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Analyzing the Role of the Chemical Hygiene Officer in Scientific Laboratories: A Professional Position on Regulations, Function, and Needs for Program Effectiveness

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Abstract

Work-related hazards and risks continue to be a challenge in workplaces across industry. It is no secret that engineering and administrative control measures are critical for protecting employees, and despite this knowledge, protecting employees using properly implemented occupational safety and health (OSH) programs remains to be a continuous challenge. Although fatality rates have decreased over the past several decades, the overall numbers of occupational accidents and work-related diseases occurring globally continues to be a serious problem. Globally, there are hundreds of millions of occupational injuries and diseases, both fatal and non-fatal, every year, even in the United States, which has a prevalent and active agency, the Occupational Safety and Health Administration (OSHA) that addresses OSH. Nevertheless, injury and illness occurs in a great multitude of professions, job tasks, and industries, including in scientific research and academic laboratories, which are often left out of the conversation about high-risk industrial environments, despite the traditional uses of highly hazardous chemicals and processes. Although twenty years have elapsed since OSHA refined the scope of the 29 Code of Federal Regulations (CFR) 1910.1200 – *Hazard Communication*, and promulgated a second right-to-know (RTK) standard, CFR 1910.1450 – *Exposure to Hazardous Chemicals in Laboratories* to specifically address requirements for limiting chemical exposure at laboratory scale, the required designation within the *OSHA Lab Standard* of a chemical hygiene officer (CHO) is singularly insufficient to implement an *effective* chemical hygiene plan (CHP).

Introduction

Work-related hazards and risks continue to be a challenge in workplaces across industry, including in scientific laboratories. Administrative controls, such as laws and regulations, as well as corporate policies are necessary in order to prevent injuries and protect employees. These regulations are established by organizations such as OSHA, and the policies and procedures in organizations are often created by compliance departments and safety staff, among others.

Globally, hundreds of millions of occupational injuries and diseases, occur annually, and they are not limited only to countries that do not have established public health infrastructures. Even in the U.S., where agencies such as OSHA exist to address OSH, injury and illness occur in a great multitude of professions, job tasks, and industries, including in scientific research and academic laboratories.

Occupational health and safety falls within the realm of corporate social responsibility (CSR). One concise definition of CSR that is often viewed as valid, and commonly used in industry, states that CSR is the responsibility of enterprises for their impacts on society[30, 32] including the people within the enterprise and society as a whole. Efforts towards CSR are usually based on particular social issues, and corporate entities sometimes tend to react to those with resistance, especially when corporate leaders do not value the cause as something of equal value to the economics.[33] As a result, regulatory agencies often generate regulations, laws, standards, or guidelines to address particular social responsibility issues. Under common CSR definitions, the employee domain includes work conditions and labor practices which encompasses OHS.[32]

Organizations may often underestimate the extent of OSH problems, but poor OSH practices in organizations result in not only injuries and illness, but also in billions of dollars of annual gross domestic product losses globally.[31] When organizations experience these losses, they begin to pay closer attention to the root causes for these losses. The Socioeconomic Approach to Management (SEAM) approach measures these “hidden” costs in organizations and recognizes that they are very real. Henri Savall, the developer of SEAM, realized that modern accounting does not measure nearly 40% of what happens financially in an organization, and a portion of this 40% includes occupational injuries, illness, and the byproducts of them. Workplace performance and effectiveness is closely tied to the ability of employees to remain healthy, and that health can have a direct effect on absenteeism, staff turnover, re-training, and productivity gaps.[28, 29] Thus, organizations are realizing the cost of safety incidents, and scientific laboratories, whether academic or corporate, as well as regulatory agencies, have begun to truly understand the importance of effective laboratory safety programs, including strong and thorough chemical hygiene programs.

There have been numerous laboratory accidents in pharmaceutical and biotechnology corporations and in academia, such as the incidents at the University of California at Los Angeles, the University of

Hawaii, Texas Tech, Yale University, Boise State University, the University of Maryland, and others, that have resulted in tragedy, including incredible facility damage, serious injuries, amputation, and in some cases fatalities. For the purposes of thorough discussion, but also brevity of text, this article will assess one of these incidents as a case study in order to assess and discuss the roles and responsibilities of a CHO, the requirements of a CHP, and the gaps that exist in laboratory safety programs that affect definition of CHOs, CHPs, and program effectiveness.

Literature Review and Discussion

When the OSHA first promulgated occupational safety and health regulations in 1971, there was an expectation by American workers that there would soon follow a federal RTK law. In short, this RTK law would serve to require employers to inform employees about the hazards associated with the workplace and how to protect themselves from injury while on the job. However, this did not occur for years after the inception of OSHA, which left the States, in some cases, to promulgate their own RTK laws out of necessity. When a Federal RTK law finally arrived approximately 12 years later, in 1983, in the form of 29 CFR 1910.1200 – *Hazard Communication (HazCom)*, many States already had RTK laws in effect. It was resolved that under Section 18 of the OSH Act, State-specific standards had to be "*at least as effective as Federal standards,"* thus States could keep their existing, albeit, sometimes more restrictive requirements in place.[1] Even today, many of these State plans, such as Cal-OSHA, have more stringent requirements than existing federal RTK laws.[2]

Although the *HazCom Standard*, first adopted in 1983, and subsequently expanded in 1987, is intended to require *"manufacturers and importers"* to assess the hazards of chemicals and provide information to employees about the hazardous chemicals to which they are *"exposed under normal conditions of use or in a foreseeable emergency,"* OSHA determined the necessity to promulgate a second RTK law specifically aimed at preventing chemical exposure to employees during *"laboratory-scale"* chemical manipulations.[3,4] In 1991, 29 CFR 1910.1450 – *Occupational Exposure to Hazardous Chemicals in Laboratories*, more commonly known as the *OSHA Laboratory Standard*, took effect.

Before deciding which of the two RTK laws is applicable in a particular workplace situation, their similarities and differences must be better understood. Most importantly, similarities of both RTK laws include the requirement for a written program to be in place to inform workers of the hazards associated with their work with *hazardous chemicals*. High-level comparisons of both RTK laws are illustrated in Table 1.

***Table 1.* –** Comparison of *HazCom* v. *OSHA Lab Standard*[3,4]

REGULATORY REQUIREMENTS	**OSHA 1910.1200 HAZARD COMMUNICATION**	**OSHA 1910.1450 LAB STANDARD**
Scope	• Chemical manufacturers & importers	• Lab-scale use of with multiple chemicals/procedures not part of production process; utilizing protective practices or equipment
Written Program	• Provisions for information & training • Methods for conducting hazard determinations • Provisions for access to MSDS & precautionary information	• Provisions for information & training • Chemical Hygiene Plan • SOPs for working with hazardous chemicals • Designation of Chemical Hygiene Officer
Chemical List	• Up-to-date chemical inventory	• N/A
Labels	• More stringent – each container: chemical name, hazard statements, target organs, ingredients and responsible party	• Less stringent – name or chemical structure only; no labeling if exclusive lab use; use outside of lab requires adherence to HazCom
MSDS	• Maintain, retain & make accessible	• Maintain, retain & make accessible <u>or</u> maintain & retain chemical inventory
Information	• Initially & when new hazard introduced • Location of MSDS • Operations where hazardous chemicals present	• Initially & when new exposure situation • Location of Chemical Hygiene Plan • Exposure limits, signs & symptoms of exposure
Training	• Methods to detect	• Methods to detect exposure

	• Physical & health hazards • Required PPE • Details of program, labeling & obtaining hazard information	• Physical & health hazards • Required PPE • Details of Chemical Hygiene Plan
Medical	• N/A	• If signs or symptoms • Monitoring exceeds exposure limits • Accident or spill • Maintain medical records

Simply, OSHA 29 CFR 1910.1200 – *Hazard Communication* is most applicable in work situations related to commercial production involving few chemicals in large quantities.[3] On the other hand, 29 CFR OSHA 1910.1450 – *Occupational Exposure to Hazardous Chemicals in Laboratories* is most applicable to "laboratory-scale" use of multiple chemicals and procedures where handling is easily and safely completed by one person and is not part of the production process.[4] The decision tree analysis for determining *HazCom* or *OSHA Lab Standard* applicability is summarized in the process flow diagram (See Attachment A). The remainder of this discussion will concentrate on those applications where 29 CFR OSHA 1910.1450 - *Occupational Exposure to Hazardous Chemicals in Laboratories* or its equivalent State plan would apply. Key components of the *OSHA Lab Standard* will be discussed while providing insight into efforts of the CHO to comply with the spirit of the standard.

OSHA Laboratory Standard

Although intended to provide relief from some of the more burdensome requirements under *HazCom* (i.e. - labeling), the initial reaction by some affected by the new *OSHA Lab Standard* was less than favorable. Shortly after becoming effective in 1991, a scathing letter was sent to Indiana Congressman, John Myers, from Professor/Head of Biochemistry at Purdue University, Mark Hermodson, declaring, "*Those rules (CFR 1910.1450 – Occupational Exposure to Hazardous Chemicals in Laboratories) are particularly obnoxious*". He went on to say that, *"The OSHA paperwork is going to cost us a lot of productivity, and indirect costs. It will not significantly improve anything in terms of lab safety."* [5] The eventual response by then Assistant Secretary of OSHA, Gerard F. Schannel, via an OSHA Letter of Interpretation dated April 19, 1991, is still echoed by safety professionals and CHOs today.

"The Agency certainly does not intend to burden an employer with unnecessary paperwork or to cause a loss in productivity. Given the flexibility to design and implement innovative measures to reduce employee

exposure to hazardous substances, employers will reap rewards in terms of lower insurance premiums, lower property damage costs, lower turnover costs, less absenteeism, and in general increased productivity."[5]

Again, the *OSHA Lab Standard* is a performance-based standard which allows for flexibility in its application rather than a prescriptive approach to compliance. Ironically, Mr. Hermodson was enlightened to the fact that his home State of Indiana actually had jurisdiction over Federal OSHA in this instance with its own at least as effective State-plan health and safety program. Regardless, Mr. Shannel's textbook response and rationale harkens to the fundamental concepts taught in introductory occupational health and safety courses throughout academia. The point being, lack of investment in safety programs will ultimately cost an employer more money than proactively investing in employee safety. Conservative estimates put the annual cost of unintentional occupational injuries in the U.S. in excess of $120 billion. Without an organized safety movement over the course of the 20th century, these annual costs could easily be two to three times as great.[6] In other words, each dollar an employer spends for safety may be returning a clear profit of up to several hundred percent.[6] The opinion of Mr. Hermodson and the response Mr. Shannel constitute the unchanging, never-ending debate between affected party and safety professional.

Key Provisions. Two key provisions of 29 CFR 1910.1450 – *Occupational Exposure to Hazardous Chemicals in Laboratories* to be discussed in further detail are: 1) the requirement for the formulation and implementation of an effective, comprehensive Chemical Hygiene Plan, and 2) the requirement for designation of a CHO or a Chemical Hygiene Committee to be responsible for implementation of the CHP.[4]

The Chemical Hygiene Plan. The CHP requirement of 29 CFR 1910.1450 – *Occupational Exposure to Hazardous Chemicals in Laboratories* serves as the foundation of the entire standard. By definition in 1910.1450(b),

"Chemical Hygiene Plan means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section" (to be discussed later).[4]

The manner in which compliance to the CHP requirement of the *OSHA Lab Standard* is obtained is determined by each employer. OSHA provides guidance for employer's development of an appropriate CHP in 29 CFR 1910.1450 Appendix A – *National Research Council recommendations concerning chemical hygiene in laboratories (non-mandatory)*. These non-mandatory recommendations were extracted from the textbook, "Prudent Practices for Handling Hazardous Chemical in Laboratories", or simply "Prudent Practices", which was established in 1981 by the National Research Council.[7] "Prudent Practices" is cited by OSHA because of its wide distribution and acceptance and because of its preparation by members of the laboratory community.[7] This becomes an important point moving forward in the discussion of assessing the overall *effectiveness* of any given CHP. Here then, is a clear illustration of OSHA's intent for this particular standard to have "flexibility" or be performance-based, rather than be merely "prescriptive". In almost all cases, institutions adhering to the *OSHA Lab Standard* opt to use the non-mandatory 1910.1450 Appendix A as the reference for creation of their respective CHP. Whether authored within an institution by the CHO (to be defined later) or purchased in template-style from a variety of safety consultant services available and later individualized to a particular institution, the CHP *must* contain eight important components.[8,9]

1. Standard Operating Procedures – Work practices and policies essential to protect employees from chemical hazards are in place
2. Criteria for reducing employee exposure to hazardous chemicals: Documentation of engineering controls, personal protective equipment and hygiene practices.
3. Procedures that ensure chemical fume hoods and other protective equipment are functioning properly.
4. Provisions for employee training –
    - Physical and health hazards information on chemicals
    - Contents, location and availability of the CHP
    - PELs of OSHA regulated chemicals.
    - Signs and symptoms associated with chemical exposure
    - Location and availability of reference materials (i.e. MSDS)
5. Circumstances requiring employer approval of certain laboratory operations; procedures or activities before implementation.
6. Provisions for medical consultation –
    - When an employee develops signs or symptoms of exposure
    - When monitoring levels exceed action level or Permissible Exposure Limit (PEL)
    - When a spill, leak or explosion occurs
7. Measures to protect employees from particularly hazardous substances
    - Select carcinogens
    - Reproductive toxins
    - Chemicals with high acute toxicity
8. Designation of a Chemical Hygiene Officer (to be discussed in detail later)

Based on the criteria outlined above and the specificity of laboratory operations, it becomes abundantly clear that not all *effective* CHPs should look alike. For instance, the CHP for a small biotechnology company with twenty scientists performing research and development in a series of small-scale laboratories should have a vastly different CHP from a large pharmaceutical or chemical company with several thousand scientists working in hundreds of laboratories. The contrast in chemical inventories alone could span from several hundred chemicals in a small biotechnology company to tens of thousands of chemicals in a large pharmaceutical company. Therefore, the breadth and scope of a CHP should be commensurate with the complexity of the science being performed. Ideally, the CHP should be distinct enough that it does not require employees to become adept with incidental material that is not applicable to their workplace.[8] Herein is the key concern with purchasing a template-style CHP without appropriate scrutiny, the institution becomes responsible, from a regulatory and legal aspect, for adhering to whatever content is contained or missing from their respective CHP. The importance of implementing an effective CHP is beginning to reveal the ultimate need for an *effective* CHO to facilitate the desired outcome.

To this point in the discussion, the introduction and purpose of 29 CFR 1910.1450 – *Occupational Exposure to Hazardous Chemicals in Laboratories* to supersede 29 CFR 1910.1200 – *Hazard Communication* where applicable has been explained. The decision-logic for which standard applies to an institution in a given chemical operation was introduced via the process flow diagram in Attachment A. Where the *OSHA Lab Standard* applies, the major component of the standard, the requirement for a Chemical Hygiene Plan was also introduced and described as to its necessary components to ensure employee exposures to hazardous chemicals in laboratories are minimized. The remainder of this discussion will revolve almost entirely around the role of the CHO in implementing an effective CHP. A thorough analysis of CHO responsibilities, challenges and limitations will be detailed. Finally, suggested solutions and strategies for increasing CHP effectiveness will be revealed.

The Chemical Hygiene Officer. Before an in-depth discussion of the CHO can commence, it is essential to understand both what the *OSHA Lab Standard* and what the non-mandatory 1910.1450 Appendix A states about the role of the CHO.

According to 29 CFR OSHA 1910.1450 - *Occupational Exposure to Hazardous Chemicals in Laboratories,* by definition in 1910.1450(b),

"The Chemical Hygiene Officer means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure."[4]

The *OSHA Lab Standard* mentions the CHO in only one other instance within the standard in 1910.1450(e)(3)(vii), *"Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene Committee;"*[4]

The latter citation provides leeway for the role of the CHO to be carried out by committee and not by one individual alone. As previously mentioned, in a small biotechnology company may necessitate only a single individual acting as the CHO, whereas, a large pharmaceutical company may warrant more than one individual based on the number of employees, the amount of laboratories and the scope of the science being undertaken.

As for 29 CFR 1910.1450 Appendix A – *National Research Council recommendations concerning chemical hygiene in laboratories (non-mandatory)*, the role of the CHO is explained in much more detail. Since the majority of institutions where the *OSHA Lab Standard* is pertinent use the non-mandatory 1910.1450 Appendix A as the basis for their respective CHP, these are the criteria by which the vast majority of Chemical Hygiene Officers base their job description and objectives. From the non-mandatory 1910.1450 Appendix A (B)(3)(e-f),

"chemical hygiene officer(s), whose appointment is essential must:
(a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices; (b) Monitor procurement, use, and disposal of chemicals used in the lab; (c) See that appropriate audits are maintained; (d) Help project directors develop precautions and adequate facilities; (e) Know the current legal requirements concerning regulated substances; and (f) Seek ways to improve the chemical hygiene program."[7]

Worth mentioning at the onset of this discussion of the CHO is that he non-mandatory 1910.1450 Appendix A deliberately defines the roles and responsibilities for chemical hygiene at *all* levels of the institution. Secondly, if adopted as the basis of the CHP, then the guidance regarding other aspects of the CHP becomes relevant, as well. Regarding the Chief Executive Officer in (B)(1),

"who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene."[7]

Regarding the Laboratory supervisor in (B)(4)(a-e),

"who has overall responsibility for chemical hygiene in the laboratory including responsibility to: (a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided; (b) Provide regular, formal and chemical hygiene and housekeeping inspections including routine inspections of emergency equipment; (c) Know the legal requirements concerning regulated substances; (d) Determine the required levels of protective apparel

and equipment; and (e) Ensure that facilities and training for use of any material being ordered are adequate"[7]

And finally, regarding the Laboratory worker in (6)(a-b),

"who is responsible for (a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures; and (b) Developing good personal chemical hygiene habits"[7]

This complete hierarchal description of responsibilities regarding chemical hygiene as an over-riding concept in the non-mandatory 1910.1450 – Appendix A is pivotal in the implementation of an effective CHP. Prudent Practices takes these painstaking steps to define expectations from the bench scientist to the CEO as to their respective roles, not just the CHO, in chemical hygiene. This point of shared responsibility will be referenced throughout this discussion. In Table 2 below, an example from academia shows a step-wise regression from the top down in terms of chemical hygiene responsibility.[10] A similar structure would apply in private industry substituting the CEO for the University President. Additionally, the bench scientist would be covered by OSHA regulations and would equate to the Student in Laboratory Courses listed below.

Table 2. **–** Levels of Responsibility for Chemical Health and Safety in Academia[10]

HEALTH AND SAFETY HIERARCHY AT THE UNIVERSITY OF WYOMING
1. University President – Board of Trustees 2. Vice President for Finance 3. Head, Risk Management Office 4. Head, Environmental, Health and Safety Office 5. Institutional Chemical Hygiene Officer 6. A&S College Safety Coordinator – Dean of Arts and Sciences 7. Chemistry Department Head 8. Chemistry Department Chemical Hygiene Coordinator 9. Faculty Teaching/Research Laboratory Supervisor 10. Staff Laboratory Coordinator 11. Post Doctoral Researcher 12. Graduate Teaching/Research Assistant 13. Undergraduate Laboratory Employee 14. Work Study Student 15. Student in Laboratory Courses*
*Not strictly covered by OSHA regulations, but covered by UW Trustee regulations

Interpreting the OSHA Definition. The ambiguity in which OSHA describes the CHO requirements in the *OSHA Lab Standard* necessitates a great deal of interpretation as to what is meant by the definition provided in 1910.1450(b). The following scenarios will attempt to provide some insight into what experience, training and attributes have been deemed satisfactory by institutions in designating a CHO. As with the various aspects of the *OSHA Lab Standard* to date, this criterion varies drastically from institution to institution. With it varies the *effectiveness* of the CHP implementation. The requirement for an institution to "designate", or synonymously, "appoint" a CHO needs to be explored in terms of not always being voluntary in nature. This is, by far, the least palatable CHO option for many reasons. However, in many instances, smaller institutions without an Environmental, Health and Safety (EHS) department serve as CHO may find themselves offering up a scientist, shift manager or supervisor to take on this OSHA-mandated role as an add-on to current job functions. Without any prior knowledge of the basis of the *OSHA Lab Standard* and its requirements, this person is destined for failure from the onset even with a well-written CHP in hand. In the case of scientists, the majority encountered are adept at working in the laboratory, but will not have had any formal chemical safety training or coursework while in academia. Some academic institutions have taken the step of stating that their CHP applies to students. Although OSHA is not concerned with this extension, it would bring the requirements, and subsequent training pertaining to the *OSHA Lab Standard* into force long before being hired into private industry[10]. However, this is not typically the case. This leaves the lesser OSHA-savvy, ill-prepared graduate seeking employment in industry with only haphazardly implemented and enforced safety program experience, typically administered at the hands of an equally untrained Teaching Assistant, as their only perception of chemical hygiene prior to entering the workforce. As highly-educated scientists, these newly-hired employees often find themselves vulnerable to appointment into the CHO position without the tools to succeed or an established EHS program to leverage. Non-scientific managers or supervisors will most often have been exposed to even less chemical hygiene training or general safety training, for that matter, and instinctively place production and timelines ahead of safety and precautionary measures. Along with personal and professional failure, these misrepresentations of the CHO could result in far worse, from a health and safety perspective, for those under the false pretences that they are being provided with adequate technical guidance and training to perform their laboratory duties without chemical exposure or injury. Nonetheless, unwilling and professionally inexperienced individuals are thrust into this role on a routine basis. Many exist for extended periods of time without incident; others are less lucky and are faced with catastrophic incidents that result in loss of property and lives. Even in scenarios where individuals or committees are willing participants, such as EHS safety professionals, in carrying out the duties specified by OSHA for the CHO, serious incidents and injuries still occur. The 2008 laboratory fire and fatality at UCLA will be analyzed as a case study later in this discussion as a graphic example of what could go wrong at the hands of a CHO.

OSHA goes into greater detail in their definition in 1910.1450(b) to further require the designated CHO to be, *"qualified by training or experience to provide technical guidance"*. Herein is a phrase generating numerous articles and essays within the chemical laboratory safety community as to what constitutes training or experience. OSHA does not suggest courses or certifications it considers satisfactory as CHO training, nor does it explain what specific role or for how long a prospective CHO needs performing that role to constitute satisfactory CHO experience. By re-visiting some of the previously mentioned paths to becoming a CHO, it can be strikingly little and still be compliant to OSHA. Many naïve institutions simply do not understand the full responsibility of the CHO or what that means to the legal standing of the institution should OSHA become involved from a regulatory enforcement capacity. It is then in the best interests of any institution affected by the *OSHA Lab Standard* to proceed with caution and choose wisely with regard to CHO designation.

Whether designated as a willing CHO, as in the case of an EHS safety professional, or whether installed by an institution as a less than willing CHO, as in the case of the scientist or management personnel, the CHO is faced with a daunting task of controlling employee exposure to hazardous chemicals in the laboratory. Although the EHS safety professional may have a collegiate background in OSHA regulations where others may not, in either case, the experience OSHA references in 1910.1450(b) with regard to the CHO is typically insufficient or lacking altogether, until sufficient spent in the role. No matter from what discipline a CHO emerges, there is a clear convergence of skill levels and common starting point when gaining the experience component stated in the OSHA definition. However, CHO experience need not be personal in nature, but can be leveraged through such avenues (i.e. - professional listservs) that can serve as *de facto* EHS colleagues or chemical hygiene committees. For instance, a nominal membership fee to the American Chemical Society (ACS) Division of Chemical Health and Safety (DCHAS) gains subscriber's access to the DCHAS-L listserv which is the Division's e-mail list. It is intended to facilitate the conduct of division business and to provide the opportunity for subscribers to make contacts with other members to share technical questions.[11] Chemical Hygiene Officers or ACS DCHAS members at large can present, discuss and offer opinions to CHP implementation and other laboratory safety issues. This experience and networking can be a valuable asset to the newly designated or seasoned CHO. It can be re-assuring to an over-whelmed CHO to learn that others in a similar role are raising common questions. Additionally, best practices can be shared and implemented, thus saving time, money and a great deal of professional frustration. There are numerous other free safety listservs to choose from, such as The Laboratory Safety Institute, which have very active and informative contributors.[12]

While the experience component of the 1910.1450(b) definition can be simply explained as, either time spent on the job as acting CHO, or leveraging professional colleagues via listservs or professional networking (conferences, societies, etc.), the "training" component of the definition still remains vague. More often than not, professional development as the CHO is looked to be accomplished through completion of training programs aimed at providing the CHO the tools necessary to implement an effective CHP. In essence, there is an immediate return on investment via course certification or supplied Continuing Education (CE) credits earned, whereas, developing professional experience takes extended periods of time. Many laboratory safety courses exist and are marketed through numerous professional organizations and consulting agencies. However, if an institution is looking to commit to one training program to best prepare the CHO, the ACS offers several iterations of a 3-day CHO Short Course entitled, *Laboratory Safety and Health*. From the course syllabus,[13]

"This course is designed for laboratory and pilot plant employees who have responsibility for or interest in related safety and health issues, including managers, supervisors, chemists, technicians and others. The course will focus on practical measures for prevention of incidents and exposures, that may cause health impairment, injury, fire, damage to the environment, or interfere with laboratory operations. The course will include an overview of safety and health standards and regulations that may apply to the laboratory workplace."[13]

By revealing to whom the course is intended through the introduction above, it can easily be realized that the listed job functions are all those previously mentioned as possible designates for the role of CHO in an institution. Even more enticing as a training of choice for prospective and existing CHOs is the unwritten purpose of the training; serving as a preparatory course for the ACS-sanctioned, National Registry of Certified Chemists (NRCC) certification examination for CHOs. The NRCC, organized in 1967, originally certified only Clinical Chemists and Clinical Chemistry Technologists. After the ACS sponsored a Task Force on Safety Certification in 1997, the NRCC was chosen to implement and administer a certification program specifically for CHOs.[14,15] The NRCC lends its expertise in providing explicit education and experience criteria in order to sit for the examination. In doing so, it de-mystifies much of the debate on experience and training discussed previously. According to the NRCC in Table 3,[14]

Table 3. **–** Education and Experience Standards for CHO Certification[14]

Degree	Semester Hours – Chemical, Physical, Biological, Industrial Hygiene, Environmental, or Health and Safety Sciences	Experience in Chemical Health and Safety (Years)
Academic Training (No Degree)	16	3
Associate's Degree	16	2
Bachelor's Degree	16	1
Master's Degree	16	1
Doctor's Degree	16	1

Registrants meeting the education, experience and, finally, the examination standards established by the Registry, are granted the certification as a CHO (NRCC-CHO). This certification is recognized throughout the scientific and regulatory communities. Sponsors include: American Association of Clinical Chemistry, American Board of Clinical Chemistry, American board of Forensic Toxicology, American Chemical Society, American Industrial Hygiene Association, American Institute of Chemists and the National academy of Clinical Biochemistry.[14] Although the NRRCC-CHO certification is not a requirement in order to perform and succeed in the role of CHO for an institution, since 1997, the NRCC has provided this service as a valuable and much needed bench-marking tool for a CHO through its certification program.

By contrasting the various interpretations of the 1910.1450(b) definition of a CHO, it has been clearly demonstrated that OSHA has few, if any, constraints on the designation of a CHO to, *"implement the provisions of the Chemical Hygiene Plan"*.[4] However, the argument has been made that this designation brings with it great responsibilities and should be given the appropriate degree of scrutiny before a CHO for an institution is appointed. Organizations, other than OSHA, have acted for the betterment of their own interests (i.e. - ACS) to help develop criteria by which a CHO can achieve certification and recognition within the professional community for being amply knowledgeable to carry out the responsibilities of the CHO.

Beyond the professional recognition as a CHO, there are various other immeasurable qualities that a CHO would benefit from possessing. These attributes are spawned from a need to not merely demand compliance with the CHP, but to empower employees to want to comply with the CHP through the adoption of safety as a core value. These powers of persuasion are borne from a variety of personal leadership qualities that are not certifiable through training, but learned over time. First, and foremost, the CHO must show unwavering courage through demonstration of a clear conviction to staking out their position with regards to chemical hygiene and setting an unequivocal course of action for the institution. They must collaborate across all levels of the institution and use the strengths and diversity (in background, experience, knowledge, etc.) of other stakeholders to improve the overall chemical hygiene performance. Lastly, the CHO must communicate candidly through speaking clearly and formulating points succinctly, whether in one-on-one interactions, or in group meeting settings. The slightest hesitation or demonstration of lack of understanding of applicable safety requirements in the midst of less than cooperative employees could undermine the fragile respect that can exist between CHO and scientist. Therefore, the CHO must always demonstrate persistence, tenacity and resilience in the face of these types of obstacles, pushback and barriers that accompany implementation of effective safety programs.

Challenges for the CHO. At this point in the discussion, assume that a CHP has been crafted that fully encompasses the requirements set forth in the *OSHA Lab Standard* while skillfully incorporating the suggestions contained in the non-mandatory 1910.1450 Appendix A to fit the scope of laboratory work being performed. Additionally, a CHO has been designated that meets the expectations of OSHA and the institution. Arguably, these foundational aspects of the chemical hygiene program still do not ensure an effective CHP has been implemented. In other words, a good paper program does not always equate to controlling occupational exposure to hazardous chemical in laboratories, it merely points to a compliant document of reference. According to 1910.1450(e)(4),

"The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary."[4]

The annual assessment as to whether the CHP is effective is another performance-based aspect of the *OSHA Lab Standard* that is left for interpretation by the individual institution. Interpretations as to what criterion are valid markers in this determination are debated ad nauseam and have created one of the greatest challenges to the CHO; what constitutes an effective CHP?

To assess effectiveness, it first needs to be defined. According to the *American Heritage Dictionary of the English Language*, effectiveness is defined as *"producing or capable of producing the desired effect."*[16] Further clarifying the definition, *Collins Thesaurus of the English Language* provides multiple synonyms for effectiveness, *"power, strength, usefulness, efficacy and success."*[17] In applying this to the implementation of the CHP, an institution has to set its annual expectations by which it assesses and, subsequently, updates its own CHP. Since the CHP encompasses at least eight different categorical requirements, all pertaining to the control of exposure to hazardous substances in the laboratory, it seems obvious that in order to adequately assess the effectiveness of the CHP, multiple metrics must be developed, tracked and measured. Simply relying on a solitary, measurable aspect of implementation (i.e. – OSHA Recordable Injury Rate or RIR) does not create a clear argument for this determination. Therefore, by examining a sampling of both leading, as well as, lagging metrics, a broader assessment of the chemical hygiene program will result. Consider leading metrics to include those aspects of the CHP implementation that are proactive, in nature. Also, consider the lagging metrics to be the reactive or results of the successes or failures of the chemical hygiene program. Table 4 contrasts a sampling of leading versus lagging metrics with regard to possible inclusion when determining CHP effectiveness (See Table 4).

Table 4. **–** Chemical Hygiene Program Metrics

LEADING METRICS	LAGGING METRICS
% Chemical Safety Training Completed	Recordable Injury Rate (RIR)
% Completion of Chemical Hygiene Plans	Lost Time Day Rate (LTDR)
% Laboratory Safety Inspections & Action Items Completed	Lost Time Incident Rate (LTIR)
% Hazard Assessments Completed	OSHA Fines, Penalties Assessed
% Medical Surveillance Completed	First Aid to Recordable Ratio
% Injury/Illness/Near Miss Reports Completed	EPA Notice of Violation (NOV)

While leading metrics demonstrate efforts to *prevent* exposures to hazardous chemicals in laboratories, they should be justifiably accompanied by the expectations for completion that is absolute (100%). These items are all within the control of the CHO and management and should not be compromised in an effective chemical hygiene program. Conversely, lagging metrics demonstrate lack of implementation and may necessitate changes to the CHP. These goals may not be absolute (0 or none) nor should they be set to be easily attained at any level thus producing a false sense of accomplishment. In many cases, these metrics are based on reductions from a previous year's goal. For instance, an RIR goal of 1.5 (1.5 OSHA Recordable injuries per 100 workers) for the current year may translate into a goal of 20% reduction for the following year, at 1.2. These are attainable metrics that can be used to measure ongoing improvement or effectiveness of the CHP. These types of goals are intended to continually challenge a high-performing institution while providing achievable goals or momentum building in an institution without a history of good safety performance. Consideration for deeming a CHP effective should be within reason if a representative assessment of leading and lagging metrics are set and met. Accomplishing these defined metrics for an institution is a challenging endeavor for the CHO alone and will require sponsorship and support at all levels of the organization in order to be realized.

While attempting to meet pre-determined CHP metrics, specifically lagging metrics such as RIR, it is almost always dependent on the execution and completion of leading metrics. These leading metrics, such as training and inspections, are inextricably tied to individual safety values and performance, as well as, the safety culture created within the institution. The CHO, as a singular entity, does not have the bandwidth to ensure achievement of these metrics alone; neither should they be solely responsible to do so. As discussed previously, the *OSHA Lab Standard* states in 1910.1450(e)(4),

"The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary."[4]

The employer is specifically named to be responsible for this determination. However, inevitably, the CHO typically is left to make these chemical hygiene program assessments due to lack of awareness, involvement and accountability by management. Therefore, the interface between the CHO and management is an extremely challenging facet of the overall success of a chemical hygiene program. This disconnect between the two becomes even more evident as safety performance deteriorates and can result in complete breakdown when events lead to significant injury, illness or fatality. Management will not hesitate to seek the explanations from the CHO when faced with an OSHA regulatory inspection or investigation.

Limitations on the CHO. With a better understanding of the responsibilities placed on the CHO by OSHA, as well as, the burden of additional responsibilities levied through a lack of management participation in the implementation of an effective chemical hygiene program, the CHO may struggle with how to motivate employees at the individual level. When faced with executing this otherwise management-led function, the CHO is severely limited because of a lack of prescribed enforcement capabilities within his or her purview. The well-trained CHO will have an exhaustive arsenal of methods with which to attempt to motivate individuals to adhere to the CHP. These approaches include, (a) making safety personal -- working safely for your family, (b) describing the detrimental effects of non-compliance on the business -- loss of jobs, (c) explaining the basis of the CHP regulation and requirements, (d) demonstrating genuine interest in worker safety, and (e) the ability to use influence, even without authority, to help leadership foster and maintain an effective safety culture. However, when these persuasive efforts fail to gain the desired effects, without management involvement, the CHO has no disciplinary capacity with which to wield to ensure individual compliance in meeting leading metrics. This privilege is solely a function of management to initiate through the institutional disciplinary process, typically in conjunction with the Human Resources department.

These enforcement limitations on the CHO make for spirited debate between the CHO and the scientist. Rebuttals from scientists spanning from intellectual debate on real versus perceived chemical hazards to complete insubordination are experienced by the CHO. With management uncommitted to supporting CHP enforcement, and in lieu planning experiments with a safety component built-in prior to initiation, scientists will instinctively revert to the fastest way to the next great discovery or product to market. These failures in planning lead to risks of chemical exposure due to poor housekeeping, improper chemical handling and storage, lack of understanding of emergency procedures and insufficient training on the chemical hazards. These gaps in top-down safety performance and accountability only serve to empower scientists to pushback even more due to lack of consequences for their actions. Regardless of whether a laboratory resides in a university or in an industrial company, the duty to make absolutely certain that all employees understand and follow the CHP rests with the laboratory supervisor and his or her superiors. The impetus to make safety a priority must come from those able to enforce consequences.[18]

Over the past few decades, numerous laboratory accidents have made the news or been addressed by the Chemical Safety Board, with the most famous of them being the incidents at Texas Tech University, the University of Hawaii, and UCLA. For purposes of this paper, with no partiality to one incident or another, we analyze the UCLA incident as a case study.

Case Study – 2008 UCLA Laboratory Fire & Fatality

CHP effectiveness is often illustrated through the use of pyramidal diagrams that depict unsafe acts as the basis for breeding near misses, injuries and ultimately, fatalities if left unchecked. There are statistical odds that can be placed on each of the steps in the escalation to determine the likelihood of progressing to a point of a workplace fatality. However, only with a systemic breakdown in the overall safety program will an institution progress to that unfortunate pinnacle. Such was the case at a UCLA research laboratory on December 29, 2008.[19]

Event Description and Discovery. On January 16, 2009, a 23-year old female, Sheharbano (Sherri) Sangji, died of burn injuries sustained while working as a Research Associate in a UCLA chemical research laboratory. The victim had been using a syringe and needle to extract a pyrophoric chemical, (t-butyl-lithium) from a bottle. The plunger inadvertently came out of the syringe barrel during a manipulation and the t-butyl-lithium ignited on contact with room air. The ensuing flashover caused the scientist to knock over additional uncapped, flammable solvents in her chemical containment hood. Without a lab coat, the chemical splashed onto the victim's synthetic clothes and set them ablaze. Within minutes, the scientist had suffered severe, third degree burns to face, arms and body. After nineteen agonizing days in the burn unit, Sherri succumbed to her injuries.[19] Initial investigation of the accident revealed that the scientist was not wearing a laboratory coat or safety glasses at the time of the incident. Additionally, there was no written documentation that the victim had received any formal training on the safe use of pyrophoric chemicals.[20] The formal investigation was led by Cal-OSHA, not Federal OSHA, because of the State of California having its own state equivalent. Participants included UCLA EHS, Los Angeles Fire Department and the California Fatality Assessment and Control Evaluation Program (FACE), which is part of the Occupational Health branch of the California Department of Health.

It was discovered that shortly prior to the fatal accident, the UCLA EHS department staff and CHO conducted periodic laboratory inspections in their efforts to satisfy requirements of Cal-OSHA Regulation, Title 8, §5191.[21] However, with regards to inspection frequency, Cal-OSHA states in the following quotations found in the California Code of Regulations, Title 8, §5191(e)(4) (State of California):

"The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary."[22]

More specifically, as part California Code of Regulations, Title 8, §5191 - Non-Mandatory Appendix A - *National Research Council* (B)(3)(b) (State of California):

"Provide regular, formal chemical hygiene and housekeeping inspections including <u>routine</u> inspections of emergency equipment (21, 171);"[23]

Lastly, inspections are further defined later in the Non-Mandatory Appendix A at, California Code of Regulations, Title 8, §5191 - Non-Mandatory Appendix A - *National Research Council* (D)(4)(b) (State of California):

"Inspections. Formal housekeeping and chemical hygiene inspections should be held <u>at least quarterly</u> (6, 21) for units which have frequent personnel changes and <u>semi-annually</u> for others; informal inspections should be <u>continual</u> (21)."[23]

Although the latter two quotations came from the California Code of Regulations, Title 8, §5191 - *Non*-Mandatory Appendix A - *National Research Council*, it has already been established that it is commonly used as the basis of establishing a Chemical Hygiene Plan. It became apparent that UCLA EHS was only requiring annual laboratory self-inspections to assess the effectiveness of their chemical hygiene and housekeeping programs. Ironically, the frequency of inspections by UCLA EHS was not cited and penalized by Cal-OSHA. However, Cal-OSHA did cite and penalize UCLA for the following with regards failures in their inspection process (leading metrics) [24]:

T8CCR 3203 Injury & Illness Prevention Program

(a) Effective July 1, 1991, every employer shall establish, implement and maintain an effective Injury and Illness Prevention Program. The Program shall be in writing and, shall, at a minimum: Include methods and/or procedures for correcting unsafe or unhealthy conditions, work practices and work procedures in a timely manner based on the severity of the hazard:

   a. During the course of inspection, employer did not implement procedures for correcting unsafe or unhealthy conditions, work practices and work procedures in a timely manner.

> On 12-29-08, an incident occurred wherein an employee was working with a pyrophoric chemical without an appropriate body protection. A laboratory safety inspection was conducted in 10-30-08 and identified the deficiency and recommended that laboratory coats must be worn while conducting research and handling hazardous materials in the laboratory. Another finding indicated that the amount of flammable solvents kept outside of the flammable cabinets exceeded the NFPA limit.
>
> Date by Which Violation Must Be Abated: 05/18/2009
>
> Proposed Penalty: $6750.00

This citation was deemed serious by Cal-OSHA and UCLA was given 15 days to rectify this and other Cal-OSHA findings. In total, UCLA incurred over $37,000.00 in initial penalties for regulatory infractions as a result of the full investigation by Cal-OSHA into the December 29, 2008 fatal laboratory fire.[24] Recommendations on possible criminal negligence charges have been referred to the L.A. County District Attorney for consideration and are still pending.

Functional CHO and CHP Analysis. When reviewing the eight basic components of an effective CHP discussed previously, several elements were deficient or missing, including (a) the criteria for reducing employee exposure to hazardous chemicals, such as engineering controls, personal protective equipment, and hygiene practices; (b) circumstances requiring employer approval of certain laboratory operations, such as procedures or activities before implementation; and (c) provisions for employee training and measures to protect employees from particularly hazardous substances. These are all essential in protecting employees from exposure to hazardous chemicals in laboratories. Failure of even one can put employees at risk for injury, while exposing an institution to fines and irreversible damage to its reputation.

The breakdown in implementing an effective CHP at UCLA was systemic. Failures were attributed within the EHS department to the CHO, as well as, at all levels of enforcement responsibility throughout the institution. So much so, that in March 2010, Cal-OSHA returned to UCLA and proposed additional fines stemming out of lack of qualification of the university's CHO.[25] The additional serious violation claimed that at the time of the August 2009 laboratory safety inspections, the CHO was not qualified to perform his or her duties. From the citation,

“The employer failed to designate a chemical hygiene officer who was qualified by training or experience to provide technical guidance in the development and implementation of the Chemical Hygiene Plan."[25]

Furthermore,

"*The chemical hygiene officer was not aware of the requirements for the plan to address select carcinogens and reproductive toxins. Additionally … the chemical hygiene officer did not provide technical guidance in* *developing and implementing hazard control measures and standard operating procedures for the complex synthesis operations….”*[25]

This is a landmark violation in terms of fining an institution for its selection and lack of performance by a designated CHO. This fundamental shift in enforcement sets a precedent for increased scrutiny of the CHO, not just in California, but nationally. Currently, there is only one interpretative letter regarding CHO's qualifications at the federal level, stating that consultants cannot fulfill the role of a CHO. There is no other federal guidance addressing CHO qualifications.[25] With a majority of CHO positions not staffed by EHS professionals, but rather by job function collateral duties to scientists and supervisors, much more merit must be placed on the training and experience of the CHO prior to designation. Although the UCLA CHO was deemed not qualified, the institution and not the CHO was the target of the violation. This sends a clear message to management of an institution re-iterating the requirement of the employer as being ultimately responsible for ensuring the effectiveness of the CHP.

Whether in academia or industry, fundamental changes need to occur to stem the tide of these injuries and fatalities from exposure to hazardous chemicals in laboratories. The CHO cannot succeed without those that designated him or her acting as active proctors in the full and committed implementation of the CHP. Consequences must be enforced at all levels in the hierarchy of safety responsibility. Principal Investigators (PI) and laboratory supervisors, especially, must not be able to operate with impunity when placing production and discovery ahead of the safety of those in the laboratory. To that end, funding and support for projects must be based on the manner in which results are generated, not on the final outcome alone. No successes should be tolerated as the result of injury in the laboratory. Likewise, CEOs and Boards of Trustees must understand that corporate and institutional reputations are at stake. If an institution cannot perform science safely, then consumers will have reason to question product safety. Safety and Quality Assurance are closely related in the public eye. No single profit can be worth the life of an employee. Regulatory pressures to perform laboratory work safely should emanate from numerous other entities having influence on a given institution. Those include shareholders and customers, professional and EHS societies, and state and federal OSHA.

Solutions for Increased Effectiveness. The tragic events at UCLA, or events similar to them, could potentially occur in any laboratory. Regardless of the current effectiveness of a CHP in controlling exposure to hazardous chemicals in the laboratory, there will always be opportunity for the CHO to improve his or her institutional CHP performance. There are several ways in which to classify efforts by the CHO to improve CHP effectiveness. For purposes of this discussion, approaches will be separated as *Low Effort/High Impact* and *High Effort/High Impact.* Whenever possible, it is always prudent to gain the greatest improvements or desired outcomes by affecting the easiest solutions first. This is known as "picking the low-hanging fruit".

Low Effort/High Impact – The CHO is saddled with being required to understand a myriad of standards and regulations far beyond 29 CFR 1910.1450 – *Occupational Exposure to Hazardous Chemicals in Laboratories*. These requirements stem from both governmental and non-governmental organizations (NGO) by OSHA reference. When implementing these additional requirements as part of the CHP, inordinate amounts of time can be consumed while attempting to explain the impetus for every unpopular constraint placed on scientists. Many regulations are promulgated from legal origins and can forego a commonsense explanation or understanding, especially by the scientific mind. Nonetheless, all of these CHP-related requirements must be implemented and enforced to maintain compliance. The CHO is forced with a "just do it" scenario. It can be demonstrated that by simplifying the CHO implementation approach by grouping individual requirements into larger initiatives, compliance with a vast majority of these regulations can be achieved without excessive churn from scientists. For instance, by simply maintaining general laboratory housekeeping through a monthly inspection process, compliance with dozens of safety regulations can be achieved without detailed training and explanation (See Attachment B). Initially, a CHO may have greater success with instituting this "quick win" in the form of a laboratory cleanliness expectation, rather than launching directly into the nuances of specific requirements of OSHA, the American National Standards Institute (ANSI) or the National Fire Protection Association (NFPA). As the CHP program matures, drivers behind requirements can be discussed in more detail. Had a general housekeeping expectation been in place at UCLA, the outcome could possibly have been less severe. If uncapped bottles of flammable solvent were not being improperly stored in the chemical hood, but stored correctly in a flammable storage cabinet, there is a possibility that the flashover would not have caused a secondary ignition, but may have been contained in the hood and sparing the life of Sherri Sangji.

Housekeeping cannot be stressed enough as a key to an effective chemical hygiene program. In some higher performing institutions, housekeeping has been elevated to an even higher level as a productivity management system. 6S is a method used to create and maintain a clean, orderly and safe work environment. 6S is based upon the five pillars (5S) of the visual workplace in the Toyota Production System (Sort, Set in Order, Shine, Standardize, and Sustain), plus a separate pillar for Safety. Implementation of this method cleans up and organize the workplace in its existing configuration.[26]

These six pillars work together to support improvement efforts in a company. They help increase productivity, reduce defects, make accidents less likely and reduce overall costs. When expanded to include EHS-related issues, they can also help reduce workplace hazards and improve safety performance.[26]

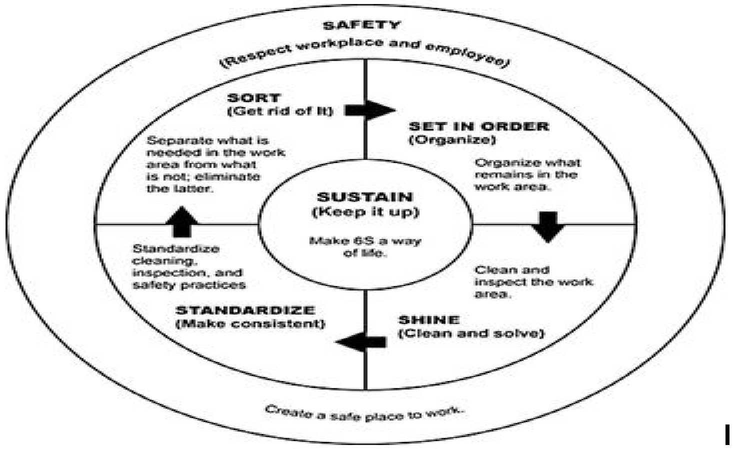

Figure 1. – 6S Flow Diagram[26]

High Effort/High Impact – Two initiatives that would entail a much greater detail of effort, but sustain CHP effectiveness for a longer period of time would be to (a) provide enhanced safety training for all employees, and (b) establish a uniform safety culture in the institution.

While interfacing with scientists in the attempt to gain compliance with the CHP, it is often beneficial to the effort and respected by the scientists, to provide specific training on regulations and their origins. All employees should be provided with baseline, hazard recognition training to establish a consistent knowledge base from which to build additional safety concepts. Additionally, laboratory scientists should receive training on the *OSHA Lab Standard*. Beyond that, enhanced in-depth training, such as the OSHA 40-Hour Training, could pay dividends far into the future by demonstrating the vast body of standards and requirements applicable within general industry. However, this approach can be cost-prohibitive as well as time consuming for scientists.

The second high effort initiative that cannot be given a timeframe for success, but essential to the success of a chemical hygiene program, is the creation of a safety culture within an institution. The CHOs, as mentioned earlier in this discussion, must demonstrate a clear conviction in staking out their positions with regards to chemical hygiene and setting an unequivocal course of action for the institution. In doing so, they must partner with management of the institution who have the primary responsibility for identifying the need for, and fostering cultural change and for sustaining a sound safety culture once it is established. This culture is based upon shared values, beliefs and perceptions that determine what is regarded as normal behavior for employees of the institution.[27] This safety culture, however difficult to cultivate, is paramount to the success and effectiveness of any CHP.

Conclusion

For as long as employees work in industrial settings, such as laboratories that handle hazardous chemicals, the challenge of keeping those employees safe will exist, and it is critical that organizations understand the necessity of this corporate social responsibility, and how to ensure its effectiveness. One such way is through the provision of effective chemical hygiene programs in their laboratories, including effective policies and procedures, plans, appointed individuals, training, and an effective and functional organizational safety culture. This article explored the fundamentals of chemical hygiene programs and CHPs based on established regulatory guidelines, and also provided a CHP analysis of one, among many, tragic laboratory incidents as a case study for program evaluation and description. The literature, discussion, and case analysis exhibit the extremely important designation of the CHO in the implementation of an effective CHP. Additionally, the article posits that the CHO will have the greatest success in implementing the CHP with the shared, top-down responsibility of the entire workforce of an institution, with absolutely necessary commitment from leadership. Where this commitment is lacking or missing, tragedies are imminent costing employee lives, financial penalties, and irreparable damage to public image and reputation. OSHA has provided institutions with an opportunity to succeed in controlling exposures to hazardous chemicals in the laboratory with the *OSHA Lab Standard*. If an institution chooses to properly champion the efforts of the CHO, an effectively implemented CHP will provide a safe workplace to the laboratory scientist.

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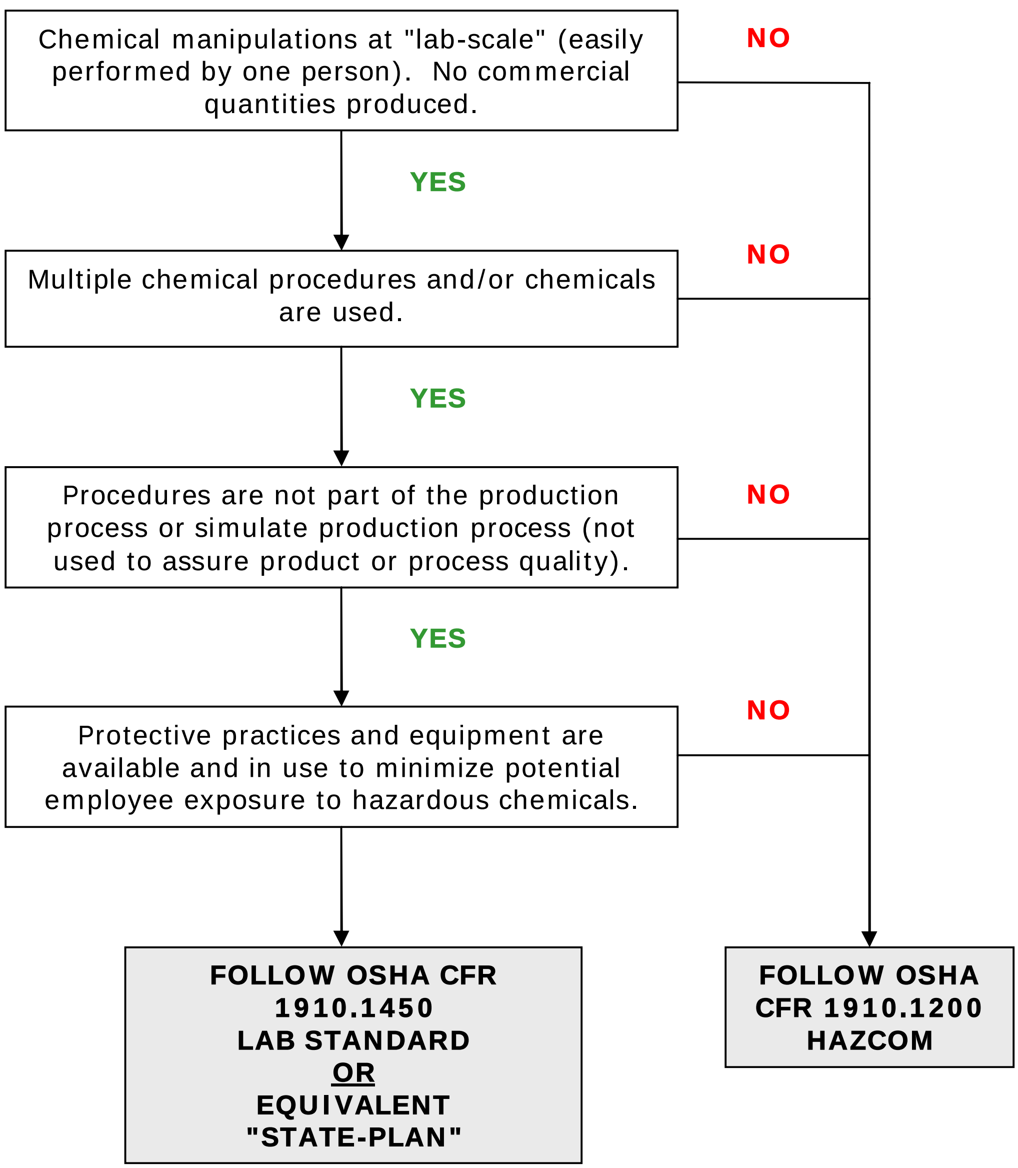
RIGHT-TO-KNOW LAW
DECISION TREE ANALYSIS



STANDARDS & REFERENCE STANDARDS ASSOCIATED WITH GENERAL LABORATORY HOUSEKEEPING	
OSH Act 1970	***General Duty Clause***
5(a)(1)	Furnish a workplace free from recognized hazards that are causing or likely to cause death or serious physical harm to employees
OSHA 1910	***Subpart D – Walking Working Surfaces***
.22(a)(1)	Provide clean sanitary work areas
.22(a)(2)&(3)	Floors - clean, dry
.22(b)(1)	Aisles - clear with no hazardous obstructions
	Subpart E – Means of Egress
.37(a)(1)	Exit routes - kept free of explosive or highly flammable furnishings
.37(a)(3)	Exit routes - kept free and unobstructed
	Appendix to Subpart E
.38(4)	Housekeeping - control accumulations of flammable and combustible wastes
	Subpart H – Hazardous Materials
.106(d)(2)	Storage – proper design, construction and capacity of flammable and combustible liquid containers
.106(d)(3)	Storage – proper design, construction and capacity of flammable storage cabinets
.106((e)(2)(ii)	Storage containers - flammable or combustible liquids shall be stored in tanks or closed containers
	Subpart I – Personal Protective Equipment
.134(h)(2)(i)&(ii)	Respirator storage – protected from damage, contamination, dust, sunlight extreme temperatures, excessive moisture and damaging chemicals; kept accessible
	Subpart K – Medical and First Aid
.151(c)	Eyewash stations – shall be provided within the work

	area for immediate emergency use
ANSI 358.1-1998	***Emergency Eyewash & Shower Equipment***
4.6.1&2	Emergency showers – path of travel clear of obstructions that may inhibit immediate use; area around shall be well-lighted
7.4.4	Eye/Face wash equipment – path of travel shall be free of obstructions that may inhibit immediate use of equipment
OSHA 1910	***Subpart L – Fire Protection***
.157(c)(1)	Fire extinguishers – readily accessible to employees without subjecting the employees to possible injury
.159(c)(10)	Sprinkler spacing – minimum vertical clearance between sprinklers and material below shall be 18 inches
NFPA 13	***Standard for the Installation of Sprinkler Systems***
A.8.6.6.	Sprinklers – storage cannot extend above a plane located 18 in. (457 mm) below the ceiling sprinkler deflectors.
OSHA 1910	***Subpart N – Materials Handling and Storage***
.176(c)	Storage areas – kept free of materials that constitute hazards from tripping, fire, explosion or pest harborage
	Subpart S - Electrical
.303(g)(i)[A]-[C]	Working space – height, depth and width of required clearances around electric equipment
.303(g)(2)(i)	Guarding - electrical equipment >50 volts or more shall be guarded against accidental contact; panel doors kept closed
.305(b)(3)(ii)	Electrical equipment - shall be closed by suitable covers securely fastened in place; panel doors kept closed
.305(g)(2)(iii)	Flexible cords and cables shall be connected to devices and fittings so that strain relief is provided that will prevent pull from being directly transmitted to joints or terminal screws
.334(a)(2)(ii)	Electrical cords - a defect or evidence of damage that might expose an employee to injury, the defective or

	damaged item shall be removed from service, and no employee may use it until repairs and tests necessary to render the equipment safe have been made
.305(a)(2)(i)[B]	Temporary wiring (extension cords) – used for a period not to exceed 90 days
.303(b)(2)	Daisy-chaining extension cords or surge protectors - listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling
NFPA 70	***National Electric Code***
590.2 B	Extension cords - temporary wiring methods shall be acceptable only if approved based on the conditions of use and any special requirements of the temporary installation
OSHA 1910	***Subpart Z – Toxic and Hazardous Substances – Ionizing Radiation***
.1096(j)	Radioactive materials storage – shall be secured against unauthorized removal from place of storage (locked storage or access if not in use)
	Subpart Z – Toxic and Hazardous Substances/ G – Occupational Exposure to Hazardous Chemicals in Laboratories
.1450(e)(1)(i)-(ii)	Chemical Hygiene Plan – protect employee from health hazards associated with hazardous chemicals; keep exposures below limits
	Subpart Z – 1910.1450 Appendix A – National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)
App. A(B)(4)[b]	Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment
App. A(D)(2)[b]	Stored chemicals should be examined (at least annually)

	for replacement, deterioration, and container integrity
App. A(D)(2)[d]	Laboratory storage – amounts permitted should be as small as practical; storage on bench tops and in hoods is inadvisable; periodic inventories should be conducted with unneeded items being discard or returned to the stockroom/storeroom
App. A(D)(4)[a]-[d]	Floors cleaned regularly; formal inspections at least quarterly; eyewash fountains inspections not less than every 3 months; respirators inspections pre-use; safety shower inspections routinely; passageways not used as storage areas and utility controls never blocked
App. A(D)(6)[b]	An easily accessible drench-type safety shower
App. A(D)(11)[d]-[e]	Waste – removed from laboratories and central waste storage areas at least once per week; hoods should not be used as means for disposal of volatile chemicals (evaporation)
App. A(E)(1)[a]	Promptly clean up spills
App. A(E)(1)[d]	Handle and store laboratory glassware with care to avoid damage
App. A(E)(1)[j]	Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of operation or at the end of each day
App. A(E)(1)[n]	Keep hood closed at all times except when adjustments within the hood are being made; keep materials stored in hood to a minimum and do not allow them to block vents or air flow
App. A(E)(1)[p]	Deposit chemical waste in appropriately labeled receptacles
App. A(E)(3) & (4)	Store chemical substances in area of restricted access