



# A Practical Approach to NFPA 45

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**Keene**  
STATE COLLEGE

Wisdom to make a difference.

**August, 2016**

# Reviewing the methanol fire scenario

1. Replacing the Hazard
2. Engineering Controls: Fume Hood?
3. Training and Oversight
4. Personal Protective Equipment
5. Emergency Planning and Response



Figure 3. Methanol igniting on the day of the incident<sup>8</sup>

# Are we doing better 8 years later?

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## Recent demonstration methanol fires:

1. New York City, January 2014
2. Reno, Nevada, September 2014
3. Denver, Colorado, September 2014
4. Raymond, Illinois, October, 2014
5. Chicago, November, 2014
6. Tallahassee, Florida, May 2015
7. Washington, DC, October 30, 2015



October 2014

### Key Lessons for Preventing Incidents from Flammable Chemicals in Educational Demonstrations

Eliminating Flash Fire Hazards by Substituting or Minimizing the use of Flammable Chemicals and Performing an Effective Hazard Review Will Prevent Injuries

#### Key Lessons Summarized:

- Due to flash fire hazards and the potential for serious injuries, do not use bulk containers of flammable chemicals in educational demonstrations when small quantities are sufficient
- Employers should implement strict safety controls when demonstrations necessitate handling hazardous chemicals — including written procedures, effective training, and the required use of appropriate personal protective equipment for all participants
- Conduct a comprehensive hazard review prior to performing any educational demonstration
- Provide a safety barrier between the demonstration and the audience



CSB • Key Lessons for Preventing Incidents from Flammable Chemicals in Educational Demonstrations

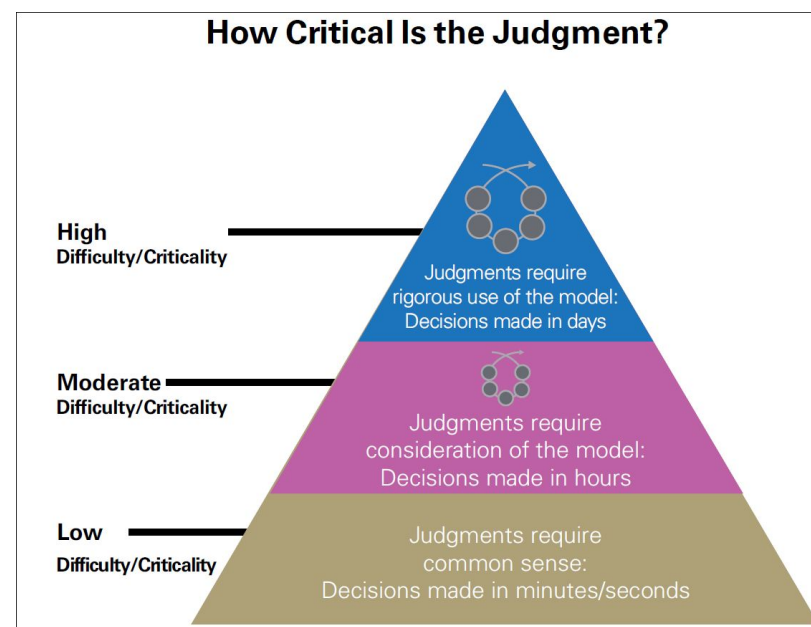
# The Challenge of Risk Assessment: Multiple Levels of Judgment

## Individual Expertise



Identifying and Evaluating  
Hazards in Research  
Laboratories

## Review Required



Guidance for Chartered  
Accountants (CAs) in a Global  
Economy

# The Resulting Requirement: NFPA 45 Chapter 12, 2015

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## Instructor Responsibilities

1. Documented hazard risk assessment
2. Safety briefing for students prior to the start of each experiment to review the hazards of the chemicals used, the PPE required for the experiment, and review emergency procedures.
3. **The Big Deal:** These requirements are protocol specific, not a generic set of rules for lab classes



# The Scope of NFPA Requirement

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- **3.3.13 Educational Laboratory Unit.**  
...students through the twelfth grade...
- **3.3.31 Instructional Laboratory Unit.**  
...education past the 12th grade and before post-college graduate-level instruction ...Experiments and tests conducted in instructional laboratory units are under the direct supervision of an instructor .
- Laboratory units used for graduate or post-graduate research are not to be considered instructional laboratory units.
- Instructor includes science teachers, assistant or associate professors, lecturers, substitute teachers, and teaching assistants



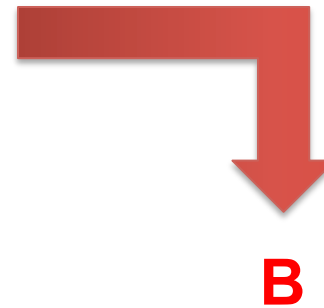
# An Artist's Rendering of the Change

A



So how do we  
move from A to B?

Risk Assessment



B

**HOW TO DO A LAB DEMO SAFELY** In response to recent accidents in the classroom, here is a guide for performing experiments or demonstrations involving open flames, fire, or the use of flammable, reactive, toxic, or corrosive chemicals.

Preparing for demos or experiments:

- Determine educational goals and how the activity will meet them.
- Perform hazard and risk assessments.
- Provide a safety briefing to students.

Store bulk quantities of chemicals in a locked separate room or cupboard. Dispense only necessary quantities to labeled, sealable bottles before students arrive.

Do not block exit.

Use a fume hood if possible. If not, place an impact-resistant barrier between the demo and students. If a barrier is not possible, ensure students are at least 10 feet (3 meters) away from the demo.

Wear appropriate personal protective equipment.

**PREP** **EXIT**

NOTE: Instructors in teaching labs shall be trained and knowledgeable in fire safety procedures, emergency plans, the hazards present in the lab, the appropriate use of personal protective equipment, and how to properly conduct a hazard risk assessment.  
SOURCE: National Fire Protection Association Standard 45, 2013 Edition

# Current Chemical Risk Assessment Education

- **Caveat emptor:** Chemistry textbooks and laboratory manuals provide an overview of generic rules, followed by "see the MSDS".
- For example, Wikipedia provides links to random MSDS sources; **Linkrot** is a serious problem as some sources are kaput, many are dated.



## Material Safety Data Sheet [\[ edit \]](#)

The handling of this chemical may incur notable safety precautions. It is highly recommended that you seek the Material Safety Datasheet (**MSDS**) for this chemical from a reliable source and follow its directions.

- [Mallinckrodt Baker](#)
- [Science Stuff](#)

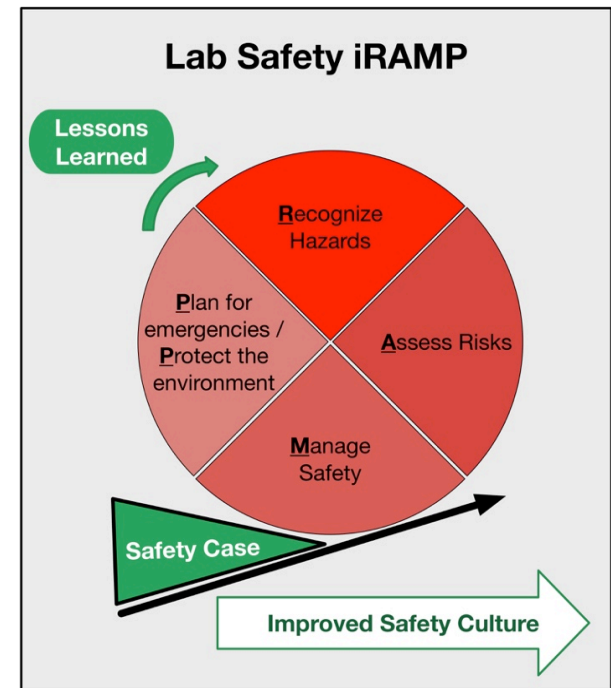


# The RAMP approach to Building a Lab Safety System

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Developing a Chemical Safety system involves addressing six elements:

1. EHS Culture
2. Hazard Identification
3. Risk Assessment
4. Managing Safety
5. Planning for Emergencies
6. Protecting the Environment



From Stuart and  
McEwen. 2016

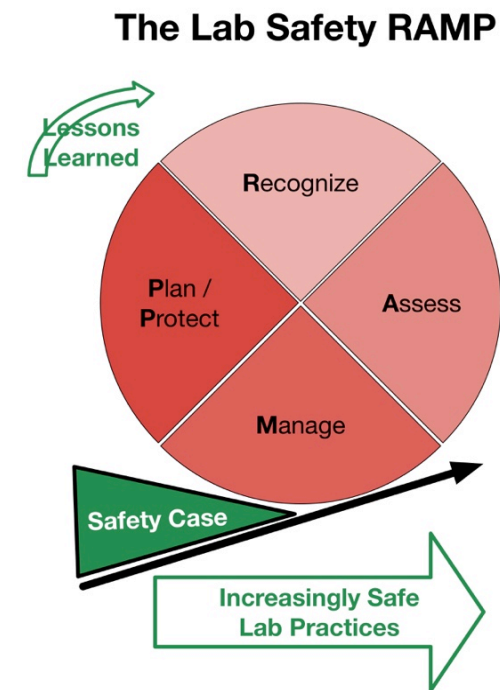
# A Sample Procedure: CO<sub>2</sub> Tracer Gas Process

Use fire extinguishers to raise CO<sub>2</sub> concentrations across the lab and then measure its decay in different locations.



# The RAMP for CO<sub>2</sub> Release

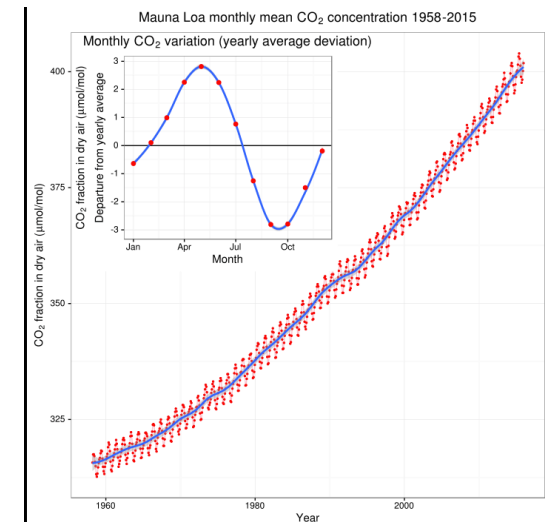
- **Recognize hazards:** CO<sub>2</sub> exposures, noise, ergonomics, static electricity
- **Assess Risks** (next page)
- **Manage Safety** (next page)
- **Prepare for emergencies:** monitor CO<sub>2</sub> concentrations, don't work alone
- **Protect the Environment:** CO<sub>2</sub> is greener than solvents
- **Review Lessons Learned:** improve the management system



# Assessing Risks: CO<sub>2</sub> concentrations

- General outdoor environment baseline: **400 ppm**
- Office spaces average between **600** and **800** ppm; comfort issues occur over **1000** ppm
- OSHA PEL: **5000** ppm over 8 hours
- Target for lab vent work: **10,000** ppm
- NIOSH IDLH: **40,000** ppm

Target concentration is 10,000 ppm for 5 minutes or less; we have hit 50,000 ppm



[Atmospheric CO<sub>2</sub> concentrations measured at Mauna Loa Observatory](#) from 1958 to 2015

# The Safety Management System

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Organic class lab,  
about 40 ACH

## For People:

- **CO<sub>2</sub> exposure:** size the extinguisher(engineering)
- **Noise:** wear hearing protection (PPE)
- **Electrostatic discharge:**  
put the extinguisher on the floor (training)
- **Ergonomics:** use carts (engineering)
- **Eye protection:** dry ice flies everywhere (PPE)
- **Gloves:** in case the hose leaks (emergency planning)

## For lab equipment and computers:

- **Dry Ice Spatter:** Cover equipment to prevent dry ice from landing on it (engineering)

# CO<sub>2</sub> RAMP and Bowtie

## Assessing general ventilation effectiveness in the laboratory

The goal of a laboratory's general ventilation system is to control airborne contaminants below concentrations of concern while maintaining a comfortable environment. One concern while managing general laboratory ventilation is how uniformly the room is ventilated. We have observed that, depending on the configuration of the ventilation supply and exhaust points relative to the geometry of the room, there may be areas of a laboratory that are less well-ventilated than others. This factor must be assessed when assigning minimum general ventilation rates for that lab.

In order to determine how effective general ventilation systems are in existing laboratories on the Cornell campus, we have measured the concentration decay rates of carbon dioxide at a variety of locations in the room after raising the CO<sub>2</sub> level across the room above 10,000 parts per million. This paper describes the reasons for this work, the method we use, and reports our observations about this approach to assessing laboratory ventilation effectiveness.

By Ralph Stuart,  
Ellen Sweet,  
Aaron Batchelder

### INTRODUCTION

General laboratory ventilation relies on dilution to prevent accumulation of significant levels of volatile chemicals while providing temperature and odor control to maintain a comfortable environment for the occupants. It is important to note that general laboratory ventilations is designed to control small sources of volatile chemicals, such as exhausts from instrumentation or bench-top use of small quantities of low hazard chemicals. More significant emission sources (as determined by a risk assessment of the process

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causing the emission) and emergencies are not expected to be controlled by the general ventilation system. Laboratory chemical hoods should be used to control large planned releases, while spills and other unexpected releases are better addressed by appropriate laboratory emergency planning and response procedures.

An emerging concern is that general ventilation represents the most energy intensive aspect of laboratory operations, thereby creating sustainability concerns for laboratory facilities. In a previous article, we described how the Cornell University Laboratory Ventilation Management Plan (LVMP) balances safety and sustainability concerns to define a laboratory ventilation program based on continuous improvement.<sup>1</sup> In this program, the general ventilation rate of campus laboratories is an important parameter of interest, with the goal of reducing them as much as prudently possible in order to enhance laboratory sustainability.

A complicating factor in implementing this strategy is that the pattern of air movement through a laboratory room is as important as the quantity of air moved in controlling volatile chemical concentrations. Thus, simple answers to the question of "How much general laboratory ventilation is enough?" are not readily apparent, beyond "It depends". For this reason, an important element of the Cornell LVMP is a general ventilation control banding

system.<sup>2</sup> The key factors in the control banding process are: chemistry being performed in the laboratory; house-keeping practices by the lab-occupants; and the ventilation effectiveness within the laboratory. In this context, "ventilation effectiveness" refers to the relative uniformity of the decay of air contaminants within the laboratory.

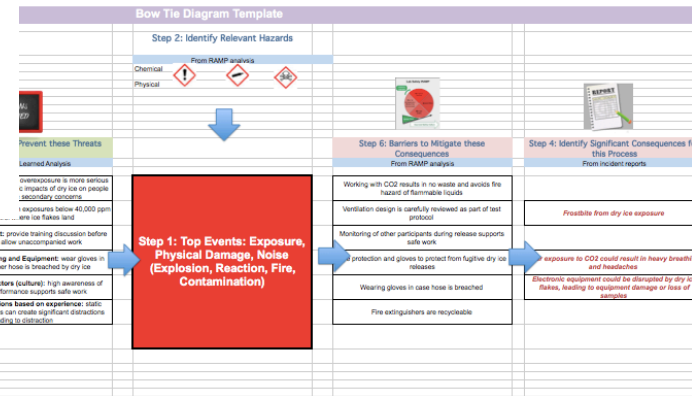
In implementing this control banding system, we identified laboratories where ventilation effectiveness was a potential concern. For this reason, we needed a reproducible approach to assess this factor in laboratories. One of the challenges we faced in evaluating this concern is that laboratory ventilation systems operate at three distinct scales. Shown schematically in Figure 1, these scales are:

- air supplied and exhausted at the building-wide level occurs at the macroscale;
- air movement within the laboratory room itself is at the mesoscale; and
- air movement in the area of a local exhaust device, such as laboratory chemical hood, are at the microscale.

Macroscale operations are described by parameters such as pressure relationships between areas of the building and primarily managed through laboratory design standards. Similarly,

The IRAMP model for Lab Chemical Safety (based on Hill and Finster, 2016 and Stuart and McEwan, 2016)			
<b>Recognize Chemical Hazards</b>			
Chemical name and concentration	Amount	GHS hazards	Signal word
Carbon dioxide	5 to 10 pounds	compressed gas	warning
		irritant	warning
		acute toxicity	warning
<b>Assess Process Risks (i.e. prioritize risks that will arise as the process proceeds)</b>			
Physical risks:	Temperature range	Pressure	
Other (describe)	cryogenic solids	pressurized container	
Circle the significant process physical risks:	pressure release	Warning	
Chemical incompatibilities identified: CO <sub>2</sub> aerosols can disrupt electronic instrumentation			
Circle the significant process chemical risks:		target Organs: eyes, respiratory	
Significant process risk(s) to manage:	Contamination		
<b>Manage Safety</b>			
Substitution	Greener than using solvents as a tracer gas		
Engineering Controls	(replace italicized elements with specific requirements)		
Storage requirements	general storage	ventilation required	
Administrative Controls (replace italicized elements with specific requirements)			
Training Required	Practice procedure		
Oversight	Requires supervisor presence		
Personal Protective Equipment	Eye protection from dry ice particles	Hand protection from dry ice particles	
<b>Prepare for Emergencies</b>			
Probable emergencies	Fire	Medical emergency	Chemical spill
Emergency equipment required	unlikely	standard medical response appropriate	unlikely
<b>Protect the Environment (circle necessary disposal options)</b>			
Refill depleted extinguishers			

Machine or tool hazards	<b>Safety Management:</b> provide training discussion before work, do not allow unaccompanied work <b>Emergency Planning and Equipment:</b> wear gloves in case extinguisher hose is breached by dry ice <b>System Safety Factors (culture):</b> high awareness of ventilation performance supports safe work <b>Other considerations based on experience:</b> static electricity discharges can create significant distractions leading to distraction
Noise levels during CO <sub>2</sub> release are significant	



Template available at  
<http://dchas.org/bcce2016/>

SOP

Hazard Risk Assessment

Bowtie Diagram

# Scope of this Discussion

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- **Included:**

- Laboratories operating at OSHA **"lab scale"**
- Teaching labs in secondary or undergrad education (and some research labs)
- Lab support includes faculty and staff who oversee the work

- **Not Included:**

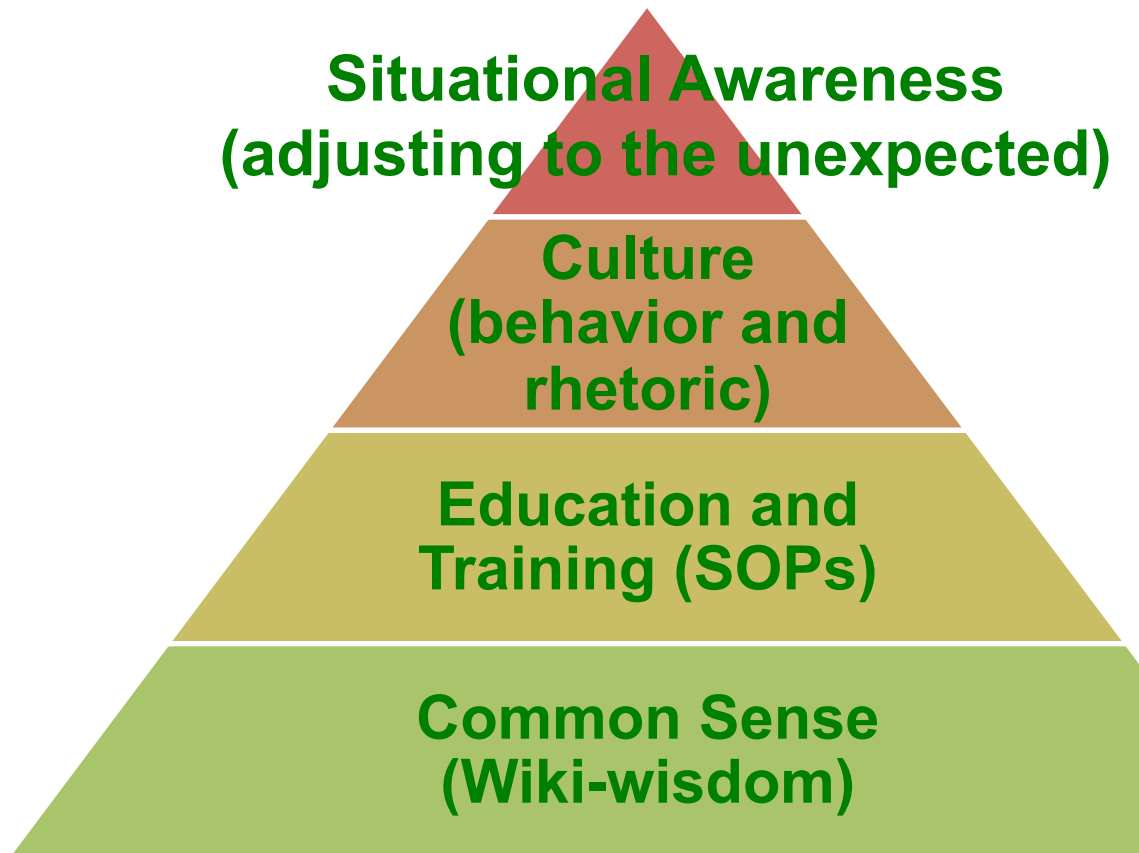
- People who rely on the name of the chemical to determine the hazard (i.e. the public and emergency responders)
- Complex research labs where process and hazards evolve unpredictably
- Work with chemicals beyond OSHA lab scale



# The Good News: Lab Safety is a Creative Process

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**Safe Decision-Making  
rests on 4 elements:**



<b>Bloom's Taxonomy</b>
Creating
Evaluating / Analyzing
Understanding / Applying
Remembering



# References

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1. *The Safety “Use Case”: Co-Developing Chemical Information Management and Laboratory Safety Skills*, Stuart and McEwen, Journal of Chemical Education  
<http://pubs.acs.org/doi/abs/10.1021/acs.jchemed.5b00511>
2. *Safety Data Sheets: Information that Could Save Your Life*, Rohrig, ChemMatters Magazine.  
<http://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/2015-2016/december-2015/safety-data-sheets.html>
3. *Assessing general ventilation effectiveness in the laboratory*, Stuart, Sweet and Batchelder. Journal of Chemical Health & Safety, November/December, 2014
4. iRAMP Template available at <http://dchas.org/bcce2016/>