Industrial hygiene is the science of anticipating, recognizing, evaluating, and controlling workplace conditions that may cause illness in the workplace. This course introduces students to the field of industrial hygiene and how industrial hygienists work to detect the extent of worker exposure to environmental hazards.
OSHAcademy Course 161 Study Guide

Industrial Hygiene: Basic

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This study guide is designed to be reviewed off-line as a tool for preparation to successfully complete OSHAcademy Course 161.

Read each module, answer the quiz questions, and submit the quiz questions online through the course webpage. You can print the post-quiz response screen which will contain the correct answers to the questions.

The final exam will consist of questions developed from the course content and module quizzes.

We hope you enjoy the course and if you have any questions, feel free to email or call:

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Course 161

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Modules and Learning Objectives

Module 1: Industrial Hygienists, Air Quality, and Hazardous Chemicals

- Define industrial hygiene and role of the industrial hygienist in protecting employees.
- Describe the worksite analysis process.
- Identify the hazard and exposure control strategies within the "Hierarchy of Controls."
- Discuss the advantages and disadvantages of hazard and exposure control strategies.
- Describe the factors affecting indoor and outdoor air quality.
- List at least five air contaminants common in the workplace.
- Define "toxic," and describe the factors that cause chemicals to be considered toxic.
- List and describe the four primary routes of chemical exposure.

Module 2: Biological and Physical Health Hazards

- Describe common biological hazards workers might be exposed to in general industry and construction.
- List and describe biological agents, including anthrax, avian flu, bloodborne pathogens and botulism, causing disease.
- List the common physical health hazards to which workers are exposed.
- Describe the two common forms of radiation and give examples of how employees might be exposed.
- Define "noise" and OSHA's permissible exposure limit (PEL) and "Action Level."
- Give one example of reducing noise through engineering controls, administrative controls, and personal protective equipment.
- Describe OSHA's recommendation for temperatures and humidity in the workplace.
- Define "ergonomics" and give examples of ergonomic solutions for injuries due to repetitive motion and vibration.
Course Introduction

Industrial Hygiene is a science and art devoted to the anticipation, recognition, evaluation, prevention, and control of those environmental factors or stresses arising in or from the workplace which may cause sickness, impaired health and well being, or significant discomfort among workers or among citizens of the community. (AIHA)

More than 40 percent of the OSHA compliance officers who inspect America's workplaces are industrial hygienists. Industrial hygienists also play a major role in developing and issuing OSHA standards to protect workers from health hazards associated with toxic chemicals, biological hazards, and harmful physical agents. They also provide technical assistance and support to the agency's national and regional offices. OSHA also employs industrial hygienists who assist in setting up field enforcement procedures, and who issue technical interpretations of OSHA regulations and standards.

Industrial hygienists analyze, identify, and measure workplace hazards or stresses that can cause sickness, impaired health, or significant discomfort in workers through chemical, physical, ergonomic, or biological exposures. Two roles of the OSHA industrial hygienist are to spot those conditions and help eliminate or control them through appropriate measures.
Module 1: Industrial Hygienists, Air Quality, and Hazardous Chemicals

The Industrial Hygienist

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, or "IHs," to evaluate jobs for potential health hazards. More than 40% of OSHA's compliance officers are IHs.

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 are trained to anticipate, recognize, evaluate, and recommend controls for environmental and physical hazards that can affect the health and well-being of workers. Important IH responsibilities include:

- Identifying, measuring and analyzing workplace health hazards and exposures (chemical, physical, biological, ergonomic) that can cause sickness, impaired health, or significant discomfort.

- Recommending hazard control strategies to eliminate/reduce hazards and employee exposure to hazards.

The primary organization concerned with industrial hygiene is the American Industrial Hygiene Association (AIHA). AIHA is a nonprofit organization devoted to achieving and maintaining the highest professional standards for its members. More than half of the 10,000 members are certified industrial hygienists (CIHs), and many hold other professional designations. AIHA administers comprehensive education programs that keep occupational and environmental health and safety (OEHS) professionals current in the field of industrial hygiene. For more information open the AIHA Fact Sheet.

1. Industrial hygienists are concerned with identifying, measuring, and analyzing each of the following health hazards and exposures, EXCEPT _____.

   a. ergonomic
   b. biological
   c. physical
   d. psychosocial
Protecting People

The goal of an IH is to keep workers, their families, and the community healthy and safe. They play a vital part in ensuring that federal, state, and local laws and regulations are followed in the work environment. According to the AIHA, typical roles of an industrial hygienist include:

- Investigating and examining the workplace for hazards and potential dangers
- Making recommendations on improving the safety of workers and the surrounding community
- Conducting scientific research to provide data on possible harmful conditions in the workplace
- Developing techniques to anticipate and control potentially dangerous situations in the workplace and the community
- Training and educating the community about job-related risks
- Advising government officials and participating in the development of regulations to ensure the health and safety of workers and their families
- Ensuring that workers are properly following health and safety procedures

Industrial Hygiene Focus Areas

The AIHA describes the various areas of interest that IHs place a focus. Industrial Hygienists work with issues including:

- Indoor air quality (sick building syndrome, second-hand tobacco smoke)
- Evaluating and controlling environmental lead exposure
- Emergency response planning and community right-to-know
- Occupational disease (AIDS in the workplace, tuberculosis, silicosis)
- Potentially hazardous agents such as asbestos, pesticides, and radon gas
- Cumulative Trauma Disorders (repetitive stress injuries, carpal tunnel syndrome)
- Radiation (electromagnetic fields, microwaves)
- Reproductive health hazards in the workplace
• Setting limits on exposure to chemical and physical agents
• Detection and control of potential occupational hazards such as noise, radiation, and illumination
• Hazardous waste management

We'll cover some of these focus areas throughout the rest of this course.

2. Areas of interest for industrial hygienists include ______.
   a. housekeeping, work schedules, and traffic awareness
   b. lockout/tagout and electrical safety
   c. noise, radiation, and illumination
   d. fall protection, good hygiene, and diet

Worksite Analysis

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

A worksite analysis is an essential first step that helps an industrial hygienist determine what jobs and work stations are the sources of these potential and existing hazards.

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.

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.

3. What is the first step industrial hygienists take to determine what jobs and workstations are sources of hazards?
   a. Conduct enforcement inspections
   b. Perform worksite analysis
   c. Conduct a records review
   d. Historical search of past citations
Recognizing and Controlling Hazards

Industrial hygienists recognize several primary control strategies to eliminate or reduce health hazards and employee exposure to those hazards. These basic control strategies are further organized into a "Hierarchy of Controls." ANSI/ASSP Z10-2012, Occupational Health and Safety Management Systems, encourages employers to use the following hierarchy of hazard controls.

Hazard Control Strategies

The top strategy areas (elimination, substitution, and engineering controls) attempt to control hazards. Controlling hazards is always preferred to controlling behavior, and that’s why these strategies are at the top of the hierarchy. After all, if you can get rid of the hazard, there's no need to control the exposure - there isn't any.

**Elimination** removes the source of the hazard. This strategy totally eliminates the hazard from the workplace. This should be the top priority for all safety professionals including industrial hygienists. An example of this strategy includes replacing a hazardous chemical with a totally non-toxic, safe, "green" chemical.

**Substitution** reduces the hazard. This strategy should be used if it is not feasible to eliminate the hazard. The idea is to replace the hazard with a less hazardous substitute. An example would be to replace a hazardous chemical with a less hazardous one. There would still be a need for protection like personal protective equipment, but the hazards of exposure would be less serious.

**Engineering controls** remove/reduce the hazard through design. This strategy involves the design or redesign of tools, equipment, machinery and facilities so that hazardous chemicals are not needed or that exposure to those hazardous chemicals are not possible. Examples include using equipment that does not require the use of hazardous chemicals in a process or for cleaning. Enclosing work processes or installing general and local ventilation systems might also be used.
4. Which of the following "Hierarchy of Controls" strategies focuses on removing the source of that hazard?
   
   a. Substitution  
   b. Engineering  
   c. Elimination  
   d. Administration

**Exposure Control Strategies**

These strategies attempt to control employee behaviors to eliminate or reduce exposure to existing health hazards when hazard controls are not adequate. Naturally it's more difficult to control behaviors than hazards because we're dealing with human behavior. Exposure controls work only as long as we behave (comply).

**Warnings** to raise awareness of exposure to hazards. Warnings include signs, alarms, signals, labels, placards, cones, and other methods to help employees to be aware of the hazards.

**Administrative controls** eliminate/reduce exposure to hazards. This strategy helps to reduce exposure by developing and implementing effective training, policies, processes, procedures, practices and safety rules. Examples include scheduling production and worker tasks in ways that minimize exposure levels. The employer might schedule operations with the highest exposure potential during periods when the fewest employees are present.

Administrative controls also eliminate/reduce exposure through safe work practices. Following safe procedures while operating production and control equipment, good housekeeping, and safe practices like not eating, drinking, or smoking in regulated areas are all good examples of work practice controls.

**Personal Protective Equipment (PPE)** eliminates/reduces exposure through personal barriers. This strategy is generally used in conjunction with the other strategies to reduce exposure. When effective elimination, substitution and engineering controls are not feasible, appropriate PPE such as gloves, safety goggles, helmets, safety shoes, and protective clothing may be required. To be effective PPE must be individually selected, properly fitted and periodically refitted, conscientiously and properly worn, regularly maintained, and replaced as necessary.

It's important to note that administrative/work practices controls and personal protective equipment are the primary control strategies used by IHs to control exposure to health hazards in the workplace.
5. Why are exposure control strategies less effective in preventing injuries than hazard control strategies?

a. They work only as long as people behave
b. They are much more expensive to implement
c. They are not permanent in nature
d. They focus on changing the hazard, not the exposure

Indoor Air Quality

Indoor air quality (IAQ) refers to the presence or absence of air pollutants in buildings. There are many sources of indoor air pollutants. Indications of potential health effects due to poor indoor air quality include:

- the presence of sources of indoor air pollutants such as tobacco smoke and radon, or
- conditions that promote poor indoor air quality, such as inadequate ventilation or moisture intrusion, that can lead to mold growth.

The quality of air inside offices, schools, and other workplaces is important not only for workers' comfort but also for their health. Poor IAQ has been tied to symptoms like headaches, fatigue, trouble concentrating, and irritation of the eyes, nose, throat and lungs.

Specific diseases have been linked to specific air contaminants or indoor environments, like asthma with damp indoor environments. Some exposures, such as asbestos and radon, do not cause immediate symptoms but can lead to cancer after many years.

Many factors affect IAQ. These factors include:

- poor ventilation (lack of outside air),
- problems controlling temperature,
- high or low humidity,
- recent remodeling, and
- other activities in or near a building that can affect the fresh air coming into the building.

Sometimes, specific contaminants like dust from construction or renovation, mold, cleaning supplies, pesticides, or other airborne chemicals (including small amounts of chemicals released as a gas over time) may cause poor IAQ.
The right ventilation and building care can prevent and fix IAQ problems.

6. Which of the following air contaminants can lead to cancer after many years?
   a. Asbestos and radon
   b. Mold and cleaning supplies
   c. Tobacco smoke and dust
   d. High humidity and ultraviolet light

Outdoor Air Quality

The Clean Air Act requires the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards for six common air pollutants. These commonly found air pollutants (also known as "criteria pollutants") are found all over the United States. They are:

1. particle pollution (often referred to as particulate matter),
2. ground-level ozone,
3. carbon monoxide,
4. sulfur oxides,
5. nitrogen oxides, and
6. lead.

These pollutants can harm your health and the environment, and cause property damage. Of the six pollutants, particle pollution and ground-level ozone are the most widespread health threats. EPA calls these pollutants "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels. The set of limits based on human health is called primary standards. Another set of limits intended to prevent environmental and property damage is called secondary standards.

7. All of the following are serious outdoor air pollutants covered by the Clean Air Act, EXCEPT _____.
   a. ozone
   b. carbon monoxide
   c. asbestos
   d. lead
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.

**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.

**Fumes** 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.

**Liquids** change into vapors and mix with the surrounding atmosphere through evaporation.

**Mists** are finely divided liquid suspended in the atmosphere. They 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.

**Vapors** are the gaseous form of substances that are normally in a solid or liquid state at room temperature and pressure. Vapors are formed by evaporation from a liquid or solid and can be found where a worker would clean and/or paint as well as where solvents are used.

**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.

**Fibers** are solid particles whose length is several times greater than their diameter.

8. Which of the following are formed when material from a volatilized solid condenses in cool air?
   
   a. Fumes
   b. Gases
   c. Vapors
   d. Mists
**Toxic and Hazardous Chemicals**

**What Makes a Chemical Toxic?**

The toxicity of a substance is its ability to cause harmful effects. These effects can strike a single cell, a group of cells, an organ system, or the entire body. A toxic effect may be visible damage, or a decrease in performance or function measurable only by a test. All chemicals can cause harm. When only a very large amount of the chemical can cause damage, the chemical is considered to be practically non-toxic. When a tiny amount is harmful, the chemical is considered to be highly toxic.

The toxicity of a substance depends on three factors: its chemical structure, the extent to which the substance is absorbed by the body, and the body's ability to detoxify the substance (change it into less toxic substances) and eliminate it from the body.

**Are "Toxic" and "Hazardous" the Same?**

No. The toxicity of a substance is the potential of that substance to cause harm, and is only one factor in determining whether a hazard exists. The hazard of a chemical is the practical likelihood that the chemical will cause harm. A chemical is determined to be a hazard depending on the following factors:

- **Toxicity**: how much of the substance is required to cause harm,
- **Route of exposure**: how the substance enters your body,
- **Dose**: how much enters your body,
- **Duration**: the length of time you are exposed,
- **Reaction and interaction**: other substances you are exposed to at the same time, and,
- **Sensitivity**: how your body reacts to the substance compared to other people.

Some chemicals are hazardous because of the risk of fire or explosion. These are important dangers, but are considered to be safety rather than toxic hazards. The factors of a toxic hazard are more fully explained below.

**Why Are Some Chemicals More Harmful Than Others?**

The most important factor in toxicity is the chemical structure of a substance (i.e., what it is made of), what atoms and molecules it contains and how they are arranged. Substances with similar structures often cause similar health problems. However, slight differences in chemical
structure can lead to large differences in the type of health effect produced. For example, silica in one form (amorphous) has little effect on health, and is allowed to be present in the workplace at relatively high levels. After it is heated, however, it turns into another form of silica (crystalline) that causes serious lung damage at levels 200 times lower than amorphous silica.

9. Each of the following is a factor in determining if a chemical is hazardous, EXCEPT ____.
   a. dose
   b. toxicity
   c. duration
   d. selectivity

Routes of Exposure

How Can Chemicals Enter the Body?

Exposure normally occurs through inhalation, skin or eye contact, and ingestion.

**Inhalation:** The most common type of exposure occurs when you breathe a substance into the lungs. The lungs consist of branching airways (called bronchi) with clusters of tiny air sacs (called alveoli) at the ends of the airways. The alveoli absorb oxygen and other chemicals into the bloodstream.

Some chemicals are irritants and cause nose or throat irritation. They may also cause discomfort, coughing, or chest pain when they are inhaled and come into contact with the bronchi (chemical bronchitis). Other chemicals may be inhaled without causing such warning symptoms, but they still can be dangerous.

Sometimes a chemical is present in the air as small particles (dust or mist). Some of these particles, depending on their size, may be deposited in the bronchi and/or alveoli. Many of them may be coughed out, but others may stay in the lungs and may cause lung damage. Some particles may dissolve and be absorbed into the blood stream, and have effects elsewhere in the body.

**Skin Contact:** The skin is a protective barrier that helps keep foreign chemicals out of the body. However, some chemicals can easily pass through the skin and enter the bloodstream. If the skin is cut or cracked, chemicals can penetrate through the skin more easily. Also, some caustic substances, like strong acids and alkalis, can chemically burn the skin. Others can irritate the skin. Many chemicals, particularly organic solvents, dissolve the oils in the skin, leaving it dry, cracked, and susceptible to infection and absorption of other chemicals.
Eye Contact: Some chemicals may burn or irritate the eye. Occasionally they may be absorbed through the eye and enter the bloodstream. The eyes are easily harmed by chemicals, so any eye contact with chemicals should be taken as a serious incident.

Ingestion: The least common source of exposure in the workplace is swallowing chemicals. Chemicals can be ingested if they are left on hands, clothing or beard, or accidentally contaminate food, drinks or cigarettes. Chemicals present in the workplace as dust, for example, metal dusts such as lead or cadmium, are easily ingested.

10. Which of the following is the most common route of exposure?
   a. Injection
   b. Skin contact
   c. Inhalation
   d. Ingestion
Module 2: Biological and Physical Health Hazards

Biological Hazards

Biological hazards 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. Laboratory and medical personnel also can be exposed to biological hazards. Any occupations that result in contact with bodily fluids pose a risk to workers from biological hazards.

In occupations where animals are involved, biological hazards are dealt with by preventing and controlling diseases in the animal population as well as properly caring for and handling infected animals. Also, effective personal hygiene, particularly proper attention to minor cuts and scratches especially on the hands and forearms, helps keep worker risks to a minimum.

In occupations where there is potential exposure to biological hazards, workers should practice proper personal hygiene, particularly hand washing. Hospitals should provide proper ventilation, proper personal protective equipment such as gloves and respirators, adequate infectious waste disposal systems, and appropriate controls including isolation in instances of particularly contagious diseases such as tuberculosis.

1. Biological hazards include all of the following, EXCEPT _____.
   a. radiation
   b. viruses
   c. bacteria
   d. fungi

Biological Agents

Biological agents include bacteria, viruses, fungi, other microorganisms, and their associated toxins. They have the ability to adversely affect human health in a variety of ways, ranging from relatively mild allergic reactions to serious medical conditions, even death. These organisms are widespread in the natural environment; they are found in water, soil, plants, and animals. Because many microbes reproduce rapidly and require minimal resources for survival, they are a potential danger in a wide variety of occupational settings.

This page provides a starting point for technical and regulatory information about some of the most virulent and prevalent biological agents.
**Anthrax:** Anthrax is an acute infectious disease caused by a spore-forming bacterium called *Bacillus anthracis*. It is generally acquired following contact with anthrax-infected animals or anthrax-contaminated animal products.

**Avian Flu:** Avian influenza is a highly contagious disease of birds which is currently epidemic amongst poultry in Asia. Despite the uncertainties, poultry experts agree that immediate culling of infected and exposed birds is the first line of defense for both the protection of human health and the reduction of further losses in the agricultural sector.

**Bloodborne Pathogens and Needlestick Prevention:** OSHA estimates that 5.6 million workers in the health care industry and related occupations are at risk of occupational exposure to bloodborne pathogens, including human immunodeficiency virus (HIV), hepatitis B virus (HBV), hepatitis C virus (HCV), and others.

**Botulism:** Cases of botulism are usually associated with consumption of preserved foods. However, botulinum toxins are currently among the most common compounds explored by terrorists for use as biological weapons.

**Coronavirus Influenza.** Infection with the novel coronavirus, officially named SARS-CoV-2, which causes the Coronavirus Disease 2019 (COVID-19) can cause illness ranging from mild to severe and, in some cases, can be fatal. Most people experience symptoms such as fever (the most common symptom), dry cough, shortness of breath, and general aches and pains.

**Foodborne Disease:** Foodborne illnesses are caused by viruses, bacteria, parasites, toxins, metals, and prions (microscopic protein particles). Symptoms range from mild gastroenteritis to life-threatening neurologic, hepatic, and renal syndromes.

**Hantavirus:** Hantaviruses are transmitted to humans from the dried droppings, urine, or saliva of mice and rats. Animal laboratory workers and persons working in infested buildings are at increased risk to this disease.

2. Which of the following biological agents is usually associated with consumption of preserved foods?

   a. Anthrax
   b. Botulism
   c. Hantavirus
   d. Avian flu
**Legionnaires' Disease:** Legionnaires' disease is a bacterial disease commonly associated with water-based aerosols. It is often the result of poorly maintained air conditioning cooling towers and potable water systems.

**Mold:** Molds produce and release millions of spores small enough to be airborne, water-, or insect-borne which may have negative effects on human health including allergic reactions, asthma, and other respiratory problems.

**Plague:** The World Health Organization reports 1,000 to 3,000 cases of plague every year. A bioterrorist release of plague could result in a rapid spread of the pneumonic form of the disease, which could have devastating consequences.

**Ricin:** Ricin is one of the most toxic and easily produced plant toxins. It has been used in the past as a bioterrorist weapon and remains a serious threat.

**Severe Acute Respiratory Syndrome (SARS):** Severe acute respiratory syndrome (SARS) is an emerging, sometimes fatal, respiratory illness. According to the Centers for Disease Control and Prevention (CDC), the most recent human cases of SARS were reported in China in April 2004 and there is currently no known transmission anywhere in the world.

**Smallpox:** Smallpox is a highly contagious disease unique to humans. It is estimated that no more than 20 percent of the population has any immunity from previous vaccination.

**Tularemia:** Tularemia is also known as "rabbit fever" or "deer fly fever" and is extremely infectious. Relatively few bacteria are required to cause the disease, which is why it is an attractive weapon for use in bioterrorism.

**Viral Hemorrhagic Fevers (VHFs):** Along with smallpox, anthrax, plague, botulism, and tularemia, hemorrhagic fever viruses are among the six agents identified by the Centers for Disease Control and Prevention (CDC) as the most likely to be used as biological weapons. Many VHFs can cause severe, life-threatening disease with high fatality rates.

3. Which of the following is a highly contagious disease unique to humans?

   a. Plague
   b. Ricin
   c. Tularemia
   d. Smallpox
Physical Health Hazards

Physical health hazards that employees face include excessive levels of ionizing and nonionizing electromagnetic radiation, noise, vibration, illumination, and temperature and humidity extremes. Throughout the rest of this module, we'll briefly look at each of the following common types of physical hazards encountered by employees in the workplace. Industrial hygienists routinely analyze workplaces for these hazards and exposures.

**Radiation**: 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.

**Noise**: Noise, another significant physical health hazard, can be controlled by various measures. Noise can be reduced by controlling the noise at the source and by controlling exposure to the noise.

**Temperature and humidity**: Another physical hazard, radiant heat exposure in factories such as steel mills, can be controlled by installing reflective shields and by providing protective clothing.

**Illumination**: Illumination in the workplace is an important consideration. Inadequate or too much illumination in the work area can cause eye strain. Work environments that are too dark can possibly cause injuries from tripping and falling.

**Ergonomics**: More injuries and physical disorders are caused by the hazards associated with poor ergonomics. Strains, sprains, repetitive motion injuries, and musculoskeletal disorders are common in the workplace. Unfortunately, OSHA does not have specific mandatory standards that address proper ergonomics.

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4. Each of the following is a physical health hazard of interest to industrial hygienists, **EXCEPT _____**.

   a. Noise
   b. Ergonomics
   c. Machine guarding
   d. Radiation
Radiation

Ionizing & Non-Ionizing Radiation

Radiation includes a wide range of energies forming the electromagnetic spectrum, which is illustrated on the next page. The energy of the radiation shown on the spectrum increases from left to right as the frequency rises. The spectrum has two major divisions:

- **Non-ionizing radiation**: Radiation that has enough energy to move atoms in a molecule around or cause them to vibrate, but not enough to remove electrons, is referred to as "non-ionizing radiation." Examples of this kind of radiation are sound waves, visible light, and microwaves.

- **Ionizing radiation**: Radiation that falls within the ionizing radiation range has enough energy to remove tightly bound electrons from atoms, thus creating ions. This is the type of radiation that people usually think of as 'radiation.' We take advantage of its properties to generate electric (nuclear) power, to kill cancer cells, and in many manufacturing processes.

Time, Distance, and Shielding

Time, distance, and shielding actions minimize your exposure to radiation in much the same way as they would to protect you against overexposure to the sun:
- **Time**: For people who are exposed to radiation in addition to natural background radiation, limiting or minimizing the exposure time reduces the dose from the radiation source.

- **Distance**: Just as the heat from a fire reduces as you move further away, the dose of radiation decreases dramatically as you increase your distance from the source.

- **Shielding**: Barriers of lead, concrete, or water provide protection from penetrating gamma rays and x-rays. This is why certain radioactive materials are stored under water or in concrete or lead-lined rooms, and why dentists place a lead blanket on patients receiving x-rays of their teeth. Therefore, inserting the proper shield between you and a radiation source will greatly reduce or eliminate the dose you receive.

5. Lead shielding is used by dentists to protect against _____.

   a. free neutrons
   b. beta rays
   c. X-rays
   d. alpha particles

**Noise**

Exposure to high levels of noise can cause permanent hearing loss. Neither surgery nor a hearing aid can help correct this type of hearing loss.

- Short term exposure to loud noise can also cause a temporary change in hearing (your ears may feel stuffed up) or a ringing in your ears (tinnitus).

- Repeated exposures to loud noise can lead to permanent tinnitus and/or hearing loss.

Noise-induced hearing loss limits your ability to hear high frequency sounds, understand speech, and seriously impairs your ability to communicate. Noise may be a problem in your workplace if:

- You hear ringing or humming in your ears when you leave work.

- You have to shout to be heard by a coworker an arm's length away.

- You experience temporary hearing loss when leaving work.
OSHA Requirements

OSHA sets legal limits on noise exposure in the workplace. These limits are based on a worker's time weighted average over an 8-hour day (called a 8-Hour TWA). With noise, OSHA's permissible exposure limit (PEL) is an average of 90 decibels (dBA) for all workers for an 8-hour day.

The OSHA standard uses a 5 dBA exchange rate. This means that when the noise level is increased by 5 dBA, the amount of time a person can be exposed to a certain noise level to receive the same dose is cut in half.

OSHA's requirement to protect all workers in general industry calls for employers to implement a Hearing Conservation Program where workers are exposed to a time weighted average noise level (called the "action level") of 8-Hour TWA of 85 dBA or higher.

Hearing Conservation Programs require employers to measure noise levels, provide free annual hearing exams, free hearing protection, and training.

6. A hearing conservation program is required if exposure to the "action level" of _____ is experienced by employees.
   a. 90 dBA or more
   b. at least 80 dBA
   c. 80 dBA or more
   d. 85 dBA or higher

Reducing Noise Hazards

Noise controls are the first line of defense against excessive noise exposure. The use of these controls should aim to reduce the hazardous exposure to the point where the risk to hearing is eliminated or minimized. With the reduction of even a few decibels, the hazard to hearing is reduced, communication is improved, and noise-related annoyance is reduced. There are several ways to control and reduce worker exposure to noise in a workplace.

**Engineering Controls:** Engineering controls involve modifying or replacing equipment, or making related physical changes at the noise source or along the transmission path to reduce the noise level at the worker's ear. Examples of inexpensive, effective engineering controls include some of the following:

- Choose low-noise tools and machinery.
- Maintain and lubricate machinery and equipment.
- Place a barrier between the noise source and employee.
- Enclose or isolate the noise source.

**Administrative Controls:** These are changes in the workplace that reduce or eliminate worker exposure to noise. Examples include:

- Operating noisy machines during shifts when fewer people are exposed.
- Limiting the amount of time a person spends at a noise source.
- Providing quiet areas where workers can gain relief from hazardous noise sources.
- Restricting worker presence to a suitable distance away from noisy equipment.

**Hearing protection devices (HPDs):** Hearing personal protection equipment (PPE) such as earmuffs and plugs, are considered an acceptable but less desirable option to control exposures to noise. HPDs are generally used during the time necessary to implement engineering or administrative controls, when such controls are not feasible, or when worker’s hearing tests indicate significant hearing damage.

7. Which of the following is an example of an engineering control to reduce the noise level of a machine?

   a. Operate machines when workers are not present
   b. Limit the amount of exposure time
   c. Enclose the machine with sound-absorbing material
   d. Provide a quiet area for workers

**Excessive Heat and Humidity**

As a general rule, office temperature and humidity are matters of human comfort. OSHA has no regulations specifically addressing temperature and humidity in an office setting. However, OSHA recommends removing air contaminants and/or controlling room temperature and humidity. OSHA recommends temperature control in the range of 68-76 degrees Fahrenheit and humidity control in the range of 20%-60%.

Operations involving high air temperatures, radiant heat sources, high humidity, direct physical contact with hot objects, or strenuous physical activities have a high potential for inducing heat stress in employees. These workplaces include: iron and steel foundries, brick-firing and ceramic plants, glass products facilities, electrical utilities (particularly boiler rooms), bakeries, commercial kitchens, laundries, food canneries, chemical plants, mining sites, and smelters.
Outdoor operations conducted in hot weather, such as construction, refining, asbestos removal, and hazardous waste site activities, especially those that require workers to wear semipermeable or impermeable protective clothing, are also likely to cause heat stress among exposed workers.

**Controls**

There are five primary engineering and administrative control methods to control exposure to excessive heat in the workplace:

1. ventilation,
2. air cooling,
3. fans,
4. shielding, and
5. insulation

Heat reduction can also be achieved by using power assists and tools that reduce the physical demands placed on a worker.

**8. OSHA recommends temperature control in the range of _____ Fahrenheit and humidity control in the range of _____.**

- a. 45-66 degrees; 65%-70%
- b. 51-69 degrees; 10%-15%
- c. 68-76 degrees; 20%-60%
- d. 75-82 degrees; 40%-70%

**Illumination**

Inadequate or poor-quality lighting systems can lead to slips, trips, and falls, shocks and burns, and inability to quickly exit a space.

Temporary lights should have guards or be recessed to prevent accidental contact with the bulb. They should be equipped with heavy duty electric cords, not be suspended by electric cords, and they should be equipped with overcurrent protection such as fuses or circuit breakers. In dark areas without temporary lighting available, provide flashlights or light sticks. Make sure workers do not enter dark spaces without suitable portable light.
Ergonomics

The science of ergonomics studies and evaluates a full range of tasks and how they impact the health of the worker. Tasks evaluated include lifting, lowering, pushing, pulling, holding, and twisting. Back injuries are more likely to occur when an employee does any of these tasks while twisting.

Many ergonomic problems result from technological changes such as increased assembly line speeds, adding specialized tasks, and increased repetition; some problems arise from poorly designed job tasks. Any of these conditions can cause ergonomic hazards such as excessive vibration and noise, eye strain, repetitive motion, and heavy lifting problems. Improperly designed tools or work areas also can be ergonomic hazards.

Repetitive Motion

Repetitive motions or repeated shocks over prolonged periods of time as in jobs involving sorting, assembling, and data entry can often cause irritation and inflammation of the tendon sheath of the hands and arms, a condition known as carpal tunnel syndrome.

Repetitiveness is influenced by machine or line pacing, piece work, and unrealistic deadlines. For instance, an experienced worker packing apples (piece work) may complete many more similar exertions or movements than a new worker. Unfortunately, he or she may be performing at such a rapid rate that they may injure themselves over time. However, repetition alone is not an accurate predictor of injury. Other factors like force, posture, duration, and recovery time must also be considered.

9. Back injuries are more likely when an employee _____ while pushing, pulling, lifting, or lowering objects.
   a. moves
   b. twists
   c. reaches
   d. holds

Vibration

Various kinds of tools may cause vibration that could lead to "white finger" or hand-arm vibration syndrome (HAVS). This is especially dangerous when proper damping techniques are not applied, if machines are not maintained, if tools are not alternated, or if a worker uses a vibrating tool for consecutive hours during a workday. Workers need to be trained on the
hazards of working with vibrating tools, and should always allow the tool or machine to do the work.

Controls to help reduce vibration hazards include vibration isolators or damping techniques on equipment, isolating machine vibrations from the work surface, and use of dampening material. Also, make sure rotating shafts are balanced, restrict the duration of exposure, and train workers on the hazards of vibrating parts.

Avoiding Hazards

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.

Overall, industrial hygienists point out that the benefits of a well-designed, ergonomic work environment can include increased efficiency, fewer accidents, lower operating costs, and more effective use of personnel.

10. Which of the following is NOT effective in reducing vibration hazards?

   a. Use dampening material
   b. Balancing rotating shafts
   c. Increasing the frequency by half
   d. Restrict the duration of exposure
Additional Resources

1. American Industrial Hygiene Association (AIHA)
2. OSHA - Heat Stress
3. Napo's Films, Via Storia
4. OSHA-Occupational Noise Exposure
5. EPA-Ionizing and Non-Ionizing Radiation
6. OSHA-Biological Agents
7. OSHA - Health Hazards (see Section III)
8. Ergonomics: The Study of Work, OSHA
9. OSHA - Ventilation