Preventing and Managing the Most Likely Lab Accidents

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My Lab Safety History

• I worked as a lab tech in environmental chemistry labs for 5 years, first at Cornell University and then at the University of Vermont.

• I starting working in Environmental Health and Safety at UVM in 1985 as new OSHA regulations led to increased concern about compliance in labs.

• In 2011, I moved back to Cornell to be the Laboratory Ventilation Specialist and then Chemical Hygiene Officer there.

• In 2014, I moved to Keene State to be the Chemical Hygiene Officer and then became the Environmental Safety Manager as well.

• I have been involved in the American Chemical Society's Division of Chemical Health and Safety programs for 25 years and served as chair of the national Committee on Chemical Safety.
Which of these best describes how often your review your lab's risks and safety practices:

1. We have regular (weekly or monthly) safety discussions as refreshers for all lab staff
2. We review our SOPs for safety concerns annually
3. We review safety as new people are hired or procedures change
4. We rely on consistent use of general best lab safety practices
The RAMP approach to Risk Assessment

Video clip available to download at
https://dchas.org/wp-content/uploads/2022/06/RAMP-intro-video.mp4
Audience Poll #2

What part of your lab safety program do you find most challenging:

1. Recognizing Hazards
2. Assessing Risks
3. Managing Safety to Minimize Risks
4. Planning for Emergencies
Dr. Karen Wetterhahn was a Dartmouth University chemistry professor. Her lab explored the impact of heavy metals on the environment, focusing on mercury and cadmium.

In August, 1996 she was exposed to dimethylmercury, when the chemical penetrated her latex gloves.

She died in June, 1997 of mercury poisoning.

OSHA investigated and determined that the glove selection criteria in Dartmouth's Chemical Hygiene Plan were inadequate.

Dartmouth was fined $9,000.
The standard NMR reference for mercury was dimethylmercury (DMM). However, due to its toxicity, Dr. Wetterhahn's lab substituted mercury chloride to prepare their standards.

The lab returned to using DMM after the Hg levels found in their NMR samples were not what they thought they should be.

While Dr. Wetterhahn was transferring the liquid DMM, several drops spilled on the back of her gloved hand.

After several months, she noticed neurological symptoms of Hg exposure and 22 days after initial symptoms she became comatose. She died 298 days following exposure.
Follow Up Work by Dartmouth on Glove Suitability

• The best practices at the time was to use "rubber" gloves when handling DMM.

• Dartmouth hired a lab to test gloves for DMM permeation rates.

• The results were:
  o PVC/latex <15 sec
  o Nitrile 15 sec
  o Neoprene <10 min
  o Butyl < 15 min
  o Viton < 15 min
  o Silver Shield > 240 min
An Informal RAMP review of this Incident

**Recognize:**
The lab understood the toxicity of DMM. DMM has a flashpoint of 5 degrees C, so it is also a flammability hazard.

**Assess:**
Because of high risk of toxicity with DMM, Dr. Wetterhahn did the benchwork herself. According to the C&EN story "this was a task she didn’t want anyone else doing"

**Manage:**
A fume hood controls the fire hazard, but does not provide protection against skin exposure to DMM. The control banding scheme for glove selection did not include information about DMM penetration time of latex gloves

**Plan for Emergencies:**
Dr. Wetterhahn did not recognize the emergency when it occurred. If she had sought medical attention immediately, chelation therapy could have potentially helped control the progression of her symptoms
A Quick Side Note on Control Bands

Control bands are used to guide the management of workplace risks by suggesting control measures based on a “band” of hazard levels (such as toxicity) and expected exposures (e.g. small, medium, or large exposure). The NIOSH website discusses the opportunities and challenges CB presents in detail.

Biosafety Levels are examples of Control Bands
Biosafety controls include work practices, personal protective equipment, facility construction and operations, and emergency plans.

Control banding requires ongoing attention to be successful.
For example, the biosafety system worked reasonably well in biolabs from the 1980’s until 2020. However, the Covid experience has shown how delicate control bands can be when an exotic hazard arises or when you leave the clinical or lab settings.
Would We Handle DMM More Safely Today? A RAMP review

**Recognize:**

GHS information available for DMM varies depending on the source used.

**Assess:**

How would we rate the risk of working with DMM today? Has the way it is used now reduced its risk?

**Manage:**

PPE selection: today, nitrile gloves are the most common laboratory hand protection; however, they provide similar protection against DMM as latex gloves.

**Plan for Emergencies:**

Do lab workers understand the signs and symptoms of exposures to the chemicals they work with?

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**GHS Information on DMM from PubChem**

**European Chemicals Agency (ECHA)**

**NITE-CMC (Japan)**

A risk assessment considers:
1) the likelihood of a risk scenario
2) magnitude of the risk
3) the people who suffer the harm
4) the benefit of the work to be performed
Audience Poll #3

What is your primary approach to communicating your lab safety practices to people in your lab?

1. We put alerts in an Electronic Lab Notebook system
2. We rely on paper Standard Operating Procedures and Lab Guidance
3. We place notices and signs pointing out specific hazards in the lab
4. We focus on word of mouth and chemical intuition
RAMP Information Tools in 2022

Recognize Hazards:
• The Globally Harmonized System: Chemical labels and Safety Data Sheets
• Identify process and human hazards

Assess Risks:
Data that can help rank hazards
• Chemical literature
• Informal communications
• Crowd sourced information

Minimize Risks / Manage Safety:
• Control bands for ventilation, training and PPE
• Maintain worker's situational awareness

Plan for Emergencies / Protect the Environment:
• Connect with institutional emergency planning services
• Understand lab waste disposal services

Lessons Learned are how we continue to improve our safety practices
The Good News: 21st Century RAMP Tools

1. Educational resources: Free ACS Safety materials based on RAMP
   • On line courses
   • Youtube videos
   • Best Practice workshops

2. Brainstorming: A Periodic table of safety elements for brainstorming during risk assessments

3. Documenting: Draft "What if" discussion template from the Committee on Chemical Safety
Organizing and Sharing Your Lab Safety Information

Video is available to view on ACS Chemical Safety Youtube Channel
Managing Your Safety Information FAIRly

- Good lab risk assessments are:
  - Collaborative
  - Inclusive
  - Documented
  - Shared FAIRly

FAIR Data is:
- Findable
- Accessible
- Interoperable
- Reusable
Who is involved in developing and reviewing your laboratory risk assessments?

1. The person who writes the SOP for procedure
2. Everyone who handles the chemicals involved in a SOP
3. Everyone in the lab, because they could be impacted by a safety incident even though they aren't conducting the procedure involved
4. Our emergency responders who are expected to provide assistance in case of an incident
I worked as a lab tech in an industrial hygiene lab in the early 1980's.

I collected airborne dust in the Barre, Vermont granite industry to assess worker exposure to granite dust.

We used dimethyl formamide to dissolve the filters that the dust collected on to prepare them for X-ray diffraction analysis.
My Experience

• One day, when I went to dissolve about 50 filters, the hood was crowded with other materials.
• I decided to set the ultra-sonicator up at the front of the hood, which meant that I couldn't close the sash.
• After about 20 minutes, I got dizzy, so I went and got a respirator; I completed the work with no further symptoms.
• However, when I went out to play softball that evening and started exercising, I suddenly got very dizzy, felt faint and had to lie down. I didn't seek medical attention.
My Investigation into How I was Exposed

- Based on my literature review, my exposure could have come from inhalation or skin exposure (I was wearing latex gloves), or both.
- Working at the edge of the hood meant that hood containment was compromised, but I did not notice any odor.
- However, DMF has poor odor warning properties, so it's not clear what level of exposure was respiratory; my guess is that the exposure was primarily inhalation, although it could have been both skin and respiratory.

<table>
<thead>
<tr>
<th>Property</th>
<th>DMF</th>
<th>Acetone</th>
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<tbody>
<tr>
<td>Lower odor detection</td>
<td>0.47 ppm</td>
<td>13 ppm</td>
</tr>
<tr>
<td>Upper odor detection</td>
<td>100 ppm</td>
<td>62 ppm</td>
</tr>
<tr>
<td>OSHA PEL (8 hours)</td>
<td>10 ppm</td>
<td>1000 ppm</td>
</tr>
<tr>
<td>NIOSH STEL (15 minutes)</td>
<td>250 ppm (skin)</td>
<td>1250 ppm</td>
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</tbody>
</table>
The Outcome

• Fortunately, I was a healthy male in my 20's and noticed no symptoms after that day.
• Pubchem now notes that "There is limited evidence that dimethylformamide is carcinogenic for human beings." I have no reason to believe that my short term exposure had this health impact.
• In 2022, GHS data on DMF is more easily available, but still requires interpretation.

DMF PubChem Entry


Flashpoint = 136 degrees F
My Lessons Learned

1. Fume hood containment is delicate – make room in the hood before relying on it for protection.

2. Similarly, review glove protection information for the chemicals you work with.

3. Investigate signs and symptoms of exposure of the chemicals before beginning work.

4. Shared lab equipment leads to housekeeping and safety concerns – coordinate with others to help everyone get their work done.
Sharing Your Lessons Learned

- For incidents involving two or more chemicals: CAS Chemical Safety Library (CSL) [https://safescience.cas.org/](https://safescience.cas.org/)
Your Opportunity

• The ACS Division of Chemical Health and Safety, in partnership with CAS, the Division of Chemical Information and CSHEMA to explore how to improve sharing of incident information and Lessons Learned among laboratories.

• If you are interested in joining us in a focus group to discuss the lab manager's perspective on this opportunity, please contact me at Ralph Stuart at membership@dchas.org
Closing Thought: The Advantages of RAMP

The RAMP approach has several specific advantages over traditional rule based safety:

- **It separates** identification, prioritization and management considerations (too often, the control banding *tail* wags the assessment *dog*)
- **RAMP includes** emergency planning (*because there are humans in the lab, so there will be errors*)
- **The RAMP approach** organizes the lab safety discussion among diverse stakeholders

RAMP helps everyone answer these 5 questions about their labwork:

1. **What are the Chemical Health, physical, & environmental and Process Hazards?**
   - The GHS labelling elements (Pictograms, Signal Words and Hazard Statements) are the key to identifying chemical hazards associated with your work.
   - Look especially for the “DANGER” signal word to identify high hazard chemicals – these are chemicals that require special planning.

2. **What Ventilation Do I Need?**
   - How much ventilation you need will depend on the fire and toxicity hazards are associated with the demonstration or experiment.
   - The room ventilation choices are:
     - No Lab Ventilation: Required (0-3 air changes/hour)
     - General Lab Ventilation (6 or more air changes/hour)
     - Local Ventilation in Fume Hood (>40 ACH for gases)
     - Outdoor Settings (variable air changes, dependent on wind speed and direction)
   - Lab ventilation means that there is no air recirculated

3. **What PPE Do I Need?**
   - Selecting Personal Protective Equipment (PPE) requires balancing three factors:
     1. The hazards of the chemicals being handled.
     2. The scenario of concern (the environment).
     3. The fit of the PPE on the person using it.
   - Precautionary: buy PPE that is not only in the present but for any future members who will be involved in handling the chemical.

4. **What Emergencies Should I Plan For?**
   - Planning Tips
     - If anyone is in danger, call 911 for assistance.
     - Be sure the demonstration appoints a “safety officer” to keep control in uncontrolled.
     - If your emergency plan includes a chemical spill, be sure to have hands-on training before the event.
     - Ensure the spill kit is stocked with appropriate materials.
     - Make sure items are accessible

5. **What Will I Do With Wastes?**
   - It is important to check with the host of the demonstration before the event to know what waste streams they are prepared to accept.
   - Consider These Wastes:
     - Chemicals
     - Biological materials
     - Contaminated lab materials
     - Glassware
     - General trash & recycling
Thank You!

- My question for you: Can you put one thing you learned today in the chat?
- What questions do you have?