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Industrial Hygiene for the Construction Industry

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Introduction

Industrial hygiene is the science of anticipating, recognizing, evaluating, and controlling workplace conditions that may cause workers' injury or illness. Industrial hygienists use environmental monitoring and analytical methods to detect the extent of worker exposure and employ engineering, work practice controls, and other methods to control potential health hazards. Are those industrial hygiene methods and techniques applicable to the construction industry, and are there special issues or concerns in construction for the industrial hygienist to consider? Applying the principals of industrial hygiene in the construction industry can be more than fast paced, ever changing, challenging and rewarding.

There has been an awareness of industrial hygiene since antiquity. The environment and its relation to worker health were recognized as early as the fourth century BC when Hippocrates noted lead toxicity in the mining industry. In the first century AD, Pliny the Elder, a Roman scholar, perceived health risks to those working with zinc and sulfur. He devised a face mask made from an animal bladder to protect workers from exposure to dust and lead fumes. In the second century AD, the Greek physician, Galen, accurately described the pathology of lead poisoning and also recognized the hazardous exposures of copper miners to acid mists.

In the Middle Ages, guilds worked at assisting sick workers and their families. In 1556 the German scholar, Agricola, described the diseases of miners and prescribed preventive measures. His book included suggestions for mine ventilation and worker protection, discussed mining accidents, and described diseases associated with mining occupations such as silicosis.

In 1700, Bernardo Ramazzini, known as the "father of industrial medicine," published in Italy the first comprehensive book on industrial medicine, De Morbis Artificum Diatriba (The Diseases of Workmen). The book contained accurate descriptions of the occupational diseases of most of the workers of his time. Ramazzini greatly affected the future of industrial hygiene because he asserted that occupational diseases should be studied in the work environment rather than in hospital wards.

In England in the 18th century, Percival Pott, as a result of his findings on the insidious effects of soot on chimneysweepers, was a major force in getting the British Parliament to pass the Chimney-Sweepers Act of 1788. The passage of the English Factory Acts beginning in 1833 marked the first effective legislative acts in the field of industrial safety.

In the early 20th century in the U. S., Dr. Alice Hamilton, led efforts to improve industrial hygiene. She observed industrial conditions first hand and startled mine owners, factory managers, and state officials with evidence that there was a correlation between worker illness and their exposure to toxins.

At about the same time, U.S. federal and state agencies began investigating health conditions in industry. In 1908, the public's awareness of occupationally related diseases stimulated the passage of compensation acts for certain civil employees. States passed the first workers' compensation laws in 1911. And in 1913, the New York Department of Labor and the Ohio Department of Health established the first state industrial hygiene programs.

The U.S. Congress has passed three landmark pieces of legislation relating to safeguarding workers' health: (1) the Metal and Nonmetallic Mines Safety Act of 1966, (2) the Federal Coal Mine Safety and Health Act of 1969, and (3) the Occupational Safety and Health Act of 1970 (Act). Today, nearly every employer is required to implement the elements of an industrial hygiene and safety, occupational health, or hazard communication program and to be responsive to the Occupational Safety and Health Administration (OSHA) and the Act and its regulations.

OSHA and Industrial Hygiene

Under the *Act*, OSHA develops and sets mandatory occupational safety and health requirements applicable to the more than 6 million workplaces in the U.S. OSHA relies on, among many others, industrial hygienists to evaluate jobs for potential health hazards. Developing and setting mandatory occupational safety and health standards involves determining the extent of employee exposure to hazards and deciding what is needed to control these hazards, thereby protecting the workers. Industrial hygienists, or IHs, are trained to anticipate, recognize, evaluate, and recommend controls for environmental and physical hazards that can affect the health and well-being of workers. Industrial hygienists also play a major role in developing and issuing OSHA standards such as OSHA's construction standards found in 29 CFR 1926 to protect workers from health hazards associated with toxic chemicals, biological hazards, and harmful physical agents.

Examples of Industrial Hygiene Hazards at Construction Sites

To be effective in recognizing and evaluating on-the-job hazards and recommending controls, industrial hygienists must be familiar with the hazards' characteristics. Major job risks can include air contaminants, and chemical, biological, physical, and ergonomic hazards.

Some Examples of Construction Health Hazards include the following:

Occupation	Potential Health Hazards
Brick-masons	Cement dermatitis, awkward postures, heavy loads
Drywall installers	Plaster dust, heavy loads, awkward postures
Electricians	Heavy metals in solder fume, awkward posture, heavy loads, asbestos
Painters	Solvent vapors, toxic metals in pigments, paint additives.
Pipefitters	Lead fumes and particles, welding fumes, asbestos
Carpet layers	Knee trauma, awkward postures, glue and glue vapor
Insulation workers	Asbestos, fiberglass and synthetic fibers, polyurethane vapor, awkward postures
Roofers	Roofing tar, asbestos, heat
Carpenters	Noise, awkward postures, repetitive motion, vapors and dust
Drillers, earth, rock	Silica dust, whole body vibration, noise
Excavating and loading machine operators	Silica dust, microbes from soils, whole-body vibration, heat illness, noise
Hazardous waste workers	Toxic substances, heat illness

In many ways, industrial hygiene at a dynamically changing construction site is far more challenging than in a static workplace. Factors increasing the health risk of construction workers include:

- constantly changing job site environments and conditions
- multiple contractors and subcontractors
- high turnover; skilled and unskilled laborers
- constantly changing relationships with other work groups
- diversity of work activities occurring simultaneously
- exposures to health hazards resulting from own work as well as from nearby activities ("bystander exposure")

Air Contaminants

Air contaminants are commonly classified as either particulate or gas and vapor contaminants. The most common particulate contaminants include dusts, fumes, mists, aerosols, and fibers. Dusts are solid particles that are formed or generated from solid organic or inorganic materials by reducing their size through mechanical processes such as crushing, grinding, drilling, abrading or blasting. All common activities on construction sites.

Fumes (e.g. welding fume) are formed when material from a volatilized solid condenses in cool air. In most cases, the solid particles resulting from the condensation react with air to form an oxide.

The term mist is applied to a finely divided liquid suspended in the atmosphere. Mists are generated by liquids condensing from a vapor back to a liquid or by breaking up a liquid into a dispersed state such as by splashing, foaming or atomizing. Aerosols are also a form of a mist characterized by highly respirable, minute liquid particles. An example of mist exposure at a construction site would include paint spray mist.

Fibers are solid particles whose length is several times greater than their diameter. Examples would include asbestos and fiberglass.

Gases (e.g. welding gases) are formless fluids that expand to occupy the space or enclosure in which they are confined. Examples are welding gases such as acetylene, nitrogen, helium, and argon; and carbon monoxide generated from the operation of internal combustion engines or by its use as a reducing gas in a heat treating operation. Another example is hydrogen sulfide, which is formed wherever there is decomposition of materials containing sulfur under reducing conditions. H2S can be released during drilling and excavation activities at various construction sites.

Liquids (e.g. fuels, lubricants, paints, solvents) change into vapors and mix with the surrounding atmosphere through evaporation. Vapors are the gaseous form and volatile form of substances that are normally in a solid or liquid state at room temperature and pressure. They are formed by evaporation from a liquid or solid and can be found where parts cleaning and painting takes place and where solvents are used.

Chemical Hazards at Construction Sites

Harmful chemical compounds in the form of solids, liquids, gases, mists, dusts, fumes, and vapors exert toxic effects by inhalation (breathing), absorption (through direct contact with the skin), or ingestion (eating or drinking). Airborne chemical hazards exist as concentrations of mists, vapors, gases, fumes, or solids. Some are toxic through inhalation and some of them irritate the skin on contact; some can be toxic by absorption through the skin or through ingestion, and some are corrosive to living tissue.

The degree of worker risk from exposure to any given substance depends on the nature and potency of the toxic effects and the magnitude and duration of exposure. Examples of chemical substances commonly found in construction work include:

• Asbestos (generally buildings build before 1981)	• Spray Paints
• Lead	• Cutting Oil Mist
• Silica	• Solvents
• Cadmium	• Hexavalent Chromium
• Carbon Monoxide	• Welding Gases
• Welding Fume	• Nuisance Dusts

Information on the risk to workers from chemical hazards can be obtained from the Material Safety Data Sheet (MSDS) or the new Safety Data Sheets (SDS's) that OSHA'S *Hazard Communication Standard* requires be supplied by the manufacturer or importer to the purchaser of all hazardous materials. The MSDS/SDS is a summary of the important health, safety, and toxicological information on the chemical or the mixture's ingredients. Other provisions of the *Hazard Communication Standard* require that all containers of hazardous substances in the workplace have appropriate warning, new pictograms and identification labels.

Biological Hazards

These include bacteria, viruses, fungi, and other living organisms that can cause acute and chronic infections by entering the body either directly or through breaks in the skin. Occupations that deal with plants or animals or their products or with food and food processing may expose workers to biological hazards. Any occupations that result in contact with bodily fluids pose a risk to workers from biological hazards.

In construction, diseases or illnesses that are not uncommon from biological sources include:

- Microorganisms: West Nile virus, Lyme Disease, Histoplasmosis (fungus from bird droppings), Hantavirus, Bloodborne Pathogens, various pathogens associated with food-borne illness
- Plants: Poison Oak, Poison Ivy and Poison Sumac
- Animals: Feral animals, wild animal attacks
- Insects: Mosquito borne illnesses, spider and snake bites, and exposure to ticks, etc.

In occupations where there is potential exposure to biological hazards, workers should practice proper personal hygiene, particularly hand washing.

Physical Hazards

Physical hazards of an industrial hygiene nature include excessive levels of ionizing and non-ionizing electromagnetic radiation, noise, vibration, illumination, and temperature.

In occupations where there is exposure to ionizing radiation, time, distance, and shielding are important tools in ensuring worker safety. Danger from radiation increases with the amount of time one is exposed to it; hence, the shorter the time of exposure the smaller the radiation danger.

Distance also is a valuable tool in controlling exposure to both ionizing and non-ionizing radiation. Radiation levels from some sources can be estimated by comparing the distances between the worker and the source. For example, at a reference point of 10 feet from a source, the radiation is 1/100 of the intensity at 1 foot from the source.

Shielding also is a way to protect against radiation. The greater the protective mass between a radioactive source and the worker, the lower the radiation exposure.

Non-ionizing radiation (sunlight, laser for field applications) also is dealt with by shielding workers from the source. Sometimes limiting exposure times to non-ionizing radiation or increasing the distance is not effective. Laser radiation, for example, cannot be controlled effectively by imposing time limits. An exposure can be hazardous that is faster than the blinking of an eye. Increasing the distance from a laser source may require miles before the energy level reaches a point where the exposure would not be harmful.

Noise, another significant physical hazard on construction sites, can be controlled by various measures. Noise can be reduced by installing equipment and systems that have been engineered, designed, and built to operate quietly; by enclosing or shielding noisy equipment; by making certain that equipment is in good repair and properly maintained with all worn or unbalanced parts replaced; by mounting noisy equipment on special mounts to reduce vibration; and by installing silencers, mufflers, or baffles.

Substituting noisy work methods and equipment for quiet ones is another significant way to reduce noise, for example, welding parts rather than riveting them. Also, promoting the use of heavy equipment with cabs which reduce noise levels to the operators. In addition, erecting sound barriers at adjacent work stations around noisy operations will reduce worker exposure to noise generated at adjacent work stations.

It is also possible to reduce noise exposure by increasing the distance between the source and the receiver, by isolating workers in acoustical cabs, limiting workers' exposure time to noise, and by providing hearing protection.

Temperature stress is another physical hazard. Heat and cold stress are common in the construction trades.

Heat-related illnesses include:

1. Heat stroke; the most serious form of heat-related illness, happens when the body becomes unable to regulate its core temperature. Sweating stops and the body can no longer rid itself of excess heat. Signs include confusion, loss of consciousness, and seizures. "Heat stroke is a medical emergency that may result in death! Call 911 immediately."
2. Heat exhaustion is the body's response to loss of water and salt from heavy sweating. Signs include headache, nausea, dizziness, weakness, irritability, thirst, and heavy sweating.
3. Heat cramps are caused by the loss of body salts and fluid during sweating. Low salt levels in muscles cause painful cramps. Tired muscles—those used for performing the work—are usually the ones most affected by cramps. Cramps may occur during or after working hours.
4. Heat rash, also known as prickly heat, is skin irritation caused by sweat that does not evaporate from the skin. Heat rash is the most common problem in hot work environments.

Cold-related illnesses include:

Hypothermia; Hypothermia occurs when a person's body loses heat faster than it can be produced. The body's "normal" deep body temperature is 99.6 degrees Fahrenheit. If your body temperature drops to 95 degrees Fahrenheit, uncontrollable shivering occurs. If cooling continues, symptoms from vague, slowed, and slurred speech to death may occur.

Hypothermia impairs your judgment. You may not be able to make good decisions about your situation. Preventing hypothermia is the best way to avoid being a victim.

Ergonomic Hazards

The science of ergonomics, studies and evaluates a full range of tasks including, but not limited to, lifting, holding, pushing, walking, and reaching. Some of the most common injuries in construction are the result of job demands that push the human body beyond its natural limits. Workers who must often lift, stoop, kneel, twist, grip, stretch, reach overhead, or work in other awkward positions to do a job are at risk of developing a *work-related musculoskeletal disorder (WMSD)*. These can include back problems, carpal tunnel syndrome, tendinitis, rotator cuff tears, sprains, and strains.

Ergonomic hazards are avoided primarily by the effective design of a job or jobsite and better-designed tools or equipment that meet workers' needs in terms of physical environment and job tasks. Through thorough worksite analyses, employers can set up procedures to correct or control ergonomic hazards by using the appropriate engineering controls (e.g., designing or re-designing work stations, lighting, tools, and equipment); teaching correct work practices (e.g., proper lifting methods); employing proper administrative controls (e.g., shifting workers among several different tasks, reducing production demand, and increasing rest breaks); and, if necessary, providing and mandating personal protective equipment. Evaluating working conditions from an ergonomics standpoint involves looking at the total physiological and psychological demands of the job on the worker.

Worksite Analysis (Evaluation) and Control

A worksite analysis is an essential first step that helps an industrial hygienist determine what jobs and workstations are the sources of potential problems. During the worksite analysis, the industrial hygienist measures and identifies exposures, problem tasks, and risks. The most effective worksite analyses include all jobs, operations, and work activities on the construction site. The industrial hygienist inspects, researches, or analyzes how the particular chemicals or physical hazards at that worksite affect worker health. If a situation hazardous to health is discovered, the industrial hygienist recommends the appropriate corrective actions.

Hazard Evaluation

In industrial hygiene, evaluation is the decision-making process that assesses the hazards to workers from exposures to chemical, physical, and biological agents and ergonomic conditions. The actions taken to protect workers are based on a combination of observation, interviews, and measurement of the levels of energy or air contaminants resulting from a process or work operation and the effectiveness of control measures used. Oftentimes the industrial hygienist will use industrial hygiene equipment to monitor the workplace. For the evaluation and control of inhalation hazards, hygienists typically compare the measured concentrations of an airborne chemical to a recognized exposure limit such as OSHA's Permissible Exposure Limit (PEL), Short Term Exposure Limit (STEL), Ceiling Limit (C) or the Threshold Limit Values (TLV's) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).

Monitoring equipment is typically available for chemical, physical (e.g. temperature extremes, radiation), and in some cases biological as well as ergonomic related hazards. Inhalation of airborne contaminants is the most common hazard and the major route of entry for systemic intoxicants in the workplace. Thus evaluation and control of airborne contaminants is an important part of any occupational health program.

Sampling and analysis of airborne contaminants is the definitive function of the industrial hygienist. While it is the joint responsibility of the hygienist and physician to interpret the results of such measurements, measurement alone makes a contribution to the awareness of hazards as well as to their evaluation. Recent developments in instrumentation have made it possible to measure very low concentrations, with the result that previously unsuspected contamination is now being discovered.

Additionally, it is important to note that instrumentation are of different types, such as personal versus area, grab versus integrated and more.

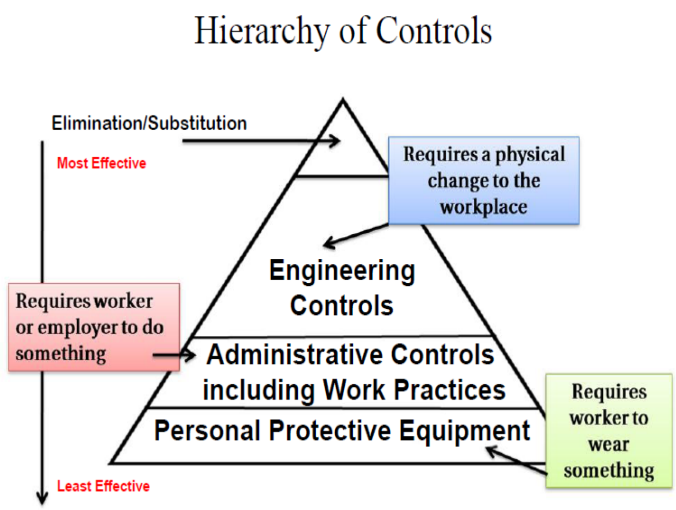
Maximum acceptable exposure limits (PEL's and TLV's) referenced above typically have been lowered in recent years as both our ability to discern clinical effects and our expectations of no risk of (detectable or undetectable) health effects have increased. A good example of this phenomenon is concern about asbestos in buildings. A hygienist should attempt to ensure that avoidable exposure to asbestos is eliminated. There is no definitive evidence that there is a threshold dose below which the asbestos-related disease mesothelioma will not occur.

Hazard Control

On completion of the hazard evaluation, the industrial hygienist should be in a position to recommend appropriate controls, if needed. Controls should be adequate to prevent unnecessary exposure during accidents and emergencies, as well as during normal operating conditions. Consideration must be given to fail-safe operation of controls; that is, recommended controls always should operate to protect workers regardless of process fluctuations.

Controlling exposures to occupational hazards is the fundamental method of protecting workers. Traditionally, a hierarchy of controls has been used as a means of determining how to implement feasible and effective controls. One representation of this hierarchy can be summarized as follows:

- Elimination
- Substitution
- Engineering controls
- Administrative controls
- Personal protective equipment



The idea behind this hierarchy is that the control methods at the top of the list are potentially more effective and protective than those at the bottom. Following the hierarchy normally leads to the implementation of inherently safer systems, ones where the risk of illness or injury has been substantially reduced.

Engineering controls is a term that generally includes eliminating toxic chemicals and replacing harmful toxic materials with less hazardous ones (substitution), enclosing work processes or confining work operations, and installing general and local ventilation systems.

Work practice controls alter the manner in which a task is performed. Some fundamental and easily implemented work practice controls include (1) following proper procedures that minimize exposures while operating production and control equipment; (2) inspecting and maintaining process and control equipment on a regular basis; (3) implementing good house-keeping procedures; (4) providing good supervision and (5) mandating that eating, drinking, smoking, chewing tobacco or gum, and applying cosmetics in regulated areas be prohibited.

Administrative controls include controlling employees' exposure by scheduling production and workers' tasks, or both, in ways that minimize exposure levels. For example, the employer might schedule operations with the highest exposure potential during periods when the fewest employees are present.

When effective work practices and/or engineering controls are not feasible to achieve the permissible exposure limit, or while such controls are being instituted, and in emergencies, appropriate respiratory equipment must be used. In addition, personal protective equipment such as gloves, safety goggles, helmets, safety shoes, and protective clothing may also be required. To be effective, personal protective equipment must be individually selected, properly fitted and periodically refitted; conscientiously and properly worn; regularly maintained; and replaced as necessary.

In summary, industrial hygiene encompasses a broad spectrum of the working environment to include the construction industry. We have seen that construction poses a number of hazards for the industrial hygienist to consider and evaluate, including air contaminants and chemical, biological, physical and ergonomic hazards. Using hazard evaluation and hazard control methods to effectively eliminate and control hazards can greatly improve construction safety and health.

Early in its history OSHA recognized industrial hygiene as an integral part of a healthy work setting. OSHA places a high priority on using industrial hygiene concepts in its health standards and as a tool for effective enforcement of job safety and health regulations. By recognizing and applying the principles of industrial hygiene to the work environment, America's construction workplaces will become more healthy and safer.

Bibliography

National Safety Council. *Fundamentals of Industrial Hygiene*, 6th Edition, 2012

The McGraw-Hill Companies, *Current – Occupational & Environmental Medicine*, 4th Edition, 2007

National Institute for Occupational Safety and Health – "Simple Solutions Ergonomics for Construction Workers", 2007