



A guide to implementing a
SAFETY CULTURE
in our universities



ASSOCIATION OF
PUBLIC &
LAND-GRANT
UNIVERSITIES

APLU Council on Research
Task Force on Laboratory Safety

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INTRODUCTION



LETTER FROM THE CHAIRS

April 2016

We can personally share that each of us has experienced tragedy at our present or former institutions involving accidents in university laboratory or field facilities. These accidents included the death of a laboratory research assistant in a flash fire at UCLA and an explosion in a lab that severely injured a graduate student at Texas Tech University.

In the wake of these tragedies, each of the institutions impacted worked diligently to examine and dramatically enhance lab safety efforts. UCLA, for example, created the UC Center for Laboratory Safety and has worked to become a national leader in the field. Texas Tech University implemented a near miss reporting system so that the institution could respond to potential hazards, unsafe conditions, and unsafe work habits, and to encourage faculty and students to take active roles to identify and ameliorate hazards and risks necessary to their work. It is critical that this commitment spread throughout academia.

As educational institutions and research universities, faculty across the nation should be at the forefront of embracing this culture of safety and adopting or developing best practices that makes this culture foundational to each of our institutions. The discovery enterprise can involve risk, but it is incumbent on all of us to embrace the idea that the culture of safety is foundational to our educational mission, the discovery process, and responsible conduct of research.

We call on every institution within APLU to embrace a renewed commitment to improve the safety culture for all academic research, scholarship, and teaching. We ask that you publicize your commitment and expectations within your institution. We ask that all academic institutions look beyond the traditional research lab to embrace a commitment to improving safety in the lab, in the teaching classroom, and in the field. Ideas, innovations and best practices are readily available from your colleagues at UCLA, Texas



Tech and other institutions that have devoted significant time and resources to such efforts.

APLU formed the Task Force on Laboratory Safety to provide research universities with recommendations and guidance on the most appropriate strategies to help enhance the culture of laboratory safety on each campus. The task force, which APLU created in coordination with the Association of American Universities (AAU), American Chemical Society (ACS), and Council on Governmental Relations (COGR), is comprised of senior

research officers, environmental and health safety officers, faculty, and industry and national lab representatives.

As you will see in this guide, our task force has articulated a path forward for each of your institutions to explore that will best suit where you are on the culture of safety continuum.

Now is the time for APLU, AAU, and all of our institutions to assume a proactive leadership role. We hope that you will make use of the information and resources here to lead your institution forward.

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CALL TO ACTION

The Task Force on Laboratory Safety calls on all universities to embrace a renewed commitment to improving the culture of safety for all academic research, scholarship, and teaching. We ask that college and university presidents publicize their commitments and expectations within their institutions. We encourage all academic institutions to look beyond the traditional research laboratory to commit to improving safety in research and teaching laboratories; in shops, studios, and stages; in teaching classrooms; and in the field.

The Task Force further recommends that the Association of Public and Land-grant Universities (APLU) and the Association of American Universities (AAU), as the member associations of research universities, call upon all academic institutions to renew their commitment to improving the culture of safety for all academic research, scholarship, and teaching. We ask APLU and its Council on Research (CoR) to routinely recognize exemplary programs and to sponsor an annual safety culture award.

HOW TO USE THE GUIDE

About the task force

The Association of Public and Land-grant Universities (APLU) formed the Task Force on Laboratory Safety¹ to provide research universities with recommendations and guidance on the most appropriate strategies to enhance a culture of laboratory safety. The task force, which APLU created in coordination with the Association of American Universities (AAU), the American Chemical Society (ACS), and the Council on Governmental Relations (COGR), is comprised of senior research officers, environmental health and safety officers, faculty, and industry and national laboratory representatives.

Significant events in recent years, including the death of a laboratory research assistant and a laboratory explosion that severely injured a graduate student, have raised awareness and highlighted the need for a stronger culture of safety in our colleges and universities. In response to this national need, the Task Force on Laboratory Safety has:

- Actively reached out across the university and science communities to hear perspectives on strengthening the laboratory safety culture from over 20 organizations and 25 institutions;
- Synthesized recommendations from the National Academies of Sciences, Engineering, and Medicine (NASEM); the ACS; and the U.S. Chemical Safety and Hazard Investigation Board (CSB) into 20 actionable recommendations for implementing and sustaining a culture of academic and research safety; and
- Developed a national implementation strategy that draws on relevant reports and research to provide recommendations and a toolbox that each campus can use to improve safety within its own unique campus culture.

Purpose of the guide

This guide is a roadmap for a university-wide effort to strengthen a culture of safety. The guide has action steps, resources, and recommendations to help navigate the

¹ See the original [Task Force on Lab Safety Charter](#) and [Position Paper](#).

challenge of changing the culture of the institution.

Audience for the guide

The guide is intended for university presidents and chancellors who have made a renewed commitment to improve their institutional culture of safety, and it is intended for the campus leadership team that the president appoints to helm this effort. The task force encourages each institution to use the guide in ways that fit their unique institutional contexts.

RESOURCES IN THE GUIDE

Call to action

The Task Force on Laboratory Safety calls on all universities to embrace a renewed commitment to improving the culture of safety within all academic research, scholarship, and teaching. The task force asks that college and university presidents publicize their commitments and expectations within their institutions and that they look beyond traditional research in their commitment to improving safety in research and teaching laboratories; in shops, studios, and stages; in teaching classrooms; and in the field.

The task force further recommends that the Association of Public and Land-grant Universities (APLU) and the Association of American Universities (AAU), as the member associations of research universities, call upon all academic institutions to renew their commitment to improving the culture of safety for all academic research, scholarship, and teaching. The task force asks APLU's Council on Research (CoR) to routinely recognize exemplary programs and to sponsor an annual safety culture award.

Core values of safety

The task force has highlighted core values foundational to a culture of safety.

Recommendations to strengthen and promote a culture of safety

The task force has identified 20 recommendations for implementing and sustaining a culture of academic and research safety, primarily drawn from four foundational reports:

- Safe Science: Promoting a Culture of Safety in Academic Chemical Research (National Research Council, 2014)
- Creating Safety Cultures in Academic Institutions (ACS, 2012)
- Creating a Safety Culture (OSHA, 1989)
- Texas Tech Laboratory Explosion Case Study (CSB, 2010)

Analysis of recommendations with key resources

The recommendations are organized in four overarching categories: institution-wide dynamics and resources; data, hazard identification, and analysis; training and learning; and continuous improvement.

This guide includes an analysis showing the alignment of the 20 recommendations with foundational reports.

Toolbox for implementing a culture of safety

For each recommendation, the task force has provided reading lists, tools, strategies, illustrative examples, and/or best practices drawn from a community of stakeholders for implementing these recommendations. These resources were selected to help an appointed campus team navigate the process of strengthening their culture of safety. This list is not comprehensive, and the task force welcomes additions to the toolbox, which may be submitted [via online survey](#). The most up-to-date toolbox may be accessed at the [APLU website](#).

Actions that support a culture of safety

The task force has provided some actions that university community members can take to advance a culture of safety. These delineate the roles and responsibilities of presidents, other senior administrators, faculty, deans, department chairs, staff, and students.

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REPORT OVERVIEW

CORE INSTITUTIONAL VALUES FOUNDATIONAL TO A CULTURE OF SAFETY

The discovery process is critical to the scholarly activity of our research universities. Much university work involves laboratories, performing arts spaces, and field sites where faculty, students, and staff engage in discovery and innovation. Cutting-edge discovery can and does involve risk, and mitigating that risk is key for the safety of all participants. The way we conduct research, engage our students, and prepare the next generation of scholars requires that we ensure their health and well-being. Strengthening and supporting a culture of safety is as important to our discovery enterprise as is peer review, publication, grant

writing, mentoring, and educating; it is integral to the responsible conduct of research.

Safety is everyone's responsibility. Every institution has a responsibility to ensure a healthy and safe environment for their entire community (faculty, students, staff, and visitors). All members of the community have a responsibility for the safety of themselves and others. We may never be able to completely eradicate accidents and injuries, but we can instill a culture of safety in our academic and research enterprises that significantly minimizes the number and severity of such accidents.

Core Institutional Values Foundational to a Culture of Safety

1. Safety is everyone's responsibility. Each institution should commit to providing a campus environment that supports the health and safety practices of its community (faculty, students, staff, and visitors) and empowers the community to be responsible for the safety of others. A safe campus environment is a right of employment for all categories of employees. A safe campus learning environment is a right of all involved in education and research.
2. Good science is safe science. Safety is a critical component of scholarly excellence and responsible conduct of research.
3. Safety training and safety education are essential elements of research and education. They instill a culture of safety in the next generation of researchers and future faculty, and they are important for our students' career development and employability.
4. An improved culture of safety is necessary to truly reduce risk throughout the academic enterprise.
5. It is best to recognize that diverse methods and flexible approaches will be used by each institution to develop a strong culture of safety, unique to its situation.

RECOMMENDATIONS TO STRENGTHEN AND PROMOTE A CULTURE OF SAFETY

Recent significant accidents have raised awareness and highlighted the need for a national-scale response that strengthens a culture of safety on campuses. These accidents include the death of a laboratory research assistant in a flash fire², the death of an undergraduate student whose hair was caught in a spinning lathe in a mechanical workshop³, the severe injury of a graduate student in a laboratory explosion⁴, and the severing of a student's wrist in an equine farm accident⁵.

In response to these events, the National Research Council (NRC) of the National Academies of Science, Engineering, and Medicine (NASEM) and the American Chemical Society (ACS) released reports with recommendations for improving the campus laboratory culture of safety. The task force has drawn on these reports and others to identify 20 recommendations for universities to strengthen and support a culture of safety. These are organized in four overarching categories: institution-wide dynamics and resources; data, hazard identification, and analysis; training and learning; and continuous improvement.

² Trager, Rebecca. "UCLA Chemist to Stand Trial for Safety Violations Linked to Sheri Sangji Death." *Chemistry World* 1 May 2013. Royal Society of Chemistry. Web. 15 Sept. 2015.

³ Foderaro, Lisa. "Yale Student Killed as Hair Gets Caught in Lathe." *The New York Times*. *The New York Times*, 13 Apr. 2011. Web. 15 Sept. 2015.

⁴ U.S. Chemical Safety and Hazard Investigation Board. *Texas Tech University Laboratory Explosion: Case Study*. Case No. 2010-05-I-TX. Washington, DC, October 19, 2011.

⁵ Callahan, Joe. "UF Student's Hand Severed in Accident at Ocala Equine Facility." *Gainesville.com*. *The Gainesville Sun*, 23 Aug. 2010. Web. 15 Sept. 2015.

INSTITUTION-WIDE DYNAMICS AND RESOURCES

President/chancellor

1. Renews commitment to improve the culture of safety for all academic research, scholarship, and teaching.
2. Designates a campus lead and leadership team to begin the process. Considers appropriate committees to help implement a culture of safety, including a safety committee of faculty, Environmental Health and Safety (EH&S) officers, and other representatives who can provide formative feedback to researchers, educators, and staff.

The campus lead and leadership team

3. Conduct campus dialogues with stakeholders to develop a shared vision of safety that aligns with the institutional mission and to develop an action plan.
4. Develop effective safety policies, procedures, and management systems, and identify the resources necessary for implementation. Establish recognition and reward systems and integrate these into tenure and promotion, hiring, and annual performance reviews.
5. Clearly articulate the roles and responsibilities of all stakeholders.
6. With the faculty, embed safety communication in laboratories, classes, departments and throughout the wider campus.

7. With the faculty, work to create a trusting and safe culture. Encourage the development of a generative culture based on open dialogue, reporting, and learning from near misses, as described by the National Academy of Sciences.

Institution

8. Develops a risk assessment process for laboratory safety that is integral to all activities conducted in the laboratory or the field.
9. Establishes a unified administrative reporting model that connects responsibility for development and implementation of academic safety policies. The model should fall under one administrative pillar in the institution and should include faculty, EH&S officers, and administrative leaders.
10. Empowers undergraduate students, graduate students, postdoctoral fellows, and staff to voice safety questions and concerns to their faculty supervisors, EH&S offices, and/or safety committee.
11. Works to strengthen collegial and collaborative relationships between faculty and EH&S staff.
12. Works to enhance effective working relationships with first responders.

DATA, HAZARD IDENTIFICATION, AND ANALYSIS

Institution

13. Implements routine hazard analyses and includes them as integral components of

undergraduate and graduate education; thesis, dissertation, and funding proposals; and experimental design for all experiments.

14. Implements a process to report incidents and near misses so that the campus community can learn from these incidents.

TRAINING AND LEARNING

Institution

15. Provides laboratory safety education and training for students, faculty, EH&S staff, and department heads.
16. Ensures undergraduate and graduate science and engineering curricula include an emphasis on safe practices.

CONTINUOUS IMPROVEMENT

Institution

17. Conducts self-assessment and benchmarking using measures that can provide feedback on whether it is moving to a safer culture.
18. Develops a continuous improvement system that provides feedback, reassessment, and on-going training and learning opportunities.
19. Develops a system of accountability, including peer-to-peer accountability.
20. Promotes academic and industrial/government partnerships that allow academic researchers to learn from strong and well-developed safety cultures in industrial and government laboratories.

ANALYSIS OF RECOMMENDATIONS AND TOOLS

We strongly encourage institutions to refer to four⁶ key documents that discuss improving safety:

1. Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014)
2. Creating Safety Cultures in Academic Institutions (ACS, 2012)
3. Creating a Safety Culture (OSHA, 1989)
4. Texas Tech Laboratory Explosion Case Study (CSB, 2010)

⁶ For the alignment of the recommendations, we drew on two additional resources for Recommendation 20. These are *Laboratory Safety Attitudes and Practices: A comparison of academic, government, and industry researchers* (Schröder, I., et. al, 2015) and *The Safe Conduct of Research* (Battelle, 2014).



INSTITUTION-WIDE DYNAMICS AND RESOURCES

1. The president/chancellor renews commitment to improve the culture of safety for all academic research, scholarship, and teaching.

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

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.

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 2. Encourage every leader to become a proponent of safety and safety education, and to demonstrate this care for safety in their actions with other staff members and students.

Creating a Safety Culture (OSHA, 1989):

Obtain Top Management "Buy-in." This is the very first step that needs to be accomplished. Top managers must be on board. If they are not, safety and health will compete against core business issues such as production and profitability, a battle that will almost always be lost. They need to understand the need for change and be willing to support it. Showing the costs to the organization in terms of dollars (direct and indirect costs of incidents) that are being lost, and the organizational costs (fear, lack of trust, feeling of being used, etc.) can be compelling reasons for looking at needing to do something different. Because losses due to incidents are bottom line costs to the organization, controlling these will more than pay for the needed changes. In addition, when successful, you will also go a long way in eliminating organizational barriers such as fear, lack of trust, etc.: Issues that typically get in the way of everything that the organization wants to do.

TOOLBOX

Actions for the president/chancellor that help strengthen a culture of safety

Responsibility for fostering and sustaining a safe campus rests on all members of the university community, and the ultimate accountability rests with the president/chancellor.

1. Demonstrate that safety is a core value of the institution through public discussion of the importance of safety, by providing adequate resources, and by developing effective policies.

2. Understand that hazards exist not just in the labs of chemistry departments, but in other settings, such as other types of laboratories, performing arts spaces, art studios, and field research sites.
3. Appoint an institutional lead and leadership team responsible for facilitating the building of a culture of safety (include language on authority and accountability). The senior research officer might be the ideal appointee.
4. Be transparent on roles, responsibilities, and accountability.
5. Align the reward and recognition system with efforts to promote safety, attending to hiring, promotion, tenure, and salary decisions for faculty.
6. Assume ultimate responsibility for safety.

To help presidents and chancellors effectively communicate the importance of safety, the task force highlights core institutional values that are foundational to a culture of safety:

1. Safety is everyone's responsibility. Each institution should commit to a campus environment that ensures the health and safety of their entire community (faculty, students, staff, and visitors) and empowers the community to be responsible for the safety of others. A safe campus environment for workers is a right of employment¹. A safe campus learning environment is a right of all involved in education and research.
2. Good science is safe science. Scholarly excellence and responsible conduct of research includes safety as a critical component.
3. Safety training and safety education are essential elements of research and education. They are important for instilling a culture of safety in the next generation of researchers and future faculty, and they are important for our students' career development and employability.
4. An improved culture of safety is necessary to truly reduce risk.

TIMELINE OF RECENT NOTABLE UNIVERSITY SAFETY ACCIDENTS AND REACTIONS

Lab safety accidents

- **2009 UCLA**
[Available at C&EN](#)
Researcher (Sheharbano "Sheri" Sangji) Dies After Lab Fire.
- **2010 Texas Tech**
[Available at C&EN](#)
University Lab Accident (Preston Brown) Under Investigation.

¹ [Occupational Safety and Health Administration \(OSHA\) Employer Responsibilities](#)

- **2010 University of Florida**
[Available at Gainesville Sun](#)
Student (Courtney Mason) has wrist severed in an equine farm accident.
- **2011 Yale University**
[Available at NY Times](#)
Yale student (Michele Dufault) killed as hair gets caught in lathe.
- **2015 Florida State University**
[Available at WJHG.com](#)
An employee of the National High Magnetic Field Laboratory at Florida State University was killed in a workplace accident while working on a magnet construction project.

Responses to lab safety accidents

- **2011 Texas Tech University**
[Available at CSB TTU Case Study](#)
Chemical Safety Board releases Investigation into 2010 Texas Tech Laboratory Accident.
- **2011 UCLA**
[Available at C&EN](#)
Charges brought in UCLA researcher's death.
- **2013 UC System**
[Available at C&EN](#)
University of California reaches agreement in connection with charges in lab researcher's death – The Los Angeles County District Attorney's Office dropped felony charges against the University of California Regents as part of an agreement involving labor code violations relating to the 2008 death of a chemistry staff research assistant. In the UC agreement, the Regents, the governing body of the University of California system, accepted responsibility for the laboratory conditions that led to researcher Sheharbano (Sheri) Sangji's death.
- **2013 UCLA**
[Available at C&EN](#)
UCLA Professor Harran was charged with four felony violations of the state labor code. The deal mandates that Harran complete multiple forms of community service and pay a \$10,000 fine. The charges were not dismissed. Instead, the case against Harran is effectively on hold while he completes the terms of the five-year agreement.
- **2015 UCLA**
[Available at LA Times](#)
Legal fees for Harran case approach \$4.5 million.

National reports on lab safety in response to lab accidents

- **2012 American Chemical Society Report**
[Available at ACS Report](#)
Creating Safety Cultures in Academic Institutions (2012).
- **2013 ACS Hazard Analysis Tools**
[Available at ACS Hazard Analysis Tool](#)
At the request of the CSB, the ACS develops and releases Identifying and Evaluating Hazards in Research Laboratories.
- **2014 Stanford Report**
[Available at Stanford University](#)
Advancing Safety Culture in the University Laboratory (2014).
- **2014 National Research Council**
[Available at National Academies Press](#)
Safe Science: Promoting a Culture of Safety in Academic Chemical Research (2014).
- **2015 APLU/AAU Joint Task Force on Laboratory Safety**
[Available at The Chronicle of Higher Education](#)
Implementation of Safety Recommendations on Campus - [C&EN](#) and Under Pressure, Universities Take a Renewed Shot at Improving Lab Safety.



Interest from federal agencies in improving a culture of safety

- **2015 USA Today Investigation**
[Available at USA Today](#)
Transparency is an important cornerstone in maintaining public trust in biological research, says the National Institutes of Health, which has issued guidance to laboratories that receive federal funding.
- **2015 USA Today Investigation**
[Available at USA Today](#)
Senators, health experts demand action to address biolab accidents.
- **2015 ACS Meeting**
[Available at Science Magazine, Chemistryworld, and CHEMJOBBER](#)
Sangji Family's presentation at ACS meeting asking that federal funding be dependent on a safe culture in the PI's lab.
- **2015 White House Memorandum**
[Available at Whitehouse.gov](#)
The National Security Council and Office of Science and Technology Policy issued a memorandum to federal agencies on next steps to enhance biosafety and biosecurity in the United States. These next steps build on two sets of recommendations released from the Fast Track Action Committee on Select Agent Regulations (FTAC-SAR) and from the Federal Experts Security Advisory Panel (FESAP), which include guidance on culture of responsibility; oversight; outreach and education; applied biosafety research; incident reporting; material accountability; inspection processes; and regulatory changes to improve biosafety and biosecurity.

2. The president/chancellor designates a campus lead and leadership team to begin the process. The president/chancellor considers appropriate committees to help implement a culture of safety, including a safety committee of faculty, Environmental Health and Safety (EH&S) officers, and other representatives that can provide formative feedback to researchers, educators, and staff.

KEY RESOURCES

Creating Safety Cultures in Academic Institutions (ACS, 2012)

Recommendation 13. Establish a series of safety councils and safety committees from the highest level of management to the departmental level or lower. Each of

these committees reports, in turn, to a committee that is higher in the hierarchy of the institution.

Creating a Safety Culture (OSHA, 1989):

Establish a Steering Committee comprised of management, employees, union (if one exists), and safety staff. The purpose of this group is to facilitate, support, and direct the change processes. This will provide overall guidance and direction and avoid duplication of efforts. To be effective, the group must have the authority to get things done.

TOOLBOX

Actions for the appointed campus lead and leadership team responsible for strengthening a culture of safety

1. Engage all stakeholders to build and implement an inclusive, collaborative plan within the institution, following the recommendations in this guide and in foundational reports: Safe Science: Promoting a Culture of Safety in Academic Chemical Research (National Research Council, 2014); Creating Safety Cultures in Academic Institutions (ACS, 2012); and Texas Tech Laboratory Explosion Case Study (CSB, 2010).
2. Develop effective working relationships with all stakeholders involved in improving the culture of safety.
3. Develop and collect qualitative and quantitative safety metrics.
4. Participate in ongoing assessment, continuous improvement, and communication with the community.
5. Report to senior leadership about progress and maturation of the culture.
6. Publish annual progress reports to the community.
7. Implement annual reviews on the safety culture.

Examples of how some universities are creating safety committees

- The Stanford University Committee on Health and Safety (UCHS) is a faculty-led committee established in 1988 to advise the president on campus safety policies and practices. In 2013, Stanford convened a task force under the UCHS and the Office of the Vice Provost and Dean of Research to review and evaluate the university's laboratory safety culture. The [Report of the Task Force for Advancing the Culture of Laboratory at Stanford University](#) is comprehensive, including their findings, recommendations, and extensive appendices that include interviews with research personnel.

- The University of Minnesota Safety Program includes faculty, graduate students, postdocs, and EH&S staff. The safety committee provides formative safety feedback to labs. A short description was provided in the NRC's Safe Science report available at [National Academies Press](#). Additional descriptions of the program available in [Science Magazine](#) and the [Journal of Chemical Education](#).

3. The campus lead and leadership team conduct campus dialogues with stakeholders to develop a shared vision of safety that aligns with the institutional mission and to develop an action plan.

KEY RESOURCES

Creating a Safety Culture (OSHA, 1989):

Align the organization by establishing a shared vision of safety and health goals and objectives vs. production. Upper management must be willing to support by providing resources (time) and holding managers and supervisors accountable for doing the same. The entire management and supervisory staff need to set the example and lead the change. It's more about leadership than management.

Develop site safety vision, key policies, goals, measures, and strategic and operational plans. These policies provide guidance and serve as a check-in that can be used to ask yourself if the decision you're about to make supports or detracts from your intended safety and health improvement process.

Continue building "buy-in" for the needed changes by building an alliance or partnership between management, the union (if one exists), and employees. A compelling reason for the change must be spelled out to everyone. People have to understand WHY they are being asked to change what they normally do and what it will look like if they are successful. This needs to be done up front. If people get wind that something "is going down" and haven't been formally told anything, they naturally tend to resist and opt out.

TOOLBOX

Implementation strategies for campus dialogue

Campus community discussions in departments, colleges, and the university are critical for strengthening a culture of safety. Consider hosting listening sessions that focus on creating a safe learning/work environment.

Consider these guiding principles to help frame the discussion:

1. Each institution should commit to a campus environment that ensures the health and safety of their entire community (faculty, students, staff, and visitors) and empowers the community to be responsible for the safety of others.
 - a) Safety is everyone's responsibility.
 - b) A safe campus environment for workers is a right of employment. Employer Responsibilities available at [OSHA](#).
 - c) A safe campus learning environment is a right of education.
2. Scholarly excellence and responsible conduct of research includes safety as a critical component. We do better science when we do safe science.
3. Safety training and safety education are critical components of research and education. They are important for instilling a culture of safety in the next generation of researchers and future faculty, and they are important for our students' career development and employability.

Reading list on advancing a culture of safety

- **American Chemical Society Committee on Chemical Safety (2012). Creating Safety Cultures in Academic Institutions. American Chemical Society, Washington, DC, 2012: 34.**
[Available at ACS](#)
This report identified elements of strong safety cultures, topics and resources for laboratory and chemical safety education, and 17 recommendations to build and enhance safety cultures in academic institutions.
- **Battelle (2014). The Safe Conduct of Research.**
[Available at APLU](#)
The Safe Conduct of Research was produced through a collaborative effort across Battelle-affiliated laboratories. The purpose of this booklet is to codify the principles and practices that Battelle believes ensure their science is performed without unnecessary risk and is sustained without operational disruption. The principles outlined form the underpinnings of the strong safety culture at Battelle.
- **Culture, I. S. (1991). A Report by the International Nuclear Safety Advisory Group. Safety Series, (75).**
[Available at IAEA](#)
This report deals with the concept of safety culture as it relates to organizations and individuals engaged in nuclear power activities, and provides a basis for judging the effectiveness of safety culture.
- **DOE Integrated Safety Management Guide (DOE 450.4-1c).**
[Available at DOE Resources](#)
The DOE established guiding principles and core safety management functions to incorporate safety into management and work practices.

- **Dupont USA Managing Operational Risk to Enhance Business Performance.**
[Available at Dupont](#)
Infographic of Process Safety Management.
- **Hill, R. H., & Finster, D.C. (2013) Academic Leaders Create a Strong Safety Culture in Colleges and Universities. Journal of Chemical Health and Safety, 20(5), 27-34.**
[Available at Science Direct](#)
The article identifies leadership as one of the seven critical elements found in strong safety cultures. The safety vision of the president drives the direction and strength of the college or university's safety culture. Deans, provosts, and department chairs are essential in carrying out the steps to achieve the president's vision. Faculty and teaching assistants are the front-line leaders who teach students laboratory safety and develop students' positive attitudes toward safety.
- **Occupational Safety & Health Administration – Creating a Safety Culture**
[Available at OSHA](#)
A fact sheet on creating a safety culture that is part of the larger Safety and Health Management Systems eTool developed by OSHA.



- Safe Science: Promoting a Culture of Safety in Academic Chemical Research (2014). Committee on Establishing and Promoting a Culture of Safety in Academic Laboratory Research; Board on Chemical Sciences and Technology, Division on Earth and Life Studies; and Board on Human-Systems Integration, Division of Behavioral and Social Sciences and Education (2014, 128 pp.; ISBN 978-0-309-30091-9).**
[Available at National Academies Press](#)

This foundational report examines the culture of safety in research institutions and makes recommendations for university leadership, laboratory researchers, and environmental health and safety professionals to support safety as a core value of their institutions. The report discusses ways to fulfill that commitment through prioritizing funding for safety equipment and training, as well as making safety an ongoing operational priority. The report emphasizes that a strong, positive safety culture arises not because of a set of rules but because of a constant commitment to safety throughout an organization. Such a culture supports the free exchange of safety information, emphasizes learning and improvement, and assigns greater importance to solving problems than to placing blame. High importance is assigned to safety at all times, not just when it is convenient or does not threaten personal or institutional productivity goals.
- Schröder, I., Huang, D. Y. Q., Ellis, O., Gibson, J. H., & Wayne, N. L. (2015). Laboratory safety attitudes and practices: A comparison of academic, government, and industry researchers.**
[Available at Journal of Chemical Health and Safety](#)

A survey on laboratory safety provided the basis for comparing safety culture attributes of respondents from academic (n = 991), government (n = 133) and industry (n = 120) laboratories.
- Shreeve, J.M. (2015). Food For Thought. Chemical & Engineering News, 93(43).**
[Available at C&EN](#)

Veteran inorganic chemist argues that the 'culture' of laboratory safety must not be compromised.
- Stanford University (2014). Report of the Task Force for Advancing the Culture of Laboratory at Stanford University.**
[Available at Stanford University](#)

In 2013, Stanford convened a task force to review and evaluate the laboratory safety culture at Stanford. The Report of the Task Force for Advancing the Culture of Laboratory at Stanford University is comprehensive with their findings, recommendations, and extensive appendices that include interviews with research personnel.
- Sutcliffe, W. (2006). Managing the unexpected: Assuring high performance in an age of complexity. John Wiley & Sons**

The authors use both case studies and theory-based analysis to explain the methods that result in organizational "mindfulness," and, through it, a more robust culture of safety. They describe high-reliability organizations.

- Universities and Colleges Employers Association has produced a number of guidance [publications](#) on Health and Safety issues. These are available for institutions to download. Institutions can also access a range of [resources](#) on matters related to health, safety and wellbeing for the HE sector.
- **U.S. Chemical Safety and Hazard Investigation Board (2010). Texas Tech University Laboratory Explosion.**
[Available at CSB](#)
Investigative report of the laboratory explosion at Texas Tech University. The UCB provided an incident analysis, lessons not learned from previous incidents, lack of organizational accountability and oversight, key lessons, and recommendations.

4. **The campus lead and leadership team develop effective safety policies, procedures, and management systems, and identify the resources necessary for implementation. They establish recognition and reward systems and integrate these into tenure and promotion, hiring, and annual performance reviews.**

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

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.

Recommendation 3. All institutions face a 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.

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 3. Establish a strong, effective safety management system and safety program for the institutions, including laboratory safety.

Recommendation 17. Identify the ongoing need to support a strong safety culture and work with administrators and department chairs to establish a baseline budget to support safety activities on an annual basis.

Creating a Safety Culture (OSHA, 1989):

Develop policies for recognition, rewards, incentives, and ceremonies. Again, reward employees for doing the right things and encourage participation in the upstream activities. Continually reevaluate these policies to ensure their effectiveness and to ensure that they do not become entitlement programs.

TOOLBOX

Implementation strategies for recognizing and rewarding effective safety practices

- Make safety, conducting hazard analysis, completion of safety training, etc. a part of all faculty annual reviews.
- Require the inclusion of the candidate's safety record in a supervisor's performance appraisal commentary and letters supporting tenure or promotion.
- Consider centralized funding for safety improvements. The [Report of the Task Force for Advancing the Culture of Laboratory at Stanford University](#) recommended centralized funding support for comprehensive, campus-wide safety related mandates, especially for personal protective equipment (PPE) and safety equipment.

RESOURCES FOR LABORATORY SAFETY AND HAZARD ANALYSIS TO AID IN DEVELOPING EFFECTIVE CAMPUS SAFETY POLICIES

Reports, handbooks, and guides on hazards

- **ACS Committee on Chemical Safety (2013). Identifying and Evaluating Hazards in Research Laboratories: Guidelines Developed by the Hazards Identification and Evaluation Task Force. American Chemical Society, Washington, D.C.**
[Hazard Analysis Tool available at ACS](#)
The report provides the key elements of hazard identification and evaluation, which include defining the scope of work, recognizing the potential hazards involved in every step of an experiment and evaluating the chances that a hazard will happen. It also discusses the selection and use of proper safety equipment and procedures.
- **Bretherick, L. (2013). Bretherick's handbook of reactive chemical hazards. Butterworth-Heinemann**
[Available at Amazon](#)
This two-volume compendium focuses on reactivity risks of chemicals, alone and in combination.
- **Furr, A. K. (2000). CRC handbook of laboratory safety. CRC Press**
[Available at CRC Press or Amazon](#)

The CRC Handbook of Laboratory Safety, Fifth Edition provides information on planning and building a facility, developing an organization infrastructure, planning for emergencies and contingencies, choosing the correct equipment, developing operational plans, and meeting regulatory requirements.

- **National Research Council (2011). Prudent practices in the laboratory: Handling and management of chemical hazards: Updated Version**

[Available at National Academies Press](#)

The book offers prudent practices designed to promote safety and includes practical information on assessing hazards, managing chemicals, disposing of wastes, and more. It is the leading source of chemical safety guidelines for people working with laboratory chemicals: research chemists, technicians, safety officers, educators, and students.



- **National Fire Protection Association (2015). NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals**
[Available at the NFPA website](#)
NFPA 45 is one of the documents that is referenced in the OSHA Lab Standard.
- **Northwestern University Research (2013). Essential Information on Laboratory Safety**
[Available at Northwestern University](#)
- **Occupational Safety and Health Administration (OSHA). Laboratory Safety Guidance. OSHA 3404-11R. United States**
[Available at OSHA](#)
OSHA Lab Safety Guidance details the OSHA standards and provides guidance on chemical, biological, physical, and safety hazards.
- **Safety in Academic Chemistry Laboratories: Volume 2 (Teacher's Edition)**
[Available at ACS.org](#)
This volume summarizes many of the aspects of laboratory safety from a teaching and administrative viewpoint, including consideration of the regulations developed under the Occupational Safety and Health Act. However, accident prevention, not regulation, is the essential component of all laboratory operations. This manual provides a basis from which both institutional and individual safety policies and procedures can be developed.
- **Salerno, R. M., & Gaudioso, J. (Eds.). (2015). Laboratory Biorisk Management: Biosafety and Biosecurity. CRC Press**
[Available at Amazon](#)
It introduces the new field of laboratory biorisk management, evolving from the traditional field of biosafety and biosecurity. It explains how biorisk management can reduce the risks of working with biological agents in laboratories and explains how to implement it. The book discusses how to implement the new Laboratory Biorisk Management Standards.

Websites with additional resources

- **The Lab Chemical Safety Summaries newly available from PubChem has 3000+ chemical hazard and safety summaries available.**
[Available at PubChem](#)
- **Aldrich Technical Bulletins provides chemical data sheets.**
[Available at Aldrich](#)
- **The Department of Health and Human Services "Enviro-Health Links – Laboratory Safety" webpage links to many useful references for chemical, biological, and nanomaterials safety**
[Available at NIH.gov](#)
- **Dow Lab Safety Academy provides many resources for enhancing safety practices.**
[Available at safety.dow.com](#)

5. The campus lead and leadership team clearly articulate the roles and responsibilities of all stakeholders.

KEY RESOURCES

Creating Safety Cultures in Academic Institutions (ACS, 2012)

Recommendation 1. Establish the lines of authority for safety; develop a safety policy that includes laboratory safety, and includes safety responsibilities in the job descriptions and performance plans of all employees.

Creating a Safety Culture (OSHA, 1989)

Define specific roles and responsibilities for safety and health at all levels of the organization. Safety and health must be viewed as everyone's responsibility. How the organization is to deal with competing pressures and priorities (i.e., production, versus safety and health), needs to be clearly spelled out.

TOOLBOX

Recommendations from foundational reports on roles and responsibilities of different stakeholders

- **National Research Council (2014). *Safe Science: Actions for Environmental Health and Safety Staff*. Washington, DC: The National Academies Press.**
[Available at National Academies Press](#)
- **National Research Council (2014). *Safe Science: Actions for University Senior Leaders*. Washington, DC: The National Academies Press.**
[Available at National Academies Press](#)
- **National Research Council (2014). *Safe Science: Actions for Laboratory Researchers*. Washington, DC: The National Academies Press.**
[Available at National Academies Press](#)
- **National Research Council (2014). *Safe Science: Actions for Principal Investigators and Department Chairs*. Washington, DC: The National Academies Press.**
[Available at National Academies Press](#)
- **National Research Council (2014). *Safe Science: Actions for Deans and Vice Presidents for Research*. Washington, DC: The National Academies Press.**
[Available at National Academies Press](#)

- **Presidential Leadership** among other leaders must be engaged to create a true change in safety culture on campus. OSHA's Safety & Health Management System eTool provides guidance to management leadership.
[Available at OSHA Management Leadership](#)
- **The Task Force on Laboratory Safety** in this guide has provided suggested roles and responsibilities.
See page 60

University examples of roles and responsibilities of different stakeholders for laboratory safety

- **Responsibilities and Procedures**
[Available at University of Texas](#)
- **Responsibilities**
[Available at University of California, Berkeley](#)
- **Policies and Programs**
[Available at North Carolina State University](#)



- **Policy 3-300**
[Available at University of Utah](#)
- **The Report of the Task Force for Advancing the Culture of Laboratory at Stanford University provides guidance on suggested roles and responsibilities**
[Available at Stanford University](#)

6. The campus lead, leadership team, and faculty embed safety communication in laboratories, classes, departments and throughout the wider campus.

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

Conclusion 4: 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 regular safety communication, for example, "safety moments" in academic research events (e.g. seminars, group meeting, doctoral defenses, and teaching*
- *includes open communication about safety as a key element that is sought out, values, and acted upon.*

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 16. Establish a system to promote safety in an institution or department that encompasses: electronic communications; printed materials; special seminars or events discussing or promoting safety; a recognition system for good safety performance; and a process to solicit, review, and act on suggestions for improving safety and identifying safety issues.

TOOLBOX

Implementation strategies for embedding safety communication

- Create campus-specific safety videos to use at public meetings.
- Open every formal meeting on campus with a safety message.

Video examples to raise awareness of the importance of safety

- **Safety Video Competition**
[Available at the University of Minnesota](#)
A humorous video that highlights some common laboratory mistakes.
- **A Day in the Lab**
[Available at the University of California San Diego](#)
Highlights some common laboratory mistakes.
- **Lab Techniques & Safety: Crash Course Chemistry #21**
[Available at CrashCourse](#)
An accessible video on some important points for lab safety.
- **Experimenting with Danger**
[Available from Chemical Safety Board](#)
Provides hazards associated with conducting research at chemical laboratories in academic institutions.

Examples of winning marketing campaigns for safety

- **WolfAlert Emergency Communication Campaign**
[Available from North Carolina State University](#)
Won CSHEMA's institutional marketing campaign Award of Excellence.
- **Focus on Safety**
[Available at University of Nevada Reno](#)
Campaign earned the 'Marketing Campaign Award of Distinction' at the CSHEMA national conference.

Daily safety communication resources

- **Safety Library**
[Available at WCF](#)
A large library of helpful safety resources, including safety posters, safety meeting resources, checklists, videos, and more.
- **Safety and Health Topics**
[Available at United States Department of Labor](#)
Regularly provides information on safety and health hazards that can be shared with the campus community.
- **Workplace Safety & Health Topics**
[Available at the Centers for Disease Control and Prevention](#)
Provides information that can be shared with the campus community.
- **Fast Facts**
[Available at University of California, Riverside](#)

Brief, one-page summaries of various safety topics that can be used for reference or training.

7. **The campus lead, leadership team, and faculty work to create a trusting and safe culture. They encourage the development of a generative culture based on open dialogue, reporting, and learning from near misses, as described by the National Academy of Sciences.**

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

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.

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 9. Adopt a personal credo: the "Safety Ethic"-value safety, work safely, prevent at-risk behavior, promote safety, and accept responsibility for safety.

Creating a Safety Culture (OSHA, 1989):

Build trust. Trust is a critical part of accepting change, and management needs to know that this is the bigger picture, outside of all the details. Trust will occur as different levels within the organization work together and begin to see success.

TOOLBOX

Resources to create an open dialogue

- **The Report of the Task Force for Advancing the Culture of Laboratory at Stanford University**

[Available at Stanford University](#)

The report provides interview findings from ethnographic studies of their research personnel as well as findings from their culture of safety climate survey. These provide context on the values, attitudes, and behaviors of research personnel that could help facilitate more open dialogue.

- Lawler, E.E. *High-Involvement Management*. Jossey-Bass, San Francisco, CA, 1986
ISBN-0-87589-686-3
- Conchie, S. M., P. J. Taylor, and I. J. Donald. Promoting safety voice with safety-specific transformational leadership: The mediating role of two dimensions of trust. *Journal of Occupational Health Psychology* 2012; 17(1): 105-115
[Available at APA PsycNET](#)

8. The institution develops a risk assessment process for laboratory safety that is integral to all activities conducted in the laboratory or the field.

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

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 mechanisms with input from faculty, students, environmental health and safety staff, and administrative stake holders and ensure that other university leader, including provosts, vice presidents for research, deans, chief administrative officers, and department chairs, do so as well.

Texas Tech Laboratory Explosion Case Study (CSB, 2010):

Academic institutions should ensure that practices and procedures are in place to verify that research-specific hazards are evaluated and mitigated.

TOOLBOX

Implementation strategies to reduce risk

- Actively engage campus risk management and boards of trustees/regents to support campus safety initiatives to mitigate and manage risk due to research and academic safety issues.
- Ensure that research and academic safety is incorporated into all unit risk analyses and are reflected in the university's heat map of risk.

- Upon identification of the risks associated with research and academic safety, risk management plans should call for regular review and changes in policies and procedures to reflect the associated risk.

References on risk management

- **Reason, J. T., & Reason, J. T. (1997). *Managing the risks of organizational accidents (Vol. 6)*. Aldershot: Ashgate.**
This book presents a set of common principles of the causes of major accidents in a wide variety of high-technology systems. It describes tools and techniques for managing these risks.

9. **The institution establishes a unified administrative reporting model that connects responsibility for development and implementation of academic safety policies. The model should fall under one administrative pillar in the institution and should include faculty, EH&S officers, and administrative leaders.**

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

Vice presidents for research and deans of schools and colleges should, in addition to deploying funds in ways that support safety, ensure that the lines of research undertaken by the institution are ones it has the capacity to perform safely. They can make certain that everyone involved in the research enterprise knows their role and responsibilities in supporting safety. They can develop reporting structures that support safety culture; an example would be for senior environmental health and safety (EHS) officials to report through the senior research management programs, typically at the vice president level or higher—a structure that may better integrate safety management into overall research management.

Texas Tech Laboratory Explosion Case Study (CSB, 2010):

Key Lesson 5. An academic institution's organizational structure should ensure that the safety inspector/auditor of research laboratories directly report to an identified individual/office with organizational authority to implement safety improvements.

TOOLBOX

Example reporting structures

- Following the laboratory explosion at Texas Tech University, the university modified its reporting structure so that EH&S reports to the vice president for research. Their pre- and post-organizational charts are included in the [CSB case study on Texas Tech University](#).
- The National Research Council in Safe Science recommended that the EH&S personnel report through “the research management programs, typically at the vice president level or higher—a structure that may better integrate safety management into overall research management” (NRC, 2014).

10. The institution empowers undergraduate students, graduate students, postdoctoral fellows, and staff to voice safety questions and concerns to their faculty supervisors, EH&S offices, and/or safety committee.

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

Conclusion 4: 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 empowers student and research trainees to have a “voice” and maintain an environment that encourages raising safety concerns freely without fear of repercussions.

TOOLBOX

Resources for empowering all stakeholders

- **Example of empowering students to be involved in laboratory safety.**
[Available at Science Magazine](#)
- **McGarry, K. A., Hurley, K. R., Volp, K. A., Hill, I. M., Merritt, B. A., Peterson, K. L., ... & Tolman, W. B. (2013). Student Involvement in Improving the Culture of Safety in Academic Laboratories. *Journal of Chemical Education*, 90(11), 1414-1417**
[Available at the Journal of Chemical Education](#)
A more in depth analysis of how the University of Minnesota empowered students

- **Dupont's Safety Training Observation Program (STOP)**
[Available at Dupont](#)
Provides a path to workplace safety by making safe behavior and workplace conditions part of the work culture.
- **OSHA provides guidance on how employees can be involved in safety**
[Available at OSHA](#)

11. The institution works to strengthen collegial and collaborative relationships between faculty and EH&S staff.

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

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.

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 14. Establish a close working relationship with EHS personnel at every departmental level, seeking their advice and experience in safety, and offering departmental and faculty advice to EHS based upon their experience and knowledge of chemistry.

TOOLBOX

Implementation strategies to build stronger relationships

- Incorporate into the campus dialogue an expectation of partnership and support between EH&S and faculty.
- Keep regular and open meetings between faculty and EH&S.

12. The institution works to enhance effective working relationships with first responders.

KEY RESOURCES

Creating Safety Cultures in Academic Institutions (ACS, 2012)

Recommendation 15. Establish a close working relationship with local emergency responders, so they are prepared to respond to emergencies in laboratories.





DATA, HAZARD IDENTIFICATION, AND ANALYSIS

13. The institution implements routine hazard analyses and includes them as integral components of undergraduate and graduate education; thesis, dissertation, and funding proposals; and experimental design for all experiments.

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

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.

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 6. Implement hazards analysis procedures in all new lab work, especially laboratory research.

Texas Tech Laboratory Explosion Case Study (CSB, 2010)

Key Lesson 1. An academic institution modeling its laboratory safety management plan after OSHA's Laboratory Standard (29 CFR 1910.1450) should ensure that all safety hazards, including physical hazards of chemicals, be addressed.

Key Lesson 2. Academic institutions should ensure that practices and procedures are in place to verify that research-specific hazards are evaluated and mitigated.

Key Lesson 3. Comprehensive guidance on managing the hazards unique to laboratory chemical research in the academic environment is lacking. Current standards on hazard evaluations, risk assessments, and hazard mitigation are geared towards industrial settings and are not fully transferable to the academic research laboratory environment.

TOOLBOX

General guidance for hazard analysis based on national standards

- **Worksite Analysis**

[Available at OSHA](#)

OSHA's Safety & Health Management Systems eTool provides general guidance on workplace safety. Analysis provides guidance on conducting a worksite analysis,

including analysis of past accident history, routine inspections, change analysis with new procedures, and more.

- **Hazard Control**

[Available at OSHA](#)

Provides guidance on minimizing hazards, including considering design, enclosure of hazards, barriers, and administrative controls.

- **Safety and Health Program Management Guidelines**

[Available at OSHA](#)

(Federal Register 54:3904-3916, 1989) consists of safety and health management practices that are used by employers who are successful in protecting the safety and health of their employees.

- **ANSI/AIHA Z10-2012 Occupational Health and Safety Management Systems**

[Available at ASSE](#)

Provides organizations a tool for continual improvement of their occupational health and safety performance. The primary purpose of this standard is to provide a management tool to reduce the risk of occupational injuries, illnesses and fatalities.

General Standard Operating Procedures (SOP) guidelines and examples

- **Document Management**

[Available at UC Center for Laboratory Safety](#)

- **SOP Guidelines**

[Available at Utah State University](#)

- **SOP FAQs**

[Available at Utah State University](#)

- **Liquid nitrogen handling guidelines**

[Available at Utah State University](#)

Hazard assessment tools for the laboratory

- **American Chemical Society Committee on Chemical Safety (2013). Identifying and Evaluating Hazards in Research Laboratories: Guidelines Developed by the Hazards Identification and Evaluation Task Force. American Chemical Society, Washington, DC.**

[Available at ACS](#)

This tool provides guidance on identifying and evaluating hazards in research laboratories and managing the associated risks. It includes chapters on hazard identification, roles and responsibilities, what-if analysis, and more.

- **Laboratory Hazard Assessment Tool**

[Available at UCLA](#)

Facilitates identification of hazards and identifies the Personal Protective Equipment (PPE) to be used during the specified work activities.

- **NIOSH Pocket Guide to Chemical Hazards**
[Available at CDC](#)
Intended as a source of general industrial hygiene information for workers and employers to help recognize and control occupational chemical hazards.

Hazard assessment guidance for fieldwork

- **Organization List**
[Available at the International Society for Agricultural Safety and Health \(ISASH\)](#)
List of organizations dedicated to improving agricultural safety with associated helpful resources.
- **Agricultural Safety Papers**
[Available at ISASH](#)
The ISASH provides papers on agricultural safety..
- **Guidance on Health and Safety in Fieldwork (2011)**
[Available at Universities and Colleges Employers Association](#)
Has core actions, good practices, and case studies to help universities navigate the hazards in fieldwork. It is based on British Standard 8848.

14. The institution implements a process to report incidents and near misses so that the campus community can learn from these incidents.

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

Recommendation 7: Organizations should incorporate non-punitive incidents 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.

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 10. Establish and maintain an Incident Reporting System, and

Incident Investigation System, and an Incident Database that should include not only employees, but also—graduate students, postdoctoral scholars, and other nonemployees.

Recommendation 12. Publish or share the stories of incidents and the lessons learned (case studies) to your institution's Web site, a public Web site, or an appropriate journal where students and colleagues from other institutions may also use these as case studies for learning more about safety.

Texas Tech Laboratory Explosion Case Study (CSB, 2010):

Key Lesson 6. Near misses and previous incidents provide opportunities for education and improvement only if they are documented, tracked, and communicated to drive safety change.

TOOLBOX

Examples of whistle blowing, accident reporting, and near-miss reporting forms

- **Safety Concerns and Near-Misses "SCANS"**
[Available at Texas Tech University](#)
- **Online Accident Reporting System**
[Available at University of Washington](#)
- **Safety Yellow Cards**
[Available at University of Wisconsin](#)
- **Memorial Wall**
[Available at The Laboratory Safety Institute](#)

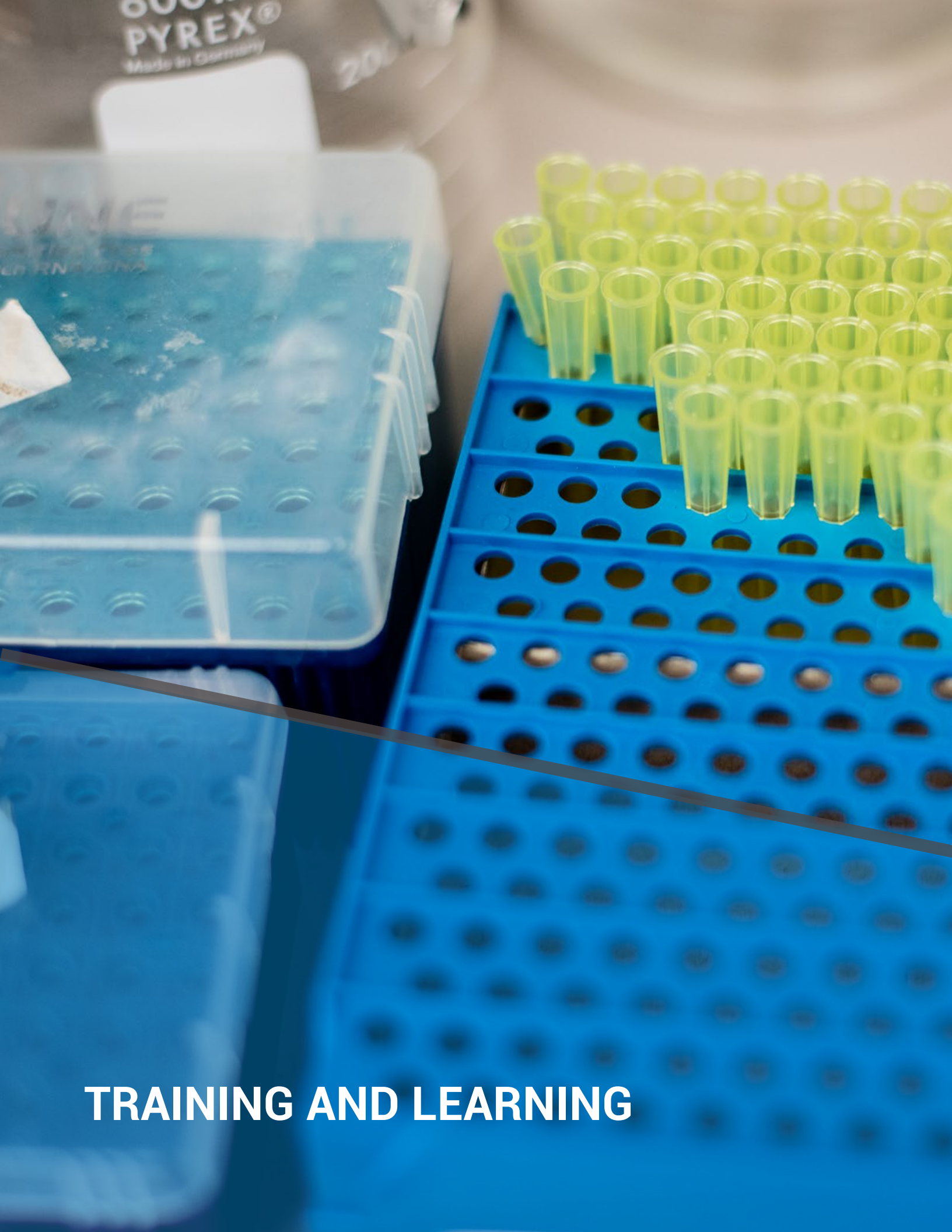
Examples of lessons-learned websites at universities

- **Lessons Learned**
[Available at UC Center for Laboratory Safety](#)
- **Lessons Learned**
[Available at Texas Tech University](#)
- **Lessons Learned**
[Available at University of California Berkeley](#)
- **Safety Moments, Alerts, and Lessons Learned**
[Available at University of California, Irvine](#)
- **Lessons Learned**
[Available at Washington University](#)

Resources to help guide the development of a near-miss reporting system

- OSHA's Safety & Health Management Systems eTool provides guidance on Incident Investigations
[Available at OSHA](#)
- Orr, M. F., Sloop, S., & Wu, J. (1999). Acute chemical incidents surveillance—Hazardous Substances Emergency Events Surveillance, nine states, 1999–2008. CDC.
[Available at CDC](#)
- Strauch, B. (2015). Can we examine safety culture in accident investigations, or should we? *Safety Science*, 77, 102-111.
[Available at Science Direct](#)
- U.S. Chemical Safety and Hazard Investigation Board (2010). Texas Tech University: Laboratory Explosion.
[Available at CSB](#)
- Hendershot, D. C. (2015). Do we recognize “near misses”? *Journal of Chemical Health and Safety*, 22(4), 38-39.
[Available at Science Direct](#)





TRAINING AND LEARNING

15. The institution provides laboratory safety education and training for students, faculty, EH&S staff, and department heads.

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

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.

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 5. Ensure all faculty, staff, and graduate and undergraduate students involved in teaching, managing, or overseeing students in laboratory courses and sessions have successfully completed a course in lab safety.

Recommendation 8. Include safety education and training (for undergraduate students, graduate students, and postdoctoral scholars participating in proposed research) in research grant proposals, and oversight of research for safety.

Creating a Safety Culture (OSHA, 1989):

Initial Training of Management-Supervisory staff, Union Leadership (if present), and safety and health committee members, and a representative number of hourly employees. This may include both safety and health training and any needed management, team building, hazard recognition, or communication training, etc. This gives you a core group of people to draw upon as resources and also gets key personnel onboard with needed changes.

Texas Tech Laboratory Explosion Case Study (CSB, 2010):

Key Lesson 4. Research-specific written protocols and training are necessary to manage laboratory research risk.

TOOLBOX

Laboratory safety training policies

[Princeton University](#) has laboratory access and training recommendations for undergraduate students, graduate students, staff, faculty, visiting researchers, and high school interns. As part

of their policy, they recommend:

Undergraduate students: *All Princeton University undergraduates must undergo laboratory safety training prior to working in a laboratory. In addition, first and second year undergraduates should not be granted unescorted key access to research laboratories and should never be permitted to work unsupervised. Third and fourth year undergraduates may be granted unrestricted key access on a case-by-case basis as determined by the laboratory and department managers. The need for these students to be supervised or not should be determined on a case-by-case basis by the PI and/or laboratory manager. This decision should be based on the student's competency, hazards present within the lab, facility security concerns, and specific projects and duties the student will be performing. These students shall never be alone in the laboratory during hazardous operations and must only perform hazardous operations when senior, trained laboratory staff members are present.*

Laboratory safety training resources

- **Lab Safety Videos List**
[Available at Google Spreadsheets](#)
Google spreadsheet organized by safety category with the URL, organization, length of video, and description of available safety videos.
- **Lab Safety Training Modules**
[Available at Dow](#)
Provide training modules on fume hood basics, interpreting material safety data sheets, inspections, mentoring, and more.
- **Lab Safety Videos**
[Available at Cornell University](#)
Short informational videos.
- **Safety training videos**
[Available at Northwestern University](#)
Northwestern University's Office of Research has a collection of safety videos.
- **Safety & Health Management Systems eTool**
[Available at OSHA](#)
Provides guidance on Safety and Health Training.
- **The Safety Training Consortium**
[Available at Safety-Consortium.org](#)
Higher education membership organization founded by research universities, for the purpose of developing safety training for the research community. Excellence in Safety Education.
- **Lab Safety Certificate**
[Available at Cornell University](#)

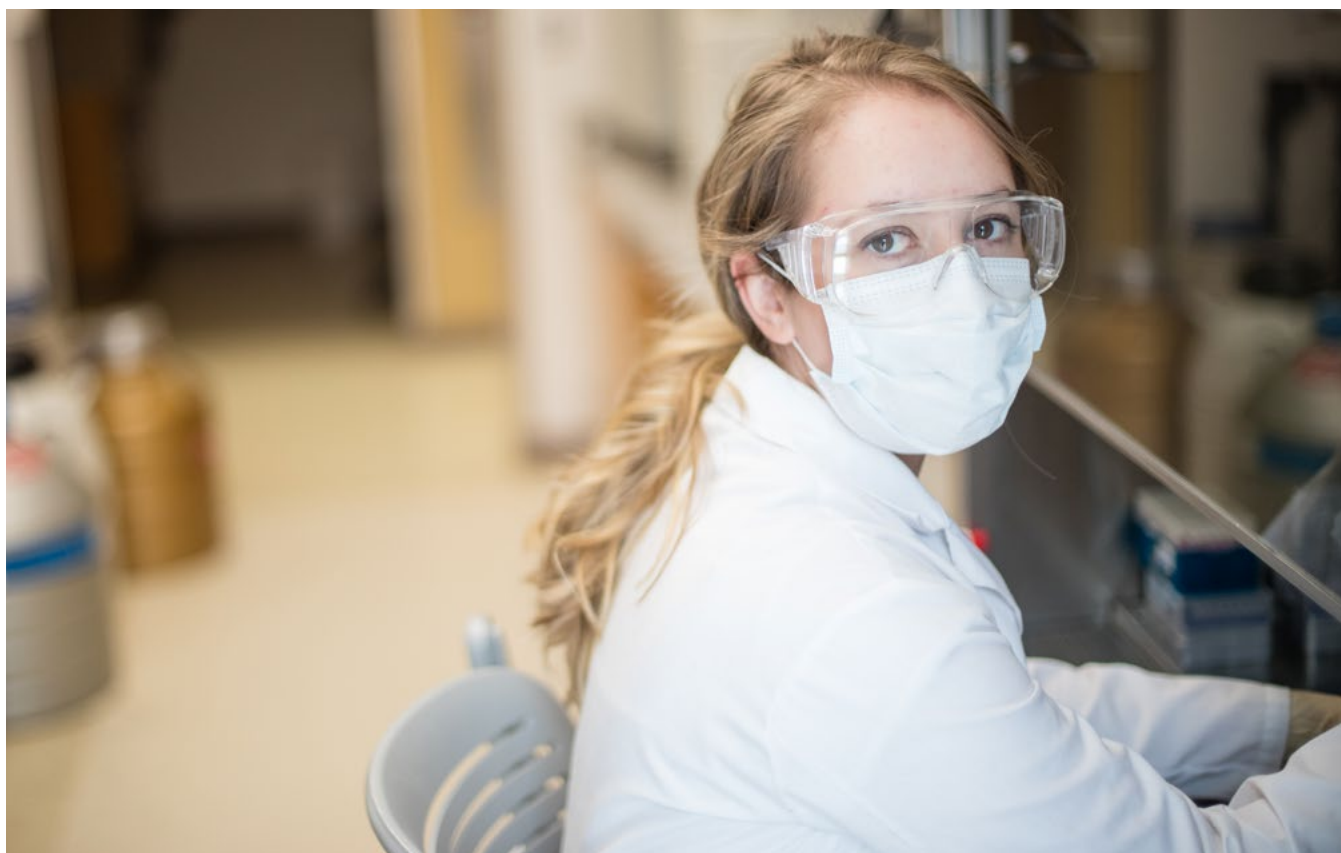
Designed for laboratory workers who want to expand their safety knowledge. It is a 20-hour course.

Examples of tools for determining training needs

- **Utah State University's Training Matrix Survey**
[Available at Utah State University](#)
Allows employees a different method to determine training needs.
- **UCLA Lab Training Matrix**
[Available at UCLA](#)
Outlines the minimum medical and training requirements for personnel (PIs, lab supervisors, graduate and undergraduate students and staff) working in a research setting.

Approaches to emergency training

- Northern Arizona University stages mock emergencies, which can occur after work hours and include fake spills, fake blood, confusion, etc. to help students understand how chaotic an emergency can be. Submitted by John Nauman, Director of Northern Arizona University Undergraduate Laboratory Program in Chemistry and Biochemistry.
- [Approaches to Emergency Training](#) by Dawn Mason includes a list of possible safety “pop quizzes” and activities to inspire creative thinking when discussing safety.



16. The institution ensures undergraduate and graduate science and engineering curricula include an emphasis on safe practices.

KEY RESOURCES

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 4. Ensure graduating chemistry undergraduate students have strong skills in laboratory safety and strong safety ethics by teaching safety lessons in each laboratory session, and by evaluating and testing these skills throughout the educational process.

Recommendation 7. Build awareness and caring for safety by emphasizing safety throughout the chemistry curricula.

TOOLBOX

Resources for developing safe practices in science and engineering curricula

- **Key Lessons for Preventing Incidents from Flammable Chemicals in Educational Demonstrations**

[Available from the CSB](#)

Includes a report and video.

- **CUR Listserv**

[Available at CUR](#)

The Council on Undergraduate Research (CUR), which supports and promotes high-quality undergraduate research and scholarship, has the CUR Listserv, a resource for undergraduate education directors. CUR also has the CUR Quarterly for 2007, which focuses on risk management related to undergraduates participating in research¹:

- [How to get Started Using Chemicals and Radionuclides in an Undergraduate Research Laboratory](#)
- [Risk Management: Training Undergraduates in Research Ethics in Social and Behavioral Sciences](#)
- [Risk Management in International Undergraduate Field Classes: A Costa Rican Case Study](#)
- [The OUR-IRB Project: A Necessary Tool for Risk Management and Ethics Education](#)

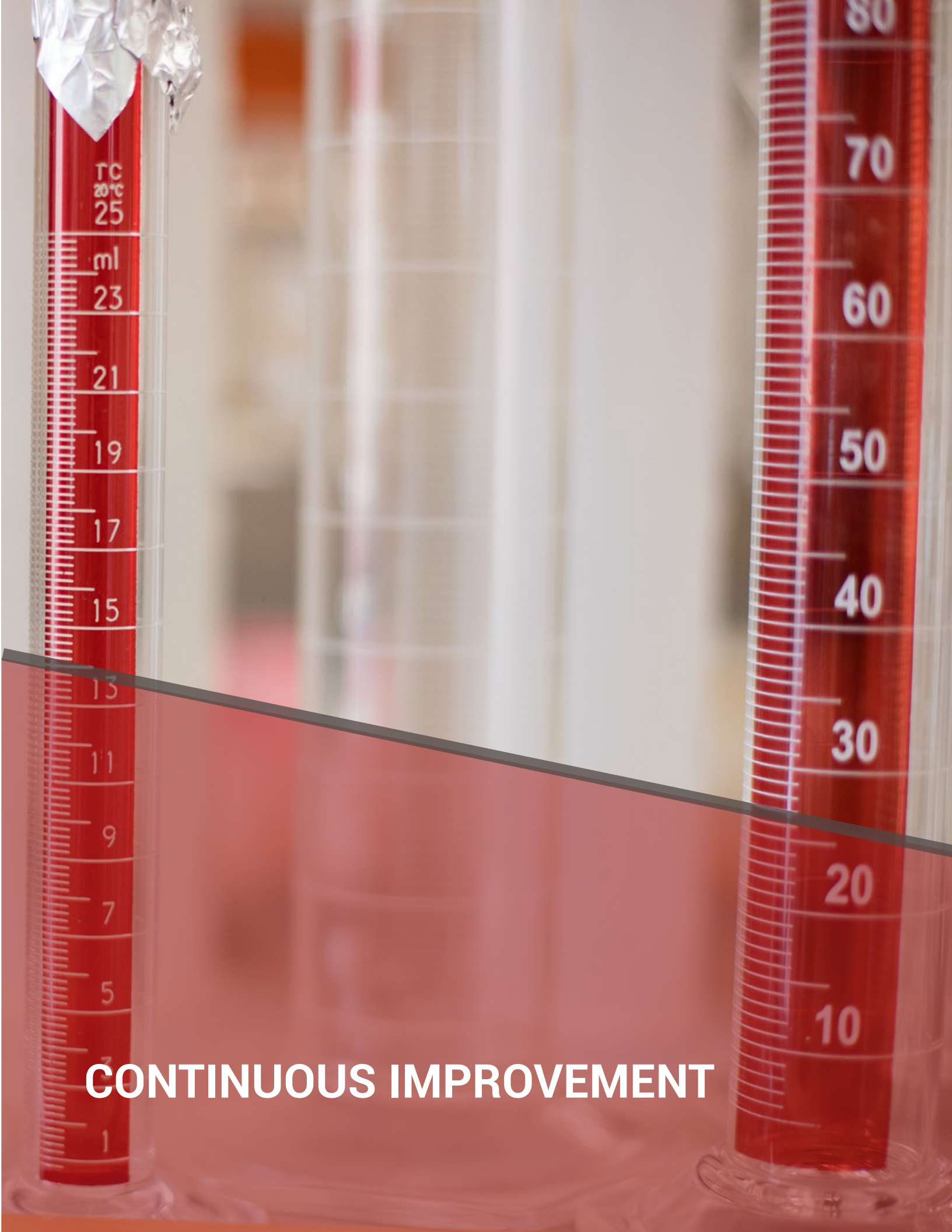
¹ These references are made available freely by the Council on Undergraduate Research. For more information about the Council on Undergraduate Research, including additional articles pertaining to undergraduate research program operation, please see: <http://www.cur.org>.

- [ACS's Chemical Safety in the Classroom webpage](#)
Provides resources for elementary through college classrooms.
- [Chemical Laboratory Information Profiles \(CLIPs\)](#)
Describe the hazards of particular chemicals to assist teachers and students in determining precautions for laboratory work. CLIPs can also be used to guide student discussions and create assignments.

Resources for students on safe laboratory practices

- **Hill, R. H., & Finster, D. (2011). Laboratory safety for chemistry students. John Wiley & Sons**
[Available at Wiley](#)
Written for undergraduate students, it is organized around four core principles of safety: recognizing hazards, assessing risks of hazards, minimizing hazards, and preparing for hazards.
- **Safety in Academic Chemistry Laboratories: Volume 1, Accident Prevention for College and University Students. American Chemical Society**
[Available at ACS.org. \(Also in Spanish and Arabic\)](#)
This volume, primarily for students in college and university chemistry laboratories, emphasizes the importance of knowing the hazards before beginning experiments and the necessity of taking appropriate precautions.
- [ACS's Safety for Introductory Chemistry Students brochure](#)





CONTINUOUS IMPROVEMENT

17. The institution conducts self-assessment and benchmarking using measures that can provide feedback on whether it is moving to a safer culture.

KEY RESOURCES

Creating Safety Cultures in Academic Institutions (ACS, 2012):

Recommendation 11. Establish an internal review process of incidents and corrective actions with the Departmental Safety Committee (faculty, staff, students, graduate students, and postdoctoral scholars), and provide periodic safety seminars on lessons learned from incidents.

Creating a Safety Culture (OSHA, 1989):

Conduct self assessments/bench marking. To get where you want to go, you must know where you are starting from. A variety of self-audit mechanisms can be employed to compare your site processes with other recognized models of excellence such as Star VPP sites. Visiting other sites to gain first- hand information is also invaluable.

Develop measures and an ongoing measurement and feedback system. Drive the system with upstream activity measures that encourages positive change. Examples include the number of hazards reported or corrected, numbers of inspections, number of equipment checks, JSA's, pre-start-up reviews conducted, etc.

Continually measure performance, communicate results, and celebrate successes. Publicizing results is very important to sustaining efforts and keeping everyone motivated. Everyone needs to be updated throughout the process. Progress reports during normal shift meetings allowing time for comments back to the steering committee opens communications, but also allows for input. Everyone needs to have a voice, otherwise, they will be reluctant to buy-in. A system can be as simple as using current meetings, a bulletin board, and a comment box.

TOOLBOX

Assessment tiers

- Internal self-assessment can be done at the institutional level or at the sub-unit level (e.g. departments, colleges, institutes).
- External peer assessment is a practice common to the academy, especially around graduate program review. Peers can be selected based on their academic and research

profiles and maturation of their safety culture. As an example, see [The University of Texas System](#).

Assessment resources

The Campus Safety Health and Environmental Management (CSHEMA) Environmental Safety Tracking, Assessment, and Rating System ([ESTARS](#)) program is a comprehensive and extensive campus-wide guided self-assessment. Typically, this is a yearlong process.

University examples of self-assessment

- **The Report of the Task Force for Advancing the Culture of Laboratory at Stanford University**
[Available at Stanford University](#)
Self-assessment of Stanford's safety culture. The report provides detail on how they did their assessment, their findings, and their recommendations.
- **Lab Safety Score Cards**
[Available at Emory University](#)
As part of their internal self-assessment, Emory University uses the cards. Every PI is required to complete an annual lab self-inspection and receives a lab safety card. Each department chair also receives a scorecard with how every PI is complying with safety expectations.
- **Laboratory Audit Form**
[Available at Utah State University](#)
Utah State University uses this form for self-assessment.
- **Yemoto, C. E. (2012). Laboratory Self-Inspection: Using a Checklist for Safety and Health Audits. *Lab Medicine*, 43(6), 307-312**
[Available at Lab Medicine](#).
A concise article on developing a laboratory checklist.

18. The institution develops a continuous improvement system that provides feedback, reassessment, and on-going training and learning opportunities.

KEY RESOURCES

Safe Science: Promoting a Culture of Safety in Academic Chemical Research (NRC, 2014):

Conclusion 4: 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

- Values learning and continuous improvement with respect to safety

Creating a Safety Culture (OSHA, 1989):

On-going Support - Reinforcement, feedback, reassessment, mid-course corrections, and on-going training is vital to sustaining continuous improvement.

TOOLBOX

- **Self-assessment**

[Available at CSHEMA ESTARS](#)

Program can be done on an on-going basis for continuous improvement and reassessment.

- **The Report of the Task Force for Advancing the Culture of Laboratory at Stanford University**

[Available at Stanford University](#)

Provides the interview guide that was used for the ethnographic studies of Stanford's research personnel. The report also includes the culture of safety climate survey questions. These might be useful as assessment tools for other campuses.



19. The institution develops a system of accountability including peer-to-peer accountability.

KEY RESOURCES

Creating a Safety Culture (OSHA, 1989):

Develop a system of accountability for all levels of the organization. Everyone must play by the same rules and be held accountable for their areas of responsibility. Sign of a strong culture is when the individuals hold themselves accountable.

TOOLBOX

Guidance on conducting audits and reviews

- **Program Audits and Reviews**

[Available at OSHA](#)

OSHA's Safety & Health Management Systems eTool provides guidance on including doing a root cause analysis, accident analysis, re-evaluating disciplinary/incentive programs, retraining, and evaluating effectiveness of corrective actions.

University example of safety compliance procedure

- **Laboratory Safety Compliance Procedure and Implementation Plan**

[Available at UCLA \(Compliance Procedure\) and \(Implementation Plan\)](#)

A three-tiered approach to dealing with PIs with repeat non-compliance findings on EH&S inspections. This procedure was developed by a faculty-led Chemical and Physical Safety Committee.

20. The institution promotes academic and industrial/government partnerships that allow academic researchers to learn from strong and well-developed safety cultures in industrial and government laboratories.

KEY RESOURCES

Laboratory safety attitudes and practices: A comparison of academic,

government, and industry researchers (Schröder, I., et. al, 2015):

The safety culture in academic labs is less well established as compared to the safety culture in government and industry research labs. Industry labs, overall, display the best functioning safety culture. In our study, PPE compliance and risk assessment were used as indicators of safety culture and the statement is based on the finding that researchers' risk perception in all three work places was similar.

The Safe Conduct of Research (Battelle, 2014):

1. Everyone is personally responsible for ensuring safe operations.
2. Leaders value the safety legacy they create in their discipline.
3. Staff raise safety concerns because trust permeates the organization.
4. Cutting-edge science requires cutting-edge safety.
5. A questioning attitude is cultivated.
6. Learning never stops.
7. Hazards are identified and evaluated for every task, every time.
8. A healthy respect is maintained for what can go wrong.

TOOLBOX

Safety in the nuclear industry

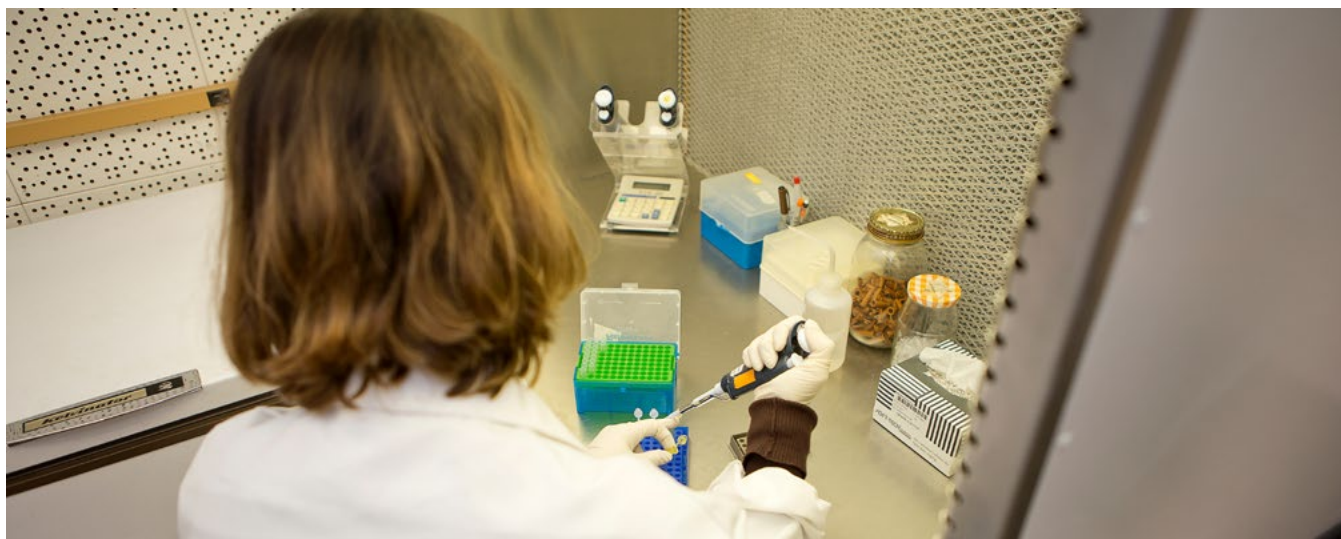
- **Safety Series**
[Available at International Nuclear Safety Advisory Group](#)
Deals with the concept of safety culture in the nuclear power industry.
- **Rethink Biosafety**
[Available at Nature.com](#)
Tim Trevan (2015) argues that the biological research community can learn from the nuclear industry, which has a culture that focuses on preventing failure. The nuclear industry adopts the practices of a “high-reliability organization” (HRO). Some characteristics of an HRO are that all members of the organization ask “What can go wrong, and how do we prevent it?” They are mindful of their environment, pay attention to unexpected changes to a process, and look for possible causes of catastrophic failure. The systems are designed to be redundant to mitigate system-wide failure. Finally, they value expertise and recognize that new members of the team might have the knowledge and skills to spot unsafe practices.
- **Weick, K. E., & Sutcliffe, K. M. (2011). Managing the unexpected: Resilient performance in an age of uncertainty (Vol. 8). John Wiley & Sons.**
[Available at Wiley](#)
A more in-depth resource on HROs

Safety in the healthcare industry

- **Chassin, M. R., & Loeb, J. M. (2011). The ongoing quality improvement journey: next stop, high reliability. *Health Affairs*, 30(4), 559-568**
[Available at Health Affairs](#)
Example of the healthcare industry as an HRO.
- **Kohn, L. T., Corrigan, J. M., & Donaldson, M. S. (Eds.). (2000). To err is human: building a Safer Health System (Vol. 6). National Academies Press**
[Available at National Academies Press.](#)

Safety in industry

- **One of the Best Safety Speeches Ever By Alcoa CEO, Paul O'Neill (2012)**
[Available at EHS Safety News America](#)
- **Managing Operational Risk to Enhance Business Performance**
[Available at Dupont USA](#)
An infographic on Process Safety Management.
- **Safety Training Observation Program (STOP)**
[Available at Dupont](#)
Provides a path to workplace safety by making safe behavior and workplace conditions part of the work culture.
- **Dow Lab Safety Academy**
[Available at Dow](#)
Provides resources for enhancing safety practices.
- **Driving Toward "0": Best Practices in Corporate Safety and Health**
[Available at OSHA](#)
Describes how leading companies develop safety cultures. The report includes survey responses from 65 companies eliciting their best practices for leading safety.





**ACTIONS THAT SUPPORT
A CULTURE OF SAFETY**

The task force suggests the following actions for members of the university community to best support a culture of laboratory safety, although these are not exhaustive. In the toolbox, we have provided documents from foundational reports and some universities that further articulate and delineate the roles and responsibilities of university members.

Responsibility for fostering and sustaining a safe campus rests on all members of the university community, and the ultimate accountability rests with the president/chancellor.

**President/Chancellor,
Provost, and Senior
Research Officer**

1. Demonstrate that safety is a core value of the institution through public discussion of the importance of safety, by providing adequate resources, and by developing effective policies.
2. Understand that hazards exist not just in the labs of chemistry departments, but in other settings, such as other types of laboratories, performing arts spaces, art studios, and field research sites.
3. Appoint an institutional lead and leadership team responsible for facilitating the building of a culture of safety (include language on authority and accountability).
4. Be transparent on roles, responsibilities, and accountability.
5. Align the reward and recognition system with efforts to promote safety, attending to hiring, promotion, tenure, and salary decisions for faculty.
6. Assume ultimate responsibility for safety.

**Appointed Institutional
Lead and Leadership
Team Responsible for
Strengthening a Culture of
Safety**

1. Engage all stakeholders to build and implement an inclusive, collaborative plan with the institution.
2. Develop effective working relationships with all stakeholders involved in improving the culture of safety.
3. Participate in ongoing assessment, continuous improvement, and communication with the community.
4. Develop and collect qualitative and quantitative safety metrics.
5. Report to senior leadership about progress and maturation of the culture.

Deans and Department Heads/Chairs

6. Publish annual progress reports to the community.
7. Implement annual reviews on the culture of safety.
1. Effectively communicate the importance of a strong culture of safety to all members of the department.
2. Work collaboratively with researchers toward the common goal of supporting a culture of safety.
3. Work collaboratively with EH&S personnel.
4. Ensure that adequate expertise is available during the development, implementation, and assessment of the culture of safety plan.
5. Lead by example, by modeling good safety behavior.
6. Incorporate efforts to foster a strong, positive culture of safety as an element in the criteria for faculty promotion, tenure, and salary decisions.
7. Ensure that all safety incidents are reported to the department head/chair and dean.
8. Assume ultimate responsibility for safety in the college (deans) and department (heads/chairs).



Environmental Health & Safety Personnel

1. Work collaboratively with research personnel.
2. Encourage open and ongoing dialogue about safety to promote a questioning attitude, a healthy respect for what can go wrong, and continuous learning from operational experiences.
3. Assist the university community in the evaluation of hazards and the development of procedures and other resources.
4. In coordination with the research community, committees, and leadership, develop best practices and documentation to convey institutional standards.
5. Provide a central repository of safety resources to the research community.
6. Monitor and communicate regulatory and advisory changes to the research community.
7. Collect and report safety metrics to the research community, committees, and leadership.
8. Deliver training and education to the research community.

Faculty

1. Facilitate open dialogue about safety in labs, studios, and field sites.
2. Conduct a hazard analysis prior to conducting any experimental procedure.
3. Ensure everyone in the lab/studio/field site receives proper safety training.
4. Lead by example, by modeling good safety behavior.
5. Incorporate considerations of safety into scholarly work, presentations, and lab meetings.
6. Discuss lessons learned from accidents, incidents, and near misses with their research group.
7. Assume ultimate responsibility for safety in their laboratory, studio, or field site.



Undergraduate and graduate students, postdoctoral scholars, and research personnel

1. Be mindful of the potential risks to their safety and those of their neighbors in the lab, field, shop, studio, stage, and in the classroom.
2. Stop any experiment or activity that is potentially unsafe and notify the faculty supervisor.
3. Immediately report all accidents and incidents to the faculty supervisor.
4. Follow all verbal and written laboratory safety rules, including the appropriate use of personal protective equipment (PPE), regulations, and standard operating procedures required for the tasks assigned.
5. Conduct a hazard analysis prior to conducting any experimental procedure.
6. Include a hazard analysis in thesis, dissertation, and funding proposals.
7. Incorporate considerations of safety into presentations and lab meetings.
8. Discuss lessons learned from accidents, incidents, and near misses with faculty supervisor and fellow researchers.



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- Council of Graduate Schools (CGS)
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- U.S. Chemical Safety and Hazard Investigation Board (CSB)
- Oak Ridge National Lab
- Eastman Chemical Company
- Centers for Disease Control and Prevention (CDC)
- American Biological Safety Association (ABSA)
- Association for the Accreditation of Human Research Protection Programs (AAHRPP)
- Campus Safety, Health, and Environmental Management Association (CSHEMA)
- Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC)
- Federation of American Societies for Experimental Biology (FASEB)
- Federal Demonstration Partnership (FDP)
- University Risk Management and Insurance Association (URMIA)
- National Association of College and University Attorneys (NACUA)
- National Association of College and University Business Officers (NACUBO)
- National Postdoctoral Association (NPA)
- Council on Undergraduate Research (CUR)
- Council of Colleges of Arts and Sciences (CCAS)

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- Texas A&M University System
- University of Maryland
- University of Tennessee, Knoxville
- Utah State University
- University of California, Los Angeles
- University of Arizona
- University of Nevada, Reno
- University of Illinois at Urbana-Champaign
- Emory University
- Michigan Technological University
- University of Calgary
- Harvard University
- Cornell University
- University of Minnesota, Twin Cities
- Texas Tech University.

We have included a [chronology](#) of Task Force meetings with these organizations.

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