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Title: ***An Analysis of the Industrial Hygiene Exposure Control Practices at ABC Electric's Thermal Generation Operations***

The accompanying research report is submitted to the **University of Wisconsin-Stout**, **Graduate School** in partial completion of the requirements for the

Graduate Degree/ Major: M.S. Risk Control

Research Advisor: Dr. Brian Finder, CIH

Submission Term/Year: Spring, 2014

Number of Pages: 154

Style Manual Used: American Psychological Association, 6th edition

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Torres Guerrero, Avelino V. ***An Analysis of the Industrial Hygiene Exposure Control Practices at ABC Electric's Thermal Generation Operations***

Abstract

The purpose of this study was to analyze the industrial hygiene exposure control practices at ABC Electric's thermal generation operations by utilizing regulatory and industry standards as benchmarks. IH-based documents were reviewed to identify potential employee exposure to hazardous chemical and physical agents at ABC Electric's coal and renewable power generation facilities, and to evaluate the organization's current IH exposure control management practices. The results suggest that employees are at the highest risk of exposure to chemical/physical hazards during maintenance/cleaning-based tasks. It was noted that formerly established site specific IH plans were successful at characterizing risks and prioritizing IH exposure control needs, however, such plans became unsustainable as these failed to identify the required supporting systems including key employee roles and accountability, compliance audits, management review, and correction of identified deficiencies. It was recommended that the organization implement a corporate IH policy which unifies each site's chemical/physical hazard exposure control efforts. The policy should mimic successful management systems already employed at ABC Electric to minimize the learning curve process which could be involved. In addition, a plan should be established to initially sustain minimum compliance with IH exposure control-based regulations. Improvements should be incorporated after each management review period.

Acknowledgments

First and foremost, I would like to express my endless gratitude to my wife Jennifer for her boundless support and encouragement from the moment I decided to embark a career change, which also involved moving to a new country, away from friends and family. I am indebted with you and hope to correspond in the same manner with your future career plans. I love you, Jen.

Second, I would like to express my gratitude to the University of Wisconsin-Stout for being a very welcoming community to this international student. The professionalism and knowledge of its professors have enriched me as a person. Thank you, Vickie Kuester for being so caring in moments of distress. Thank you, Dr. Elbert Sorrell for your commitment to constantly encourage the students in the MS. Risk Control program to seek excellence, you have coached me into accomplishing what I once thought as unachievable.

Third I would like to thank my family and friends who in a manner have contributed to my academic success: My parents Abdias and Marbella, my sister Maye and brothers Angel and Abdias J., my friends Juan Gamboa and the Kinney family. Wade Roseth, thank you for your selfless mentorship into the field of industrial hygiene, your influence in my academic life extends into the professional world and beyond.

Forth, I would express my appreciation to the Safety and Industrial Hygiene Department at the organization where this study was conducted. Without your support this project would not have been possible.

Finally, I would like to acknowledge Dr. Brian Finder's dedication to continuously encourage me to become a safety advocate to the statue of the challenges of this exciting and emerging field. Thank you for sharing your wisdom and for your dedication both in class and in the process of advising this research.

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Chapter I: Introduction

Occupational exposure control programs require revision and re-adaptation to modern occupational health demands and changing work conditions. In other words, if such processes are not renewed due to potential complacency with traditional ways of managing risks, the success to control the organization's health and safety-related risks will be in jeopardy as defenses will become eroded or outdated (Reason, 2011). Not only do work conditions change, but the complexity of industrial processes usually presents numerous forms of hazards to the workers' health (Crossman et al, 2009). In addition, research performed with enhanced instrumentation and cumulative experience tends to insist on setting higher standards beyond the outdated regulatory compliance requirements in order to accurately protect workers from workplace hazards (Anna, 2011). An example of this trend is the evolution OSHAS 1971 asbestos's eight-hour time weighted average (8-hr TWA) permissible exposure limit (PEL), which was changed from the 12 fibers per cubic centimeter (f/cc) to 0.1 f/cc (OSHA, 2006; OSHA, 1994). Asbestos's 8-hr TWA PEL today is therefore 99.17% lower than originally mandated 32 years ago. Similarly, other non-regulatory organizations such as the National Institute of Occupational Health and Safety's (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH) propose new occupational exposure limits (OELs) which are usually more stringent than PELs, but do not possess the force of law (Anna, 2011). Ever-changing work conditions, the complexity of industrial processes and the dynamics of ensuring employees' exposure are the lowest possible regardless of compliance are elements which challenge the administration of occupational exposure controls (Reason, 2011; Anna, 2011; Crossman et al, 2009). This endeavor requires flexible and enhanced risk management practices to assist in proactively providing in the anticipation, identification, analysis, and control of exposures which may result in human loss and consequentially other forms of loss such as enhanced liability, worker compensation premiums, reduced productivity and decreased company reputation (Reason, 2011; Anna, 2011). It is therefore reasonable to conclude that an efficient exposure control policy will provide appropriate defenses against hazardous occupational exposures and thus protect an organization's human assets and ultimately its bottom line.

ABC Electric serves 144,000 residents across 26,000 square miles of service territory within the mid-western region of the United States. Its industrial customers represent approximately 50% of the organization's regulated utility sales, which requires power generation at a constant, high load factor. This generation pattern contributes to lower than average operational costs as a result of the organization's reduced power generation fluctuation rates. ABC Electric's power generation resources include hydroelectric, wind, biomass, coal and combined biomass-coal blend. Utilizing a variety of energy sources is part of the organization's strategic plan to reduce emissions, however, this is a mid-to-long term goal and coal-fired steam plants still account for 60 percent of ABC Electric's generation capacity. The organization's goal is to reduce coal power generation by 66% of the total by 2023. Today there are six thermal power generation plants, which combined, generate 1,481.6 megawatts of electricity. Operations within these thermal power generation plants include a varied number of activities which present a complex combination of exposures to chemical and physical hazards. Several of the most common industrial hazards that are present in a thermal power generation plant include heat, noise, vibration, electricity, mechanical, dust (respirable, nuisance and explosive), silica, heavy metals, asbestos, acids, volatile organic compounds, polycyclic aromatic hydrocarbons and pentachlorophenol. If employee exposures to these hazards are not efficiently controlled, there could be adverse consequences to the health of the workers. Moreover, the facility's integrity could be compromised in the case of a fire, explosion or other unintended destructive event.

Despite the risks described above, there are a series of leading, current and lagging indicators which demonstrate performance gaps within ABC Electric's exposure control policy. Based on a preliminary and cursory assessment, ABC Electric's current exposure control process presents flaws in the following areas:

- Recording/maintaining past exposure assessments.
- Employee notification of the hazards present in the workplace, including IH monitoring results.
- Safety Data Sheet (SDS) database administration.
- Definition of roles in the administration of safety and accountability for each party's safety performance.
- Chemical/physical exposure monitoring and follow-up schedules.
- Housekeeping protocols.
- Employee awareness of workplace chemical and physical hazards.

The issues indicated above are latent conditions within ABC Electric's organizational and local factors, which consequently reflect on the overall performance of the organization's exposure control in a negative manner. As an example, there has been a recent first-aid case of an employee who developed dermal irritation, allegedly caused by exposure to PAH's at a wood chip storage complex. In addition, air sampling results obtained after the above dermal-based incident suggested that the allowed work time in this area be reduced from 2 hours, 35 minutes to 1 hour and 38 minutes (at least until engineering controls are in place and the area is re-categorized). Workplace assessments performed within the last six months have also demonstrated the occurrence of chromium (VI) exposure issues with at least two welders, while surface area studies confirmed this toxic substance has been transferred into break rooms and a company owned vehicle. At the moment there are no specific procedures to address these and other employee exposure issues other than the recommendations which were provided in the last assessment reports. Moreover, there are no general guidelines that would address chemical and physical hazards assessment and control. Therefore, the inexistence of a formalized industrial hygiene exposure control policy is placing ABC Electric's employees at risk of being overexposed to various workplace chemical and physical hazards.

Purpose of the Study

The purpose of this study is to analyze the industrial hygiene exposure control practices at ABC Electric's thermal generation operations.

Goals of the Study

Several performance gaps have been empirically identified within ABC Electric´s exposure control practices. In order to delve into the problem and fully identify its extent, the following data collection-oriented activities are proposed:

- Identify the hazardous chemical and physical agents to which employees at ABC Electric's coal and biomass power generation facilities may be exposed to.
- Audit ABC Electric's current occupational exposure control management practices.

Background and Significance

It is believed that the results of this study will assist in the establishment of ABC Electric's formalized exposure control policy in thermal generation operations, which would potentially resolve various observable deficiencies such as:

- The absence of a thorough monitoring program which includes all previously identified chemical and physical hazards besides a protocol for conducting exploratory baseline surveys.
- A cumbersome system of recording / maintaining past exposure assessments which hinders data availability for occupational exposure planning, auditing and incident analysis purposes.
- An inefficient and time-consuming employee exposure monitoring notification process has resulted in the inability to notify employees regarding exposure assessment results in a timely manner, which in turns decreases the workers' morale and erodes ABC Electric's credibility on its commitment to a culture of safety.
- The lack of a formalized Safety Data Sheet database updating system poses ABC Electric at risk of not fulfilling the goals of its hazardous communication (hazcom) program.
- The inexistence of a clear definition of parties held accountable for SDS coding, consulting and continuous awareness of workplace chemical and physical hazards. If on-site shareholders do not follow up with the organization's policy on hazcom, annual training will be useless and employee will tend to disregard the importance of consulting SDSs in the pre-planning stage of their daily duties.
- The inexistence of a formal housekeeping code which results in negligent and unnecessary exposure to chemical and physical hazards.
- The inefficient coordination in the exposure control efforts among the various thermal power plants, which results in a waste of time and effort.

All of the issues mentioned above are symptoms that organizational and local workplace practices must be revised in order to prevent unacceptable employee chemical and physical exposures. The consequences of failing to remediate any of these latent conditions will not only result in human workers' compensation-related costs, but in other less direct losses related to liability-based claims, time required to perform accident investigation, decreased productivity, loss of personnel, excessive legal expenses and down-graded company reputation. A unified and formalized exposure control policy will likely integrate these defenses and aid in the management of risks which are derived from workplace chemical and physical hazards at ABC Electric.

Assumptions of the Study

This researcher's principal assumptions include the following:

- Documents provide sufficient evidence of ABC Electric's compliance with IH regulations/conformance to industry standards in the control of occupational exposure to chemical/physical hazards.
- The current OSHA Permissible Exposure Limits (PELs) are adequate at protecting employees from being overexposed to such chemical and physical hazards.
- Management will follow the final recommendations which are provided at the conclusion of this study.

Limitations of the Study

In a broad sense, this study will focus on ABC Electric's exposure control processes at the organization's thermal generation operations to manage employee chemical and physical exposures from power generation processes, fuel handling and maintenance-related activities. The following are the limitations associated with this endeavor:

- The hazards to which employees are exposed are numerous. At these six facilities, chemical exposures alone could occur from any of the greater than eight thousand chemical products on ABC Electric's chemical inventory and by-products which are generated in the various processes.

- The scope of the study will be general with an emphasis on exposure control performance indicators data which has been generated within the last three years.

Definition of Terms

Occupational exposure limits (OELs). This term refers to a set of scientific and regulatory criteria on relatively safe industrial exposure levels to chemical, biological and physical agents. These are based on each agent's toxicity or potential of causing adverse health effects. Exposures are traditionally weighted against an 8 hour/day, 5 days/week work schedule typically referred to as an 8-hr TWA. OELs are expressed in different forms and values depending on the source consulted, several of these sources are The National Institute of Occupational Health and Safety (NIOSH), The American Conference of Governmental Industrial Hygienists (ACGIH) and the Occupational Safety and Health Administration (OSHA). Only the OELs established by the latter possess the force of law, meaning these are the limits that must be met for compliance, but litigation and bureaucratic obstacles usually prevents this federal agency from establishing safer compliance criteria (Anna, 2011).

Exposure control. In the risk management profession, this expression infers to a set of protocols conceived for the reduction of identified occupational risks to the workers' life and physical integrity. Two major categories are engineering and administrative controls. The former includes techniques such as hazard isolation, diffusion, and major process modifications. Administrative controls include the communication of hazards, protocols, training, personal protective equipment (PPE) programs, employee medical surveillance, and the recordkeeping of incidents (Burton, 2003).

Chapter II: Literature Review

The purpose of this study was to assess the current industrial hygiene exposure control program at ABC Electric's thermal generation operations. The control of exposures to physical/chemical hazards involves a myriad of technical and managerial aspects which will be addressed in the following review of literature. This chapter describes the characteristics of the industrial environment with regard to the presence of chemical and physical hazards, the need for the assessment of these types of hazards, and the control of the related risks through industry's standards and practices. The chapter is presented from the perspective of occupational health management systems and current industry standards in the field of industrial hygiene. The key management and technical elements needed in the successful establishment and evaluation of a chemical/physical exposure control program as well as its specific policies and procedures will be addressed. In summary this chapter describes the process of anticipating, identifying, analyzing and controlling industrial hygiene-based hazards and the related occupational health risks for the purpose of aligning such with the overall management process.

The Industrial Environment

Focus on the industrial environment has gained importance as advancements in occupational medicine, industrial hygiene, toxicology, occupational epidemiology, safety and occupational risk management have contributed to the increasing awareness among industry stakeholders of various hazardous industrial processes present and the establishment of regulations to protect workers (Bratt et al, 2012). Even though history dates efforts to understand and control the risks associated with occupational environments as early as the middle ages, it wasn't until the early 1900's that the industrial environment became a subject of increasing interest among scientists and later, regulators (Blunt et al, 2012). During the initiation of modern industrial hygiene practices in the early 1900's, exposures to chemical and physical hazards in the workplace were to such degree that the evaluation process performed by early practitioners of industrial hygiene, such as Dr. Alice Hamilton, would only require the researcher's "sense of sight" and an understanding of the principle of cause and effect due to the evident/highly acute health effects manifested among the exposed (Rose, 2003:4). Since then, the advancements of technology in quantitative measurement techniques have aided the identification of the acute and chronic exposures to hazardous physical and chemical agents with augmented precision (Rose, 2003). Within the regulatory arena, the Occupational Health and Safety Act enacted in 1970 declared that "every employer shall furnish to each employee a place of employment free from recognized hazards that are causing or likely to cause death or serious physical harm" (OSHA, 1970). In addition, the Occupational Health and Safety Administration (OSHA) has provided several regulatory tools in the attempt to enforce the realization of this mission, but even if standards were not sufficiently protective or inexistent, employers are still held accountable for the health of workers through this agency's general duty clause. There have been important advances in the level of general awareness of occupational health hazards and the establishment of regulations due to the scientific/technical efforts in the field of occupational health and safety, however Klone (2012) highlights the fact that 75,000 chemicals are listed in the Toxic Substances Control Act inventory, while only a few thousand possess an occupational exposure limit (OEL). The previous statement exemplifies a significant challenge that surrounds the process of understanding numerous exposures which likely exist within the industrial environment.

In a broad sense, the environment of a workplace is comprised of various factors which include processes, equipment, material, people and controls (Irish, 1973). These factors may contribute to and/or be affected by different chemical/physical hazards which are involuntarily created by the interaction among such. Irish (1973) refers to the interaction of such factors as the "industrial ecosystem" and warns of the necessity to even include cultural aspects such as the employee's health habits as a variable in the practice of an industrial hygiene monitoring system. According to Irish (1973), physical hazards in industrial settings could result from various types of energy (heat, radiation, noise, vibration, etc.) and mechanical entities (moving parts, falling objects, sharp objects), although it should be noted that chemical health hazards are subtle and may result from multiple agents being present in a single working environment (Klone, 2012). National and international groups (e.g., the American Conference of Governmental Industrial Hygienists or the European Agency for Safety and Health at Work to name a couple) have contributed to the identification and characterization of hundreds of chemical hazards. However the substances which have been identified are only a fraction of the chemicals that exist in the world, and while groups which propose OELs and/or review toxicological information strive to maintain up-to-date inventories, new manmade chemicals are being manufactured (Klone, 2012). The industrial environment is controlled by regulatory requirements which are mostly set forth by the U.S. Department of Labor. Nonetheless, mere compliance to regulations does not exempt an organization from its responsibilities to protect a worker's health condition in the event that regulatory standards may be insufficient or ineffective. Therefore, it should be the interest of every employer to support any proactive worker protection approach, even when it means establishing a mark which exceeds minimal compliance levels (Mulhausen and Damiano, 2012).

Understanding the peculiarities of each working environment is a challenge because of the multiple work conditions and employee-based factors discussed above and the uniqueness of each process. It is also a critical step for the accurate allocation of the resources necessary to minimize/eliminate health risks and consequently prevent other types of organizational losses (AIHA, 2012). According to Mulhausen and Damiano (2012), the first step in managing occupational health risks is the anticipation of agents and events which possess the potential of downgrading the health of workers. The declaration stated by the authors is analogous with the potential of loss resulting from uncontrolled factors in functions of business other than safety (Petersen, 2003). In this trend of thought, standards for the management of occupational safety and health such as ANSI Z10-2012 and OHSAS 18001are tailored after environmental and quality standards in order to facilitate the integration of both functions into the overall management process (Kausek, 2007; AIHA, 2012).

A physical/chemical hazard exposure control program would not result from a regulatory requirement in particular, but rather, such a system-based approach would serve in the integration of overlapping regulatory requirements and safety and health management consensus standards in order to trace the core technical and managerial aspects into other supporting components essential to the success in the management of occupational safety and health in complex situations. Mulhausen and Daminano, (2012), Kausek (2007) and (AIHA, 2012) describe in similar terms the need for a well-organized structure/system, including a study of the current working conditions in reference to regulatory and/or consensus standards, specific goals and objectives, management commitment and support, employee participation and accountability, recordkeeping, and evaluation and rectification.

Recognized Health and Physical Hazards in the Coal Power Generation Industry

Power generation is an enterprise comprised of numerous processes, which therefore causes the sources of potential occupational health hazards to be abundant. The following discussion describes several of the physical and health hazards which were identified in coal power generation operations based on two previous studies. One study focused on routinely-performed operations, while the other was conducted during a major boiler retrofitting project.

Bird et al. (2004) published a study which provided information with regard to the presence of chemical and/or physical occupational exposure during routinely activities in coal power generation plants (minor repairs, instrument reading, fuel handling among others), as opposed to maintenance activities such as repairs on cooling towers, boiler retrofitting, ash unplugging on chutes which in these authors' opinions, had received a minimal level of attention. Bird et al. (2004) affirm that routinely activities constitute 60 to 70 percent of operations in coal power plants. This study collected data from five power plants and the test subjects were divided into the following similar exposure groups (SEGs):

- Electricians
- Fossil fuel services
- Instruments and control (instrument technicians)
- Mechanics
- Operations (of boiler turbines and auxiliary equipment)

The specific chemical and physical agents which were of interest to Bird et al. in this particular study included:

Asbestos. The material has largely been used as an insulating agent on boilers and steam pipelines. Asbestos control/abatement programs are common in industry with boilers and steam as aging thermal generation plants maintain this material on boiler and steam systems, even though asbestos can cause adverse health effects such as asbestosis (Agency for Toxic Substances and Disease Registry, 2012).

Coal dust. This agent is believed to be the source of various health and physical hazards. Coal releases significant amounts of dust during various handling processes. In power generation plants, coal is also crushed into a fine powder. Although one of the greatest concerns with coal dust in this type of industry is its potential for creating explosive environments as well as the various heavy metals which are contained in it, Bird et al. (2004) studied worker exposures to respirable fraction of coal dust, crystalline silica and sulfur dioxide.

Fly ash. A byproduct of burning coal is both fly and bottom ash. The latter is the conglomerate of heavy particles which precipitate due to gravity and hence provide its name. Fly ash is prone to become fugitive because the particles which it is comprised of are light and easily disturbed. Wet scrubbers are a common method of control for fly ash by turning it into sludge. By being in proximity to fly ash, employees are at risk of exposure to arsenic, respirable dust and various heavy metals. Fly ash was one of the agents included in the study which was performed by Bird et al. (2004).

Noise. The sources of occupational noise during routine activities at coal power plants are comprised of a set of various pieces of equipment and activities. Important sources include fans (forced and induced draft), sump pumps, trucks, bull dozers, mixers, compressors, coal mills and turbines.

Heat. Thermal energy is a primary resource in the power generation industry. For this reason, the propagation of heat in undesired areas does not only constitute a safety issue, but an efficiency problem as well. Boilers are constantly maintained to guarantee the insulation of hot surfaces, however heat-based releases may still occur and thus cause particular areas within the power generation plant to be significantly warmer than others. Leakages do not only occur on boilers, this is true about steam lines as well. One area which may be particularly warmer than on others is the top of boilers, where a steam drum is located and connected to the main, the reheat and the low pressure lines. These pipelines transport steam at temperatures ranging from 625^{o}F to 1052^{o}F. Worker exposure to extreme heat is of particular concern on the top as well as in proximity to boilers, especially during hot summer months.

The above coal-fired plant study conducted by Bird et al. (2004) concluded that exposure to the airborne contaminants of interest (respirable coal dust, respirable fly ash, sulfur dioxide, asbestos, crystalline silica and arsenic) were lower than the OSHA's action and permissible exposure limits (PEL) during routinely activities defined above. OSHA's action limit is 50% of the PEL, which is defined as the maximum level to which an employee can be exposed to a particular contaminant/toxic agent for a period of eight hours per day, five days a week during the course of a person's working period. If OSHA's action limit is reached, there may be additional regulatory requirements to comply with, for example, engineering controls such as the enclosure of a process installation of additional local ventilation, and/or administrative controls like increased medical surveillance, standard operating procedures and/or use of personal protective equipment. The type and extent of the measures to lower the risk of worker exposure depend on the industry and feasibility of the various controls. When testing results have been confirmed to be below the OSHA's action limit, regulation will often permit to discontinue testing unless there is a change in the process which may foreseeably result in worker exposure to chemical or physical agents.

In the study conducted by Bird et al. (2004), noise area samples indicated that sound pressure levels across the five plants ranged from 70 dbA to 104 dbA. Still approximately 18% of the 302 subjects who wore a dosimeter presented results at or above OSHA hearing conservation program action level of 85 dbA for an 8-hour time weighted average. Only approximately 4% of subjects were exposed at or above the OSHA permissible exposure limit of 90 dbA for an 8-hour TWA. It was concluded that the lower-than-expected results were obtained due to the fact that personnel at these power plants spend time in significant quieter areas after performing routinely duties. The researchers also explained that the two SEGs which experienced the highest exposures to occupational noise were the mechanics and the operations. In this study's description of the selected SEGs, Bird et al. (2004) did not explain if bulldozer operators were included in the Fuel Fossil Services SEG, which would have probably presented several of the greatest critical exposures to noise.

In an earlier study which was not directly related to coal power generation, Mattorano (1997) conducted an evaluation of the health hazards which contractors were exposed to during a boiler retrofitting project at Clinch River Power Plant in Virginia. As part of a NIOSH comprehensive study, bulk samples (a method in which certain materials are collected in arbitrary or irregular quantities) were collected and analyzed to determine the types of toxic metals which were present in ash and coal dust. An analysis of each particular duty through a job hazard assessment among the boiler makers also contributed in the anticipation of health and physical hazards created during the retrofitting operations. Various crew members were in charge of dismantling the inner (from inside the boiler) and outer boiler casing while another group prepared/repaired the boiler's frame for new parts. The dismantling and preparation processes involved the use of grinders, oxyacetylene torches, arc air and shielded metal arc welders. Each of these metal cutting and joining techniques may disturb the particles which accumulate on the boilers and thus become airborne. A group of laborers was in charge of vacuuming and preparing work areas while another team of workers was in charge of hoisting pieces from the boilers and moving such to a disposal area with forklifts (Mattorano, 1997).

During the Virginia coal power plant study, operations ran two ten-hour shifts (day and night) for 6 days a week, which meant that the employees’ workload was 50% higher in comparison to the traditional work schedule. Thus, any results obtained from later personal air sample analysis needed to be adjusted to the increased exposure time to guarantee accuracy. Once the bulk sample analysis and the job hazard assessments were completed, it was determined that personal breathing zone (PBZ) air samples needed to be collected in order to determine exposures to heavy metals as well as respirable and silica dust through inhalation. Hand wipe samples were also collected to study potential employee exposure to the toxins of interest through ingestion and the presence of elements that have a skin notation in the AIHA TLV guidelines because of being corrosive, irritant, a carcinogen or may cause adverse health effects on the skin. Similarly NIOSH Method 7300, which is used to analyze the presence of a number of minerals, was used to determine the concentration of heavy metals in bulk, PBZ and wipe samples. This NIOSH method allows for the analysis of 28 heavy metals, of which various substances are elemental such as iron or zinc. The study focused on the following substances which possess the highest levels of toxicity or have been categorized as a carcinogen or suspected carcinogen:

- Arsenic
- Beryllium
- Cadmium

- Lead
- Nickel
- Titanium (Mattorano, 1997)

In the course of the Virginia coal power plant worker exposure study, PBZ air samples were collected on 37mm, 5µm pore size polyvinyl chloride (PVC) membrane filters and eventually analyzed for crystalline silica and respirable dust by using NIOSH methods 7500 and 0600 respectively. This NIOSH-supported study collected a total of 12 bulk fly ash samples, 9 PBZ air samples for respirable dust and silica, 8 hand wipe samples and 48 PBZ air samples for heavy metals. The study concluded that the highest concentrations of lead, nickel, cadmium, beryllium, arsenic, silica and respirable dust occurred among employees working inside the boiler as well as those working on the boiler casing from the outside. It was also noted that the grey scale/slag which needed to be forcibly removed from the boiler for analysis presented concentrations of arsenic 40 times higher as compared to the results obtained in settled dust and fly ash. The grey scale is considerably hard, however it is a significant arsenic exposure source when a task requires breaking or removing it with regard to the retrofitting project in question. Traces of the aforementioned heavy metals were detected in the hand wipe samples despite the fact that employees had been ordered to wash their hands before the sample collection. Mattorano (1997) interpreted the results of this study as an indication that employees may also be exposed to heavy metals through ingestion and thus adds to the workers' overall exposure to recognized toxins. It should be noted that nickel and beryllium are elements which may cause health effects such as itch, sensitization, irritation and ulceration (ACGIH, 2013).

A health hazard evaluation of a boiler retrofitting project at a coal power plant such as the one conducted by Mattorano (1997) with the assistance of other NIOSH experts may certainly appear distant to the reality of routine activities performed at such locations, such as instrument calibration/operation, fuel handling, minor maintenance activities, and the disposal of waste, among others. However, the writer of this research paper has recently observed the division of labor at a mid-western electric power plant and noted that:

- There are crews of individuals who are referred to as ash handlers that process ash into sludge. At the end of the shift, these workers must clean various mixers which potentially expose them to heavy metals that may cause adverse skin health effects. Truck drivers in this area must transport the ash to final disposal areas (i.e. ash yards), and on particularly windy days, these individuals are likely to be exposed to airborne fugitive fly ash.
- Ash mixers include stainless steel moving paddles which are plated to increase the service life of such parts. Besides the group of heavy metals typically contained in ash, the welders are exposed to hexavalent chromium from stainless steel plating processes for the treatment of paddles (i.e. hard facing). There is a specific OSHA regulation for hexavalent chromium, and this substance is also a confirmed carcinogen (ACGHI, 2012).
    - Plant laborers often need to service ash chutes which become plugged due to the presence of moisture from environmental conditions and/or burner calibration issues. This means that such workers must enter these confined spaces to break the ash rocks which block ash conveying pipelines and buildup on the walls. Worker exposures to hazardous substances during such activities may not be too different from the results Mattorano (1997) obtained during the boiler retrofitting project study.
- Ash buildup accumulates on the blades of induced and forced draft fans. For this reason, maintenance personnel will eventually need to enter such equipment to sandblast ash

sediments off the blades. The sandblasting material used is silica free, however, it may contain other elements worthy of analysis such as copper or synthetic-based compounds.

- As a means of reducing sulfur dioxide emissions, anhydrous ammonia is a compound which has recently been employed at coal power generation plants. Anhydrous ammonia could be significantly harmful should there be an accidental leak.
    - Coal dust may be extremely fine from a particle size standpoint and significant accumulations can be observed in related handling areas such as storage yards, conveyor belts and crushers. Coal dust will contain a majority of the heavy metals which are present in its ash.

For each of the reasons aforementioned, it is this author’s opinion that an assessment of the health and physical hazards identified at coal power plant operations in general will not be complete unless the study focuses on each task, including minor maintenance activities. It is also this author’s experience that the following exposures may occur in coal power generation operations:

Carbon monoxide. Emissions of carbon monoxide at power plants may occur due to incomplete combustion in boilers, or in fossil-fueled equipment such as propane forklifts.

Noise and vibration. Coal is moved and handled with great tonnage bulldozers at a coal fired electric generation plant. This coal-moving equipment generates high sound level pressures and also constitutes an ergonomic hazard to the operators who drive such bulldozers due to the presence of whole-body vibration.

PHAs and PCP from biomass. As a means of reducing sulfur dioxide, nitrogen oxide and mercury emissions, coal power plants may opt to operate a hybrid or alternative combustion process by fueling boilers with a mixture of coal and biomass. Certain power plants’ source of biomass includes railroad ties and decommissioned wooden electric poles. These are treated with creosote for preservation and thus hazardous concentrations of pentachlorophenol (PCP) and polycyclic aromatic hydrocarbons (PAH's) from this chemical may occur after the wood has been crushed into smaller pieces.

The Management of Occupational Chemical/Physical Exposures

Organizations may employ diverse approaches in the management of occupational health and health and safety, although internal standards need to be established in order to assess or evaluate the outcome of the activities and measures engaged to protect the health of employees. Occupational health and safety management systems (OHSMS) similar to OHSAS 18001 and ANSI Z-10 were developed to satisfy such a need through a business approach founded on upper management commitment, all-employee participation, placement of accountability for safety-oriented activities at the point of control, a continuous improvement cycle (starting with minimal compliance) as well as management review and correction (AIHA, 2012; Kausek, 2007). Health and safety goal-specific programs may be created and administered in the context of an occupational OHSMS, depending on the complexity of processes needed to accomplish them and/or as a response to a regulatory/customer requirement (Bird, 1997). The management-based processes which are utilized to control occupational exposures to chemical/physical agents may require the implementation of a program in order to organize these activities and the resources needed. The features of a particular industrial hygiene program are dependent on the characteristics of the workplace, workforce, types of confirmed/potential occupational exposures and regulatory requirements (Mulhausen and Daminano, 2012). The control of occupational chemical/physical exposures are described below in the context of such considerations and Deming's (1986) continuous improvement cycle, which in the context of occupational health and safety, has been adopted by both ANSI Z-10 and OHSAS 18001 standards (AIHA, 2012; Kausek, 2007).

The planning phase. The administration of an occupational industrial hygiene (IH) exposure control program spans boundaries of the safety and industrial hygiene staff. It requires the support of line management and involves the coordination of activities across various departments which staff personnel may possess no authority over. Therefore, a basic requirement for the success of an industrial hygiene exposure control program is top management's commitment to provide leadership and support the program´s initiatives with the necessary resource allocations (Kausek, 2007; AIHA, 2012).

To obtain an initial commitment of management as well as the employees themselves, it is necessary to create awareness of the health risks which are associated with exposure to chemical and physical agents in the various processes engaged both in operation and maintenance activities (29 CFR §1910.1200, 2012). Also, top management must be informed of the impact of occupational illnesses and diseases on the organization's assets (Kausek, 2007). Bratt et al (2012) argue that losses caused from an employee's chronic disease as a result of exposure to occupational contaminants are not only great from a financial perspective for both the employer and employee, but this individual's quality of life may be affected in the same proportion. Other sources of information which should be used to properly argue the importance of preventing occupational injuries and illnesses are past loss assessments, medical historical data and occupational epidemiological case studies (Kausek, 2007; Polton and Mellendick, 2012).

A proactive approach to eliminating or minimizing exposure to chemical and physical hazards may add significant value to a business and therefore management should commit and engage to such a program. Saving money on reduced worker compensation insurance premiums, medical costs and interrupted production time are a few of the benefits. The successful implementation of an industrial hygiene (IH) exposure control program could support an organization's strategic goals, which may include improving safety history, increasing the employees' morale, obtaining a higher talent retention rate and maintaining a favorable public opinion (Kausek, 2007). For the reasons aforementioned, a chemical/physical hazard exposure control program should not be viewed as a productivity constraint or a necessary cost of business, but rather, as a tool which contributes to the organization's strategic plan.

Conformance to an occupational health and safety management system (OHSMS) based on standards such as ANSI Z10-2012 and OHSAS 18001, would likely guarantee the availability of key supporting elements for the design, implementation and evaluation of any health and safety specific program, including a focus on hazardous chemical/physical agent exposure control (Kausek, 2007; AIHA 2012). Such key element processes would potentially include:

- Top management representation in the form of a management appointee and/or a management safety commission
- Cross functional teams comprised of personnel including engineers, human resources, legal and/compliance staff, medical professionals, safety and IH specialists, safety committee members, environmental and supervisory line management as well as logistics and procurement representatives.
- Risk assessment teams which have been trained on job hazard analysis (JHA) and/or process hazard analysis (PHA).
- Internal auditors and other supporting staff who may provide professional advice and/or specialized services (technicians and IH third party administrators).

- A data compilation and risk assessment process which includes the management of risk assessment tools, equipment, documents and records. Criteria for equipment calibration, update and handling of data must also be established (Kausek, 2007; AIHA, 2012; Polton and Mellendick, 2012).

According to Kausek (2007), the initial planning phase in an OHSMS includes the creation of a project plan, training of the individuals involved, a safety and health draft policy statement and a communications plan. These activities would also apply to the development of an IH exposure control program, although such would occur in a more focused manner. Another advantage of designing a worker exposure control plan in conformance to either ANSI Z10-2012 or OHSAS 18001 standards is the integration of IH activities into an organization's overall OHSMS continuous improvement process under Deming's PDCA (plan, do, check, act) approach (Kausek, 2007; AIHA 2012). Before establishing the specific goals of an IH exposure control program and the processes needed to accomplish such, it is necessary to identify the hazards and assess the risks which are present. It is also essential to perform a review of the applicable legal/regulatory implications of federal, state and local entities as well as other requirements which may be derived from an organization's union or customers/clients, even if these do not possess the force of law (AIHA, 2012; Leibowitz, 2012; Kausek, 2007). Due to the number of activities to be performed in the planning phase to guarantee the effectives of an OHSMS, the full implementation of such may take up to a year (Kausek, 2007).

Regulatory and logistic requirements of an IH exposure control program. The design stage of an IH exposure control program must consider the description of applicable regulations, standards and other logistic-oriented requirements (relevant business systems, resource allocation, and operational processes). Regulations must be met to comply with the law, however an organization may establish other strategic goals which exceed regulatory requirements. In the case of an I.H. exposure control program, this translates into a careful review of regulatory requirements related to the degree/extent of exposures and the treatment of related health risks (Kausek, 2007; Leibowitz, 2012). The next section of this chapter will discuss these considerations as part of the general regulatory standards, the establishment of OELs, and voluntary standards as well as other legal considerations.

Occupational exposure limits. Such were briefly defined in Chapter I. Careful consideration must be granted to the nature and rationale employed by each group which proposes limits/standards (OSHA, ACGIH, NIOSH, etc) in the establishment of such before attempting to implement any policy with regard to internal occupational exposure limits (Klone, 2012). Zero exposure to chemical or physical hazards would be an ideal scenario, but such a situation would be highly improbable in most industrial settings. Limits or exposure levels are needed to assist in the control of employee exposure to hazardous agents (Klone, 2012). Every OEL is based on a maximum degree of exposure to chemical and physical agents that would not affect the health or well-being of the majority of the workers. In this respect, the American Conference of Governmental Industrial Hygienists (2012:3) refers to its threshold limit values (TLVs) as representing "conditions under which it is believed that nearly all workers may be repeatedly exposed (to airborne concentration of chemical substances), day after day, over a working lifetime, without adverse health effects". Similarly, The Occupational Safety and Health Administration's mission establishes that the efforts of this agency are aimed at assuring "insofar as practicable that no employee will suffer diminished health, functional capacity or life expectancy as a result of his work experience" (OSHA, 1970: 29 USC 651). Based purely on scientific criteria, the National Institute of Occupational Safety and Health (NIOSH) focuses on the development of recommended exposure limits (RELs) to assist federal regulatory agencies (e.g. OSHA and the Mine Safety and Health Administration (MSHA) in the establishment of occupational exposure regulatory standards. However, NIOSH also warns that exposure limit criteria are dependent on the level of technical and scientific advancement in the various fields which contribute to this endeavor, such as toxicology, epidemiology and industrial hygiene (NIOSH, 1992). It is important to understand that OELs are based on a risk characterization process which continues to face important constraints and are therefore generic in nature. Epidemiological studies have not been able to determine factual dose rates to human disease/illness relationships for a majority of chemical agents and the criteria used in the formulation of limits are derived from experimentation on animals, which means that the OELs may be based on untested assumptions implicit in the dose-response extrapolation process (Brown, 1998; Klone, 2012). In brief, the risk assessment processes on which OELs are determined often face scientific uncertainty because a sound theoretical basis cannot be identified and/or empirical data is inconclusive (Klone, 2012). Additionally, chemical/physical agent risk assessments rely on complex models from numerous scientific disciplines (pathology, biostatistics, toxicology, carcinogenesis, epidemiology, nutrition, genetics, medicine, biochemistry, and teratology) and each add additional degrees of insight and considerations which are as valid as important (Brown; 1998; Klone, 2012). While OELs constitute benchmarks for the management of occupational exposure to chemical and physical agents, it is crucial not to disregard the risks associated with employee exposures solely on the basis of compliance/conformance to OELs.

Independent and regulatory standards. The Occupational Safety and Health Administration’s Permissible Exposure Limits (PELs) possess the force of law, which means that all industrial entities must comply with such. PELs are also the basis on which the majority of mandatory rules regarding employee exposure hazard assessment, abatement and control activities which are required (NIOSH, 1981). OSHA (1970) defines PELs as standards which result from the consensus of different stakeholders and thus include scientific, technical, legal and socio-economic implications in the process of adopting the various OELs. However, it should be noted that PELs were initially an adoption of the 1968 ACGIH Threshold Limit Values (TLVs). Until 2012, only 12 PELs were either updated or adopted (Bathurst et al, 2012; Klone, 2012). Unfortunately, the process of turning a standard into law is described by Klone, (2012:62) as being “difficult and contentious”. The net result is a list of OELs and standards which “does not account for over 40 years of advances in technology or the latest peer-reviewed published toxicological information” due to the bureaucratic nature of the exposure limit modification process (Bathurst et al, 2012:2). Therefore, meeting PELs should be regarded as a minimal effort with regard to the process of achieving regulatory compliance. Other OELs, such as ACGIH TLVs or NIOSH RELs, constitute an increasingly updated resource for generating superlative, substantiated scientifically-informed decisions. Despite its original objective to serve as a scientific source to influence the course of updating or adopting OSHA PELs, a majority of NIOSH RELs remain a recommendation due to the reasons stated previously. It should be noted that RELs are still valuable because such are based on comprehensive studies of up-to-date toxicology information and are applicable to a wide spectrum of processes (Klone, 2012).

The American Conference of Governmental Industrial Hygienists (ACGIH) has published OELs since 1946. ACGIH’s Threshold Limit Values (TLVs) are based on comprehensive studies from the various discipline related to occupational health and a continuous peer-review process. This organization also publishes an annual revision of its TLV booklet and a compendium of exposure values from OSHA, NIOSH and Germany's maximum allowable concentration (MAK). As opposed to the organizations previously discussed, ACGIH does not employ the term *limit* to define the organization´s proposed OELs, but instead, the word *threshold* is employed because it implies that the stated values should not be considered a definite line between safe and unsafe (Klone, 2012; ACGIH, 2012).

In conclusion, the OSHA PELs are enforceable limits and provide a basis for minimal compliance, although these should not be considered entirely accurate to ensure the workers' health. As an alternative, the NIOSH RELs and ACGIH TLVs provide updated and comprehensive information, but lack the force of law. If limits to certain chemical/physical hazards are not addressed by any of the groups identified, other resources encouraged are the American Industrial Hygiene Association's (AIHA) Workplace Environmental Exposure Limit (WEEL) and Germany's MAKs. Resources obtained from any other international standards should also be considered for reference. It must be noted that safety data sheets of manufactured/formulated chemicals may not provide a detailed description of the product's ingredients due to copyright protection. In this type of a situation, the manufacturer must be consulted regarding the internal OEL and analytical method designed for employee exposure monitoring purposes in operations using this particular product. Finally, it is important to realize that while PELs define compliance and other OELs may provide an important reference in the risk characterization process, these should not be adopted blindly and thus merely serve as reference in the establishment of workplace internal standards (OSHA, 1970; ACGIH, 2012; Klone 2012)

The Establishment of internal OELs. Voluntary OELs (TLVs, RELs, and WEELs) serve only as guidelines for developing an organization's internal standards. It is necessary to also incorporate the following stipulations in order to utilize the criteria on which OELs are based in an informed manner:

- Limits do not constitute a fine line between safe and unsafe, but serve as a reference (ACGIH, 2012).
- Each organization should consider establishing its own limits or using OELs as is only after analyzing the conditions of each operation in order to adjust limits if necessary (Mulhausen and Daminano, 2012).
- Dose-response relationships to the majority of the chemicals are equivalent to a long-normal distribution of which 5% of the population is overly sensitive to any particular chemical threat (Mulhausen and Damiano, 2012).
- There are approximately 75,000 substances on the Toxic Chemical Control Act inventory. Only a few thousand of these chemicals have been assigned an OEL (Klone, 2012).
- OELs are established on the assumption that the company/organization possesses a healthy workforce within a typical work environment and shift (i.e. 8 hours a day, 5 days a week) (Klone, 2012).
- OELs are based on the assumption that only one route of exposure exists, while in the real world, a chemical agent may enter the body from multiple routes simultaneously (ACGIH, 2012)
- Several hazardous agents could be present in the same process and thus OELs must be adjusted in relation to the possible:
    - Additive effect. Various substances contributing to a particular health effect as a result of an exposure to a mix of chemicals.

    - Synergistic effect. One substance potentiating/aggravating the health effects which may result from an exposure to another chemical agent (ACGIH, 2012; NIOSH 1992).

- Airborne concentrations will vary due to physicochemical properties of different substances (e.g., size and weight of particles, density, volatility, etc) and the various situations that may emerge at the workplace (e.g., temperature, pressure levels, air flow, size of room) (Klone, 2012).

OELs are based on generalizations, and therefore a highly proactive approach to chemical and physical exposure control is needed to establish internal OELs since every organization and process is unique. The establishment of internal OELs is successfully achieved through the characterization of the risks related to each particular process in consideration of the employee's work shift, general health conditions, mixture of chemicals, the possibility of multiple routes of exposures and the overall working environment (Mulhausen and Damiano, 2012)

Other regulatory and general considerations of chemical/physical exposure control. PELs (and community based OELs in the case of the Environmental Protection Agency) are the basis for the establishment of a series of processes and activities which OSHA may deem as mandatory or discretionary (NIOSH, 1992). Mandatory requirement of these processes and activities will often depend on the employees' exposure dose to specific physical or chemical hazards. Exceptions may apply depending on the type of industry, size of operative units and hours exposed per employee. In this respect, a validation of chemical/physical exposure levels must be performed in order to verify whether PELs are below action limits or else further actions need to be engaged to eliminate or reduce the related risks according to physical/chemical hazard general and specific OSHA standards. The following are general areas of regulatory considerations which relate to the control of chemical/physical exposures (OSHA, n.d.a):

Exposure determination, monitoring and classification.

- CFR 29 1910 Subpart G - Occupational Health and Environmental Control
- CFR 29 1910 Subpart J - General Environmental Controls
- CFR 29 1910 Subpart Z - Toxic and Hazardous Substances

Employee information, training and hazard awareness

- CFR 29 1910.1200 - Hazard Communication.
- CFR 29 1910.1201 - Retention of DOT markings, placards and labels.
- Other regulations specific to special tasks / industries.

PEL regulated work areas

- CFR 291910 Subpart G - Occupational Health and Environmental Control
- CFR 29 1910 Subpart J - General Environmental Controls
- CFR 29 1910 Subpart Z - Toxic and Hazardous Substances

Personal protective equipment

- 1910 Subpart I - Personal Protective Equipment
- CFR 29 1910.134 – Respiratory Protection
- CFR 29 1910.29 – Adequacy of hearing protection attenuation

Removal, storage, cleaning, disposal and laundering of contaminated clothing or equipment

- CFR 29 1910 Subpart Z - Toxic and Hazardous Substances
- CFR 29 1910.120 - Hazardous waste operations and emergency response.

Plant hygiene areas and practices

- CFR 29 1910 Subpart Z - Toxic and Hazardous Substances

Housekeeping and disposal of hazardous scrap

- CFR 29 1910 Subpart Z - Toxic and Hazardous Substances
- CFR 29 1910.120 - Hazardous waste operations and emergency response.

Employee medical surveillance

- CFR 29 1910 Subpart Z - Toxic and Hazardous Substances (agent specific)
- 29 CFR 1910.1020 - Access to employee exposure and medical records.
- 29 CFR 1019.95 – Occupational exposure to noise – Hearing conservation

OSHA Recordkeeping

- CFR 29 1904 (general)
- CFR 29 1910 Subpart Z - Toxic and Hazardous Substances (agent specific)

The list presented above covers the most common regulatory considerations and since every organization is different, an exposure control system should include an indexed list of regulatory/legal resources relevant to the organization's processes. In the attempt to control hazards from processes that involve a diverse number of agents, OSHA's chemical sampling information search engine could be useful. This tool presents data on a vast number of chemical agents and includes details on other voluntary OELs.

Regulatory compliance is essential to ensure the protection of employees as well as other organizational assets/resources. Nonetheless, a proactive approach to physical/chemical agent exposure control will often establish standards that exceed minimal compliance. Other non-regulatory considerations include customer and industry requirements, corporate commitment and voluntary/mandatory participation in local, state and federal programs in the area of occupational health and safety (Kausek, 2007). In the upper Mid-West, local considerations include Minnesota Statutes Chapter 182 (A Workplace Injury and Reduction programs) which is a core element in the administration of occupational health and safety in this state (Minnesota Department of Labor, 2012).

A Workplace Accident and Injury Reduction (AWAIR) program and its various components were developed in order to comply with the 1990 Occupational Safety and Health Act, Minnesota Statues Chapter 182 (M.S. 182.653, subd. 8). This Act requires employers to develop written, comprehensive safety and health programs, and is enforceable to businesses that possess at least one code listed under Minnesota AWAIR National American Industry Classification System (NAICS) List. NAICS is a standard set by American, Mexican and Canadian federal agencies for establishing a high level of comparability in business statistics among the North American countries. Minnesota OSHA statutes allow the use of the NAICS to create a list of industrial classification codes which possess incidence and fatality rates above the national average. Employers engaged in the listed industrial activities must comply with AWAIR in an effort to reduce work-related injury and illnesses. This list is updated every two years based on each industry classification's performance, and for this reason there are proactive Minnesota employers who opt to implement this act on a voluntary basis in case the AWAIR standard becomes enforceable to them as a result of a revision in which their primary, or additional NAICS code becomes listed. Another advantage of complying with AWAIR, regardless of regulatory enforcement, is that it aids in the organization of other programs such as the right-to-know, respiratory protection, and personal protective equipment (Minnesota Department of Labor, 2012). An AWAIR program includes the following elements:

- Management commitment. The program must be signed off by a high raking authority with overall control of the company, such as the owner or president. Upper management must also provide the necessary resources (monetary, technical and human) to guarantee the success of the program.

- Safety and health goals and objectives. These must possess a time frame, be measureable and be revised annually.
- Strategy for hazard recognition and control. Techniques such as self-inspections, job hazard assessments, incident and near miss investigation, substandard acts and conditions reporting, hazard mitigation approaches must be included. Each of the aforementioned practices must be documented and include the participation of every employee based on the role assigned.
- Definition of roles. AWAIR is defined as an all-inclusive program, accountability for key health and safety elements must be placed upon every employee, from upper management to laborers. Employees are expected to participate to a minimal extent, but managers, supervisors and safety committee members present a higher level of participation in hazard recognition and mitigation processes.
- Training. Safety committee members, area managers and supervisors must be trained in the role to be played in the prevention of workplace injuries and illnesses. The level of expected involvement determines the extent that these individuals must be trained.
- Follow up. Identified safety/health action items identified though self-inspections, hazard assessments, employee reports, recordkeeping trends and incident investigations must be followed up and documented.
- Corrective actions. Deviations from safety and health policies, practices and procedures must be corrected. A disciplinary process must be fully described, documented and

applied. Proactive measures include rewarding desired behaviors (Minnesota Department of Labor, 2012).

The mitigation and control of health and physical hazards must be reflected in the goals and objectives of an AWAIR program. Participants need to be trained beyond general safety if the organization requires that chemical and physical hazards be identified and mitigated. Employees must be trained based on the level of involvement and the extent/specificity of the hazards encountered in the organization's process (Minnesota Department of Labor, 2012).

Another topic which must be considered and further discussed due to its direct correspondence to the topic of this research is the hazard communication standards CFR 29 1910.1200 on the federal level and the MNOSHA Rules Chapter 5206 from a local context. The Federal OSHA standard is intended to establish the parameters for dealing with issues concerning the classification of chemical and physical hazards in the workplace, the means of communicating this information to employees, and any other training with regard to hazard recognition and mitigation techniques. OSHA's latest Hazard Communication standard final rule became effective in May of 2012. The revision has adopted the United Nations Globally Harmonized System of classification and labeling of chemicals. Material safety data sheets (MSDS) requirements have also been revised and a new unified format called safety data sheets (SDS) will replace the old format (29 CFR § 1910.1200, 2012) - (See Appendix A for OSHA informative cards and illustrations).

It's interesting to note that coal and/or biomass electric power generation plants typically play the role of a hazardous chemical consumer, however a few will sell the ash obtained as a byproduct to the concrete industry. This practice places the power plant's management in the chemical product manufacturer role with certain regulatory implications (generating SDSs, labeling, etc). Even when a hazardous substance is not a manufactured good, but the byproduct of a process, the applicable company is still required to disclose information regarding the hazards involved as well as and furnish its employees with the knowledge on hazard identification, early recognition of symptoms and chemical/physical hazard exposure mitigation techniques (29 CFR § 1910.1200, 2012).

In the local context, Minnesota possesses a federally-approved state plan. MNOSHA Rules Chapter 5206 (2008) stipulate that employers must analyze all workplaces to determine the existence of hazardous substances, harmful physical agents and infectious materials. The state right-to-know standard mandates that training be provided to new employees once initially and annually thereafter. Similar to the Federal OSHA requirements, a system for continual flow of information on workplace hazards and mitigation techniques must be provided to applicable employees and/or certain product customers.

OSHA's 29 CFR 1910.1200 and MNOSHA Rules Chapter 5206 require employers to develop and maintain a written hazard communication program. This program must define key roles and responsibilities as well as describe the organization's hazard communication system (meaning MSDS/SDS stewardship and employee access, container labeling systems, an inventory of hazardous chemical used or manufactured, a description of every workplace physical hazards and potential infectious agents, training outline and contractor safety measures). The program and chemical inventory must continuously be updated. Applicable industrial hygiene testing results must be included and chemical/physical exposure control methods need to be employed. Both the Federal OSHA and Minnesota OSHA standards require that the complete written programs be accessible to employees. (29 CFR §1910.1200, 2012; Minnesota Department of Labor, 2013b). During the transition from the old to the new standard, manufacturers may opt to provide a SDS or continue to offer the old format until the full implementation of the standard in June of 2015 (OSHA, n.d.b). Employers must guarantee that SDS/MSDS documents are updated periodically to ensure access to information on any of the hazardous chemicals which are either used or present in the workplace. The MSDS/SDS location or electronic access is to be known and understood by every employee. In cases where employees may need to commute to various work sites, it is acceptable for the employer to maintain one set of MSDSs/SDSs in the primary location. In such circumstances, the employer is required to devise a strategy to provide MSDS/SDS in a readily accessible manner in case of an emergency. It is important to note that the regulation does not exempt wood treated with hazardous chemicals (which is the case of recycled railroad ties and electric posts used as a source of biomass) from being included in an MSDS/SDS system. Similarly, MSDSs/SDSs are required for materials which generate nuisance dusts (including coal) which pose recognized health or physical hazards (29 CFR §1910.1200, 2012).

Certain activities may create hazards which are not covered or described in a MSDS/SDS. For instance, the simple act of mowing the lawn in a hot summer day will expose an individual to physical hazards such as the heat, UV radiation from the sun and the noise from the lawn mower. In such instances, OSHA's hazard communication standard states that employers must follow a protocol to plan and discuss non-routine activities in order to furnish employees with important safety information on other hazards (including chemical, physical and/or biological) from which there is a need for protection (29 CFR §1910.1200, 2012). Employees must also be trained on how to perform such tasks safely and any safety protocol required (Lockout/Tagout, confined space entry, respirator use, etc.) before any activity involving recognized or foreseeable occupational hazards is attempted.

This researcher's intention is not to be fully comprehensive at this point, but based on what OSHA (n.d.c) establishes as hazard communication training requirements and an employer's particular process/es, a training outline may need to include each or several of the following items:

- **Introduction**
  - Objectives
  - Training frequency
  - Availability for employees to access the written program and employee exposure monitoring results
- **Purpose of Hazard Communication (Right to Know/Right-to-Understand) and GHS**
- **Responsibilities**
- **Training needs**
  - Orientation for new employees
  - Refresher training for existing employees
  - Contractors
- **Task/Work Evaluation**
  - Every work areas in the facility which are evaluated for potential hazards both physical and chemical
  - Hazards and respective controls are outlined on the facility job hazard assessment Forms (JHAs).
- **Detection of Hazardous Chemicals/Materials in the Workplace**
  - Primary locations of chemical and hazardous substance use and storage
  - Employee exposure monitoring

- **Non-Routine Tasks**
    - Review process and procedure
- **Hazard Classification**
    - Process
    - Types of Hazards
    - Health Hazards
    - Acute Toxicity
    - Skin Corrosion or Irritation
    - Serious Eye Damage or Eye Irritation
    - Respiratory or Skin Sensitization
    - Germ Cell Mutagenicity
    - Carcinogenicity
    - Reproductive Toxicity
    - Specific Target Organ Toxicity
    - Single or Repeated Exposure
    - Aspiration Hazard
    - Physical Hazards
    - Explosive
    - Flammable
    - Gases, aerosols, liquids or solids
    - Oxidizers
    - Liquid, solid or gas
    - Self-Reactive

  - Pyrophoric
  - Liquid or Solid
  - Self-heating
  - Organic Peroxide
  - Corrosive to Metal
  - Gas under pressure
  - Or it contact with water emits flammable gas
  - Other Hazards
  - Combustible dust
  - Simple asphyxiation hazards
  - Pyrophoric gas hazards
  - Hazards not otherwise classified
- **Material Labeling**
  - Manufacturers labels on original raw material chemical or substance containers
  - GHS System Label Requirements
  - Method for labeling secondary containers
  - Important differences between old and new labeling systems. (For example, GHS category severity levels are opposite of NFPA/HMIS severity levels (the greatest hazards are category 1).
  - NFPA or HMIS Labeling System
  - Waste handling/management and labels
- **Safety Data Sheets**
  - Purpose

- Definition of terms
- SDS 16 Sections
- Consulting: location and access
- Procedures for introducing new MSDS/SDS
- Chemical inventory and cross-reference to MSDS/SDS

- **Site Specific Chemical & Hazardous Substances**
  - Means of Exposure/Primary Routes of Entry
  - Absorption
  - Inhalation
  - Ingestion
  - Mucous Membranes
  - Injection
  - Hazardous Chemical, Substance & Release Recognition, Detection and Identification
  - Employee exposure monitoring and permissible exposure limits
  - Dose-Response Effect
  - Types of Chemicals and Hazardous Substances at the workplace
  - Precautions and Controls:
    - Engineering (ventilation, barriers, etc.)
    - Administrative (Safety operating procedures, job hazard assessment, etc.)
    - Personal protective equipment (proper use, maintenance, storage, etc.)
      1. Methods of Control

- **Site specific physical hazards – types, sources, controls/precautions, health concerns and emergency protocol:**
    - Heat/cold
    - Noise
    - Radiation (ionizing and non-ionizing)
    - Potentially explosive atmosphere
- **Site specific Infectious agents – types, sources, routes of exposure, controls/precautions, health concerns and emergency protocol:**
    - Legionella (usually in cooling towers)
    - Bloodborne (HIV, HBV, HCV, etc. - usually a concern in first aid situations)
    - Insect caused (lime disease, West Nile, etc.)

Question and answer period. (US Compliance, 2013) The outline described above may seem extensive, but it includes most of the elements which a hazard communication program will likely need. If employees are not trained in all of the aspects included in a safety program, it will not likely be followed as intended and misinterpretations may occur, especially with some of the technical aspects such as labeling symbols or personal protective equipment (PPE) requirements.

Objectives of an occupational chemical/physical exposure control program. Goals and objectives may be oriented towards the achievement of compliance with state and federal regulations or conformance to industry consensus as well as internal standards. Compliance refers to meeting requirements which possess the force of law and mandates adherence to defined protocols, although it typically only guarantees a minimal level of protection for employees (Bathurst et al, nd). In the context of occupational exposure to chemical and physical hazards, requirements include meeting OELs and performing a series of activities to minimize the risk associated with common chemical and physical hazards (Muhalsen and Damiano, 2012). On the other hand, conformance implies the commitment to meet standards which do not possess the force of law, although these are included or succeeded by extra protective/effective standards (Kausek, 2007). In the design of a proactive approach to physical/chemical hazard exposure control, it is important to consider that state and federal regulations are typically general, meaning they are established under the assumption of ideal/or foreseeable situations and may not include certain industry or site specific situations, which a are often addressed through letters of interpretations as clarification is requested by the public. However, compliance is a starting point in the continuous improvement process as proposed by OHSAS 18001, ANSI Z10-2012 and OSHA's federal and state voluntary protection programs (VPP). In this regard, Bird (1997) stresses the importance of implementing improvements progressively to avoid adverse employee and/or management reaction to change.

The implementation of an organization's IH exposure control program should be directed to the assurance of compliance with policies, standards and regulations in its initial phase. To determine if the objectives are being accomplished, an organization must assess the operational controls employed through audits, surveys and monitoring of both active (pre-loss) and passive (post-loss) performance indicators (Kausek, 2007). After an initial assessment of the current IH exposure control practices and results has been communicated to the upper management, its members must decide on the corrections to be executed and what to commend the team for. Upper management must also decide on the deployment of the next phase of improvement (AIHA, 2012, Kausek, 2007). In the particular case of an IH occupational exposure program, objectives would need to be prioritized in accordance with the outcome of a preliminary risk assessment/characterization process, which will be discussed later in this chapter. The objectives should focus on the underlying causes and contributing factors associated with occupational and health risks and reflect the organization's general OHSMS. These should be designed to follow a continual improvement process and be sufficiently flexible to change as suggested in the ANSI Z10-2012 standard (AIHA, 2012). The objectives of a chemical/physical hazard exposure control program may include:

- An initial identification and characterization of actual and potential (chemical/physical) health hazards.
- The enhancement of information systems to ease the prioritization of efforts to eliminate health hazards or minimize exposures to regulatory limits based on informed decisions.
- The integration of organizational resources for the formalization of an effective occupational exposure control program.
- Compliance with internal processes which guarantee the accomplishment of the established objectives.
- Communication and management of change (AIHA, 2012).

In order to manage complex processes such as the control of employee exposure to chemical and physical agents, it is necessary to understand the extent and nature of the problem, possess the necessary technical and financial resources, enforce the established rules, and employ a strategic approach to promote change. In a continual improvement endeavor, the focus is refined as information on the problem and the effectiveness of measures become available, then correction or reaffirmation may be engaged (AIHA, 2012; Mulhausen and Damiano, 2012)

Chemical/physical hazard identification and risk assessment. The identification of pure loss exposure and the subsequent assessment of hazards (which constitute a condition or practice with the potential for causing accidental losses) is the first step in the management of risks (Bird, 1997). Once hazards are identified, the likelihood of occurrence and the severity of related potential losses are forecasted through a risk assessment process. Such activities will assist with the prioritization of measures to eliminate or reduce risk in an efficient manner (Leibowitz, 2012). Following a similar line of thought, Kausek (2007:44) considers a job hazard analysis to be “the heart of the health and safety management system.” In the specific context of hazards which present toxicological, epidemiological, technical and environmental implications, the detail and thoughtfulness required to assess the associated health risks require a comprehensive approach. Mulhausen and Damiano (2012) present a risk assessment model which suggests the buildup and organization of data in an incremental matter with the intent of increasing accuracy through a loop of continual improvement, starting and ending in the characterization of risk (see Appendix B). This model includes the following:

Basic risk characterization. An organization’s effectives during the anticipation of occupational health risks will depend on the entity’s understanding of basic information on the workplace, workforce, operations and other aspects of the industrial environment. In other words, a basic risk characterization will produce informed criteria for the efficient alignment of efforts in the assessment of employee exposure to chemical/physical hazards, control and emergency planning. According to Mulhausen and Daminano (2012:234), the process of characterizing health risks must gather information on:

- Workforce, tasks and division of labor
- Potentially hazardous agents (chemical, physical and biological) from materials used and byproducts
- Critical exposure conditions (the environment and the task itself).

- Previous IH monitoring data (if any)
- Engineering and administrative controls already in place and the effectiveness of such.
- Potential health effects, mechanism of toxicity and the occupational exposure limits of agents (if any). (Mulhausen and Daminano, 2012)

As viewed by the model in discussion, a basic health risk characterization is the starting point in a continuous improvement process. An initial exposure/work conditions information gathering effort is performed even before attempting to monitor exposures. Data must be analyzed to determine whether the risk levels are acceptable, unacceptable or uncertain. Uncertainty will likely be the outcome of an initial attempt to characterize risks, and in such a case additional exposure and/or work conditions information will need to be gathered and further formal, quantitative approaches such as chemical exposure monitoring may be performed (Mulhausen and Damiano, 2012).

A quantitative exposure assessment of any chemical agent will be of no/little value if there is no OEL or benchmark that would help describe the exposure in terms of recommended or regulatory requirements/measures. If a chemical agent does not possess an OEL, the industrial hygienist would need to establish an internal OEL based on a careful study of the physical/chemical properties of the sustance, its toxicity, and the mechanisms of absorption, distribution and elimination (Bratt et al. 2012).

The existence of an OEL does not necessarily mean it should be adopted without further considerations. A proactive approach to exposure control should include a thought process that questions the criteria used for establishing such limits (Bratt et al. 2012). Questions regarding safety factors used, the consideration of adverse health effects, the adequacy of the data supporting the OEL, employee work schedules, a skin notation (warning) and absorption rate as described in the ACGIH threshold limit value booklet, and the additive/synergistic effects in relation with other chemical agents are variables which may deserve analysis (Mulhausen and Daminano, 2012). In such respect, a basic risk characterization needs to describe:

- **The workforce on the basis of:**
    - Working schedules. The majority of OELs are established on the assumption of a regular 8-hour, 5-day-a-week working schedule. If workers are on a 12-hour rotating schedule, then time-based adjustments to work shifts may need to be employed in order to minimize chemical exposures (Klonne, 2012).
    - Demographics. Criteria for the establishment of OELs include epidemiological studies of particular groups. The younger and aging workers are usually increasingly susceptible to the adverse effects from chemical/physical exposures. Women may at times be pregnant or in a lactation period and it is therefore important to determine such critical episodes. Also, certain racial groups are resilient to physical/chemical hazards while others are overly-sensitive (e.g. the relationship between skin color and risks associated with exposure to UV radiation) (Still et al. 2012).
    - Awareness and skills set. There may be situations in which the lack of awareness on a chemical/physical hazard or training will create the conditions for overexposure as a result of a misoperation (Reason, 2012).
    - Culture. This consideration is equally crucial and challenging to determine because culture deals with the belief systems of individuals which may not favor the importance of abiding by the safety rules over personal or organizational interests (Reason, 2012).

- **The tasks.** By consulting accurately documented description of duties and standard operative procedures, the industrial hygienist could anticipate several hazards which employees may be exposed to. It is important to consider that an organization may describe tasks as these should be executed, but the manner in which these are actually performed is completely different. For this reason the technician or industrial hygienist also needs to be able to recognize any deviations from the established standard operating procedures (SOPs) while the task is being monitored. It is also important that those involved in the analysis be fully aware/informed of changes in SOPs to determine if work methods employed by employees do not accentuate or create a new hazard (Mulhausen and Daminano, 2012; Reason, 2012).
- **Potentially hazardous agents**. Chemical/physical hazards may originate from the misused of materials, byproducts, weather, process failure and/or unintended environmental conditions such as a flood or sudden change of direction and speed of the wind. (Silk 2012).
- **Critical exposure conditions**. Example of critical exposure conditions include work in confined spaces, special weather, and non-routinely situations which are often common, but not limited to maintenance work. Because maintenance activities may not be a part of an organization’s daily process and thus fall out of the routine, the likelihood of the occurrence of an adverse outcome, such as an accidental exposure to a dangerous concentration of a toxic agent, is higher. Similarly, an emergency response activity may not be the ideal occasion to monitor exposures to chemical/physical agents, and therefore a comprehensive risk characterization could employ modeling techniques to determine

worse case scenarios as part of the emergency planning efforts (Mulhausen and Daminano, 2012; Reason, 2012).

- **Previous monitoring data**. If available, the information obtained from previous IH monitoring would constitute a baseline of the employee exposures registered historically. High exposure situations could be targeted for additional monitoring and analysis and other situations may be re-assessed in order to validate the data or detect changes that need to be addressed (Leibowitz, 2012).
- **Controls in place**. A detailed description of engineering and administrative controls in place will assist in the determination of the residual health risks and anticipate how critical it is to periodically reassess the effectiveness of such (Mulhausen and Daminano, 2012; Reason, 2012).
- **Potential health effects and mechanism of toxicity**. Depending on the hazard classification of a chemical agent, an exposure may be rendered as unacceptable regardless of its OEL (e.g. an agent which is a confirmed carcinogen may cause cancer regardless of exposure levels). If an initial health risk characterization is thoroughly performed, the occupational health staff will be able to prioritize the efforts for risk mitigation, control and emergency response (Mulhausen and Daminano, 2012; Still et al. 2012).

The benefits of performing an initial health risk characterization include:

- Obtaining an informed anticipation of health risks for proper allocation of resources
- The creation of an initial exposure profile which will serve as a benchmark, and the foundation of a robust risk characterization process.

- The development of informed criteria for the adoption of external and internal OELs
- A methodical process for the creation of similar exposure groups (SEGs)
- A continuous improvement process for the update of chemical/physical exposure control plans (Mulhausen and Daminano 2012).

An initial risk characterization will help organize ideas and provide the groundwork necessary for further studies of employee exposure, whether factual or likely, to hazardous chemical and physical agents. During this phase, an industrial hygienist can attempt an initial analysis of processes, materials, products/byproducts and possible occupational exposure from work/activities. The information will be valuable in the creation of solutions to abate health and physical hazards.

The deployment phase. Health and safety related-processes and activities may be organized into formalized programs based on the complexity and technical challenges involved (Kausek, 1997; AIHA, 2012). As previously discussed, the process of creating a basic risk characterization presents the need to gather information from a myriad of sources, bridges interdepartmental organizational boundaries, and requires both basic and specialized knowledge as well as technical resources. The elements of a chemical/physical exposure control program are described below under the assumption that an organization's occupational health management system (OHMS) is modeled after the consensus standards discussed in this chapter.

Structure and responsibility. The success of a chemical/physical exposure control program depends on the establishment of a shared vision, responsibility and accountability. This may be accomplished thorough the participation of key members of an organization. The synergy created through the contribution of every stakeholder may efficiently produce the desired outcome and impact the organization positively (Leibowitz, 2012). Below is a brief description of what a chemical/physical exposure control program should encompass based on the proposals of the AIHA (2012), Kausek (2007) and (Bird, 1997) as the ideas presented by these researchers may equally apply to the control of chemical and physical hazards, which is also part of an occupational health and safety management system:

- Top management safety and health representatives should establish the program mission and vision, actively engage in the communication of the program's expectations and commit to allocating the necessary resources.
- A cross functional safety and health commission should actively participate in the planning phase and provide assistance in the logistics of program implementation. As an example, information technology (IT) would provide technical assistance in the update of database feed and granting access of critical information needed by the industrial hygienist in the initial characterization of risk. Since health risks associated with chemical and physical hazards may be challenging to determine, a cross functional team (CFT) should be responsible for procuring specialized training for participants beyond the basic chemical risk identification and assessment techniques.
- The safety and health department should dispense assistance and leadership in the provision of technical knowledge and expertise. The senior industrial hygiene specialist should direct the creation of the tools that will enable line management and hazard recognition teams to gather information in a systematic and understandable manner. These may include chemical/physical hazard recognition checklists, job/process hazard analysis forms, health risk matrix tools, program specific cost/benefit analysis forms, database entry and exposure monitoring request forms. Safety and health specialists

should serve as consultants to floor managers and hazard recognition teams. Depending on the size of the organization, this responsibility may be divided and assigned to different safety specialists who would serve as the appointed OH&S safety advisor (Leibowitz, 2012).

Training, awareness and competence. The organization's initial JHA or hazard recognition effort would need to include employee training on the awareness of the physical/chemical hazards of the applicable operating settings. The team must be furnished with the ability to interpret safety data sheets (SDSs) and integrate health and safety concerns into task descriptions. Various stakeholders such as supervisors, team leaders, or unit/floor managers will also need to be trained on specific tools provided by the Health and Safety Department for an in-depth risk assessment of duties where chemical/physical exposure control is critical or knowledge on the related hazards is limited (29 CFR §1910.1200, 2012; AIHA, 2012; Kausek, 2007).

Activities regarding the evaluation and control of chemical/physical hazards may constitute a valuable opportunity for educating the parties involved on hazard awareness. Regulatory requirements mandate that employees be notified of monitoring results, which is an opportunity to meet and discuss the findings and the significance of such. Even in cases where monitoring is not required, it is advantageous to engage a dialogue with employees on the importance of assessing risks and establishing controls. Adults will likely comply with requirements if stakeholders are instructed on the reasons for the established controls (AIHA, 2012; OSHA, 2001).

Consultation and Communication. As in any human endeavor, a constant flow of information is likely to be crucial for the success of an exposure control program. Protocols can be included into the general management process to guarantee the parties involved from all levels of an organization effectively inform and/or request advice from the Health and Safety Department any time, and may include situations such as:

- New materials, equipment and chemical products are procured or incorporated.
- Changes have been integrated to particular processes.
- Non-routine activities are scheduled.
- New employees are hired.
- Services from third party administrators or contractors are procured to performed. activities that may produce unexpected physical/chemical hazards (Kausek, 2007; Minnesota Department of Labor, 2012).

Chemical/physical exposure control needs to be integrated to processes beyond occupational health and safety, along with quality, production and procurement. Various management tools may be employed but in every case, accountability for consultation and communication activities needs to be established and documented. Open discussion with employees is also necessary when addressing alternatives to reduce or eliminate hazards. This is especially critical in cases where the solution involves changes and thus the possibility of resistance from the employees who are affected (Kausek, 2007, MNOSHA Rules. Chapter 5208).

Documentation and control of documents. The documentation of activities is an important aspect of a chemical/physical exposure control program (CPECP). Documents such as forms, checklists, and permits are instruments which help ensure there is uniformity in all processes as established in a program. Once utilized, documents are records and serve as a means of proving compliance and conformance to regulations, standards, and procedures relevant to the control of occupational chemical/physical exposures. In a description of the elements of a learning organization, Senge (2006) regards the documentation process as a source for organizational learning.

Records generated on processes, activities and procedures constitute a means of proving a program is being carried out, and can also be utilized for evaluation and correction purposes. However, assessing health risks require data from numerous sources and depending on the size of organization, the flow of data may be overwhelming. In such case, a tracking system would be ideal for the creation and maintenance of documentation. Data retention and disposal may also be administered with the assistance of technology in order to produce an alert on the expiration date of documents as well as delete such automatically if the retention time of such is due (AIHA, 2012).

Operational Controls. These are the methods employed to control an organization's health and safety hazards once such are identified during the planning phase (Kausek, 2007). These hazard controls may include additional documented procedures, operating criteria and policies. In the context of comprehensive exposure assessment, Muhalsen and Damiano (2012) outline the following as being intrinsically related to the control of chemical and physical hazards:

- Hazardous material management
- Hearing conservation
- Engineering controls
- Administrative controls
- Work practice controls
- Personal protective equipment
- Radiation safety

- Medical surveillance
- Epidemiology
- Hazard communication
- Education and training
- Exposure monitoring
- Recordkeeping (Mulhausen and Damiano, 2012)

The number and type of operational controls as well as the extent to which such are employed will vary depending on an organization's chemical/physical hazards, the severity of the potential risks to be abated and the legal requirements (Federal or State OSHA) which govern occupational exposures. In conclusion, operational controls deal with the proper implementation of risk reduction measures and ensuring such are implemented as intended.

Checking and corrective action phase. In general, an OHSMS and the programs which it organizes need to be evaluated in order to measure the degree of conformance to standards and compliance with regulatory requirements, as well as determine whether specific goals and objectives are being met (AIHA, 2012; Kausek 2007: Bird 1997). Due to the management systems' complexity, Kausek (2007) and Bird (1997) emphasize the possible necessity to divide the evaluation process into manageable components. Kausek (2007) argues that in an initial stage of this phase, only compliance and conformance are the criteria for evaluation before any attempt is made to focus on the ultimate desired outcome, such as incident and injury reduction. Bird (1997) explains that activities within the implementation of a program need to be identified and compared against the applicable standards in order measure performance gaps, evaluate the effectiveness of such actions, or correct deficiencies in performance standards. The evaluation process may include areas such as human performance, data recording and handling, technical and financial resources, maintenance of equipment and calibration, accident investigation and frequent program conformance audits (AIHA, 2012; Kausek, 2007; Crossman et al 2009; Bird, 1997). Basically, the evaluation and correction actions may focus on pre-loss or post-loss activities, or both. Although post-loss activities offer a significant opportunity for learning, the level of engagement and effectiveness of pre-loss activities from a proactive approach should promote continuous improvement and thus the need for post-loss activities would become less frequent.

Management review. Employee commitment to evaluating any particular process within the OHMS will determine the quality of reports presented to the upper management and thus constitute a valuable support in the realization of a continuous improvement process. Reports must be presented in a businesslike manner and reflect on the relationship between the data and the goals and objectives which were established in the planning phase (McDonald, 2012). The management review process must encourage employee participation and communication in order to gain support for any subsequent course of action. Correction of deficiencies must not only be performed in a positive manner without establishing blame on particular individuals, but also describe the causes within the management system itself in order to avoid unnecessary reduction of the team's morale and therefore gain the commitment of the members to perform the actions which will solve the root cause of the problem (Reason, 2012). It should be noted that there may be situations in which individuals perform unacceptable behaviors and therefore it is important to establish a protocol which defines the gravity of the actions based on organization's code of ethics, and the criteria for corrective measures which may include termination of certain personnel (Petersen, 2003).

Summary

This chapter discussed several of the known chemical and physical hazards encountered in the coal power generation industry based on the literature review of previous studies which may shed light on the potential occupational exposure issues at ABC Electric. Then the control of occupational exposures to chemical and physical hazards was described in the broad context of OHSMS which follow Deming's (1986) PDCA cycle of improvement (plan, do, check, act), as well as in the specifics of various industrial hygiene continuous improvement processes and considerations. The management of occupational exposure to chemical/physical agents was also described in terms of:

- A planning phase which includes the consideration of regulatory and logistic requirements of an IH exposure control program, the establishment and pursuit of measureable objectives, and the activities to be employed during chemical/physical hazard identification and risk assessment.
- A deployment phase which involves the effective creation of a structure and an accountability system (roles and responsibilities), employee training and awareness of chemical/physical hazard recognition and the controls available to abate such, a consultation/communication system, the control of documents, and operational controls established to reduce occupational risk.
- A checking and corrective action phase in terms of established checks and balances to ensure IH exposure control policies, practices and procedures are exercised as intended, and deviations from established regulatory or consensus standards are corrected.
- An established management review process which provides support and guidelines to improve an IH exposure control system.

Chapter III will describe the methods to be employed in the analysis of ABC Electric's IH exposure control practices in consideration of the elements included in an IH exposure management system as summarized above. In detail, an audit form will be employed to evaluate such chemical/physical risk control practices through a review of documents. Similarly, a checklist will be utilized to evaluate compliance to OSHA's regulations which are identified as applicable during the review process. The evaluation is expected to identify areas of improvement within ABC Electric's IH exposure control management from a regulatory compliance and conformance to industry standards perspective. The outcome of this study will be a baseline of recommendations which ABC Electric may employ in order to improve the organization's ability to mitigate/eliminate employee exposure to harmful chemical/physical agents.

Chapter III: Methodology

The purpose of this study was to analyze the industrial hygiene exposure control practices at ABC Electric's thermal generation operations in light of regulatory and industry standards. The goals pursued in this endeavor include:

- The identification of the hazardous chemical and physical agents to which employees at ABC Electric's power generation facilities may be exposed
- An audit of the organization's current occupational exposure control management practices.

This chapter will describe the methods and guidelines which were employed to achieve such purpose and goals. In detail, the sample selection and description process, the instruments and methods utilized for data collection and analysis, as well as the limitations of the present study are discussed in this chapter.

Sample Selection and Description

ABC Electric's generation operations include six thermal power plants. At these locations, boilers are fueled by coal and/or a biomass mixture which is mainly comprised of decommissioned wood electric poles and wood collected from recycling processes. The workforce at these plants is divided into four principal groups which include boiler operators, fuel handlers, ash handlers and maintenance workers. The data to be analyzed as part of this study includes industrial hygiene (IH) records from this organization's largest coal facility and a biomass/renewable power generation plant, and these operations will be referred to as plant A and B respectively. The document review process included records from plant A and B which provide an indication of compliance with IH exposure control management practices during fiscal year 2013 and/or documents which substantiate the fulfillment of IH exposure control system elements as outlined in the instruments utilized for the collection of data (see appendix C). However, in order to accomplish a consistent analysis of accidents which have resulted from employee exposures to chemical/physical agents, the review of both plants' OSHA 300 logs included fiscal years 2013, 2012, 2011 and this is the exception. In detail, the following documents were analyzed:

- Investigation reports of accidents and/or incidents involving chemical/physical agents which occurred in 2013.
- Current IH testing documents.
- The organization's current IH Policy.
- Job hazard assessments (JHA) of the principal functions which are performed by the groups described above.
- Programs required for the control/abatement of chemical or physical hazards identified in current JHAs as applicable (e.g., hazard communication, respiratory protection, chemical spill response, hearing conservation, chromium VI, Isocyantes, combustible dust, incident and illness prevention, etc.).
- Required training records as applicable (hazard communication, hearing conservation, IH-related roles expected to be performed by employees, group leaders, supervisors or safety committee members, etc.).
- Documents which prove specific programs designed for the control of chemical/physical hazards are audited and updated internally.
- Documented management review of instituted IH control performance.

- Written procedures for IH document and record control, chemical inventory/SDS updating, contractor material control, IH equipment calibration, and change of process hazard assessment and communication.

This study also involved a review of the organization's incident and injury prevention program in order to determine the degree of inclusion of IH exposure control practices in the organization's overall health and safety management system. Special caution was exercised to omit personal/employee-based references or identifiers to protect the identity of individuals included in any of the documents reviewed.

Instrumentation

In the initial stage of the organization's IH exposure control program review, two logs were utilized to compile information on the hazardous chemical and physical agents to which employees at ABC Electric's power generation facilities may be exposed to, as determined in both current job hazard assessments and IH testing records (see chemical/physical hazard and JHA assessment logs in appendix C). Similarly, an audit instrument which is based on a model designed for the assessment of occupational health and safety management systems and was customized, as proposed by Kausek (2007), to assess ABC Electric's IH exposure control practices, with a focus on general regulatory requirements as well as specific regulations which are relevant to the control of the identified hazards (see appendix D).

Data Collection Procedures

1. Information was received from ABC Electric's corporate industrial hygienist and a human resources appointee to facilitate performing an initial review of documents which included IH testing records, OSHA 300 Logs (fiscal years 2011, 2012, 2013), incident investigation reports as well as job hazard assessments and work descriptions

of boiler operators, ash handlers, fuel handlers and maintenance workers. This initial assessment served as a means to obtain the necessary information to analyze potential employee exposures to chemical and physical agents based on historical records as well as determine which hazard specific regulations, programs and procedures apply to ABC Electric's power generation process. It is important to mention that the identities of employees involved in accidents/incidents were not disclosed by ABC Electric and therefore the researcher's access to personal references or identifiers was limited to guarantee employee privacy.

2. A second document review was performed in order to evaluate ABC Electric's IH exposure control practices in the following primary areas:
   a. IH control system planning and compliance reviews
   b. Operational controls (methods employed to abate or eliminate physical/chemical hazards)
   c. Improvement process
   d. Program and procedure monitoring and corrective action
   e. Document and record control, material control, equipment calibration and training
3. Finally, the organization's incident and illness prevention program was reviewed to determine whether elements which are relevant to the control of occupational exposure to chemical/physical hazards have been included within ABC Electric's corporate safety goals and objectives and definition of key roles.

Data Analysis

Once the data was collected, a description of the chemical/physical hazards to which employees at ABC Electric may be exposed was developed. Similarly the results from ABC Electric exposure control practices audit were summarized in a scorecard which rates the stage at which the organization is in the continual improvement cycle as presented by Kausek (2007):

- 16 to 20. Commitment to IH exposure control management is weak. The organization may be in violation of current health and safety regulations.
- 21 to 50. A basic IH exposure control management is in place, but full organizational commitment does not yet exist.
- 50 to 64. Assuming no scores in any area were less than 3, the organization has a comprehensive IH exposure control management in place. The stage is set for continual improvement. (See Appendix E for details).

Limitations of the Study

- This study focuses in the overall occupational IH exposure control management process and was not intended to perform an in-depth audit of any specific programs/procedures, although several key components such as training records or key role definitions were reviewed.
- Several of the IH exposure control processes (e.g., confined space entry, respiratory protection) which could, and should be verified thorough a walkthrough visual inspection are process sensitive and would likely require multiple visits. For this reason no visual inspection was conducted at this time.
- The document review process may be limited by the time committed from company individuals who assisted in the process.

Chapter IV: Results

The purpose of this study was to analyze the industrial hygiene exposure control practices at ABC Electric's thermal generation operations in light of regulatory and industry standards. The goals pursued in this research include:

- The identification of the hazardous chemical and physical agents to which employees at ABC Electric's power generation facilities may be exposed
- Perform an audit of the organization's current occupational exposure control management practices.

This chapter will present the information obtained from the data gathering period of this study as defined in Chapter III. A series of documents were reviewed in order to identify potential employee exposures to chemical and physical agents based on historical records such as OSHA 300 logs (fiscal years 2011, 2012 and 2013), past industrial hygiene monitoring results and incident reports. Similarly, an audit instrument which is based on a model designed for the assessment of occupational health and safety management systems was customized to serve the evaluation of ABC Electric's IH exposure control practices with regard to the following components:

a. IH control system planning and compliance reviews
b. Operational controls (methods employed to abate or eliminate physical/chemical hazards)
c. Improvement of established IH exposure control practices
d. Program and procedure monitoring and corrective actions
e. Document and record control, material control, equipment calibration and training

Chemical and Physical Agents at ABC Electric Power Generation Operations

In the process of identifying the chemical and physical agents which employees at ABC Electric may be exposed to, the following documents were reviewed:

- ABC Electric's past chemical/physical hazard assessment results
- Results from recent IH testing
- OSHA 300 Logs from fiscal years 2011-2013
- Accident investigation reports of incidents which involved a chemical/physical agent in fiscal years 2011-2013.

The results are reported below in three sections:

1. IH hazard assessment at ABC Electric
2. Recent IH testing results
3. Recent incidents at ABC Electric which involved a chemical/physical agent

IH hazard assessment at ABC Electric. In order to manage employee exposures to environmental agents through the proper control methods, ABC electric established a site-specific five year IH exposure control plan for plant B (coal power generation) which was carried out until 2011. IH monitoring and assessment data was utilized to establish a semi-quantitative risk matrix. The final rating aided in the prioritization of the various workplaces or activities requiring further or continuous IH review. Chemical/physical hazards yet to be monitored/assessed, and which also possessed a high risk rating, were granted priority in the process of establishing controls or gathering information. Tables 1 and 2 provide an overview of the process of determining a risk rating for employee chemical/physical exposure in consideration of:

- The workplace/activity.

- Substance/agent of concern according to previous assessment of processes, materials and byproducts.
- Workers involved in specific activities or operating in certain areas (see Tables 1 and 2).

The final risk rating for each of the place/work specific similar exposure groups was calculated with the assistance of a software which proposes a health effects rating scheme based on a criteria similar to AIHA's health risks rating. In addition, monitoring results and controls of hazardous substances/agents are factored into the final risk rating equation by this software. The numerical calculation is divided into the following three sections:

- Section 1
  - Health hazards of the substance or agent (HH):
    0. No known health effects
    1. Low (reversible health effects of limited or little concern)
    2. Medium (reversible health effects of moderate concern)
    3. Medium (reversible health effects of serious concern)
    4. High (irreversible health effects)
    5. Unacceptable (life threatening)
  - Workers exposure to the substances (EX)
    0. No exposure
    1. Incidental exposure
    2. Low exposure (rare contact)
    3. Moderate exposure (frequent at low levels or infrequent or infrequent at high levels)
    4. High (frequent at high levels)

5. Unacceptable level exposures (continuous at high levels)

- Primary type of control (CT)
  0. No controls needed
  1. Control measures are evaluated
  2. Numerous controls used
  3. Engineering controls
  4. Administrative practices
  5. Personal protective equipment

- Section 2
  - Monitoring program results
    0. Near sampling/analytical detection limits
    1. Below action levels
    2. Above action levels
    3. Below exposure limits, over 50% between action AL and OEL
    4. Above exposure limits

- Section 3
  - Knowledge on the hazard (HK)
    0. Complete knowledge of the substance/agent
    1. Substantial knowledge of the substance/agent
    2. Certain knowledge of the substance/agent
    3. Limited knowledge of the substance/agent
    4. Substance under review
  - Effectiveness of workplace controls (EC)

0. Controls cannot fail
1. Controls are highly effective
2. Moderate effectiveness of controls
3. Low effectives of controls
4. Unknown effectives of controls

- Changes in workplace exposures (CX-in terms of variability in exposure levels)

0. Workers exposure cannot change
1. No changes in workers exposure
2. Small changes in workers exposure
3. Moderate changes in workers exposure
4. Large changes in workers exposure

The final risk rating was calculated by utilizing the following formula:

(HHxEX)+CT+(MOx2)+HK+EC+CX= final risk

The results obtained in the first assessment, years 2002-2007, indicate that the exposure group named sandblasting the blades from inside the induced draft fans presented the highest level of hazard in terms of exposure to silica quartz contained in coal ash (see Table 1). The concern is comparable to the cleaning super sucking precipitator group, with final risk rating of 34. Such a piece of equipment is an environmental control which must be maintained periodically to guarantee its effectiveness. During the second five-year risk assessment term, the identical two activities (with the exception that sandblasting was performed from the outside) rated the first 3 places for the highest level of IH related risk due to metal and total particle exposures (see Table 2). It should be noted that working from the inside of ID fans was minimized, which is why the results obtained from the second term risk assessment were lower for the exposure group sandblasting ID fans. Sandblasting from the inside is currently performed only in extreme situations and usually by contractors.

Table 1

IH risk matrix for plant B, term 2002-2006

Workplace/Job	Substance/Agent	Workers	Risks			Monitoring Results	Evaluate			Final Rating
			HH	CT	EX		HK	EC	CX	
Sand Blasting ID Fan (in)	Silica Quartz	Operators	5	2	4	4	0	3	3	36
Super Sucking Precipitator	Silica Quartz	Contractors	5	5	3	4	0	3	3	34
Unit #4	Noise	All Employees	4	5	3	4	0	3	3	31
Sucking Precipitator	Total Particulate	Contractors	3	5	3	4	0	3	3	28
Sucking Precipitator	Respirable Dust	Contractors	3	5	3	4	0	3	3	28
Sand Blasting ID Fan (in)	Respirable Dust	Operators	3	2	4	4	0	3	3	28
Sand Blasting ID Fan (in)	Total Particulate	Operators	3	2	4	4	0	3	3	28
Sand Blasting ID Fan (in)	Metals	Operators	3	2	4	4	0	3	3	28
Unit #4	Heat	All Employees	3	4	3	4	1	3	2	27
Condensor	Legionella	Contractors	3	4	3	4	0	3	2	26
Seal Coating Discharge	Styrene	Contractors	3	4	3	3	1	2	3	25
Sand Blasting ID Fan (out)	Respirable Dust	Operators	3	2	4	3	0	3	2	25
Welding (in fan)	Total Particulate	Maintenance	3	2	3	4	0	3	3	25
Welding (in fan)	Metals	Maintenance	3	2	3	4	0	3	3	25
Sand Blasting ID Fan (out)	Silica Quartz	Operators	5	2	3	1	0	3	2	24
Cooling Towers	Legionella	Various	3	4	2	4	0	3	2	23

Notes: compiled from plant B's site specific IH plan for term 2002-2006

All employee exposures to occupational noise rated the third highest final level of risk during the first assessment term, however, new controls such as sound deadening curtains were installed recently and a re-assessment needs to be conducted. Employee exposures to heat from the boiler systems and legionella from cooling towers were among the first ten task specific exposure groups deemed to present the highest level of risk.

It may be inferred that activities which generate dust, especially maintenance work, pose the highest probability of exposure to heavy metals, silica and respirable dust (including wood dust in the case of plant A). Exposure to asbestos is also granted importance during remodeling and boiler refurbishing activities as this is material is still widely utilized at coal and biomass power generation plants for insulation.

Table 2

IH risk matrix for plant B, term 2007-20011

Workplace/Job	Substance/Agent	Workers	Risks			Monitoring Results	Evaluate			Final Rating
			HH	CT	EX		HK	EC	CX	
Super Sucking Precip	Metals	Contractors	3	5	3	1	0	3	2	21
Sand Blasting ID Fan (outside)	Total Particulate	Operators	3	2	3	1	0	3	2	18
Sand Blasting ID Fan (outside)	Metals	Operators	3	2	3	1	0	3	2	18
Normal Duties	Asbestos	All Emp	5	2	2	1	0	2	2	18
Inspecting Boiler	Metals	Contractors	3	2	3	1	0	3	2	18
Inspecting Boiler	Total Particulate	Contractors	3	2	3	1	0	3	2	18
Scrubber Duties	Silica Quartz	Operators	5	2	2	1	0	2	2	18
Aerosol Can Use	Hydrocarbons, Organic Vapors	Maintenance	3	3	2	1	1	2	2	16
Painting	Lead	Contractors	4	2	2	1	0	2	2	16
Demineralizer	HCL	Lab Tech	5	3	1	1	1	2	2	15
Demineralizer	Caustic soda	Lab Tech	4	3	1	1	1	2	2	14
Scrubber Duties	Metals	Operators	3	2	2	1	0	2	2	14
Scrubber Duties	Total Particulate	Operators	3	2	2	1	0	2	2	14
Scrubber Duties	Respirable Dust	Operators	3	2	2	1	0	2	2	14

Notes: compiled from plant B's site specific IH plan for term 2002-2006

It is important to mention that even though plant A lacked a detailed IH plan, the matrix generated in plant B has also served as a reference for employee IH exposure control efforts. Also, Plant A presents an additional concern in terms of exposure to hazardous chemical agents originating from chemicals utilized to treat wood products which are recycled into the biomass that fuels the boilers at this renewable energy facility. This topic is adressed in the recent IH testing results review section of this chapter.

In favor of the monitoring and control of the identified chemical/physical hazards, the safety and industrial hygiene department performs periodic IH testing for the following agents/substances:

- Metals
    - Silver
    - Aluminum
    - Arsenic
    - Barium
    - Beryllium
    - Calcium
    - Cadmium
    - Cobalt
    - Chromium
    - Copper
    - Iron
    - Potassium
    - Manganese
    - Molybdenum
    - Nickel
    - Phosphorus
    - Lead
    - Antimony
    - Selenium
    - Tin
    - Strontium
    - Titanium
    - Thallium
    - Vanadium

    - Magnesium
    - Tungsten

- Particulates
    - Respirable
    - Total
    - Quartz: tridymite and cristobalite
    - Asbestos (during removal and remodeling operations)
- Organic compounds
    - Polycyclic Aromatic Hydrocarbons
    - Pentachlorophenol
    - VOC's such as acetone, amyl acetate, heptane, methylcyclohexane – depending on spirits/solvent material utilized by painters/maintenance
- OSHA national emphasis program (NEP) related chemicals
    - Chromium VI (stainless steel and hard facing operations for now)
- Biological
    - Legionella
- Other
    - Occupational noise
    - Heat stress

Recent IH testing results. A review of the latest IH testing results at plant A and B was performed and it was observed that:

- Individuals sand-blasting ID inside fans at the coal power plant experience the highest exposure levels to heavy metals, silica, and both total and respirable particulate. Table 3 compiles results on the various agents analyzed from two employees who participated during the 2012 sampling campaign, and the higher exposure levels of the two was recorded on this table. During this period, the permissible exposure limit for crystalline silica was exceeded a maximum of 270 times, followed by calcium and total particulates with exposure levels of 106 and 62 times the PEL respectively.

- Even though precipitators may be significantly dusty, few agents presented exposure levels above the action level (50% the PEL) or PEL in comparison to the sand blasting group at plant B. Total and respirable particulates accounted for the highest exposure levels of 22 times the PEL. Exposure levels to phosphorus and manganese were also significant (see Table 4).

Table 3

Sandblasting ID Fan Inside – 2012

Agent	Exposure Level	OEL	# of times above the PEL
Aluminum	340	15	22.7
Arsenic	0.13	0.01	13.0
Barium	1.4	0.5	2.8
Beryllium	0.027	0.002	13.5
Calcium	530	5	106.0
Cobalt	0.094	0.05	1.9
Copper	0.55	0.1	5.5
Iron	91	10	9.1
Lead	0.019	0.05	0.4
Magnesium	130	10	13.0
Manganese	0.92	0.1	9.2
Nickel	0.19	0.1	1.9
Phosphorus	2.9	0.1	29.0
Sodium	90	15	6.0
Strontium	18	10	1.8
Titanium	19	10	1.9
Vanadium	0.057	0.05	1.1
Total Particulate	4300	15	286.7
Respirable Particulate	250	5	50.0
Silica	27	0.1	270.0

Notes: Analytical methods employed: NIOSH 7300, 7500, 500 and 600

Table 4

Blowing down super sucking precipitator – 2007

Agent	Exposure Level	OEL	# of times above the PEL
Aluminum	27	15	1.8
Iron	4.7	10	0.5
Manganese	0.24	0.1	2.4
Phosphorus	0.64	0.1	6.4
Vanadium	0.042	0.05	0.8
Total Particulate	330	15	22.0
Respirable Particulate	110	5	22.0

Notes: Analytical methods employed: NIOSH 7300, 7500, 500 and 600

- Operators' IH testing results in during the 2012 sampling campaign at plant A and B identified exposure levels to heavy metal, dust or silica below the action level or PEL. However, it may be assumed with confidence that exposures to these agents may and actually do occur. Unlike the previous IH testing, these were not conducted during dust generating activities, which may be a reason for the lower exposure levels which were observed (see Table 5).
- Samples collected in 2012 on operators in the ash handling department of plant B did not present evidence of employee over exposure to heavy metals, dust or silica (see Table 6). This may be explained due to the fact that a new HVAC system was installed previous to this sampling campaign, which indicates that the current engineering control is effective. One dusty operation which has yet to be sampled in this department involves cleaning ash

mixers at the end of the employees' shift. Plant B processes the ash from various plants, which is transported by trucks from four different sites across the state into plant B's designated ash treatment and final ash disposal area.

Table 5

Boiler operator performing non-maintenance duties – 2012

Agent	Exposure Level	OEL	# of times above the PEL
Aluminium	0.01905	15	0.0
Barium	0.00169	0.5	0.0
Calcium	0.0487	5	0.0
Iron	0.01059	10	0.0
Phosphorus	0.00233	0.1	0.0
Titanium	0.0019	10	0.0
Total Particulate	0.41283	15	0.0
Quartz	0.0062	0.1	0.1
Respirable Particulate	0.11148	5	0.0

Notes: Analytical methods employed: NIOSH 7300, 7500, 500 and 600

- Welders' exposures to heavy metals, total and respirable dust and silica were also below OSHA's AL or PEL. However, hexavalent chromium is an agent of recent concern, and awareness has increased after such was included in OSHA's list of national emphasis programs. Hexavalent chromium sampling was performed in 2012 during equipment hard-facing activities on stainless steel parts in plant B and the detected exposure levels exceeded 1.6 to 6.69 times the OSHA PEL of 5 µg/m^3. Hardfacing/plating by arc welding is a surfacing operation applied to extend the service life of industrial components (see Table 7).

Table 6

Operators in Plant B's Ash handling department – 2012

Agent	Exposure Level	OEL	# of times above the PEL
Aluminium	0.05366	15	0.0
Barium	0.00454	0.5	0.0
Calcium	0.08978	5	0.0
Iron	0.0227	10	0.0
Magnesium	0.01754	10	0.0
Phosphorus	0.00248	0.1	0.0
Sodium	0.01754	10	0.0
Strontium	0.00206	15	0.0
Titanium	0.00413	10	0.0
Total Particulate	0.85655	15	0.1
Quartz	0.02578	0.1	0.3
Respirable Particulate	0.3438	5	0.1

Notes: Analytical methods employed: NIOSH 7300, 7500, 500 and 600

- IH testing performed on yard workers in the coal power plant, namely fuel handlers, indicated exposures to the various heavy metals monitored as well as silica and respirable and total dust at levels above the OSHA AL or PEL, although not in the similar number and concentrations as in the case of the sandblasters group (see Table 8). Heavy metal, dust and silica samples were collected during housekeeping activities, which may be considered as being highly dust disturbing. This IH assessment was conducted in 2012 and in the case of fuel handlers' at the renewable energy plant, the concern is employee exposure to pentachlorophenol (PCP) and polycyclic aromatic hydrocarbons (PAHs) which are substances contained in wood treatment products. In this particular case, a majority of the wood utilized for fuel is derived from decommissioned electric poles and railroad ties. Various aromatic hydrocarbons do not possess an OEL, but when exposure results were calculated based on the additive effects of such from a toxicological relationship standpoint, it was determined that an administrative work time restriction needed to be established for work in the wood shed despite the ventilation system being previously installed as a control mechanism. In 1999, there was a four-hour of work restriction period which was subsequently shortened to 1 hour and 20 minutes in 2012.

Table 7

Welders performing hardfacining activities – 2012

Agent	Exposure Level Welder 1/ Welder 2		OEL	# of times above the PEL Welder 1 / Welder 2	
Aluminium	0.00124	0.01156	15	0.0	0.0
Barium	ND	0.00168	0.5	0.0	0.0
Calcium	ND	0.02102	5	0.0	0.0
Copper	0.00103	ND	1	0.0	0.0
Iron	0.14437	0.03258	10	0.1	0.0
Manganese	0.02063	0.01471	1	0.2	0.01
Nickel	ND	0.00158	1	0.0	0.0
Phosphorus	0.00155	ND	0.1	0.0	0.0
Potassium	0.05672	0.04835	0.1	0.5	0.4
Titanium	0.00299	0.03363	10	0.0	0.0
Total Particulate	0.72186	4.79	15	0.0	0.3
Hexavalent Chromium	33.47981	8.22147	0.5	6.69	1.64

Notes: Analytical methods employed: NIOSH 7300, 7500, 500, 600 and 7605

Table 8

Yard worker/fuel handling – 2012

Agent	Exposure Level	OEL	# of times above the PEL
Strontium	0.0064	0.01	0.6
Respirable Particulate	19	5	3.8
Crystaline Free Silica	0.38	0.1	3.8
Total Particulate	37	15	2.5

Notes: Analytical methods employed: NIOSH 7300, 7500, 500 and 600

- Maintenance workers utilize degreasers when working on equipment. Organic compound IH testing was performed, although the results did not indicate an overexposure to such substances (see Table 9)

Table 9

Maintenance workers, use of degreasers – 2007

Agent	Exposure Level	OEL	# of times above the PEL
Acetone	15	750	0.0
Amyl Acetate	0.74	100	0.0
Heptane	0.33	400	0.0
Methylcyclohexane	7.4	400	0.0
N-Butonal	0.31	100	0.0

Notes: Analytical method employed: NIOSH 1501M, 1500, 1450

Table 10

Noise dosimetry results – Plant B

Location	Start Date	Duration	Job	TWA*	ZPeak**
U3	6/19/2012 9:03:15 AM	07:32:03	Inside Op	77.7	145.0
U4	6/20/2012 7:04:32 AM	08:50:32	Inside Op	79.5	146.1
U3	6/19/2012 8:54:21 AM	07:44:00	Upstairs Op	87.3	145.9
U4	6/20/2012 7:06:01 AM	08:51:08	Upstairs Op	83.4	145.9
U3	6/19/2012 9:00:12 AM	07:44:56	Downstairs Op	77.3	144.0
U4	6/20/2012 7:08:10 AM	08:47:11	Downstairs Op	81.5	143.4
U3	6/19/2012 9:01:45 AM	07:47:32	Outside Op	89.2	146.3
U4	6/20/2012 7:02:28 AM	08:51:42	Outside Op	83.7	145.9
U3	6/20/2012 7:28:29 AM	06:44:28	Electrician†	87.5	146.3
U3	6/20/2012 7:18:06 AM	06:47:53	Mechanic†	90.7	145.0
U4	7/5/2012 7:30:13 AM	06:28:33	Mechanic†	89.1	145.9
U4	7/5/2012 7:56:15 AM	06:10:44	I&C Technician†	91.6	146.8
Coal yard	7/5/2012 8:56:15 AM	07:47:32	Yard worker‡	77.1	121.3

*Notes: * Time Weighted Average (TWA) The [equivalent] noise level, in dBA, based on an 8-hour exposure time frame, in other words, the average projected for and 8-hr period.*

*** The absolute highest reading irrespective of the frequency weighting and time response selected in the dosimeter. It is usually measured with the zero (or Z) frequency weighting.*

-- SEGs: operators (OP), Maintenance (†), fuel handlers (‡)

- Noise dosimetry IH surveys which were performed in 2012 in plant B demonstrate exposure levels to occupational noise ranging from 77.7 decibels in the A weighted scale (dBA) to 91.6dBA, which are just above OSHA PEL of 90 dBA for an eight-hour time weighted average period. It should be noted that sound level measurements have indicated the presence of sound pressure levels of 113dBA in the ID fans room. Operators also spend over 50% of their work time in quiet areas, which means that an employee working permanently on the floor (e.g. a mechanic) will be exposed to greater sound pressure levels (see Table 10). It is also important have in mind that this is the only PEL which OSHA will adapt based on the length of an employee shift to enforce proper protection. Employees at this plant work 12-hour shifts, however noise dosimetry tests were conducted under the assumption of an 8-hour work shift. No recent noise dosimetry results were observed for plant A, however it is believed that this result may be considered comparable. Plant A is still quieter as energy is generated utilizing one-third of the plant's capacity only. Plant A is mainly dedicated to creating high quality steam which is sold to a neighboring company, in which case only one turbine operates at a time.

- Heat stress is a hazard present in thermal power plants whether the boilers are fueled with coal or biomass and Table 11 illustrates the form of monitoring which was performed at plant B, and the results obtained from such. Dust collectors are one of the warmest locations in the plant because these carry hot ash. However, heat leaks typically occur through the corners of boilers. Areas near super heated drums on top each boiler could also reach a wet bulb global temperature (WBGT) of 115Fo on a hot summer day, according isolated measurements performed before starting work in the area. Table 11 presents the allowable time periods based on WBGT results and the nature of work.

Table 11

WGTB measurements at Plant B

Location	*WBGT °F	*July 25th (2008) Outside Temperature 81°F* **Maximum Time of Work Per 2 Hour Period	
		***Moderate Work	Heavy Work
Control Room	65.1	120	120
Fan Floor	85.1	85	65
Drum Level North #4	86	80	60
Mechanical Dust Collector	111.1	35	25
CCG North End #4	94.1	55	40
Mixer Level	84.5	85	65
Boiler Front #3	83.4	95	70
Turbine #3	79.7	120	90
Lunch Room	76.2	120	120
Turbine Deck #3	71.9	120	120
Boiler Feed Tank Level #3	75.5	120	120
Drum Level Between Boilers	85.2	85	65
Mechanical Dust Collector #3	98.2	50	35
Mechanical Dust Collector #4	110.3	35	25
North End CCG	96.2	50	40
South End CCG	91.7	60	45
Fan Floor #3 ID Fan	84.4	85	65
Fan Floor #4 ID Fan	85.4	80	65
Drum Level South #3	83.3	95	70
Wood Chutes #3	83.4	95	70
Wood Chutes #4	87.9	70	55
Pump Room - Chemical Tanks	80.4	115	85

*Notes: * WBGT (Wet Bulb Globe Temperature) is an index that factors humidity, ambient air temperature and radiant heat. This index is utilized to calculate work/rest regimens for preventing heat stress.*

*** Maximum time of work per 2 hour period is based on a 2-hour time weighted average calculation required by Minnesota OSHA. Employees should cool off and rehydrate in either the control room or any shops on the ground floor for the remainder of the hour.*

****Light Work= E.g. Sitting or Standing performing light hand or arm work,Moderate Work= E.g. Walking about with occasional lifting and pushing, Heavy Work= E.g. Heavy lifting and pushing, shovel work*

In summary, after reviewing ABC Electric's risk assessment and IH testing results, it may be concluded that:

- Heavy metals, total and respirable dust and silica are agents of concern in maintenance-related operations during which dust may disturb dust in coal power plants.
- Common physical hazards of concern for every employee are occupational noise and heat.
- In the particular case of plant A, a relevant topic of concern is exposure to PCPs and/or PAHs.
- Even though this hazard was not discussed in detail because it pertains to a special IH control plan, it is important to mention that coal and wood dust constitute an explosion hazard.

Table 12

OSHA Recordable Medical Attention Incidents resulting from exposure chemical/physical agents – FY 2011 thru 2013

Incident Date	Company/Area	Description of Injury/Illness	Agent	LT	# of days lost to date
06/21/12	Plant B Generation	Burns; coal bunker explosion	Explosive dust	Yes	162
03/23/13	Plant B Generation	Burn skin-neck/wrist, sore throat; inhaled hot air/ash	Hot air/ash	Yes	12
04/05/13	Plant A Generation	Hot fly flash; slight burn, right side of face	Ash	No	
06/20/13	Plant B Generation	Burn right arm; hot reheat steam line	Steam	No	

Recent incidents at ABC Electric. The organization's OSHA 300 logs for fiscal year 2011, 2012 and 2013 were reviewed to identify chemical/physical hazard related incidents and such are summarized in Table 12. Similarly, the incident investigation reports of such undesirable events were studied to understand whether a management-based control failure contributed to the loss.

The incident which occurred in June 2012 is still under investigation, but it has been determined that a carbon monoxide detector which was utilized to detect combustion-based concentrations inside the coal bunker failed to warn of the toxic as well as explosive byproduct being produced. The operator opened a hatch to perform a visual inspection and the sudden oxygen intake through this opening triggered the explosion. The operator was wearing rubber gloves obtained from an onsite vending machine which were inappropriate for the task, and this aggravated the burn on his hands as the melted material adhered to the individual's skin.

In the case of the incidents which occurred in March and April 2013 that involved employees who were working through an opening at the bottom of the boiler to distribute ash, it was determined that face shields which were employed did not provide the needed level of protection as a sudden air intake disturbed the ash/hot air and caused such to bypass the barrier on the side. It should be noted that procedures which include standing on a side before opening the doors were not followed just prior to this incident.

An incident in June 2013 involved a control room operator who walked through a steam leak which he could not spot. The organization had established a preemptive maintenance schedule to avoid steam leaks, however other methods still need to be identified to prevent incidents if a steam line should burst despite the organization's prevention efforts.

An event which became a recordable medical treatment injury in an earlier time involved a fuel operator who was working in the wood shed at the renewable energy plant. The employee reported the appearance of a rash on his neck which required a visit to the dermatologist. It was determined that a possible cause of the problem was the wood treatment chemicals which may vaporize or be contained in wood dust after the material has been crushed into small pieces. PCP and PAH's are known to be sensitizers. PAH's also react with ultra violet radiation and thus cause a type of sun burn if the affected portion of the skin is exposed the sun. This incident triggered IH testing for both agents and the subsequent development of controls at this location. In conclusion, the trends of incidents involving chemical/physical hazards during the studied three-year period of time indicate that various forms of hot sources are the cause of employee-based incidents.

ABC Electric Occupational Exposure Control Management Practices

This are of the study focused on the assessment of the current industrial hygiene exposure control practices at ABC Electric's thermal generation operations. The audit instrument employed was divided into the following components:

- IH management system planning and compliance.
- Implementation and operation of occupational exposure controls.
- Improvement of established IH exposure control practices
- Management monitoring and corrective action
- Document control, purchasing, calibration and training

IH management system planning and compliance reviews. This component of the audit focused on the assessment of the organization's practices with regard to the strategic planning phase of an IH exposure control plan. The sections to be addressed included:

- Policy
- Hazard Identification and Risk Assessment
- Regulatory requirements, compliance reviews
- Emergency Preparedness and Response

ABC Electric's IH Policy. At the time of this review, the organization lacked a formal, corporate IH policy statement. Site specific five-year plans had been developed, although these initiatives have not been followed up/updated since 2011. It should be noted that there was no IH site-specific plan for plant A. Management was involved in the establishment of the site-specific IH plans since an appointed chief executive officer participates in the organization's safety strategy group (SSG), where safety and IH initiatives are reviewed and discussed at the corporate level for final approval. It may be inferred that the corporate IH policy is in a manner embedded into the organization's injury and illness prevention program, however, the following points should be noted:

- A corporate IH policy would bond site-specific programs into a unified strategic IH exposure control approach.
- All of the site-specific plans have not been revised since 2011.
- Employee involvement requirements for the site specific IH exposure control plans was not established, and thus failed to promote participant accountability. In general, at ABC Electric, managers and supervisors are accountable for the employees' well-being. However, the definition of specific employee-based expectations is an aspect which is lacking.
- No formal process has been established to communicate the IH exposure control participation expectations to key individuals within the organizational structure such as managers, supervisors, safety committees, safety improvement teams and technical support staff.
- According to ABC Electric's site specific plans, commitment has been established to achieve and sustain minimal compliance to regulatory standards established by OSHA. Continual improvement was mentioned as the next stage after compliance was achieved, but as previously mentioned, the latest five-year IH site specific plans expired and such have not been granted continuation since then.

Hazard identification and risk assessment. This section of the audit evaluated the organization's process for identifying chemical/physical hazards, assessing associated risks, and identifying appropriate controls to eliminate or minimize these risks. The results of this evaluation process are follows:

- The procedures for the identification and assessment of health risks are established in a general manner in the site specific plans, however, a preemptive IH exposure reassessment time period was not established to align with regulatory requirements for task/activity re-assessment, depending on exposure level results and health risks. The systematic assessment approach should include:
    - An initial assessment of chemical/physical hazards and associated health risks
    - Depending on the level of uncertainty or the need of additional information, additional IH monitoring may be conducted to determine exposure levels
    - Exposure levels and health risks evaluation against the established controls to determine whether such are sufficient or if additional protective measures are necessary.
- According to the reviewed IH site specific plan, after performing a basic characterization of the risks and a chemical/physical hazard exposure assessment, various actions may be activated depending on the results as proposed by Mulhausen and Daminano (2012):
    - If exposures are acceptable, reassessment is conducted to confirm the results
    - If the risks and/or the level of exposure to chemical/physical hazards are uncertain, further information is gathered
    - If exposure to a particular chemical/physical hazard is deemed to be unacceptable based on the levels or health hazard rating, controls (engineering, administrative and/or personal protective equipment) are studied and implemented based on level of risk and feasibility.

- Regarding the management of established IH exposure controls:
    - The organization's IH site-specific plan establishes that administrative controls such as medical monitoring (asbestos, respiratory sufficiency, audiograms, etc), training, use and maintenance of personal protective equipment, confined space entry procedures, etc. be managed through the respective specific programs to ensure compliance.
    - One lacking element is the establishment of a preemptive maintenance schedule and the periodic review/audit of established engineering controls such as ventilation systems and hazard enclosure/isolation features, which may be critical in the prevention of illnesses and injuries at ABC Electric due to the nature and size of the organization.
    - IH monitoring of routine and non-routine activities were addressed in each of the site specific IH plans.
    - IH monitoring has been performed during activities/jobs which are performed by sub-contractors.
- Site specific IH plans included a process to maintain information on IH hazard exposure assessments up-to-date, however, this has not been performed since 2011.
- Job safety analysis forms lacked a comprehensive method for assessing health and physical hazards.
- There is a lack of tools (e.g. flowcharts, checklist) that would assist in the identification of chemical/physical hazards. The organization then relies on the expertise of designated technical staff, who may not be able to cover every task.

Regulatory requirements, compliance reviews. This section assessed whether the organization has identified and evaluated its legal/regulatory requirements. During this particular assessment, it was noted that:

- The organization lacks a formal process for identifying the regulatory requirements which are relevant to the control of chemical/physical hazards. Compliance expectations are communicated to employees who depend on the safety and IH staff to provide advisement in an informal manner.
- The organization is in the process of outsourcing the creation of an information management system that would assist on the categorization of chemical/physical hazards and the regulatory requirements which apply.
- Various programs which have been developed to ensure follow up with regulatory compliance in the control of IH hazards were not audited internally or updated in a timely manner. This includes the organization's emergency contingency plan, a respiratory protection program, a hexavalent chromium program, and an injury and illness prevention program.

Emergency preparedness and response. Applicable plans were developed and these corresponded to the level of chemical/physical hazards in the anticipation of emergencies in confined spaces, accidental spills, dust explosion and medical emergencies. There was evidence that procedures for anticipated emergencies have been tested on a regular basis (confined space practical training, emergency drills) and such formalized practices have been revised after the occurrence of incidents such as in the case of a recent combustible coal dust explosion. Areas that still require additional attention include:

- An update of the names and contact information of each site's assigned emergency coordinator, emergency communicator and other onsite emergency responders.
- An update of emergency maps, especially after recent remodeling/reconstruction at plant B.

Implementation and operation. In order to obtain an idea of ABC Electric's implementation of IH exposure control, the process of hard-facing on stainless steel equipment was assessed. Hardfacing by arc welding is a surfacing operation to extend the service life of industrial components or as part of a regular maintenance program. A concerning byproduct of hard-facing is hexavalent chromium, which is known to be a carcinogen. Recent IH testing indicated exposure levels above the action limit, which triggers the need for reassessment and a program was established to manage the control of employee exposure to hexavalent chromium. With regard to current hardfacing process, the following items were noted:

- Proposed work safety procedures have not been fully implemented.
- Appropriate localized ventilation has not been refurbished or procured.
- Periodic re-assessment of hexavalent chromium exposure levels during hardfacing activities has not been completed.
- Training on hexavalent chromium has not been completed as indicated by the fact that this topic is not included in the welders' training roster

In conclusion, neither the periodic re-testing regulatory requirement nor the established internal standards are being met.

Improvement of established IH exposure control practices. In order to assess the organization's process for the continuous improvement of IH exposure control management, the following sections were included in this portion of the audit:

- IH Objectives and management program
- Management review

IH Objectives and management program. This section of the audit assessed ABC Electric's IH objectives and the process employed in establishing the control of chemical/physical hazards. Table 13 presents the objectives defined in the organization's site specific five-year IH plan (2007-2011) for plant B. Every objective was achieved and sustained except for the last three. Objectives 6 and 8 may have been achieved initially, but the first was dependent on a technological tool which is no longer utilized, while the second won't be re-achieved until every piece of historical data is consolidated into a database/information tracking system which is still on trial. Objective 7 requires the establishment of a systematic method to ensure that affected employees are informed of health/physical hazard assessment and/or IH testing results in a timely manner, and not just through training and informal communication. A revision of the hexavalent chromium IH testing report confirmed that affected employees had been informed of overexposure beyond the fifteen-day time-frame which is established in OSHA's hexavalent chromium regulation.

Table 13

Objectives established in ABC Electric's site specific IH plans

Accomplished:	Y/N	Notes:
1. Determine exposure to all potentially hazardous chemical, physical and biological agents	Y	Ongoing
2. Determine the exposure intensity and variability of hazards that workers are exposed to	Y	
3. Assess the potential risks form these hazards	Y	
4. Control and prioritize exposures that have unacceptable risks	Y	
5. Determine which exposures have need additional information gathering	Y	
6. Document exposure and control efforts	N	Not since 2010
7. Communicate exposure assessment finding to all workers	N	Procedure needed
8. Maintain Record (database) of exposure for all workers to be used for future references	N	Records maintained, not all in a consolidated location

In regard to the establishment of IH exposure control objectives and the performance in achieving such, it was noted that:

- There is a communication structure which aids the inclusion of employees from every level in the setting of objectives. This includes employee safety committees, safety improvement teams, and the safety strategy group (management).

- There was no evidence that accountability for the accomplishment of relevant IH exposure controls was deployed at the relevant levels and functions of the organization. In other words, responsibilities were not established at every level of the organization in the 2007-2011 site specific plans.
- There are a number of documented management programs which have been created to assist in the achievement of IH exposure control objectives, although these are not reviewed at regular planned intervals.

Management review. In this section, the effectiveness of the organization's management review process was reviewed. It was noted that for the management review process, the organization depended on external auditors which were obtained as one of the benefits of being in OSHA's Voluntary Protection Program (VPP). This organization is not a VPP member any more since a decision was ruled to leave such program, and thus does not currently experience the related benefits. The periodicity of such reviews did not conform to either OSHAS 18001 or Z10 standards as these occurred every three years, not on an ongoing planned basis. The management review process included every aspect of safety and IH management, which means that the review did not pertain particularly to IH exposure control efforts per se. Thus, it can be asserted that the lack of an internal periodic review process of the organization's IH exposure control efforts places ABC Electric at risk of falling into complacency and an inability to learn of critical issues before such become a problem.

Document control, purchasing, calibration and training. The centralized elements of document control practices were assessed as such are part of this component. Such elements include the following:

- Document and record control

- Training, awareness and competence
- Control of vendors/purchasing
- Calibration

Document and record controls. It was observed that there was no unified procedure for document or record control, nor various forms of documentation possess a control number/code. Format/technological conflicts were also evident as a number of records are in paper copy, while others are in a format which cannot be accessed because the software is obsolete. Also, the use of a newer information tracking system is still in its experimental phase, but other departments which may need to access IH documents, such as Human Resources, do not employ this option or weren't included in the testing and/or configuration phase of the proposed information tracking system. Document and record control is important because it is an interdepartmental process and the organization should guarantee that every department may access and utilize information at the appropriate level of clearance. Record retention times are maintained in accordance to regulations, however since there's not a unified tracking system it cannot be assumed that records are maintained in a lean and readily accessible manner.

Training, awareness and competence. There is a procedure for the management of training which includes levels of responsibility, literacy, as well as the ability/skills requirements per each job function. The information is also included in a skills matrix which is updated by the Safety and IH Department assistant and automatic alerts are activated when periodic re-training is due for each employee. Flaws in the current system include:

- Evidence of times in which the safety and IH department has not been informed of new training needs (which arise as a new chemical/physical hazard arise due to a change in the process or the creation of a new task/job).

- Job titles are generic and there are times when specific tasks which require additional training are assigned to employees, but the change is not communicated to the Safety and IH Department in expedient manner.

Regarding contractor training, each facility is equipped with the necessary material to train visitors and contractors. The approach employed includes the use of videos which are produced by the Corporate Communications Department, which guarantees that the information is site and task specific. There is also a control system to track whether contractor orientation and task specific safety procedures have been covered prior to contract employee's admittance, although documented proof of training on the contractor employer side is not requested as part of the contracting process.

Control of vendors/purchasing. Purchased products are reviewed by an onsite safety specialist in order to assess the risks which are associated with such materials. MSDS/SDS are tracked through an online service which also provides automatic updates when a MSDS has been re-written in the new globally harmonized system format. If a product's MSDS/SDS has not been included, a request may be sent to the online provider in order to obtain an update on the system. In general, ABC Electric's chemical product information practices exceeds expectations, however a procedure has not been established to review the integrity of equipment which has been introduced by outside contractors.

Equipment calibration. This organization owns IH monitoring equipment such as air pumps, a sound level meter, noise dosimeters, dry calibrators, and multi gas detectors. Manufacture's calibration certificates are filed and provide proof that such equipment is calibrated and serviced in accordance to the stated requirements. For the particular case of multi-gas detectors, which are utilized by a broad number of employees, records provide evidence that training is provided on how to test air in confined spaces and designated areas.

Scorecard survey results. A scorecard was completed based on the document review performed to assess ABC Electric's IH exposure control practices (see Figure 1). Each component was assessed based on a rating system of one to four, depending on the organization's level of regulatory compliance and conformance to industry standards (see Appendix E for details).

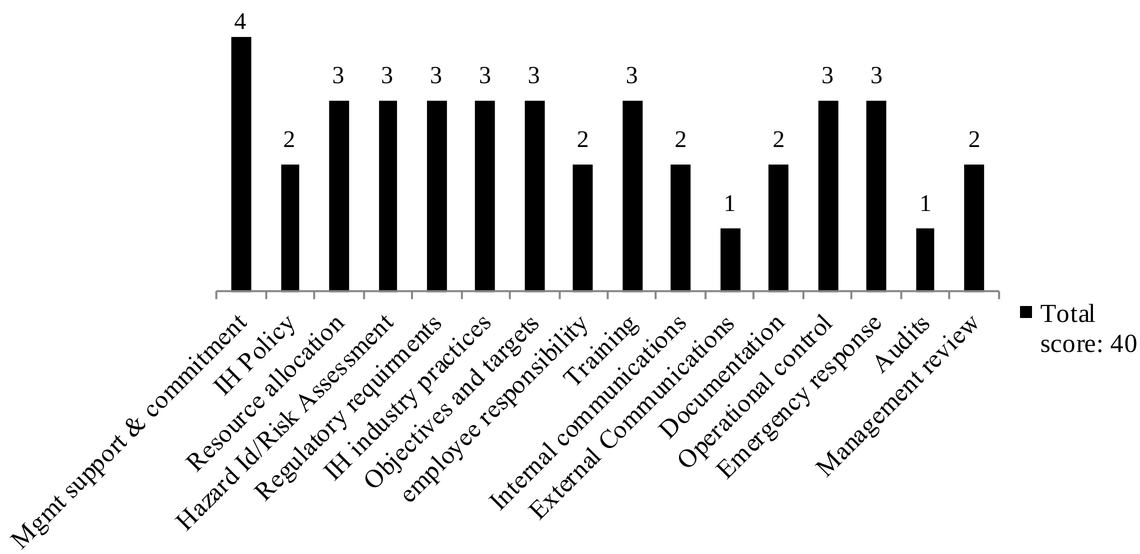

Figure 1. IH exposure control management scorecard survey results

The final score is interpreted based on the following criteria as proposed by Kausek (2007), which has also been adapted to correspond to the evaluation of IH control practices:

16 - 20 Commitment to IH is weak. The organization may be in violation of current health and safety regulations.

21 - 50 Basic IH management is in place, but full organizational commitment does not yet exist.

50 - 64 Assuming no scores in any area were less than 3, the organization has a comprehensive IH system in place. The stage is set for continual improvement.

ABC Electric rated 40/64, which means that the organization’s IH management system may be considered basic. It should be noted that internal and external auditing processes rated 1/4. In order to proactively guarantee minimum regulatory compliance as well as the conformance to established internal IH standards, a check and balance system such as periodic internal/external audits must be in place. It is also a fact that the lack of a formal corporate IH policy is a weakness as expectations and accountability of participants are not clearly established. Management support and commitment rated 4/4, and there was evidence that the area of resource allocation exceeds regulatory expectations (e.g., exposure assessment may be based on IH testing results from similar processes in industry, but at ABC Electric, performing site specific IH testing is the preferred method instead of relying on IH assessments performed in other power plants owned by the organization). Management commitment is a key requirement for the success of a Safety and IH management system, which is a strength the organization already possesses. Recommendations will be dispensed in Chapter V on how to move from a basic to a comprehensive IH exposure control system.

Chapter V: Discussion

The purpose of this study was to analyze the industrial hygiene exposure control practices at ABC Electric's thermal generation operations by utilizing regulatory and industry standards as a benchmark. This study established two goals which served in the understanding of the organization's IH exposure control system. These goals were to identify the hazardous chemical and physical agents to which employees at ABC Electric's power generation facilities may be exposed, and to evaluate the organization's current occupational industrial hygiene exposure control management practices.

The literature review included a discussion of the recognized health and physical hazards in the thermal power generation industry which was based on past IH assessments performed in similar operations. In addition, a comprehensive exposition on the management of occupational exposure to chemical and physical agents described the managerial components, regulatory requirements and industry practices employed in the control of such. The literature review served as the basis to customize the audit tool which was employed to assess the organization's IH exposure control practices through a review of documents. Records of past IH results and risk assessments, OSHA 300 logs, incident investigation reports and job safety analysis were also reviewed to identify the chemical and physical hazards present in ABC Electric's power generation operations, recent incidents which involved such hazards, and how controls failed to provide the required protection. Finally, a scorecard which summarized industry's IH management components was utilized to describe how the organization rates within a three stage scale.

The remainder of this chapter will discuss conclusions which were drawn from the study's results. Recommendations will also be provided in order to advise the organization on management practices which will assist in assuring regulatory compliance as well as guarantee the proper management and control of occupational exposures to chemical and physical agents.

Conclusions

A variety of conclusions can be drawn with regard to the analysis of ABC Electric's existing chemical and physical hazards and the organization's occupational exposure control practices. The following are conclusions which can be derived from this author's reflection on the study's results:

- The organization lacks a unified IH policy which would clearly define upper management's commitment, the employees' level of participation and accountability, up-to-date goals and objectives, the necessary resources, and training requirements of key participants in the management of occupational exposures to chemical and physical hazards.
- The analysis indicated that the five-year site specific IH plans were outdated since 2011. Although this attempt received initial management support and achieved the hazard identification and risk assessment components which were set during a period of ten years, it became unsustainable because documentation-related objectives depended on a technological platform which became obsolete. In hindsight, the assistance of onsite technical support could have prevented the loss of digital IH-related data. In the same manner, a strategy was not established to achieve the communication-based objective in an effective manner. Also responsibility for the administration of the IH site specific plans was almost solely placed on the safety and IH staff, when in fact, industry standards for the administration of an occupational health and safety management system, as outlined by ANSI Z10 and OHSAS 18001, insist on the importance of placing

accountability at the point of operation. For instance, supervisor cooperation is a key activity in coordinating IH testing activities, communicating IH exposure assessment results with employees and enforcing established controls.

- Internal as well as external audits of IH exposure control practices or the related compliance programs are not being performed. As a result, key programs such as hazard communication, contingency emergency plans and respiratory protection maybe outdated or lacking important elements such as a detailed, updated list of health and physical hazards (in the case of the hazard communication standard). Enforcement of administrative controls is also uncertain if there is no documented supervisory overview. The lack of a check and balance system also reflects on the engineering component of the operational IH controls, for example there is no scheduled assessment/preventative maintenance of local ventilation systems in the welding shops.
- ABC Eclectic's IH hazard identification and risk assessment process employed a comprehensive approach as established by Mulhausen and Daminano's (2012). However, a clear criterion with regard to utilizing regulatory or consensus standards (e.g., TLVs, RELs, etc.) in order to establish internal occupational exposure limits has not been defined. Further, procedures have not been developed in order to assess chemical mixtures in terms of the relationship of such from a toxicological standpoint.
- There is a lack of key IH management tools such as a checklists or flowcharts specific to the identification of chemical/physical hazards which may be included in the organization existing job safety analysis forms and pre-work hazard assessment. This was only available in cases where strictly required per OSHA regulations such as in hot work or confined space entry situations for which there is a permitting system.

- There are gaps in various lines of communications. For example, it was noted that supervisors do not report the change of employee duties in a timely manner, which thus fails to determine whether the involved individual should be trained in additional safety topics. Even when reported, the Human Resources Department only relays this information to the Safety and IH Department annually.
- The control of documents or records was substandard. Since documents/records lack a control number/code, it cannot be guaranteed that such are found in a time-efficient manner or include the most recent update (in the case of documents). Storage was also not unified in one location/specific locations. However, the use of a SDS subscription service proved to be an efficient approach to ensure MSDS/SDS are up-to-date and readily accessible.

In consideration of the items presented above, the following final conclusions can be established:

- The organization may be experiencing a complacency period which places it at risk of an increase of incidents and illnesses involving hazardous chemical and physical agents and with this, a potential of additional organizational losses (e.g. company reputation, employee morale, worker's compensation costs, increased insurance premiums rates and the like).
- The organization possesses resources and strengths, such as a robust amount of historical IH assessment data which are being underutilized because of a lack of procedures that would organize such, or establish training requirements for proper use and maintenance. Another example is a tracking system which will be of no profit until a reasonable

amount of data has been entered and designated users (administrators included) have been trained on how to utilize the resource.

- Management involvement requires participation beyond the mere allocation of resources or discussions with safety and IH advocates on emerging exposure-based issues. The vision should to develop be an all-inclusive IH occupational exposure control management system which may be integrated in all other functions of business, with action items and well-defined metrics for which applicable employees can be held accountable to complete.

Recommendations

In what appears to be a status quo in the organization's administration of IH controls, it is this author's recommendation to work upon the examination of the other existing systems, practices, processes and procedures to establish a strategy to guarantee compliance to IH-related regulations, and incorporate improvements to correct deficiencies in the various components of the organization's IH exposure control management system. The approach towards a continuous improvement process of ABC Electric's IH management system should include the following considerations:

- A general draft IH policy that would unify criteria and efforts across site-specific IH plans should be established. The proposed IH policy should be agreed upon and driven by key individuals from upper management. In the particular case of ABC Electric, discussion should occur within the Safety Strategy Group level (SSG) with the expertise of safety and IH staff as well as other supporting specialized participants from the Legal, Human Resources, Engineering, Environmental and Information Technology Departments. The benefit of utilizing a myriad of perspectives from different areas of expertise is that a possible number of considerations may be incorporated into decisions that possess an augmented level of insight. It should be noted that in order to minimize the participants' learning curve and/or resistance, the approach should mimic management systems which have already been implemented at ABC Electric and have proven to be successful.

- Communication of established expectations. Once a draft IH policy statement and general guiding principles have been established, it should be communicated downstream at already existing levels with the assistance of the technical experts mentioned above. In the particular case of ABC Electric's management structure, this includes the safety improvement teams (SITs), joint safety committee (JSC), and employees' safety committees (SCs). When clear expectations are communicated by an organization's leadership and the proper level of technical assistance and resources are provided, employee participation is a natural response and resistance to change will likely be minimized (Kausek, 2007; AIHA, 2012).
- Definitions of goals and objectives should be discussed at the levels of participation described above, but as a general guideline, it is necessary that such be measureable/quantifiable in terms of time and level of achievement. At this stage, it is recommended that goals and objectives in the management of IH occupational exposure controls (both administrative and engineering) be focused towards the achievement of:
    - An understanding of the organization's current level of compliance to applicable regulations. A control list should be developed and maintained in a systematic manner. It should be noted that an OSHA National Emphasis Program which is related to the control of a family of highly reactive, low molecular weight

chemicals (isocyantes) was recently placed into effect, however, no testing has been performed to determine possible employee exposures to such from paints and epoxy-based materials which are used in the plant.

    - Corrections of employee chemical/physical exposure control deficiencies should be organized into action items with a defined administrator and expected time of completion. Also, an emphasis should be placed into solving deficiencies which violate minimal regulatory compliance and/or pose a high level of risk to employee health/physical integrity.
    - The recovery and organization of legacy IH testing and assessment records which are currently saved in various locations and formats, and certain documents can't be accessed due to technological limitations arisen after a software became obsolete.
    - The completion of required IH risk assessments/testing, especially in the areas of explosive dust control and wood treatment chemical agents.
- Strategic planning is necessary in order to define and procure the tools, skills, time and technical expertise necessary for the achievement of the established goals and objectives, and should include the following:
    - Management should consider the development of tools which may include forms, checklists, documents, and equipment necessary for the assessment of chemical/physical hazards. In addition, internal compliance auditing tools will assist in the communication of IH exposure control program expectations.
    - Activities designed for the achievement of IH goals and objectives require training on tool/equipment utilization, and various techniques/methods for the

recognition/control of chemical/physical hazards. It is recommended that training be proportional to the level of risks, supervisory level, and voluntary participation in the program. ABC current's training matrix should be revised after the establishment of IH goals and objectives to accommodate additional training modules

  - ABC Electric's management has demonstrated commitment towards providing time allocation to perform safety and health-related activities. A conscientious use of the time-oriented resource will assist with performing IH exposure control specific activities in an efficient manner.
  - There will be activities (such as the preparation of technical reports, or the configuration of database feature) that require technical/professional expertise, and thus in such cases a criteria should be established to ease the process of contracting with a third party administrator or to employ available technical staff.

- A roster defining chemical/physical hazards and employee exposure controls should define the frequency of periodic inspection and the preemptive maintenance of engineering controls. Once these activities are organized, technology may be employed to set automatic reminders to alert applicable participants of the required inspections/maintenance orders when such are due to be performed.
- Once operational controls are evaluated, a discussion of the findings should be expected to occur within the organization's various safety and occupational health employee groups. E-mail lists and reporting forms named "good catch cards" are already available at ABC Electric, and such should be employed as a vehicle for the open discussion of ideas.

- Monitoring and corrective actions should be performed after objective data has been collected through internal and external review/audit of IH exposure control practices (leading indicators). OSHA 300 logs, incident and near hit reports (lagging indicators) which are already utilized should also be reviewed in a periodic manner to establish current incident/illnesses trends involving chemical/physical agents throughout the power generation plants. A proactive management practice includes tracking incidents/illnesses involving chemical/physical agents in industry with the National American Industry Classification System (NAICS) codes which are pertinent to ABC Electric's generation operations. The Bureau of Labor Statistics provides such information in its website.
- Finally, document and record control, purchasing, calibration and training processes should possess the appropriate level of resource allocation in terms of tools and costs. Expected administrators and/or users should be trained and included in the experimental launch of such tracking and administrative systems (e.g. the HR, Safety and IH, and Information Technology departments should be involved in the launch of Open Range).

Areas of Further Research

This study was limited to the review of chemical and physical hazards present at ABC Electric's generation operations and related occupational exposure controls. Further research may include:

- IH occupational exposure control practices within the organization's transmission and distribution operations.
- A review of the organization's practices in the control of biological hazards among employees conducting work in cooling towers or remote areas when installing electric poles.

- A comprehensive regulatory compliance audit which includes interviews, visual observations, and document review-based activities.
- The design of an epidemiological profile of the various similar exposure groups within the thermal power generation industry.

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Appendix A: OSHA Hazard Communication Standard Informative Cards and Illustrations

OSHA® QUICK CARD™

Hazard Communication Safety Data Sheets

The Hazard Communication Standard (HCS) requires chemical manufacturers, distributors, or importers to provide Safety Data Sheets (SDSs) (formerly known as Material Safety Data Sheets or MSDSs) to communicate the hazards of hazardous chemical products. As of June 1, 2015, the HCS will require new SDSs to be in a uniform format, and include the section numbers, the headings, and associated information under the headings below:

Section 1, Identification includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.

Section 2, Hazard(s) identification includes all hazards regarding the chemical; required label elements.

Section 3, Composition/information on ingredients includes information on chemical ingredients; trade secret claims.

Section 4, First-aid measures includes important symptoms/effects, acute, delayed; required treatment.

Section 5, Fire-fighting measures lists suitable extinguishing techniques, equipment; chemical hazards from fire.

Section 6, Accidental release measures lists emergency procedures; protective equipment; proper methods of containment and cleanup.

Section 7, Handling and storage lists precautions for safe handling and storage, including incompatibilities.

(Continued on other side)

For more information:

OSHA® Occupational Safety and Health Administration

U.S. Department of Labor

www.osha.gov (800) 321-OSHA (6742)

OSHA 3493-02 2012

OSHA® QUICK CARD™

Hazard Communication Safety Data Sheets

Section 8, Exposure controls/personal protection lists OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE).

Section 9, Physical and chemical properties lists the chemical's characteristics.

Section 10, Stability and reactivity lists chemical stability and possibility of hazardous reactions.

Section 11, Toxicological information includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.

Section 12, Ecological information*
Section 13, Disposal considerations*
Section 14, Transport information*
Section 15, Regulatory information*

Section 16, Other information, includes the date of preparation or last revision.

*Note: Since other Agencies regulate this information, OSHA will not be enforcing Sections 12 through 15 (29 CFR 1910.1200(g)(2)).

Employers must ensure that SDSs are readily accessible to employees.
See Appendix D of 29 CFR 1910.1200 for a detailed description of SDS contents.

For more information:

OSHA® Occupational Safety and Health Administration
U.S. Department of Labor
www.osha.gov (800) 321-OSHA (6742)
OSHA 3493-02-2012

OSHA® QUICK CARD™

Hazard Communication Standard Labels

OSHA has updated the requirements for labeling of hazardous chemicals under its Hazard Communication Standard (HCS). As of June 1, 2015, all labels will be required to have pictograms, a signal word, hazard and precautionary statements, the product identifier, and supplier identification. A sample revised HCS label, identifying the required label elements, is shown on the right. Supplemental information can also be provided on the label as needed.

For more information:

OSHA® Occupational Safety and Health Administration

(800) 321-OSHA (6742)
www.osha.gov

SAMPLE LABEL

CODE ____________________
Product Name ____________________ } **Product Identifier**

Company Name ____________________
Street Address ____________________
City ______________ State ____
Postal Code ____________ Country ____
Emergency Phone Number ____________ } **Supplier Identification**

Hazard Pictograms

Signal Word
Danger

Highly flammable liquid and vapor.
May cause liver and kidney damage. } **Hazard Statements**

Keep container tightly closed. Store in a cool, well-ventilated place that is locked.
Keep away from heat/sparks/open flame. No smoking.
Only use non-sparking tools.
Use explosion-proof electrical equipment.
Take precautionary measures against static discharge.
Ground and bond container and receiving equipment.
Do not breathe vapors.
Wear protective gloves.
Do not eat, drink or smoke when using this product.
Wash hands thoroughly after handling.
Dispose of in accordance with local, regional, national, international regulations as specified.

In Case of Fire: use dry chemical (BC) or Carbon Dioxide (CO_2) fire extinguisher to extinguish.

First Aid
If exposed call Poison Center.
If on skin (or hair): Take off immediately any contaminated clothing. Rinse skin with water. } **Precautionary Statements**

Supplemental Information

Directions for Use

____
____
____

Fill weight: __________ Lot Number: __________
Gross weight: __________ Fill Date: __________
Expiration Date: ________

OSHA 3492-02 2012

OSHA® QUICK CARD™

Hazard Communication Standard Pictogram

As of June 1, 2015, the Hazard Communication Standard (HCS) will require pictograms on labels to alert users of the chemical hazards to which they may be exposed. Each pictogram consists of a symbol on a white background framed within a red border and represents a distinct hazard(s). The pictogram on the label is determined by the chemical hazard classification.

HCS Pictograms and Hazards

Health Hazard	Flame	Exclamation Mark
• Carcinogen • Mutagenicity • Reproductive Toxicity • Respiratory Sensitizer • Target Organ Toxicity • Aspiration Toxicity	• Flammables • Pyrophorics • Self-Heating • Emits Flammable Gas • Self-Reactives • Organic Peroxides	• Irritant (skin and eye) • Skin Sensitizer • Acute Toxicity (harmful) • Narcotic Effects • Respiratory Tract Irritant • Hazardous to Ozone Layer (Non-Mandatory)
Gas Cylinder	**Corrosion**	**Exploding Bomb**
• Gases Under Pressure	• Skin Corrosion/ Burns • Eye Damage • Corrosive to Metals	• Explosives • Self-Reactives • Organic Peroxides
Flame Over Circle	**Environment** (Non-Mandatory)	**Skull and Crossbones**
• Oxidizers	• Aquatic Toxicity	• Acute Toxicity (fatal or toxic)

For more information:

OSHA® Occupational Safety and Health Administration

U.S. Department of Labor

www.osha.gov (800) 321-OSHA (6742)

OSHA 3491-02 2012

OSHA® DATOS RÁPIDOS

Pictograma para la norma sobre la comunicación de peligros

A partir del 1.° de junio de 2015, la norma de comunicación de peligros (HCS, por sus siglas en inglés) exigirá pictogramas en las etiquetas para advertir a los usuarios de los peligros químicos a los que puedan estar expuestos. Cada pictograma representa un peligro definido y consiste en un símbolo sobre un fondo blanco enmarcado con un borde rojo. La clasificación del peligro químico determina el pictograma que muestra la etiqueta.

Pictogramas y peligros según la HCS

Peligro para la salud  • Carcinógeno • Mutagenicidad • Toxicidad para la reproducción • Sensibilización respiratoria • Toxicidad especifica de órganos diana • Peligro por aspiración	**Llama**  • Inflamables • Pirofóricos • Calentamiento espontáneo • Desprenden gases inflamables • Reaccionan espontáneamente (autorreactivas) • Peróxidos orgánicos	**Signo de exclamación**  • Irritante (piel y ojos) • Sensibilizador cutáneo • Toxicidad aguda (dañino) • Efecto narcótico • Irritante de vías respiratorias • Peligros para la capa de ozono (no obligatorio)
Botella de gas  • Gases a presión	**Corrosión**  • Corrosión o quemaduras cutáneas • Lesion ocular • Corrosivo para los metales	**Bomba explotando**  • Explosivos • Reaccionan espontáneamente (autorreactivas) • Peróxidos orgánicos
Llama sobre círculo  • Comburentes	**Medio ambiente** (No obligatorio)  • Toxicidad acuática	**Calavera y tibias cruzadas**  • Toxicidad aguda (mortal o tóxica)

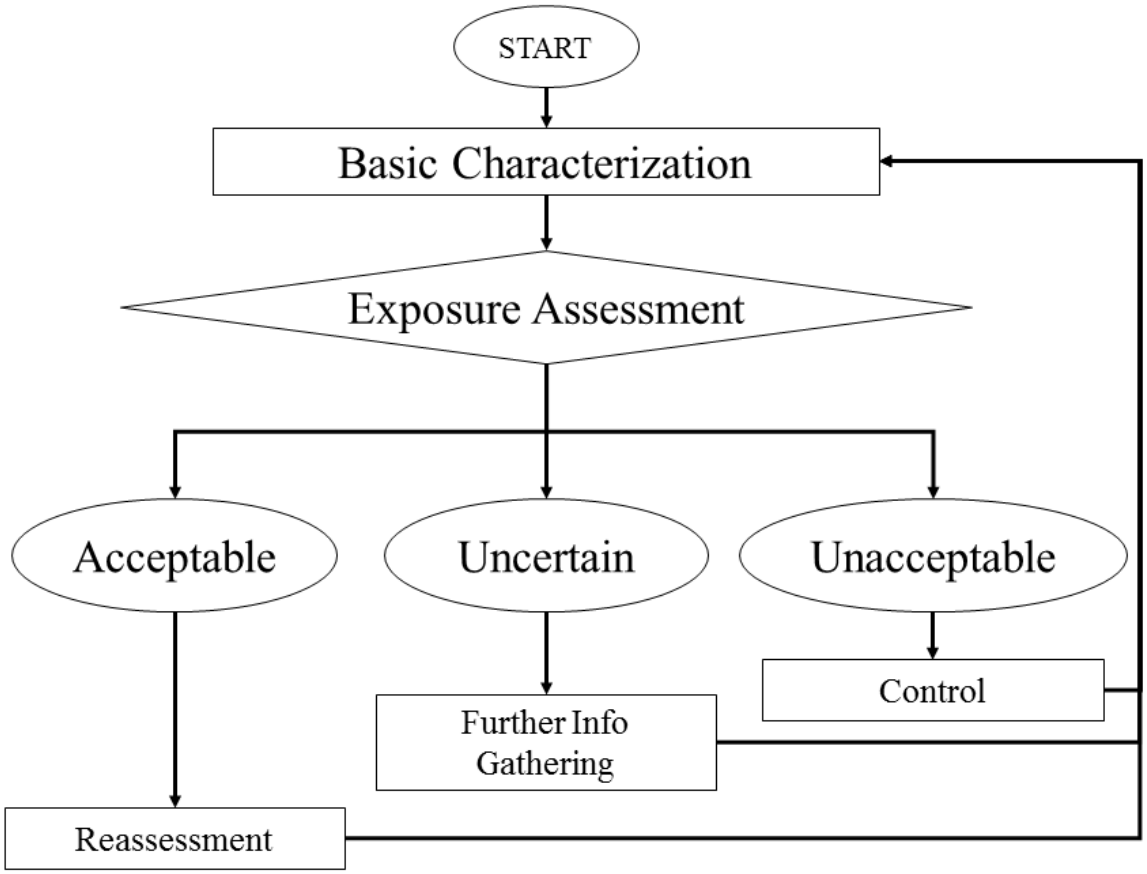
Para más información:

OSHA® Administración de Seguridad y Salud Ocupacional

Departamento de Trabajo de los EE. UU.

www.osha.gov (800) 321-OSHA (6742)

Appendix B: Comprehensive Risk Assessment Model.



Mulhausen and Damiano, 2012

Appendix C: Data Collection Toolbox.

Information about the case: **(use information in log 301 to complete each summary of cases which involved chemical/physical agents)**			
Date of injury or illness			
Time of event		AM/PM	Check if time cannot be determined
What was the employee doing just before the incident occurred?			
What happened?			
What was the injury or illness?			
What object or substance directly harmed the employee?			
If the employee died, when did death occur?			
Was the case properly recorded? Explain:			

Compliance Review Log

	SECTION/GENERAL DESCRIPTION	COMPLIANT	COMMENTS: Describe all non-compliances in comments section.
	Injury and Ilness prevention - Minnesota Statutes §182.653, subd. 8 - Date of last audit/revision:		
	is the policy signed by the top management official?	Y N N/A	
	Have industrial hygiene-related goals and objectives been defined?	Y N N/A	
	Has progress been made in achieving the previous year's goals and objectives?	Y N N/A	
	Do the goals and objectives need to be reevaluated?	Y N N/A	
	Are supervisory responsibilities in the administration of IH exposure controls defined?	Y N N/A	
	Management Responsibilities		
	Does management definition of responsibilities include the overview of occupational exposure control practices?	Y N N/A	
	Have the necessary resources been made available? (training, equipment, technical support)	Y N N/A	
	Has management demonstrated a commitment to the control of exposure to hazardous chemical/physical agents? (i.e. involvement in inspections, discussion of related topics during safety committee meetings)	Y N N/A	
	Communication		
	Are Safety Committee members trained on health hazard recognition? Are training records properly maintained?	Y N N/A	
	Does new employee safety orientation training include the chemical/physical hazards to which he/she may be exposed to and how to protect from these?	Y N N/A	
	Enforcement		
	Is the disciplinary system outlined being followed?	Y N N/A	
	Are disciplinary actions properly documented?	Y N N/A	

Hazard Communication - 29 CFR 1910.1200 - Date of last audit/revision:			
Program and Chemical Inventory			
	Have program and chemical list updating responsibilities been determined?	Y N N/A	
	Are all applicable testing results included in the program?	Y N N/A	
	Has a chemical list been created? Is it up to date?	Y N N/A	
	Have all applicable chemical and physical hazards been determined?	Y N N/A	
	Are all exposure control methods included in the program for the chemical and physical hazards?	Y N N/A	
	Is the w ritten program accessible to employees?	Y N N/A	
	Does the program include the requirements outlined in the latest version of the hazard communication standard	Y N N/A	
Safety Data Sheets			
	Have SDS maintenance responsibilities been determined? Is an employee designated to ensure SDSs are maintained in accordance w ith 29CFR1910.1200?	Y N N/A	
	Has the frequency of review for SDSs been determined?	Y N N/A	
	Has the SDS location been identified and ALL employees are informed of location?	Y N N/A	
	Has the location of the master set of SDSs been documented and maintained?	Y N N/A	
	Are new chemical SDSs review ed to ensure proper precautions have been taken?	Y N N/A	
	Are SDSs for chemicals no longer being used kept in a separate location and/or saved in a dead file for 30 years?	Y N N/A	
Labeling System			
	Have the labeling system(s) been determined and documented in the policy?	Y N N/A	
	Have labeling responsibilities been determined?	Y N N/A	
	Have the methods for finding correct labeling information been determined? (i.e. SDS, original container)	Y N N/A	
	Have pipe labeling methods been assessed and provided for reference?	Y N N/A	
	Has pipe labeling applicability been assessed?	Y N N/A	
Training and Education			
	Has the employee training frequency been determined?	Y N N/A	
	Date(s):____________________	Y N N/A	
	Has training been completed for all temporary employees?	Y N N/A	
	Date(s):____________________	Y N N/A	
	Has training been completed for all employees in the follow ing areas: Initially, prior to assignment to w ork, Upon introduction of new hazards (new chemicals, new tasks, etc.), Upon assignment to non-routine tasks	Y N N/A	
	Does the training outline include a detail description of chemical/physical hazards to w hich employees may be exposed to, according to their role w ithin the organization?	Y N N/A	
	Have the additional employee training topics been determined? (i.e. chromium VI, respirator use, hearing protection, etc.)	Y N N/A	
Contractors			
	Has the method of relaying the Right to Know information to contractors been determined?	Y N N/A	
	Have outside contractors been informed of hazardous chemicals to w hich they may potentially be exposed?	Y N N/A	
	Are outside contractors informing the organization of hazardous materials they are bringing onsite?	Y N N/A	
	Have Outside contractor been informed to dispose and remove of all hazardous materials before leaving the facility?	Y N N/A	
Emergency Procedures			
	Are there w ritten procedures for anticipated medical emergencies as a result of exposure to chemical/physical hazards and chemical spill/release, confined space non-entry rescue	Y N N/A	
	Are spill kits provided and inspected?	Y N N/A	
	Are eyew ash stations provided and inspected w eekly?	Y N N/A	
	Are emergency response team trained in accordance to their level of involvement in the above anticipated emergencies	Y N N/A	

Respiratory protection - 29 CFR 1910.134 - Date of last audit/revision:			
	Written Program		
	Is the w ritten Respiratory Protection Program complete?	Y N N/A	
	Date of last revision ______________________	Y N N/A	
	Have employees w ho are using respirators completed the medical questionnaire and received approval from a medical professional? Note: This is necessary for all employees w ho are required to w ear a respirator and for employees w ho voluntarily use respirators beyond particulate filtering face pieces (e.g. half-face masks, PAPRs, etc.)	Y N N/A	
	Have all areas been assessed for potential air contaminants? (I.e. Gas, Vapors, Fumes, Dusts, Mist, Smoke, and Oxygen Deficiencies)	Y N N/A	
	Has employee exposure monitoring been completed for all air contaminants and areas?	Y N N/A	
	Is any additional air testing w arranted?	Y N N/A	
	Is an IH evaluation roster complete and up-to-date?	Y N N/A	
	Are all areas/tasks that require a respirator documented in the program?	Y N N/A	
	Are all areas/tasks w here respirators are offered on a voluntary basis documented in the program?	Y N N/A	
	Employee training and fit testing		
	Have all employees w ho use a respirator received annual training? Note: Training is necessary for all employees required to w ear a respirator and for employees w ho voluntarily use respirators beyond filtering face pieces.	Y N N/A	
	Have all employees w ho use a respirator received the proper annual fit testing per the type of mask?	Y N N/A	
	Are respiratory protection requirements reviewed during new employee orientation?	Y N N/A	
	Is there supportive documentation/testing to demonstrate that there is no potential for over-exposure and a voluntary use program may be implemented?	Y N N/A	
	Is Appendix D review ed for all employees w ho voluntarily use particulate filtering face pieces?	Y N N/A	
	Respiratory Protection Equipment		
	Is all of the provided respiratory protection NIOSH approved?	Y N N/A	
	Is the equipment provided appropriate and does it have a sufficient APF for the identified employee exposures? See Table 1 1910.134(d)(3)	Y N N/A	
	Does the employer ensure that defective or damaged equipment is not used? New respiratory protection equipment can be obtained from : ________________________________	Y N N/A	
	Have filter and cartridge changing procedures been established?	Y N N/A	
	Are respirators stored properly w hen not in use?	Y N N/A	
	Are procedures and materials in place for cleaning and disinfecting?	Y N N/A	
	Are emergency respirators inspected monthly?	Y N N/A	
	Are engineering controls in good w orking order?	Y N N/A	
	Are any additional engineering controls needed/recommended?	Y N N/A	
	If Yes, please list in Comment section	Y N N/A	
	Have employees required to w ear respiratory protection been consulted during the audit? Ask them questions regarding the status of their equipment, comfort, storage, cleaning, filter/cartridge change-out frequency, or any other area of the program that may apply.	Y N N/A	

Hearing Conservation - 29 CFR 1910.195 - Date of last audit/revision:			
Source of Noise			
	Have all areas above 85dB been identified through the appropriate noise monitoring/time w eighted average (TWA) testing?	Y N N/A	
	Are high noise areas (above 90dB) posted w ith the appropriate w arning signs?	Y N N/A	
	Are w arning signs posted on mobile high noise producing equipment?	Y N N/A	
PPE & Noise Reduction			
	Are engineering controls in place or considered to reduce noise?	Y N N/A	
	(List any areas of concern or engineering recommendations based on the audit.)	Y N N/A	
	Are there multiple types of hearing protection equipment available to employees?	Y N N/A	
	Is reusable hearing protection clean/in good condition and stored properly?	Y N N/A	
	Is hearing protection w orn in the required areas?	Y N N/A	
Written Program			
	Is the w ritten program the most recent U.S. Compliance version?	Y N N/A	
	Has a copy of the w ritten standard 29 CFR 1910.95 been posted?	Y N N/A	
	Has the program been updated w ith the most recent TWA testing results and/or noise map?	Y N N/A	
Training & Education			
	Has training been conducted annually?	Y N N/A	
	Is the training documented properly?	Y N N/A	
Audiometric testing and standard threshold shifts			
	Have individuals w orking in high noise areas received audiometric testing annually?	Y N N/A	
	Most recent test date: ______________________	Y N N/A	
	Have new employees in high noise areas received baseline audiograms w ithin 6 months of employment (12 months for mobile test van exception)?	Y N N/A	
	Have all Standard Threshold Shifts (STS) of 10 dB or more been properly documented on the OSHA 300 log?	Y N N/A	
	Have employees had the opportunity to review their STS w ithin 21 days of testing?	Y N N/A	
	Are retests given to employees w ith STS w ithin 30 days?	Y N N/A	
CROMIUM VI - REF: 29 CFR. 1910.1026 - Date of last audit/revision:			
Exposure determination			
	Have PBZ testing been perform in all operations in w hich exposure can be anticiparted? Describe	Y N N/A	
	Have PBZ re-testing been perform in cases w here exposure w as detected to be above the PEL?	Y N N/A	
Controls			
	Have ingineering conrols been implemented to mitigate/eliminate exposure? Describe	Y N N/A	
	Have administrative controls been outlined? (e.g., personnal hygiene, area isolation/w arning, PPE)	Y N N/A	
Training & Education			
	Is chromium VI exposure aw areness level included in Hazcom training?	Y N N/A	
	Are employees exposed to Chromium VI as a result of their duties trained in the proper hazard mitigation/abatement procedures?	Y N N/A	
Communication & awareness			
	Have employees been informed of exposure monitoring results w ithin 15 days of obtaining lab results?	Y N N/A	
	Are employees exposed to Chromium VI as a result of their duties trained in the proper hazard mitigation/abatement procedures?	Y N N/A	
	Are bags containing debris contaminated w ith Chromium VI properly labeled treated as hazardous w aste for disposal?	Y N N/A	

Combustible dust: Date of last audit/revision:			
	Have onsite explosive hazards been determine	Y N N/A	
	Are there processes established to eliminate exposive hazards as outlined by NFPA 85: Boiler and Combustion Systems Hazards Code?	Y N N/A	
	Do job hazard assessments address explosive dust hazards w hen applicable?	Y N N/A	
	Is explosive dust aw areness training included in new employee/annual Right-to-know training?	Y N N/A	
	Is there documented evidence that regular inspections are being performed to avoid explosive dust accumulations	Y N N/A	
	Are emergency response procedures included in the organization's emergency contigency plan? If offsite response service is employed, has the party been invited into the plant to perform drills and assess the risks involved in potential explosive-dust emergency situations at the facility?	Y N N/A	

Appendix D: IH Management System Audit Instrument

Topics
IH Management System Planning and Compliance Reviews
IH Policy
Hazard Identification and Risk Assessment
Legal and Other Requirements, IH Management Compliance Reviews
Emergency Preparedness and Response
Implementation & operation
Controls implemented
Improvement
IH Objectives and Management Programs
Management Review
Monitoring and Corrective Action
Internal Audit Program
Accidents, Incidents, Nonconformances, Corrective/Preventive Action
Document and Record Control, Purchasing, Calibration and Training
Document Control
Record Control
Training, Awareness and Competence
Roles and Responsibilities
Purchasing
Calibration of equipment
Consultation and Communication
Audit Summary

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

IH Management System Planning and Compliance Reviews	
IH Policy Review the IH Policy Statement A) Is it appropriate to the nature and risks of the organization? Yes ☐ No ☒ B) Does it include commitments to continual improvement and compliance to regulatory and other requirements? Yes ☒ No ☐ C) Is it documented? Is there a formal process to communicate the policy to the workforce? Yes ☐ No ☒ D) Is there a policy and method to make the policy available to the general public/interested parties? Yes ☐ No ☒ E) Is there evidence that the policy is periodically reviewed and revised to keep it relevant to the organization? Yes ☐ No ☒ F) Was top management involved in the policy development? Yes ☒ No ☐	**Requirements and Scope:** **Overall evaluation:** ☐ Did not check. ☐ Did not apply. ☐ Conforms. No deficiencies identified. ☐ Opportunity for improvement. Detail below. ☐ Best Practice. Detail below. Be specific. ☒ Nonconformity. Provide details below. Reference the specific requirement violated. List the commitments made in the policy below: 1. Determine exposure to all potentially hazardous chemical, physical and biological agents 2.Determine the exposure intensity and variability of hazards that workers are exposed to 3.Assess the potential risks form these hazards 4.Control and prioritize exposures that have unacceptable risks 5.Determine which exposures have need additional information gathering 6. Document exposure and control efforts 7. Communicate exposure assessment finding to all workers 8. Maintain Record (database) of exposure for all workers to be used for future references Issue Date: February 2002 Last Revised: January 2004 **Comments and Findings:** - (A) There is no formal, corporate IH policy statement except for site specific plans which lays out the objectives expressed above. - (B) The commitment made at the moment of its latest review was minimal compliance to regulatory standards established by OSHA. Continual improvement was mentioned as the next state after compliance was achieved. - (C), (D) Up-to-this date there is no formal process established to communicate a formal IH policy since there is none explicitly written. The site specific plans which were established for a period of ten years (2000 to 2010) has not been renewed and it not being communicated either - (E) The IH site specific plans have not been reviewed/followed up in a formal manner since 2010 - (F) One of this organization's CEO is member of the safety strategy group (SSG) and all plans/policies are reviewed in periodic meetings.

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

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Hazard Identification and Risk Assessment

A) Review the methods and results of the hazard identification and risk assessment. ☒

B) Does the organization have a procedure for the ongoing identification and assessment of health risks?
Yes ☒
No ☐
Is it properly controlled? ☐
Yes ☐
No ☒

C) Does the procedure address:
– Routine and non-routine activities?
Yes ☒
No ☐

D) Visitors and activities performed by subcontractors? Yes ☒

E) All facilities, areas of functions? (list in area to right) Note: for ongoing review list modifications or new processes/jobs Yes ☒

F) Is there evidence that the above were evaluated? Are the results documented? Yes ☒

G) Is there a process to keep this information up-to-date? Is there evidence that it is being kept up-to-date? Yes ☐ No ☒

H) Does the procedure address the scope, nature and timing of chemical/physical hazard ID and risk assessment? Yes ☐ No ☒

I) Does the procedure provide for the classification and elimination or control of risks? Yes ☒

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Requirements and Scope: This section evaluates the organizations process for identifying chemical/physical hazards, assessing associated risks, and identifying appropriate controls to eliminate or minimize these risks. The implementation and monitoring of effectiveness of associated controls will be reviewed during the Implementation and Operation audit; the use of these risks to set objectives will be evaluated during the audit of objectives and improvement.

Overall evaluation:
☐ Did not check.
☐ Did not apply.
☐ Conforms. No deficiencies identified.
☒ Opportunity for improvement. Detail below.
☐ Best Practice. Detail below. Be specific.
☐ Nonconformity. Provide details below. Reference the specific requirement violated.

Procedure: ______________________ Revision date: ____________
(Basic risk characterization, IH sampling, comprehensive IH study)
Major Areas or Functions **Evaluated?**

1. See Roster attached at the end of instrument ☒ **Yes** ☐ **No**
(Per functions prioritized in 2000 – 2010 IH plans)

Comments:

- (B) Comment: IH risk assessment plan has not been formally followed up since 2010
- (C) Comment: see Hazard Communication program. Tool needs to be more specific about health and physical risk assessment (include noise, review of SDS, etc)
- (G) The plan has not been followed up after beyond 2010. There are new engineering controls which, according to IH testing performed in 2012 has significantly reduced exposure levels to chemical and physical agents. This has not been documented in IH site specific plans/reports since such have not been followed up. An example of this is noise deadening curtains installed to reduce exposure to noise or a recently installed HVAC system to reduce exposure to metals, silica, arsenic and total & respirable dust. Testing results have not been updated in plans.
- (H) General IH policy and site specific plans need to include timing for periodic re-assessment and include it is a standard procedure to reassess whenever conditions change due to remodeling, new controls in place, use of new/different materials or change of work practices per se.
- (I) As outlined by Mulhausen and Daminano (2012) in the continual improvement cycle. Improvements are made by changes have not been followed up beyond 2010

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(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

J) Are controls, facility requirements and/or training needs identified to minimize or eliminate risks? Yes ☒ No☐ K) Is there evidence that the process is proactive, vs. reactive? Yes ☒ No☐ L) Is performance in completing JHAs satisfactory in terms of the inclusion of chemical/physical hazards and the controls required? Yes ☐ No ☒ M) Is there evidence that the overall process of identification and control of health risks is effective? Yes ☒ No☐ (see comments about G) N) Is there evidence that personnel involved in JHA completion were trained in how to identify chemical/physical hazards and the required procedures for developing a basic characterization of risks? Yes ☐ No ☒ O) Is there evidence of employee involvement in the development of JHA, assessment of risk/IH monitoring or identification of necessary controls? Yes ☒ No ☐ P) Were tools (e.g. checklists or flowcharts) developed to assist in the identification of chemical/physical hazards and have they been used? Yes ☐ No ☒	**Comments and Findings:** - (J) Training needs are updated annually by HR as requested. However, there has been situations when new risks and or/tasks arise and this has not been integrated to training roster due to lack of communication. - (K) For the most part it has been towards maintaining minimal regulatory compliance. However, incidents such as burns from dust explosion which would have been less severe if employee had been wearing the proper gloves, or an employee having rashes due to exposure to sensitizing agents vaporizing from chipped wood demonstrate that there is room for improvement. - (N) This organizations does not employ job hazard analysis, instead a job safety analysis (which can be considered equivalent) and personal protective equipment hazard assessment form are used. - (O) & (P) Although there is evidence of employee participation through the safety committee at each plant, the joint safety committee across the organization and the safety strategy group at the upper level, there was no evidence of training provided to help in the identification specific health/physical hazards while performing/reviewing JSAs, nor was there a tool which may ease the process. This part is often performed by SIH, which places a great burden. Especially since JSAs are many and these should be reviewed on a regular basis

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Legal and Other Requirements

Review the organization's process for identifying, maintaining and evaluating compliance to its legal and other requirements.

A) Does the organization have a process for identifying its legal requirements as these apply to the control of chemical/physical hazards? Is it properly controlled?
Yes ☐ No ☒

B) Does the organization have access to the requirements that apply to it? Yes ☐ No ☒
(other than online)

C) Does the organization have a process for keeping these requirements up-to-date?
Yes ☐ No ☒
In the process of outsourcing thru EMIS/Open Range (environmental management information system)

D) Has the organization identified and incorporated other IH requirements into the overall administration of occupational health (e.g. voluntary use of respirator or additional medical surveillance) into the system?
Yes ☒ No ☐
VPP requirements

E) Does the organization have a process to communicate the above requirements to appropriate personnel in the workplace? Yes ☒ No ☐

F) Pick several of the legal requirements that have been identified by the organization. Can the organization provide evidence that compliance reviews were conducted for these requirements? Yes ☐ No ☒

Requirements and Scope: This section evaluates whether the organization has identified and has access to its legal/regulatory requirements, and evaluates its compliance to them. It also evaluates whether the organization has recognized and incorporated any voluntary requirements (e.g. additional medical surveillance or voluntary use of respirators) into its management system structure. Actual compliance will be examined during Implementation and Operation audits.

Overall evaluation:

☐ **Did not check.**
☐ **Did not apply.**
☐ **Conforms. No deficiencies identified.**
☐ **Opportunity for improvement. Detail below.**
☐ **Best Practice. Detail below. Be specific.**
☐ **Nonconformity. Provide details below. Reference the specific requirement violated.**

Requirement	**Access?**	**Evaluated?**
1 HazCom (chemical inventory, sds, training)	☒ **Yes** ☐ **No**	☐ **Yes** ☒ **No**
2 Respiratory Protection (fit tesing, PBZ testing results, training)	☒ **Yes** ☐ **No**	☐ **Yes** ☒ **No**
3. Hearing Conservation Hearing Conservation (posting of regulation, noise map, hearing protection, audiograms)	☒ **Yes** ☐ **No**	☐ **Yes** ☒ **No**
4. National Emphasis programs (Chromium VI, Isocyanates, combustible dust – hazard id & control)	☒ **Yes** ☐ **No**	☐ **Yes** ☒ **No**
5. Heat / Cold stress	☒ **Yes** ☐ **No**	☐ **Yes** ☒ **No**
6. Injury & illness prevention program	☒ **Yes** ☐ **No**	☐ **Yes** ☒ **No**

Comments and Findings:

- (A) A list of required training which indirectly refers to IH related regulatory standards is provided in this organization incident and illness prevention program. There is no formalized process
- (C) the organization is in the process of outsourcing the process and thru EMIS (environmental management information system). This will need to be integrated to the Damarco (for SDS management) and Open Range platforms
- (F) There is no formal process or policy which establishes frequency of compliance reviews internally. The organization relied on Voluntary Protection Program auditors for such reviews. Programs recently updated, there should be established frequency for programs update after compliance review.

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Emergency Preparedness and Response	**Requirements and Scope: This section reviews the organization's emergency procedures.**
Review the organization's emergency procedures which relate to chemical/physical harmful agents.	**Overall evaluation:** ☐ **Did not check.** ☐ **Did not apply.** ☐ **Conforms. No deficiencies identified.** ☒ **Opportunity for improvement. Detail below.** ☐ **Best Practice. Detail below. Be specific.** ☐ **Nonconformity. Provide details below. Reference the specific requirement violated.**
A) Are the procedures up-to-date? Yes ☐ No ☒	**Emergency Procedure — Complete? — Up-to-date?** **1.** ☐ **Yes** ☐ **No** ☐ **Yes** ☐ **No** **Accidental hazardous material spill response** **Last Tested: ______________** **2.** ☐ **Yes** ☐ **No** ☐ **Yes** ☐ **No** **Confined space rescue** **Last Tested: ______________** **3.** ☐ **Yes** ☐ **No** ☐ **Yes** ☐ **No** **Medical emergencies** **(in general and heat stroke, hypothermia, burns, heart stroke)** **Last Tested: ______________**
B) Is there evidence that the procedures have been tested? ☒	
C) Have the procedures been reviewed after the occurrence of accidents and incidents? ☒	**Incident — Date — Procedures Reviewed?** **1. Electrical incident involving fire** ☒ **Yes** ☐ **No** **2. Fuel bunker explosion resulting in evacuation and medical emergency** ☒ **Yes** ☐ **No** **Comments and Findings** (A) Names and contact information of emergency coordinators and other key personnel not up-to-date. Emergency maps need updating to better reflect exit routes and features after recent remodeling

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Implementation and Operation

Process: Hard facing on stainless steel equipment

For the process being evaluated:

Have the controls been identified for this process? Yes ☒ No ☐

Have they been implemented? Are they being maintained? Yes ☐No☒

A) Have any criteria been established for the safe operation of this process? If so, is it being monitored? ☒ - not being monitored

B) Are operators aware of the risks and controls? Are they properly using and/or monitoring them? Are they aware of the consequences of not adhering to the controls? ☒ not all of them

C) Are operators aware of the applicable IH exposure control policy and procedures? ☒ not all of them, training needed

D) Are the operators aware of their roles and responsibilities? No, see above ☒

E) Are the operators aware of who the management appointee is? ☒

F) If there is any safety monitoring equipment in use, is it calibrated? ☐ N/A

G) Are safety related documents and records properly controlled? Yes ☒ (permits, training)

H) Are regulatory requirements associated with this process being met? List in the right column. ☐

Requirements and Scope: This section evaluates whether the organization has implemented the controls needed to minimize the risks identified during its risk assessment, and whether these controls are effective. It will also evaluate whether other system elements (e.g. documents, records, training) have been adequately implemented.

Risks — **Controls**

1. Skin ulceration – contact minimization, use of disposable coveralls

2. Respiratory disease – respiratory protection with appropriate protection factor, localized exhaust ventilation

3. Ingestion of CrVI through cross contamination – housekeeping and hygiene, moving welding process away from break room.

4.

Overall evaluation:

☐ Did not check.
☐ Did not apply.
☐ Conforms. No deficiencies identified.
☐ Opportunity for improvement. Detail below.
☐ Best Practice. Detail below. Be specific.
☒ Nonconformity. Provide details below. Reference the specific requirement violated.

Topic	Awareness		Training Record	
1. Hexavalent Chrome	☐ **Yes**	☒ **No**	☐ **Yes**	☒ **No**
2. Hot Work	☒ **Yes**	☐ **No**	☒ **Yes**	☐ **No**
3. PPE	☒ **Yes**	☐ **No**	☒ **Yes**	☐ **No**

Equipment	Calibrated/Controlled	
LEV needs replacement	☐ **Yes**	☒ **No**
	☐ **Yes**	☐ **No**

Legal Requirement	Compliant?	
§1910.1026- housekeeping, training, coverall, retesting	☐ **Yes**	☒ **No**
§1910.1200 awareness level training	☐ **Yes**	☒ **No**
§1910.252 – standard hot work procedures met	☒ **Yes**	☐ **No**

Comments:

- **There is a monitoring requirement to follow which must be followed when testing results show evidence of exposures at or above the OSHA's action limit (2.5micrograms/m3)**
- **Ventilation and other IH controls should be inspected periodically**
- **Break/lunch room should be moved away from welding operations to prevent cross contamination**
- **Training must be included in HR's roster**

MAKE COPIES AS NEEDED

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Objectives and Improvement	
IH Objectives and Management Program A) Has the organization established documented IH Objectives? ☒ B) Hav**e** objectives been deployed at relevant levels and functions of the organization? ☒ Yes, in the organization's injury and prevention program there is a mention, but need to be laid out in more detail. C) Is there evidence that the organization considered its legal and other requirements, its technological options, its financial, business and operational requirements when it set its objectives? ☒ D) Is there a process to include the views of employees and other interested parties in the setting of objectives? Is there evidence that they were considered? ☒ IH topics, as with safety are discussed at different levels thru employee safety committee, safety improvement teams (management) at each plant.	**Requirements and Scope:** This section evaluates whether the organization has identified IH objectives and its performance in achieving them. Procedure No: ____________________ Rev. _____________ **Overall evaluation:** ☐ Did not check. ☐ Did not apply. ☐ Conforms. No deficiencies identified. ☒ Opportunity for improvement. Detail below. ☐ Best Practice. Detail below. Be specific. ☐ Nonconformity. Provide details below. Reference the specific requirement violated. **Objective** **Mgmt Program?** **Performance Summary** **1** Determine exposure to all potentially hazardous chemical, physical and biological agents**.** ☒ **Yes** ☐ **No** **ongoing** **2** Determine the exposure intensity and variability of hazards that workers are exposed to ☒ **Yes** ☐ **No** **ongoing** **3** Assess the potential risks form these hazards ☒ **Yes** ☐ **No** **accomplished** **4.** Control and prioritize exposures that have unacceptable risks ☒ **Yes** ☐ **No** **accomplished** **5** Determine which exposures have need additional information gathering ☒ **Yes** ☐ **No** **requires updating** **6** Document exposure and control efforts ☐ **Yes** ☒ **No** **accomplished, not in an systematic manner after 2010** **7.** Communicate exposure assessment finding to all workers ☒ **Yes** ☐ **No** **procedure needed to guarantee this is performed in a timely manner (through training, safety meetings, etc.** 8. Maintain Record (database) of exposure for all workers to be used for future references ☐ Yes ☒ No procedure needed to outline proper document & record management. – not accomplished entirely

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

E) Have documented management programs been established for the IH objectives? Yes☒ Not all under a general policy. This is outlined at the various IH plans for different facilities and thru the various safety programs. F) Do these programs include timeframes, responsibilities and resources needed? No ☒ Current IH plan is outdated. G) Is there evidence that the organization is making progress in achieving its objectives? If not, is there evidence that action is being taken to correct this? Yes ☒ Progress: recent monitoring results evidence improvement. However IH objectives outlined need to be followed up as established in original plan, which also needs updating. Plans need details on resources needed and completion timeframe. Plans need to be reviewed on an annual basis. A general IH policy should be written and commitment be made in written to support with monetary and technical resource allocation. H) Are the objectives and management program reviewed at regular and planned intervals? Are they being amended to address changes? NO ☒	**IH Objectives and Management Program (continued)** **Comments and Findings** **A general IH policy should be the guiding criteria for developing a unified IH exposure control plan for each facility. This would define the purpose, objectives, responsibility of every participant to guarantee cooperation, accountability and achievement of goals and objectives. The general IH policy, and site specific exposure control plan should then serve as a ground for unifying criteria which will dictate specific controls and procedures to be outlined in programs and safety manuals .**

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Management Review	Requirements and Scope: This section evaluates the effectiveness of the organization's management review process.
A) Does the organization conduct planned, periodic management reviews? Yes ☒ - not anymore B) Is the periodicity appropriate? NO ☒ C) Are these reviews documented? ☒ they were D) Review several records of management review. Are these reviews attended by top management? ☒ yes E) Do these reviews evaluate system suitability (design)? ☒ F) Do these reviews evaluate system adequacy (resources)? ☒ G) Do these reviews evaluate system effectiveness (results)? ☒ H) Do these reviews include evaluation of performance in meeting IH exposure control objectives? ☒ I) Is there evidence that changes to policy, objectives and other elements are considered? ☒ J) Is there evidence that the management review leads to action? Are actions followed up and completed? List in right column.☒*	**Overall evaluation:** ☐ Did not check. ☐ Did not apply. ☐ Conforms. No deficiencies identified. ☐ Opportunity for improvement. Detail below. ☐ Best Practice. Detail below. Be specific. ☐ Nonconformity. Provide details below. Reference the specific requirement violated. **Comments and Findings** - (B) Management used to rely on 3 year period reviews from external auditors which they obtained as one of the benefits of being in the Voluntary Protection Program. This organization is not a VPP member anymore since a decision was made to leave the program, and thus does not possess the benefit now. - (C) Not formally by the management. A form containing audit results and corrective action was developed by auditors with proposed date of completion. This was followed up by the organization and reported back. See example attached to this survey - (D) Upper management is present in the Safety strategy group - (I) & (J) Action Item list was documented by VPP auditors and followed up by ABC Electric

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Internal Audits, Accidents, Corrective and Preventive Action

Internal Audit Program

Review the audit procedure and several internal audits.

K) Is there a documented audit procedure? Is it properly controlled? Yes ☐ No ☒

L) Does the procedure describe audit scope, responsibilities, frequency, methods and competencies of auditors? ☐

M) Does the audit program include all elements of the IH exposure control management? ☐

N) Are previous audits reviewed as part of audit planning? ☐

O) Are audit results provided to management? ☐

P) Does the audit program and corresponding schedule reflect the organization's risks and results of previous audits? ☐

Q) Are auditors independent of those having responsibility for the area/activity being audited? Have they been trained? ☐

R) Are audit findings documented, reported and addressed in a timely manner? ☐

S) Is the audit program effective? ☐

Requirements and Scope: This section evaluates the organization's internal audit process.

Overall evaluation:

☐ Did not check.
☐ Did not apply.
☐ Conforms. No deficiencies identified.
☐ Opportunity for improvement. Detail below.
☐ Best Practice. Detail below. Be specific.
☒ Nonconformity. Provide details below. Reference the specific requirement violated.

Audit	Complete/Documented?	Independent?
	☐ **Yes** ☐ **No**	☐ **Yes** ☐ **No**
	☐ **Yes** ☐ **No**	☐ **Yes** ☐ **No**
	☐ **Yes** ☐ **No**	☐ **Yes** ☐ **No**
	☐ **Yes** ☐ **No**	☐ **Yes** ☐ **No**
	☐ **Yes** ☐ **No**	☐ **Yes** ☐ **No**

Audit Finding	Date	Addressed?
______________	__________	☐ **Yes** ☐ **No**
______________	__________	☐ **Yes** ☐ **No**
______________	__________	☐ **Yes** ☐ **No**
______________	__________	☐ **Yes** ☐ **No**
______________	__________	☐ **Yes** ☐ **No**
______________	__________	☐ **Yes** ☐ **No**

Auditor Name	Evidence of Training?
______________________	☐ **Yes** ☐ **No**
______________________	☐ **Yes** ☐ **No**
______________________	☐ **Yes** ☐ **No**
______________________	☐ **Yes** ☐ **No**
______________________	☐ **Yes** ☐ **No**
______________________	☐ **Yes** ☐ **No**

Comments and Findings

The process is under development. The organization used to rely on VPP audits performed every three years.

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Accidents, Incidents, Nonconformance and Corrective and Preventive Action involving chemical/physical harmful agents A) Does the organization have a procedure for accidents, incidents, nonconformance and corrective and preventive action? Is it controlled? Yes ☒ No ☐ B) Does the procedure(s) address: – Handling and investigation of accidents, incidents and nonconformances? Yes ☒ No ☐ – Requirements for taking actions to mitigate consequences, including corrective action? Yes ☒ No ☐ – Preventive action? Yes ☒ No ☐ – Requirements to confirm the effectiveness of actions taken? Yes ☒ No ☐ – Requirements to assess the risk of actions prior to implementation? Yes ☒ No ☐ C) Are changes to documented procedures resulting from the action documented and recorded? Yes ☒ No ☐ D) Are corrective actions closed out in a timely manner? Review several. Choose different ones than those evaluated as part of the audit program review? Yes ☒ No ☐ E) Is there evidence that the corrective action program is effective? Yes ☒ No ☐	**Requirements and Scope:** This section evaluates the organization's processes for effecting corrective action, preventive action and for investigating accidents and incidents. Procedure No: ____________________ Rev. _____________ **Overall evaluation:** ☐ Did not check. ☐ Did not apply. ☒ Conforms. No deficiencies identified. ☐ Opportunity for improvement. Detail below. ☐ Best Practice. Detail below. Be specific. ☐ Nonconformity. Provide details below. Reference the specific requirement violated. **Incident/Accident** **Investigated?** **Action Taken** **1.**Employee working in woodshed developed a rash ☒ **Yes** ☐ **No** Time restriction, permanent monitoring for PAHs & Pentachlorophenol **2.** ______________________ ☐ **Yes** ☐ **No** ____________________ **3.** ______________________ ☐ **Yes** ☐ **No** ____________________ **4.** ______________________ ☐ **Yes** ☐ **No** ____________________ **Comments and Findings** – The organization has a reward program for reporting near misses, unsafe acts/conditions named "good catch cards" – Accidents, near hits, unsafe acts and conditions are investigated by an incident review committee (IRC) conformed by employees as well as mid and upper level management representatives – FM Global provides advice on IH matters through its risk management group.

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Common Elements - Document and Record Control, Purchasing, Calibration and Training

Document Control

A) Is there a procedure for document control? Is it controlled? Yes ☐No☒

B) Does the procedure address:

- The location/distribution of documents (e.g. master list or equivalent)? ☐ NA
- The periodic review and revision of documents? ☐ NA
- Who is authorized to review and approve types of documents? ☐ NA
- Controls needed to ensure that only current documents are used? ☐ NA
- The control of obsolete documents, including identification? ☐ NA
- The control of external documents (e.g. regulations, standards, etc.? NA

C) Are electronic documents adequately controlled (i.e. can they be located, are they password protected, is control maintained when printed)? Yes ☒ No ☐

D) Is there a policy manual or other combined information that describes the core elements of the IH system? Yes ☒ No ☐ Does it/do they provide reference to related information? Yes ☐ No☒

Requirements and Scope: This section evaluates the centralized elements of the IH exposure control management document control practices. The control of individual documents will not be evaluated during this audit.

Procedure No: ____________________ Rev. _____________

Overall evaluation:

☐ Did not check.
☐ Did not apply.
☐ Conforms. No deficiencies identified.
☐ Opportunity for improvement. Detail below.
☐ Best Practice. Detail below. Be specific.
☒ Nonconformity. Provide details below. Reference the specific requirement violated.

Pick several documents from the Master List. List them below. For each, evaluate whether the documents are properly controlled by looking for evidence of:

- Indication of review and/or approval authority
- Locations/Distribution
- Proper security, if electronic (e.g. password protection)
- Ready availability, if electronic (logical file path, easy to locate)
- Consistency with local formatting requirements

Document	**Properly Controlled**
1. Calibration logs	☐ **Yes** ☒ **No**
2. Near hits, unsafe act/condition report forms	☐ **Yes** ☒ **No**
3. Incident investigation forms	☐ **Yes** ☒ **No**
4. Permits (confined space, hot work, etc.)	☐ **Yes** ☒ **No**
5. Training rosters	☐ **Yes** ☒ **No**

Comments and Findings

- (A) no written procedures
- (C) open range can be used and is available. It is not being used.
- (D) The site specific IH plans describes core elements of the IH systems but provide no reference to related information.
- Damarco is used to keep track and maintain SDSs

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

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Record Control

A) Is there a procedure for record control? Is it controlled?
Yes ☐ No ☒

B) Does the procedure address:

– Identification of records (number, name, etc)? ☐ N/A

– Maintenance of records (e.g. storage, protection, backup)? ☐ N/A

– Disposition of records (retention and disposal)? Are retention times for specific types of records documented? ☐ N/A

C) Is there evidence that retention times meet legal requirements? List some IH records in the right column, their stated retention times, and then verify legal requirements after the interview.
Yes ☒ No ☐

</td>
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Requirements and Scope: This section evaluates the centralized elements of IH record control. The control of individual records will not be evaluated during this audit.

Overall evaluation:

☐ Did not check.
☐ Did not apply.
☐ Conforms. No deficiencies identified.
☒ Opportunity for improvement. Detail below.
☐ Best Practice. Detail below. Be specific.
☐ Nonconformity. Provide details below. Reference the specific requirement violated.

Record	**Documented Retention Time**	**Legal Retention Time**
1. OSHA 300 logs	**5 years**	**5 years**
2. Employee chem exposure records	**indefinitely**	**at least 30 years**
3. MSDSs/SDSs		**30 years**
4. Employee noise exposure records	**indefinitely**	**2 years**

Comments and Findings

- **There is no procedure. IH related records are kept in the corporate office, while a few are made available on the organization’s intranet. Retention time is governed by regulatory requirements**

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(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Training, Awareness and Competence	Requirements and Scope
Training, Awareness and Competence A) Is there a procedure for training? Is it controlled? Yes ☒ No ☐ B) Does the procedure address: – How differing levels of responsibility, literacy, ability and risk are or should be taken into account in training procedures/documents? ☒ – How training needs are identified? ☒ – The need for and methods of providing awareness training? ☒ – Subcontractors, temporaries and visitors? ☒ C) Is there a skills matrix or other means for identifying required competencies? Does it appear complete? ☒ D) Is there a system for retention of training records? ☒ E) Review the methods used to provide awareness training (e.g. orientation training). Do they address: – The importance of conformance, and the consequences of not complying? ☒ – Individual's roles and responsibilities relative to the IH exposure control, including for emergency response? ☒ – The job hazards peculiar to their specific job, and the consequences of not following/using the controls put in place? Not entirely ☒	**Requirements and Scope:** This section evaluates the centralized elements of the IH training program. Training for individual tasks will not be evaluated during this audit. ______________ **Overall evaluation:** ☐ Did not check. ☐ Did not apply. ☐ Conforms. No deficiencies identified. ☒ Opportunity for improvement. Detail below. ☐ Best Practice. Detail below. Be specific. ☐ Nonconformity. Provide details below. Reference the specific requirement violated. Review the list of Job Hazards. Pick several functions (e.g. warehousemen, production operator). Review the competency matrix, skills matrix or training plans for these functions. Do they reflect relevant health and safety training needs? Is there a systematic process for providing awareness training to visitors and contractors? **Function** **Training Needs IDed?** **See roster attached at the end of this survey** **Visitors** ☒ **Yes** ☐ **No** **Contractors** ☒ **Yes** ☐ **No** **Comments and Findings** - (B) Per job/title. Time is established if re-training is required by OSHA. Re-training may also be conducted if employee shows lack of kills or understanding during an evaluation, or if a violation is made or an incident occurs and the investigation demonstrate an employee's responsibility. Training is also provided if workplace process or conditions change. - Job titles are generic, which makes it hard to predict the kind of training needed as required by specific tasks. - (C) Skill matrix is not necessarily up-to-date. HR e-mails and updates matrix an annual basis. There is evidence of lack of communication when a new role is created -

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Roles and Responsibilities

A) Has a member of the top management team been appointed to be responsible for IH management system? ☒

B) Is this individual's role defined? ☒

C) Was this individual involved in the design and implementation of the IH management system? ☒

D) Is this individual involved in the maintenance and improvement of the IH management system? ☒

E) Does this individual make periodic reports on the performance of the IH management system to other top management? ☒

F) Is the role of safety representatives (e.g. Safety Committee members) defined as these apply to the control of employee exposure to chemical/physical agents? ☒

G) Is the role of occupational health internal auditors defined?
Yes ☐ No ☒

H) Are the roles of other safety professionals defined? ☒

I) Is there evidence that members of the management team are committed to the management of occupational exposure to chemical/physical agents? List some of the methods used to demonstrate that commitment. ☒

J) Is there a formal process to identify resources needed for the effective operation of occupational exposure controls?
Yes ☐ No ☒

Requirements and Scope: This section evaluates whether the organization has identified and communicated central IH system-related roles and responsibilities throughout the organization. Awareness of individual roles and responsibilities will also be reviewed during process-based audits.

Procedure No: ____________________ Rev. _____________

Overall evaluation:

☐ Did not check.
☐ Did not apply.
☐ Conforms. No deficiencies identified.
☒ Opportunity for improvement. Detail below.
☐ Best Practice. Detail below. Be specific.
☐ Nonconformity. Provide details below. Reference the specific requirement violated.

Methods used to demonstrate commitment

1. Management signs off stating their commitment with safety and IH

2. Resource allocation. In 2012 IH testing budget was $ 12,000, but management approved an excess to cover expenses over $ 22,000 to complete IH testing campaign across generations

3. Safety and IH is integrated in the organization's discussion of strategic plans each year

4. Participants of safety groups (JSC, SIT teams, etc) are encouraged to attend safety conferences and take courses, the organization provides financial support for such activities.

Methods used to identify resource needs

1. **none**

2.

3.

4.

Comments and Findings

- **(A) Senior Vice president delegates over corporate director of Safety and Industrial Hygiene. Corporate director coordinates efforts with Safety and IH specialists.**
- **(B) Roles are defined through job descriptions in general.**
- **(F) In general in Injury and Illness Prevention Program. Not very specific**
- **(G) No. a more comprehensive auditing system is needed.**
- **(H) Job description and in the level of expected participation is outlined in various programs (hazcom, injury and illness prevention, respiratory protection, etc.)**
- **There is no formal process. Resources are allocated based on a yearly budget prepared as part of the annual strategic plan for safety and industrial hygiene.**

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Control of Vendors/Purchasing

A) Is there a process to ensure that the risks associated with purchased products are recognized? Yes ☒ No ☐

B) Is there evidence this process is being used? Yes ☒ No ☐

C) Is there a process to ensure that the risks associated with subcontractor activities are recognized? Verify MSDS/SDS sheets are received and reviewed for new products/materials and appropriate safeguards considered. Yes ☒ No ☐

D) Is there evidence this process is being used? Yes ☒ No ☐
- Contractor training facility on site
- Audiovisual resources produced in house
- Safety manual review

E) Is there a process to communicate IH requirements and/or procedures to potential or new subcontractors and vendors? Yes ☒ No ☐

F) Is there evidence that subcontractors are provided relevant training to protect them and employees? Yes ☒ No ☐

Requirements and Scope: This section evaluates whether the organization has communicated basic safety and health requirements/procedures to subcontractors and suppliers. It will also evaluate how the organization determines the risk of purchased products and services.

Procedure No: ____________________ Rev. _____________

Overall evaluation:

☐ Did not check.
☐ Did not apply.
☐ Conforms. No deficiencies identified.
☒ Opportunity for improvement. Detail below.
☐ Best Practice. Detail below. Be specific.
☐ Nonconformity. Provide details below. Reference the specific requirement violated.

List some suppliers or contractors used by the organization. Examples include contractors, HVAC maintenance and contracted technicians. Review evidence they were briefed and/or trained on organization safety rqmts.

Contractor/supplier	**Evidence of briefing/training?**
1. tailgate meetings	☒ **Yes** ☐ **No**
2. Contractor orientation training rosters	☒ **Yes** ☐ **No**
3. Review of contractor skills/training	☒ **Yes** ☐ **No**

Pick several products/materials that are purchased by the facility. Verify that a MSDS/SDS sheet is available for the product/material.

Products selected randomly had MSDS/SDS. Organization exceeds expectations as it has even created an SDS for the ash produced at three coal power plants even though the product is not sold. MSDS/SDS for decommissioned wood electric poles or railroad ties were not available, however hazards have been characterized by analyzing bulk sample of the material after being crushed.

Comments and Findings
- **A) this is true about chemical products, however there is no process in place to inspect equipment**
- **C) On site Safety Specialists are in charge of this**
- **(E) & (F) There is a general orientation training which also includes asbestos as this material is still widely used for insulation. Contractors are expected to train their employees on the required training for the project, and then site specific information is delivered to them by ABC electric. However, there is no system in place to review contractor training records and guarantee such training has been delivered before being deployed at the site.**

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Calibration

A) Does the organization have any IH monitoring equipment (e.g. explosive meters, noise meters)? Yes ☒ No ☐

B) If so, are they part of the organization's calibration control system? List equipment used and then verify it is in the calibration program. Also verify calibration if kept in calibration lab. Yes ☒ No ☐

C) Is the equipment properly stored and/or handled when not in use? Yes ☒ No ☐

D) Are personnel using the equipment properly trained in its use? Yes ☒ No ☐

E) Are calibration records for any such equipment maintained? Yes ☒ No ☐

F) Review the calibration records. If any equipment is found to be out-of-calibration when received for calibration, is re-monitoring performed? Yes ☒ No ☐

Requirements and Scope: This section evaluates whether the organization calibrates and controls any monitoring and measurement equipment that support the control of occupational exposure to chemical/physical agents.

Procedure No: ____________________ Rev. _____________

Overall evaluation:

☐ Did not check.
☐ Did not apply.
☐ Conforms. No deficiencies identified.
☒ Opportunity for improvement. Detail below.
☐ Best Practice. Detail below. Be specific.
☐ Nonconformity. Provide details below. Reference the specific requirement violated.

Equipment	**In Calibration Program?**	**Records?**
1. SKC AirCheck 2000 pumps	☒ **Yes** ☐ **No**	☒ **Yes** ☐ **No**
2. 3M SE/DL sound level meter	☒ **Yes** ☐ **No**	☒ **Yes** ☐ **No**
3. 3M NoisePro 5NP-DLX dosimeters	☒ **Yes** ☐ **No**	☒ **Yes** ☐ **No**
4. Bios Dry Cals DC-2	☒ **Yes** ☐ **No**	☒ **Yes** ☐ **No**
5. Micro 5 IR Portable Multi-Gas Detector	☒ **Yes** ☐ **No**	☒ **Yes** ☐ **No**

Comments and Findings

- Equipment is factory calibrated according to specifications. Calibration certification documents are kept with equipment
- Records of pre-use calibration are kept. However, calibration of IH sampling equipment documents and record lack substantial control. Forms need to be made standard and assigned a control number
- Ventilation systems lack preventative maintenance plan.

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Consultation and Communication A) Is there a process in place to involve employees: – In the development and review of policies and procedures to manage health/physical risks Yes ☒ No ☐ – In any changes that affect workplace health and occupational exposure controls? Yes ☒ No ☐ – On health and safety matters? Yes ☒ No ☐ B) Is there a process in place to communicate IH/occupational exposure information to and from employees? Yes ☒ No ☐ C) Is the process effective? Yes ☐No☒ D) Is there a process in place to communicate IH/occupational exposure information to or from other interested parties? Yes ☐No☒ E) Is the process documented? Is it controlled? Yes ☐No☒	**Requirements and Scope:** This section evaluates whether the organization has established processes to involve and communicate with its employees and interested parties. Procedure No: ____________________ Rev. _____________ **Overall evaluation:** ☐ Did not check. ☐ Did not apply. ☐ Conforms. No deficiencies identified. ☐ Opportunity for improvement. Detail below. ☐ Best Practice. Detail below. Be specific. ☒ Nonconformity. Provide details below. Reference the specific requirement violated. List the methods used to involve/communicate with employees **1. Program and procedures** **2. Safety Training** **3. Safety meetings and minutes (Safety improvement team, Joint Safety committee, safety strategy group, tail gate meetings, toolbox talks)** **3. Electronic safety communications** **Comments and Findings** - **Standard operative procedures need to be established to guarantee an effective way of communicating/updating IH exposure testing results. It was noted that CrVI exposure results was not communicated to employees in a timely manner (within 15 days of obtaining results per 29CFR 1910.1026(d)(4)(i))**

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)

Appendix E: IH Management System Scorecard

Scorecard Survey

Please rate the organization's current status in relation to the questions that follow. Once you have answered each question, total your score on page 4.

Management Support and Commitment

1. There is no clear management responsibility.
2. An IH Coordinator has been named, but it is a part-time job filled by a front-line or mid-level manager. Little or no discussion of IH topics (other than after accidents) occurs during senior level management meetings.
3. An IH Manager has been named, reporting to line management. Little or no discussion of IH topics (other than after accidents) occurs during senior level management meetings.
4. A senior-level manager (Director or VP) has been formally assigned ultimate responsibility for IH, or the IH Manager has a direct reporting path to the Plant Manager or CEO. Senior level management meetings often discuss safety and health issues and performance, even in the absence of accidents.

4

IH Policy

1. No defined policy exists
2. An informal policy exists, or is stated in the employee handbook, but it is not actively communicated after initial orientation training or enforced.
3. A formal policy exists and is posted in various areas of the facility, but it is not often used as the basis for action or improvement.
4. A formal policy exists, is well understood by the workforce, and often serves as the basis for action (corrective or preventive) and improvement.

2

Resources

1. Specific resources (time, money, personnel) are not allocated or budgeted for IH.
2. Specific resources are allocated and budgeted for mandatory IH training, after accidents or inspection deficiencies.
3. Specific resources are also allocated (beyond item 2) in advance of new or impending regulations.
4. IH is a standard line item in the operating budget and strategic planning process. Resources are commonly allocated for health and safety improvements even in the absence of new laws and regulations.

3

Hazard Identification/Risk Assessment

1. The organization has never, to my knowledge, carried out a risk assessment

3

2. The organization has conducted a high-level risk assessment, but it is several years old, and is only reviewed after accidents.
3. The organization conducts annual (or more frequent) risk assessments for some perceived high-risk activities.
4. The organization has conducted a comprehensive risk assessment of all of its activities and processes and has a system to keep these assessments up-to-date.

Legal and Other Requirements

3

1. The organization has little knowledge of the legal requirements that apply to it. Knowledge is primarily gained through occasional federal, state and/or local inspections.
2. The organization has some knowledge of the primary legal requirements that apply to it, and has an informal system to ensure compliance to these requirements.
3. The organization has knowledge of most of the legal requirements that apply to it and has a formal system (procedures, policies and systems) in place to ensure compliance to these requirements.\
4. The organization has a very good knowledge of all of the legal requirements that apply to it and has a formal system, including regularly scheduled compliance reviews, to ensure compliance to these requirements.

Best Practices

3

1. The organization has little knowledge of industry best-practices relating to IH, and does not perform any benchmarking of IH practices or systems.
2. The organization is aware of some industry best-practices, or has performed some benchmarking in the past of IH best practices.
3. The organization has systems in place to stay aware of industry best practices and has performed benchmarking of same within the previous two years.
4. The organization has systems in place to stay aware of industry, supplier, customer, and non-industry best practices and regularly benchmarks these.

Objectives and Targets

3

1. The organization does not set IH objectives and targets.
2. The organization sets informal (i.e. no formal assignment of responsibility, metrics or routine tracking) IH objectives after incidents or inspection deficiencies.
3. The organization routinely and formally sets IH objectives, but these are not communicated to all employees.
4. The organization routinely and formally sets IH objectives, involves the workforce in their establishment and achievement, and communicates and reinforces these objectives to all employees.

Employee Responsibility

2

1. IH responsibilities are not assigned to the workforce.

2. IH responsibilities are informally assigned to the workforce, but enforcement is seen as supervisors or management's responsibility.
3. IH responsibilities are formally assigned to the workforce, are understood by employees, and include responsibilities for enforcement.
4. In addition to 3 above, the workforce routinely self-enforces compliance to the IH policies and provide recommendations for improvement.

Training

1. IH training is not conducted except after accidents or inspection deficiencies. 3
2. Some mandatory IH is conducted, possibly in combination with initial awareness training.
3. All mandatory training is conducted; awareness training is provided initially and refreshed at periodic intervals.
4. A formal and comprehensive training program is in place that goes beyond initial awareness and mandatory training, and that includes assessment and assurance of IH competencies required to maintain a safe working environment.

Internal Communications

1. IH information is not communicated to the workforce. 2
2. Only mandatory accident reporting and HAZCOM is provided to the workforce.
3. Some IH information, beyond mandatory reports and HAZCOM is provided to the workforce.
4. A comprehensive system of communication exists, that includes detailed performance information, policies, objectives, recognition and current/future issues, and is regularly updated.

External Communications

1. No IH information is disclosed, unless required by law. 1
2. IH info is released to the general public only when required by discovery (legal action)
3. In addition to 2 above, the organization's IH policy is released when requested but only to selected groups or individuals.
4. A policy exists to freely communicate information about the organization's IH policies, performance and issues.

Documentation

1. No formal documentation for IH exists (other than possibly an IH policy). 2
2. Some formal documentation exists, but it only covers very high-risk operations, is not readily available at the activities, or is not formally controlled.
3. Some formal documentation exists, and is formally controlled and updated as needed. Documents are generally available where needed.

4. A comprehensive system of documentation exists that includes a policy manual, system level procedures, and specific policies/instructions for most moderate- to high-risk activities. All documentation is controlled and available where needed.

Operational Control

3

1. The focus of the organization is almost exclusively on business issues.
2. Some controls have been established where accidents have occurred in the past. The majority of these controls are procedure-based or in the form of Personal Protective Equipment.
3. Controls have been established for most jobs, although these controls were not necessarily developed as a result of formal job hazard analysis or risk assessment.
4. A comprehensive system of pro-active control is in place throughout the organization and is based on formal risk assessment. Engineered controls are always considered before procedural or PPE for moderate- to high-risk activities. Procedure controls are integrated into other operating procedures and instructions where possible.

Emergency Response

3

1. No formal procedures exist for emergencies or emergency response.
2. A general Fire and Evacuation Plan exists, but that is the extent of it.
3. Emergency response procedures exist for most situations where appropriate, but these are rarely reviewed or tested and are often out-of-date.
4. Emergency response procedures exist where needed, are regularly reviewed and tested to ensure they are effective and up-to-date, and all employees understand their responsibilities as called out in the procedure(s).

Audits

1

1. No audits or compliance reviews are performed, other than by government agencies.
2. IH compliance reviews are conducted after accidents or prior to inspections, where known. Compliance reviews tend to focus only on a few key areas and/or conducted by personnel without detailed knowledge of regulatory requirements.
3. Trained safety professionals perform periodic and comprehensive IH compliance reviews at least annually. Trained auditors conduct system audits periodically of the overall IH system. Timely action is always taken to address deficiencies.

Management Review

2

1. Senior management does not review the IH activities or the IH system.
2. Senior management conducts reviews only after accidents and government inspections only.
3. Senior management conducts or participates in periodic safety reviews.

4. Regular, comprehensive reviews are conducted by senior management of the organization's IH system and performance. These reviews result in actions to improve the IH system.

Total Score

16 - 20	Commitment to IH is weak. The organization may be in violation of current health and safety regulations.
21 - 50	Basic IH management system is in place, but full organizational commitment does not yet exist.
50 - 64	Assuming no scores in any area were less than 3, the organization has a comprehensive IH system in place. The stage is set for continual improvement.

(Kausek, 2007; AIHA, 2012; Mulhausen and Damiano 2012)