The National Academies of
SCIENCES · ENGINEERING · MEDICINE

Safe Science: Promoting a Culture of Safety in Academic Chemical Research

Douglas Friedman
Board on Chemical Sciences and Technology

Briefing to the
ASEE National Meeting of
Engineering Research Deans

March 9, 2016

Celebrating 50 Years 1964-2014
NATIONAL ACADEMY OF ENGINEERING

The Task at Hand

- Examine laboratory safety in **chemical research in non-industrial settings**.
- Compare practices and attitudes in these settings with knowledge about promoting safe practices from the **behavioral science** literature.
- Describe, identify the strengths and shortcomings of, and provide guidance on, the roles of the current **hierarchy of actors** responsible for laboratory safety in U.S. education.
- Examine knowledge from the behavioral sciences and experience with **safety systems from other sectors** (such as industrial research facilities, nuclear energy, aviation, and health care) for key attributes of successful safety systems and cultures.
- Provide guidance on **systems and tools** that might be established, maintained, and utilized to raise the overall safety performance.

Why?

- Rise in the incidence of serious and sometimes fatal accidents in university chemistry research laboratories, particularly over the past two decades
    - Notable incidents
        - Dartmouth University – 1996
        - UCLA – 2008
        - Texas Tech University – 2010
- Serious accidents in research labs are not limited to academia
- These incidents have evoked a broad range of institutional responses
- *Deficient safety culture identified as a primary cause*

The Study Team:
Broad Community Engagement

Committee

H. Holden Thorp (*Chair*), Washington University in St. Louis

David M. DeJoy (*Vice-Chair*), University of Georgia

John E. Bercaw, NAS, California Institute of Technology

Robert G. Bergman, NAS, University of California, Berkeley

Joseph M. Deeb, ExxonMobil Corporation,

Lawrence M. Gibbs*, Stanford University

Theodore Goodson, III, University of Michigan

*Resigned June 10, 2014

Principal NRC Staff

Douglas Friedman, Study Director

Toby Warden, Associate Director

Andrew S. Imada, A. S. Imada & Associates

Kimberly Begley Jeskie, Oak Ridge National Laboratory

Bradley L. Pentelute, Massachusetts Institute of Technology

Karlene H. Roberts, University of California, Berkeley

Jennifer M. Schomaker, University of Wisconsin–Madison

Alice M. Young, Texas Tech University

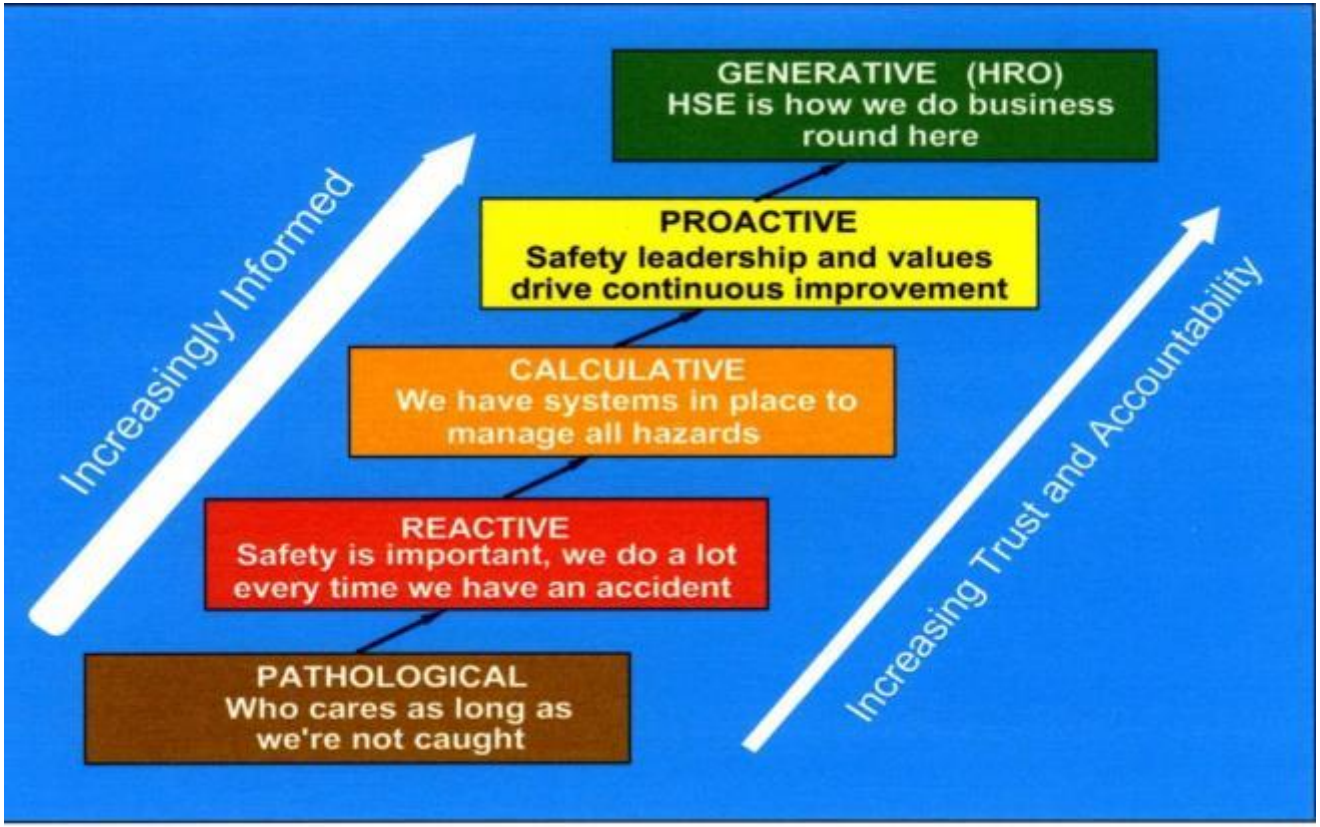
Key

University Administration
Chemists
Social and Behavioral Scientists
EHS Professionals

Organizational Change:
Cultural Topology

Pathological	Bureaucratic	Generative
Power oriented	Rule oriented	Performance oriented
Low cooperation	Modest cooperation	High cooperation
Messengers shot	Messengers neglected	Messengers trained
Responsibilities shirked	Narrow responsibilities	Risks are shared
Bridging discouraged	Bridging tolerated	Bridging encouraged
Failure→ scapegoating	Failure→ justice	Failure→ inquiry
Novelty crushed	Novelty→ problems	Novelty implemented

Culture Topology – Focused on Safety



Hudson, 2007; Parker et al., 2006

What is Safety Culture?

- Refers to an organization's shared values, assumptions, and beliefs specific to workplace safety or, more simply, the importance of safety within the organization **relative to other priorities**.
- Arises not because of a set of rules, but because of a **commitment to safety throughout an organization**
- Supports the free exchange of safety information, emphasizes learning and improvement, and assigns greater importance to identifying and **solving problems rather than placing blame**
- **High importance is assigned to safety all the time**

Conclusions and Recommendations

FOCUS ON CHEMICAL RESEARCH

Four Core Categories

- **Institution-Wide Dynamics and Resources**
- **Research Group Dynamics**
- **Data, Hazard Identification, and Analysis**
- **Training and Learning**

Institution-Wide Dynamics and Resources
Conclusions

- [C1] If laboratory safety is an unquestioned core value and operational priority for the institution, then safety will never be traded for research productivity.

- [C2] University policies and resource allocations have a strong impact on a department's ability and willingness to provide for a strong, positive safety culture. If an institution or individual laboratory wants to develop and sustain a safe and successful research program, then it needs to consider the resources it has available for safety and explore research options and requirements accordingly.

Institution-Wide Dynamics and Resources Recommendations

- **Recommendation 1:** The president and other institutional leaders must actively demonstrate that safety is a core value of the institution and show an ongoing commitment to it.

- **Recommendation 2:** The provost or chief academic officer, in collaboration with faculty governance, should incorporate fostering a strong, positive safety culture as an element in the criteria for promotion, tenure, and salary decisions for faculty.

Institution-Wide Dynamics and Resources Recommendations

- **Recommendation 3:** All institutions face the challenge of limited resources. Within this constraint, institutional head(s) of research and department chairs should consider the resources they have available for safety when considering or designing programs, and identify types of research that can be done safely with available and projected resources and infrastructure.
- **Recommendation 4:** University presidents and chancellors should establish policy and deploy resources to maximize a strong, positive safety culture. Each institution should have a comprehensive risk management plan for laboratory safety that addresses prevention, mitigation, and emergency response. These leaders should develop risk management plans and mechanisms with input from faculty, students, environmental health and safety staff, and administrative stakeholders and ensure that other university leaders, including provosts, vice presidents for research, deans, chief administrative officers, and department chairs, do so as well.

Research Group Dynamics
Conclusions

- [C3] Contribution and engagement by both principal investigators and by researchers through an open and ongoing dialogue are critical to creating a strong, positive safety culture. Safety culture is more likely to be sustained when safety issues are discussed broadly and frequently as an integral part of the research training and development process.

- [C5] A research group with a strong, positive safety culture engages with environmental health and safety personnel collaboratively.

Research Group Dynamics

Conclusions

- [C4] There are several key attributes related to research group dynamics that contribute to the advancement of the laboratory safety culture. A strong, positive safety culture:
  - includes open communication about safety as a key element that is sought out, valued, and acted upon;
  - values learning and continuous improvement with respect to safety;
  - includes regular safety communication, for example, "safety moments," in academic research events (e.g., seminars, group meetings, doctoral defenses, and teaching); and
  - empowers student and research trainees to have a "voice" and maintain an environment that encourages raising safety concerns freely without fear of repercussions.

Research Group Dynamics
Recommendations

- **Recommendation 5:** Department chairs and principal investigators should make greater use of teams, groups, and other engagement strategies and institutional support organizations (e.g., environmental health and safety, facilities), to establish and promote a strong, positive, safety culture.

- **Recommendation 6:** Department chairs should provide a mechanism for creating a robust safety collaboration between researchers, principal investigators, and environmental health and safety personnel.

Data, Hazard Identification, and Analysis Conclusions

- [C6] Information is a key input to establishing and promoting a strong, positive safety culture. Incident and near-miss reports are important learning tools for laboratory safety, but presently are not effectively reported, compiled, analyzed, and disseminated within the research community. To ensure that useful data are available, a change in reporting and the availability and sharing of information is necessary.

- [C7] Routine hazard analysis is a critical component in research planning and execution. It represents an element of a strong, positive safety culture. Comprehensive hazard analysis and the use of engineering controls are especially important for experiments that are new to the individual and/or are being scaled-up.

Data, Hazard Identification, and Analysis Recommendations

- **Recommendation 7:** Organizations should incorporate non-punitive incident and near-miss reporting as part of their safety cultures.
  - The American Chemical Society, Association of American Universities, Association of Public and Land-grant Universities, and American Council on Education should work together to establish and maintain an anonymous reporting system, building on industry efforts, for centralizing the collection of information about and lessons learned from incidents and near misses in academic laboratories, and linking these data to the scientific literature.
  - Department chairs and university leadership should incorporate the use of this system into their safety planning. Principal investigators should require their students to utilize this system.

Data, Hazard Identification, and Analysis Recommendations

- **Recommendation 8:** The researcher and principal investigator should incorporate hazard analysis into laboratory notebooks prior to experiments, integrate hazard analysis into the research process, and ensure that it is specific to the laboratory and research topic area.

Training and Learning

- [C8] A high-quality training program is an important element of a strong, positive safety culture.
- [C9] Classroom and online training is necessary but not sufficient to ensure knowledge, skills, qualifications, and abilities to perform safely in a laboratory environment and to establish a strong, positive safety culture.

- **Recommendation 9**: Department leaders and principal investigators, in partnership with environmental health and safety personnel, should develop and implement actions and activities to complement initial, ongoing, and periodic refresher training. This training should ensure understanding and the ability to execute proper protective measures to mitigate potential hazards and associated risks.

Recommendations Recap

What Can We Do?

1. Institution leaders must **actively demonstrate** that safety is a core value.
2. Leaders should **include fostering a positive safety culture** in criteria for faculty promotion, tenure, and salary decisions.
3. Leaders should **consider what research can be done safely,** given resources available.
4. Institutions should **have comprehensive risk-management plans** for lab safety.
5. Department chairs and principal investigators (PIs) should **use engagement strategies and institutional support** to promote a strong safety culture.
6. Department chairs should **promote robust safety collaborations** among PIs, researchers, and safety professionals.
7. ACS and other organizations should **establish and maintain** an incident and near-miss reporting system.
8. Researchers should **incorporate hazard analysis** into lab notebooks and research processes.
9. Department chairs and PIs should **develop lab-centric activities** to complement other safety training.

Paraphrasing of recommendations from Chemical and Engineering News (2014), 92(41), 7.

Complexities of Student Perceptions of Laboratory Safety

Acknowledgments

Thanks to all of the individuals who shared information during the study process, as well as those who reviewed the draft report.

Particularly thanks to the sponsors of the study: the National Science Foundation, the U.S. Department of Energy, the National Institute of Standards and Technology, ExxonMobil Chemical Company, E. I. du Pont de Nemours, and Company, and the American Chemical Society.

http://dels.nas.edu/safescience

This material is based upon work supported by the National Science Foundation under Grant No. CHE-1215772, the U.S. Department of Energy under Award Number DE-SC0007960, the National Institute of Standards and Technology under contract number SB1341-12-CQ-0036/13-100.

Thank you.

http://dels.nas.edu/safescience

Contact us at:

BCSTSafety@nas.edu

Douglas Friedman
dfriedman@nas.edu