/or refer to Provost
Chemistry Fire
Factors - Chemistry Fire

- Melting paraffin on hot plate in fume hood
- Paraffin ignited, grad student removed from fume hood and placed on floor
- Fire activated sprinkler system
- Fume hood was cluttered with numerous cylinders of oxygen, cylinder of propane and 4L container of a flammable liquid
- Grad student called PI before calling 911
- Thousands of dollars in water damage
Fire Procedures

- Activate fire alarm
- Shut off equipment in your area
- Evacuate Building, immediately
- Call 911 or 301-405-3333 from safe location
- Must notify fire department even if fire is extinguished

- Fire extinguishers can only be used if fire is small, fire alarm activated, and you are trained. Use is voluntary.
Questions?
What’s New in Lab Safety
New Position

- Gaps identified and position created to fill gaps
  - Laser Safety Officer
  - Develop electrical safety program for laboratories
  - Provide guidance for physical hazards

- Two shocks and one laser accident
Purchased BioRAFT training module
  Importance of properly setting up labs in system
Thank you!