

Study Guide
**Fundamentals of
Industrial Hygiene**

Fifth Edition



NATIONAL SAFETY COUNCIL MISSION STATEMENT

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1

Overview of Industrial Hygiene

Quiz 1 (25 total points)

True/False (7 points)

1. Environmental stress has no effect on the aging process.
 - a. true
 - b. false
2. The first vital component to an effective health and safety program is the commitment of senior management and line management.
 - a. true
 - b. false
3. It is possible that the responsibilities of a safety professional and an industrial hygienist can be found in the same person.
 - a. true
 - b. false
4. In many cases it is extremely difficult to differentiate between the symptoms of occupational and nonoccupational disease.
 - a. true
 - b. false
5. The majority of occupational health hazards arise from living organisms that can cause adverse responses in humans.
 - a. true
 - b. false

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6. Solvent vapors enter the body mainly by skin absorption, although some inhalation can occur.
 - a. true
 - b. false
7. Storage of dangerous chemicals should be limited to one week's supply.
 - a. true
 - b. false

Multiple Choice (8 points)

8. The _____ must draw upon specialized knowledge in the physical and social sciences, including knowledge of engineering, physics, chemistry, statistics, mathematics, and principles of measurement and analysis.
 - a. senior manager
 - b. safety professional
 - c. line manager
 - d. occupational medicine physician
9. The _____ provides the critical link between the employee's health status, the work process, and the determination of employee ability to do the job.
 - a. occupational health nurse
 - b. line manager
 - c. occupational medicine physician
 - d. employee
10. The primary goal of the _____ is to prevent occupational illness and, when illness occurs, to restore employee health within the context of a healthy and safe workplace.
 - a. line manager
 - b. occupational medicine physician
 - c. occupational health nurse
 - d. safety professional
11. Joint labor-management safety and health committees are often used where employees are represented by a _____.
 - a. lawyer
 - b. agent
 - c. union
 - d. senior manager

12. In what year did the Occupational Safety and Health Administration (OSHA) come into official existence?
 - a. 1969
 - b. 1970
 - c. 1971
 - d. 1972

13. What is the principle federal agency engaged in occupational health and safety research?
 - a. Occupational Safety and Health Administration
 - b. National Institute for Occupational Safety and Health
 - c. American Academy of Industrial Hygiene
 - d. American Conference of Governmental Industrial Hygienists

14. _____ are capable of destroying living tissue and have a destructive effect on other substances, particularly on combustible materials.
 - a. Explosives
 - b. Toxic chemicals
 - c. Corrosives
 - d. Oxidizing materials

15. _____ are chemicals that decompose rapidly under certain conditions to yield oxygen.
 - a. Explosives
 - b. Oxidizing materials
 - c. Corrosives
 - d. Dangerous gases

Short Answer (8 points)

16. Define *industrial hygiene*.

17. In late 1994, four major U.S. industrial hygiene organizations gave final endorsements to a revised Code of Ethics for the Practice of Industrial Hygiene. Name these four organizations.

18. Name at least three individuals or groups that should belong to an occupational health and safety team.

Quiz 2 (27 total points)

True/False (7 points)

1. Hazard is the capacity of a material to produce injury or harm when the chemical has reached a sufficient concentration at a certain site in the body.
 - a. true
 - b. false
2. People function efficiently in a very narrow body temperature range, measured on the skin or at body extremities.
 - a. true
 - b. false
3. The body attempts to counteract the effects of high temperature by increasing the heart rate.
 - a. true
 - b. false
4. Allergy is usually a factor in primary irritation dermatitis.
 - a. true
 - b. false
5. Alpha-particles do not penetrate thin barriers such as paper, cellophane, or skin.
 - a. true
 - b. false
6. Broadcast radio waves can produce heating of the body.
 - a. true
 - b. false
7. Sick-building syndrome is a clinically diagnosed disease in one or more building occupants.
 - a. true
 - b. false

Multiple Choice (8 points)

8. According to the Hearing Conservation Amendment, in all cases when the sound levels exceed _____ dBA on an eight-hour time-weighted average, a continuing, effective hearing conservation program shall be administered.
 - a. 75
 - b. 80
 - c. 85
 - d. 90

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9. Humidity, or the moisture content of the air, is generally measured with a _____.
 - a. dry bulb thermometer.
 - b. psychrometer.
 - c. barometer.
 - d. odometer.

10. _____ is an important mechanism for increasing body temperature by causing metabolic heat production to increase to several times the resting rate.
 - a. Shivering
 - b. Conduction
 - c. Vasoconstriction
 - d. Sweating

11. Of the following types of radioactivity, which is not used in ordinary manufacturing operations?
 - a. alpha
 - b. beta
 - c. neutron
 - d. x ray

12. A barrier such as concrete or lead is required to stop _____.
 - a. beta-radiation.
 - b. alpha particles.
 - c. x rays.
 - d. none of the above.

13. Which device measures accumulated amounts of radiation?
 - a. dosimeter
 - b. psychrometer
 - c. Geiger-Mueller meter
 - d. ionization chamber-type instrument

14. _____ are the volatile form of substances that are normally in the solid or liquid state at room temperature and pressure.
 - a. Fumes
 - b. Vapors
 - c. Mists
 - d. Gases

15. When sampling air, where should the sample be taken from?
- ground level
 - near entryways
 - breathing zone
 - warmest area

Short Answer (9 points)

16. What are the typical functions of a safety and health committee?
17. The degree of hazard is determined by many factors or elements. What are the key elements to be considered when evaluating a health hazard?
18. What are the effects of noise on the human body?
19. What factors influence the effect of noise exposure?
20. What are the signs of heat exhaustion?
21. Radioactive materials can be hazardous in two different ways. Name and describe these ways.
22. What are the most common strong producers of ultraviolet radiation in industry? What is the overall most common exposure?
23. What is *barotrauma*?

24. What organs form the respiratory system? What are the main respiratory hazards?

Short Essay (3 points)

25. The eye is the organ that is most vulnerable to injury by laser energy. What factors affect the degree of eye injury induced by laser light? Name at least four.

26. The injuries resulting from manual handling of objects and materials make up a large proportion of all compensable injuries. This problem is of concern to the safety and health professional and represents an area where biomechanical data relating to lifting and carrying can be applied in the work layout and design of jobs that require handling of materials. Data concerning lifting can be classified into three major categories. Name each of these categories and include two variables for each category.

27. There is a basic, systematic procedure for recognizing and evaluating environmental health hazards. Name at least five questions that you should ask.

Case Study

(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

World Trade, Inc. has decided to hire an independent industrial hygienist to help them get ready for their upcoming inspection with OSHA. Rather than simply choose someone at random from the phone book, management has decided to interview several candidates for the assignment. Professional ethics are one of their greatest concerns, and they wanted to find someone who was affiliated with one of the four major U.S. industrial hygiene organizations.

1. What are the four major U.S. industrial hygiene organizations?

It is also important to World Trade, Inc. that the selected candidate be familiar with and adhere to the Canons of Ethical Conduct.

2. Briefly stated, what are these canons?

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World Trade, Inc. was particularly impressed with Christina Mentes, a young industrial hygiene professional from Tennessee. During the course of her work, Ms. Mentes will compile a list of environmental stress factors that can cause sickness, impaired health, or significant discomfort in workers.

3. What are the general classifications for such hazards?

4. How would Ms. Mentes make use of MSDSs?

There are approximately 200 biological agents, such as infectious microorganisms, biological allergens, and toxins, that are known to produce infections or allergenic, toxic, or carcinogenic reactions in workers. Ms. Mentel would like the working population of World Trade, Inc. to be better educated as to the use of toxic substances. In particular, she would like them to be better aware of the route of entry for toxic substances.

5. Describe these routes.

2

The Lungs

Quiz 1 (20 points total)

True/False (5 points)

1. The nose serves only as a passageway for air going to and from the lungs.
 - a. true
 - b. false
2. Breathing is controlled by a series of respiratory centers in the nervous system.
 - a. true
 - b. false
3. The two lungs are mirror images of each other.
 - a. true
 - b. false
4. An emphysema patient can breathe in, but cannot breathe out efficiently.
 - a. true
 - b. false
5. The common term for trachea is throat.
 - a. true
 - b. false

Multiple Choice (5 points)

6. What are the vocal cords?
 - a. rings of cartilage
 - b. muscles
 - c. folds of membranes
 - d. ligaments

7. Approximately how many air sacs, or alveoli, does the human respiratory tract have?
 - a. 300 million
 - b. 150 million
 - c. 75 million
 - d. 20 million

8. How many pairs of ribs does the human body have?
 - a. 7
 - b. 10
 - c. 12
 - d. 13

9. What are the last two pairs of ribs called?
 - a. Adam's ribs
 - b. floating ribs
 - c. diaphragmatic ribs
 - d. sternal ribs

10. What is the common term for pharynx?
 - a. throat
 - b. voice box
 - c. mouth
 - d. tonsils

Short Answer (7 points)

11. What are the six parts of the body that make up the respiratory system?

12. How are sounds and speech created?

20. Describe the nose and its purpose.

Quiz 2 (20 points total)

True/False (5 points)

1. The organ of voice is the larynx.
 - a. true
 - b. false

2. Only the skin has a more extensive and intimate contact with the ambient atmosphere than do the lungs.
 - a. true
 - b. false

3. Significant impairment of respiratory function can exist even though the patient can perform the tests of ventilatory function normally.
 - a. true
 - b. false

4. Constriction of the bronchial tube muscles in response to irritation, allergy, or other stimulus is called rhinitis.
 - a. true
 - b. false

5. Carbon monoxide is a toxic gas that is transferred from the lungs into the bloodstream but does not damage the lungs.
 - a. true
 - b. false

Multiple Choice (4 points)

6. What is the structure that guards the opening of the trachea?
- a. septum
 - b. cilia
 - c. pharynx
 - d. epiglottis
7. What are the anterior nares?
- a. nerve filaments for smell
 - b. the nostrils
 - c. a double membrane covering the lungs
 - d. the opening of the trachea
8. What does *spirometry* mean?
- a. measurement of carbon dioxide in tissues
 - b. rate of respiration during exertion
 - c. pressure equalization across a permeable membrane
 - d. measurement of air, i.e., the ventilatory capacity of the lungs
9. What is the typical vital capacity of the lungs?
- a. 4-5 liters
 - b. 3-4 liters
 - c. 2-3 liters
 - d. 1-2 liters

Short Answer (9 points)

10. What are the two passageways at the bottom of the throat?
11. What are cilia?
12. How many lobes do the lungs have?
13. What are two diseases that are associated with an obstructive ventilatory defect?

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14. Why are fine aerosols potentially more harmful than larger aerosols?

15. What happens to fine particles that do reach the alveolar sacs?

16. On what is the classification of respiratory impairment based?

17. How is vital lung capacity measured?

18. What are two common forms of pneumoconiosis?

Short Essay (2 points)

19. Explain the basic difference between obstructive and restrictive ventilatory defects.

20. What are the three general categories of inhaled contaminants and what hazard does each category present?

Overhead 2-1.

The Respiration Process

The term *respiration* refers to the tissue enzyme oxidation processes that use oxygen and produce carbon dioxide. More generally, this term designates the phases of oxygen supply and carbon dioxide removal. The following are the general subdivisions of the overall process:

- breathing—movement of chest/lung complex to ventilate the alveoli
- external respiration—exchange of gas (oxygen and carbon dioxide) between lung (alveolar) air and blood
- internal respiration—exchange of gas between tissue blood and the tissue cells
- intracellular respiration—ultimate utilization of oxygen by the cells with the coincident release of carbon dioxide

Overhead 2-2.

Lung Volumes

The four primary lung volumes that do not overlap are as follows:

1. tidal volume (TV)—the volume of gas inspired or expired during each respiratory cycle
2. inspiratory reserve volume (IRV)—the maximal volume that can be forcibly inspired following a normal inspiration (from the end-inspiratory position)
3. expiratory reserve volume (ERV)—the maximum amount of air that can be forcibly expired following a normal expiration
4. residual volume (RV)—the amount of air remaining in the lungs following a maximum expiratory effort

3

The Skin and Occupational Dermatoses

Quiz 1 (24 total points)

True/False (5 points)

1. When it is injured, the epidermis can form new tissue, a scar, to repair itself.
 - a. true
 - b. false
2. Ulcerations are the most frequent causes of occupational skin disease.
 - a. true
 - b. false
3. The skin is the largest organ of the body.
 - a. true
 - b. false
4. Chloracne can be accompanied by systemic toxicity and is often resistant to therapy.
 - a. true
 - b. false
5. For workers to keep their skin reasonably free of injurious agents, they must use washing facilities at least three times a day, before lunch, after lunch, and before leaving the facility.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Where is the epidermis the thickest?
 - a. on the eyelids
 - b. on the scalp
 - c. on the soles of the feet
 - d. on the elbows

7. Which industry group has the highest incidence of occupational dermatoses?
 - a. services
 - b. manufacturing
 - c. construction
 - d. agriculture

8. Which of the following can sensitize the skin to light?
 - a. coal tar
 - b. poison ivy
 - c. chromic acid
 - d. nickel

9. When absorbed through the skin, which of the following can cause central nervous system depression?
 - a. aniline
 - b. carbon tetrachloride
 - c. carbon disulfide
 - d. halogenated naphthalenes

10. Which of the following helps to prevent contact with acids, alkalis, and some types of metallic acids?
 - a. solvent-repellent cream
 - b. water-repellent cream
 - c. vanishing cream
 - d. none of the above

11. Which of the following is *not* a basic requirement of industrial skin cleansers?
 - a. They should flow easily through dispensers.
 - b. They should be adequately protected against microbial contamination.
 - c. They should not harmfully dehydrate the skin.
 - d. They should be relatively abrasive in order to quickly remove industrial soil.

Short Answer (7 points)

12. How do fats and oil solvents affect the skin?

13. _____ and _____ serve as routes for the percutaneous absorption of such drugs as nicotine, nitroglycerine, estrogen, and scopolamine.

14. Which of three types of contact urticaria is the most common?

15. What are the skin's two lines of defense against sunlight?

16. Characterize a hydrofluoric acid burn.

17. Temperatures _____ than room temperature decrease the breakthrough time of chemicals.

18. Categories of glove standards depend on three factors. What are these factors?

Short Essay (6 points)

19. What factors affect the incidence of allergic contact dermatitis and what is a key difference between irritation and allergic contact dermatitis? What are some exceptions to this rule?

20. The routine use of preplacement patch tests to determine sensitivity to various materials is not recommended. Why?

Quiz 2 (24 total points)

True/False (5 points)

1. For some people, contact with natural rubber latex can result in generalized urticaria, angioedema, asthma, vascular collapse, and even death.
 - a. true
 - b. false
2. Most of the body's 2 to 3 million sweat glands are concentrated on the forehead and neck.
 - a. true
 - b. false
3. Detergents are classified as strong, or absolute, primary skin irritants.
 - a. true
 - b. false
4. Anthrax can produce granulomas, or chronic, indolent areas of inflammation that can be localized or generalized.
 - a. true
 - b. false
5. Most workers' compensation claims for occupational skin diseases involve temporary total or permanent partial disability.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Skin is the chief rate-limiting barrier against ____
 - a. organic solvents.
 - b. alkalis.
 - c. gases.
 - d. aqueous solutions.

7. The highest percentage of dermatological injuries is due to ____
 - a. nonchemical burns.
 - b. lacerations and punctures.
 - c. abrasions.
 - d. cold injuries.

8. What percentage of occupational dermatoses are caused by primary irritants?
 - a. 90 percent
 - b. 80 percent
 - c. 70 percent
 - d. 60 percent

9. Which of the following types of ionizing radiation cannot injure the skin?
 - a. alpha-radiation
 - b. beta-radiation
 - c. gamma-radiation
 - d. none of the above

10. Which of the following classes of skin disorders implies intermittent confinement at home or at another domicile?
 - a. Class 2
 - b. Class 3
 - c. Class 4
 - d. Class 5

11. A ____ burn is almost always deep and often extensive, with the type of clothing being a major factor in severity.
 - a. flame
 - b. steam
 - c. molten-metal
 - d. hot-solid

Short Answer (7 points)

12. Is body heat lost when we perspire or when sweat evaporates?

13. Most of the causes of occupational skin diseases can be classified under five broad headings. What are these headings?

14. _____ and _____ are the two types of photosensitivity that are generally recognized.

15. What are the two main types of glands found in the dermis?

16. What is the primary function of environmental control measures in preventing occupational dermatitis?

17. When evaluating glove performance, what are four important chemical parameters that should be considered?

18. Clothing worn on the job should not be worn at home. Why?

Short Essay (6 points)

19. What are some of the complications of extensive burns?

20. What are the classifications of dermatologic reactions to gloves?

Case Study

(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

For the first time in nearly two decades, Healthy Meals Inc. has seen a serious outbreak of occupational skin disease, including miliaria, among its workers. Industrial hygienists at the company are reviewing the situation and trying to understand the reasons for the sudden change. Healthy Meals has been in the food processing industry for more than fifty years and has over two hundred employees. Recently the company has had to hire younger workers with less experience, including several bakers and laboratory technicians, after some of its long-time employees decided to retire. The company's Florida location makes it attractive to workers of all ages, so it did not have any problems recruiting new staff. The location also allows Healthy Meals to benefit from the state's agricultural resources. Inside the plant, equipment and other work surfaces are cleaned on a routine basis and there are plenty of washbasins available to workers.

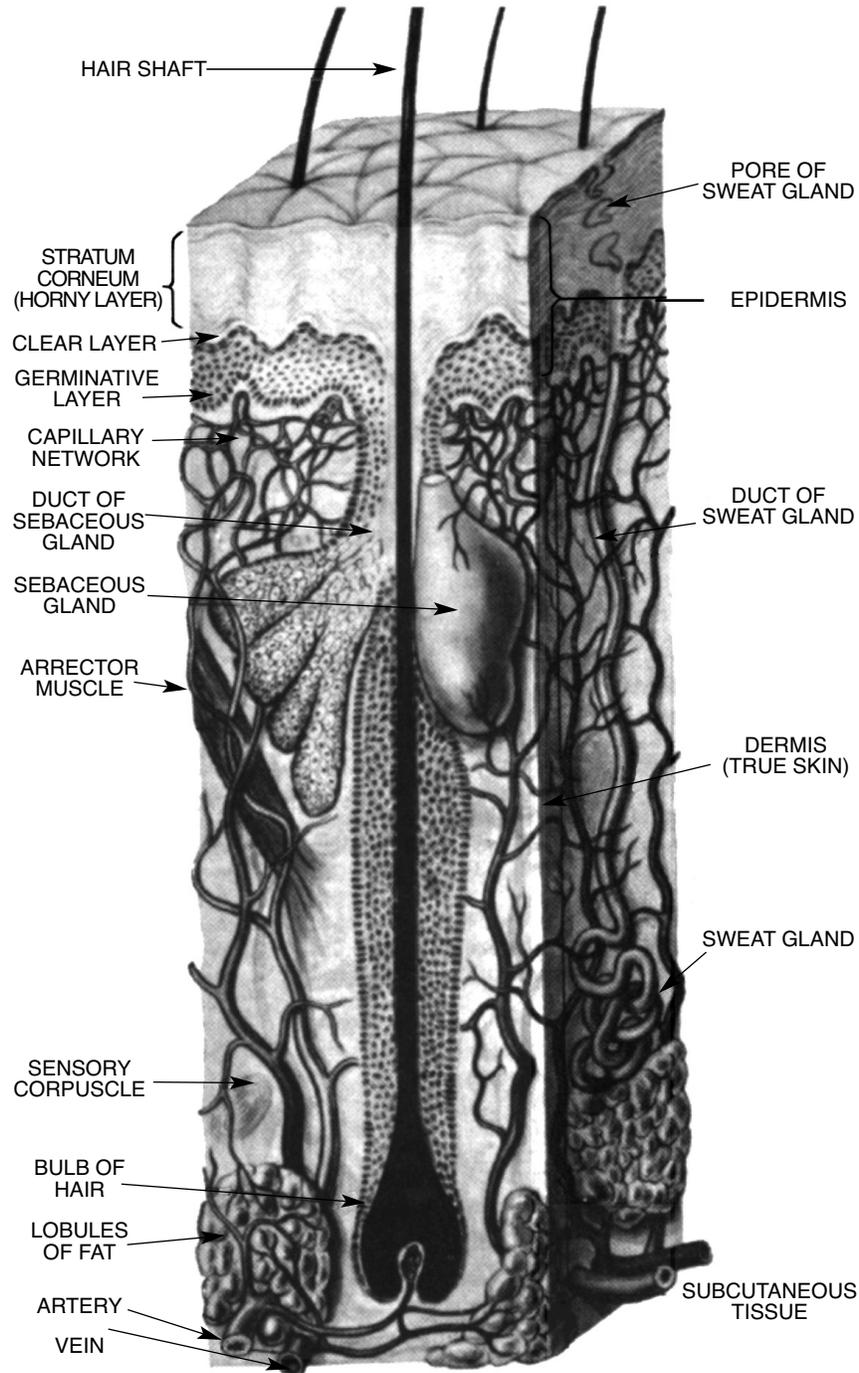
Given this information, the team of industrial hygienists needs to explain to management why so many workers are suffering from skin diseases.

1. Is it possible that predisposing factors are involved?

2. What is miliaria?

3. How does the incidence of skin disease at Healthy Meals compare to other industries?

Overhead 3-1. Magnified Cross Section of the Skin



(Reprinted with the permission of the AMA. *Today's Health Guide*. Chicago: AMA, 1965.)

Overhead 3-2.

Numbers and Incidence of Occupational Skin Diseases by Major Industry, 1997

Table 3–C. Numbers and Incidence of Occupational Skin Diseases by Major Industry, 1997

<i>Industry</i>	<i>No. of Cases</i>	<i>Incidence*</i>
Agriculture/forestry/fishing	3,000	226
Manufacturing	26,000	139
Services	15,600	61
Transportation/utilities	3,200	52
Mining	300	51
Construction	1,800	35
Wholesale/retail trade	7,600	34
Finance/insurance/real estate	500	7
Total	57,900	67

Source: Bureau of Labor Statistics (BLS): Occupational Injuries and Illnesses in the United States 1997. U.S. Department of Labor, BLS Bulletin 2518, October 1999.

* Per 100,000 full-time workers per year.

Overhead 3-3.

Predisposing Factors for Occupational Dermatoses

- age and experience
- skin type
- sweating
- gender
- seasons and humidity
- hereditary allergy
- personal hygiene
- preexisting skin disease

4

The Ears

Quiz 1 (22 total points)

True/False (7 points)

1. The auricle is the most visible part of the ear.
 - a. true
 - b. false
2. The ossicles are the smallest bones in the body.
 - a. true
 - b. false
3. The cochlea serves to equalize pressure on either side of the tympanic membrane.
 - a. true
 - b. false
4. The pinna is especially susceptible to frostbite and sunburn.
 - a. true
 - b. false
5. Infections localized to the eardrum are very common.
 - a. true
 - b. false
6. Otosclerosis is a prime example of fixation.
 - a. true
 - b. false

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7. There is no medical cure for sensorineural deafness.
- true
 - false

Multiple Choice (6 points)

8. The _____ collects sound waves from the air and funnels them into the ear canal to the tympanic membrane.
- auricle
 - eardrum
 - ear canal
 - external auditory canal
9. What is another name for the external auditory canal?
- pinna
 - meatus
 - vibrissae
 - Eustachian tube
10. What is the name for the waxy substance secreted by the ceruminous glands?
- vibrissae
 - pinna
 - cerumen
 - malleus
11. The ossicles connect the eardrum to an opening in the wall of the inner ear called the _____
- Fenestra Rotundum.
 - Fenestra Vestibuli.
 - semicircular canals.
 - cochlea.
12. The eardrum is shaped like a _____
- child's toy drum.
 - snail.
 - spider web.
 - anvil.
13. Our sense of balance is dependent on the _____
- cochlea.
 - vestibular system.
 - perilymph.
 - organ of Corti.

Short Answer (8 points)

14. What three items make up the ossicular chain?

15. Why is the ear canal prone to infection? What are some common problems?

16. What should you do if a live insect enters the ear canal?

17. Why should you avoid the use of cotton-tipped swabs?

18. What are some common causes for perforation or rupture of the tympanic membrane? Can these perforations be repaired?

19. What can cause obstruction of the Eustachian tubes? What happens when the Eustachian tubes cannot ventilate properly?

20. How would disease of the ossicles impair hearing?

21. When should an individual be referred to a physician for further medical evaluation of hearing loss?

Short Essay (1 point)

22. Briefly describe the process of how the ear hears and interprets sound.

Quiz 2 (21 total points)

True/False (6 points)

1. The measurement of hearing is done using an odometer.
 - a. true
 - b. false
2. The threshold of hearing is the very softest level at which a person is able to hear.
 - a. true
 - b. false
3. Noise exposure has no effect on pregnant women.
 - a. true
 - b. false
4. Vowel sounds are located in the upper frequencies and are the more powerful speech sounds.
 - a. true
 - b. false
5. Most ambient noise is low frequency.
 - a. true
 - b. false
6. Most noise-induced hearing loss occurs rapidly.
 - a. true
 - b. false

Multiple Choice (6 points)

7. A steady loss of hearing acuity occurs as we grow older. The normal young ear can hear tones within a range of 20 Hz up to high-pitched sounds of _____.
 - a. 12,000 Hz
 - b. 20,000 Hz
 - c. 26,000 Hz
 - d. 30,000 Hz

8. Millions of workers in the United States are exposed to significant levels of noise on the job. For this reason OSHA has required formal hearing conservation programs for most employees exposed above the Action Level. What is the current Action level for an eight-hour workday?
- 75 dBA
 - 80 dBA
 - 85 dBA
 - 90 dBA
9. Sensorineural hearing loss is the hearing difficulty caused by ____ ear damage.
- outer
 - middle
 - inner
 - Both A and B
10. Conductive hearing loss is hearing loss that arises from conditions affecting the ____ ear.
- outer
 - middle
 - inner
 - Both A and B
11. The ____ filter out particular matter and other large pieces of debris.
- cerumen
 - cartilaginous meatus
 - vibrissae
 - pinna
12. The eardrum has about ____ times as much surface area as the oval window.
- 2
 - 10
 - 15
 - 25

Short Answer (8 points)

13. What is stenosis and what are the causes of this condition?

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14. What are some of the ailments that can affect the delicate cochlea, semicircular canals, and eighth cranial nerve of the inner ear? Name at least three. Also give at least one specific example of workplace factors that can affect hearing.

15. What is Ménière's disease? What causes it? Describe some of the characteristics of this disorder.

16. What is acoustic neuroma? How would it affect the decision to hire an employee?

17. What are the two types of tinnitus?

18. What is an audiogram?

19. What are the factors that determine the duration and severity of noise-induced hearing loss?

20. What are some of the nonauditory effects of noise?

Short Essay (1 point)

21. Describe how to test hearing using the air conduction method and the bone conduction method.

Case Study

(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

You have been hired by Calhoun Industrial Plastics to conduct routine hearing exams of the entire plant staff. Mr. Sachdev, an assembly line worker, is your first patient. Although he wears earplugs while on the job, he complains of hearing loss. His medical records indicate he is 54, so you say to him that a steady loss of hearing acuity often occurs as we age. “But we will check your ears anyway, in case there is a problem.”

1. What are the possible reasons, both pathological and environmental, that may be causing Mr. Sachdev to experience loss of hearing? Come up with as complete a list as possible.

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“There are a few methods commonly used to check hearing,” you tell Mr. Sachdev. “There’s a bone conduction test and an air conduction test.”

2. Describe how each of these tests work. Which method will you most likely use on Mr. Sachdev?

As it turns out, Mr. Sachdev does have some hearing loss, most likely caused by exposure to noise.

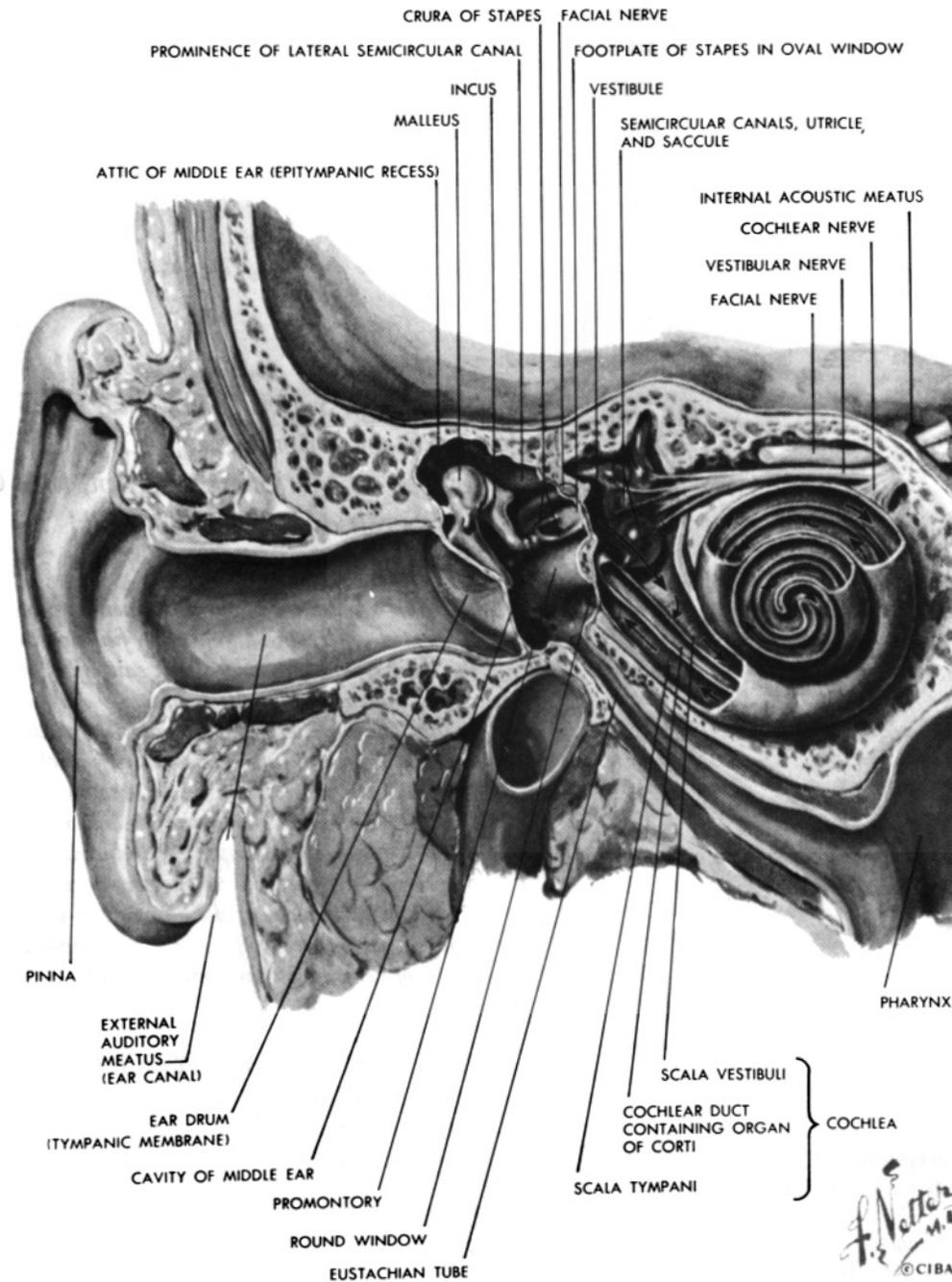
3. What are the factors that determine the duration and severity of noise-induced hearing loss?

Mr. Sachdev has many questions for you about how the ear works, and you decide that it would be beneficial to educate the employees on the hearing process. When you are done seeing patients, you arrange with management to hold a hearing clinic for any interested parties.

4. How would you explain the hearing process to your class?

Overhead 4-1.

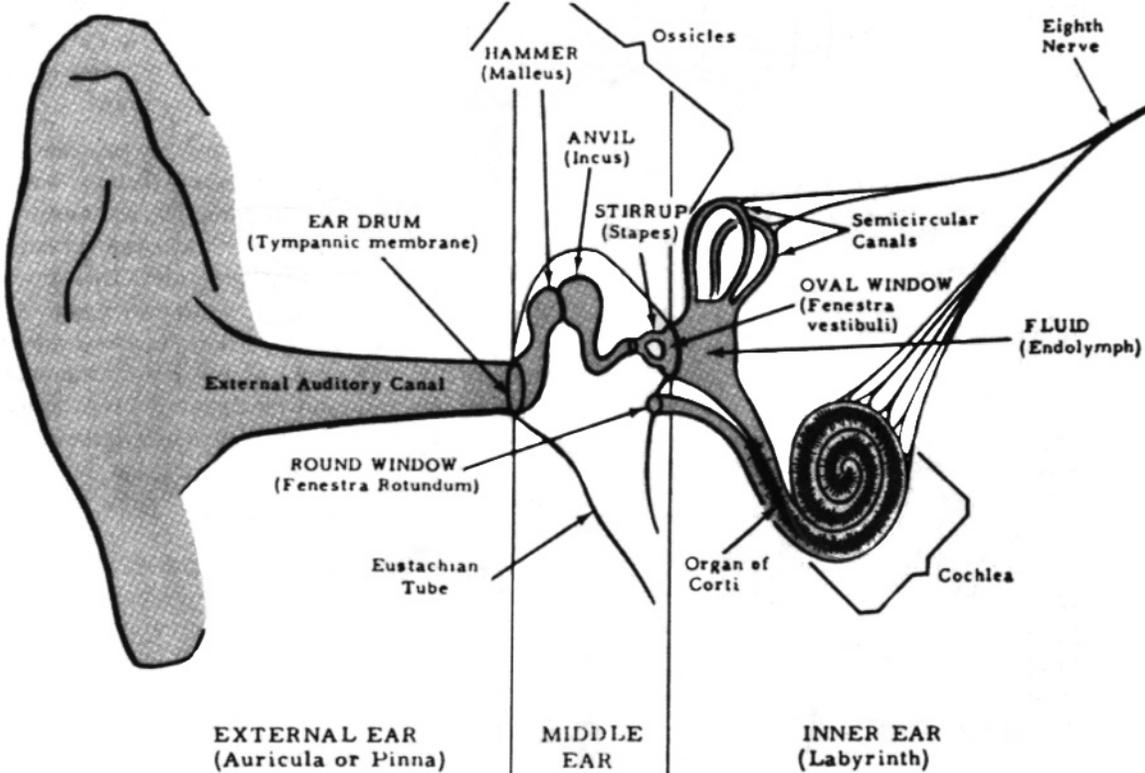
The Outer, Inner, and Middle Ear



(Reprinted with permission from Netter FH, *Clinical Symposia*. CIBA Pharmaceuticals Co.)

Overhead 4-2.

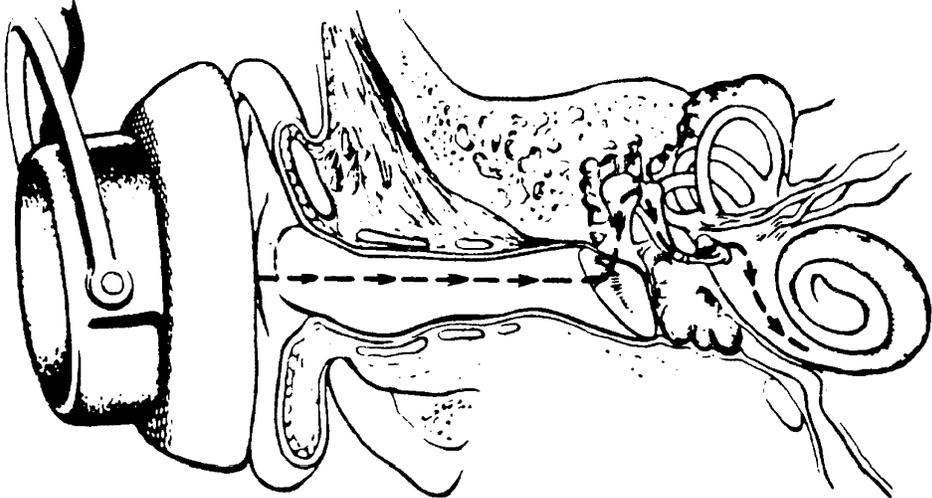
How the Ear Hears



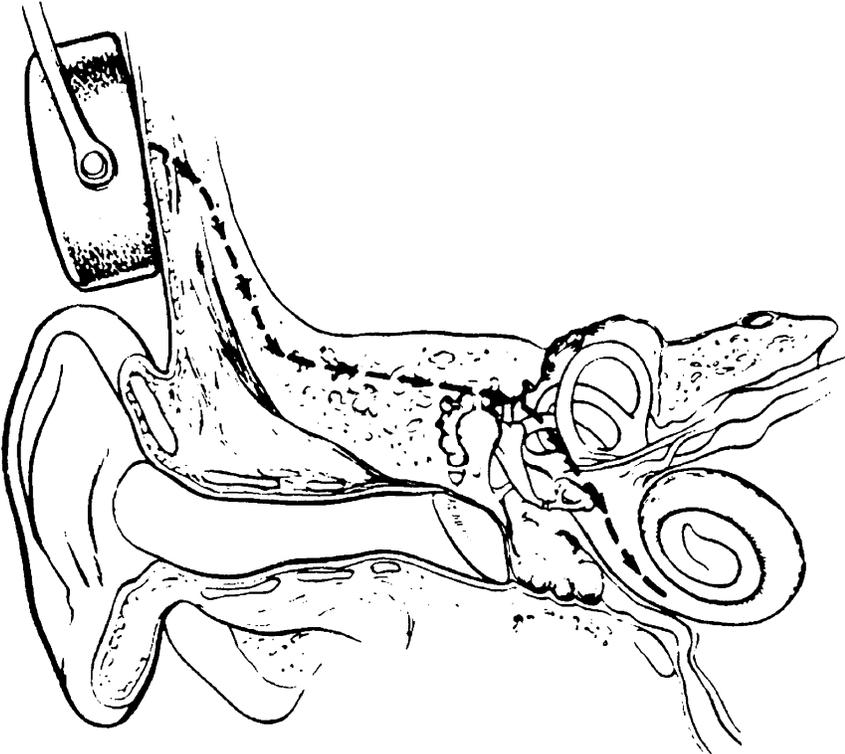
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Overhead 4-3.

An Air-Conduction Earphone



A Bone-Conduction Vibrator



5

The Eyes

Quiz 1 (22 points total)

True/False (6 points)

1. The lacrimal gland secretes an oil to lubricate the eyelids.
 - a. true
 - b. false
2. Rods are more sensitive to light than cones.
 - a. true
 - b. false
3. Opticians prescribe eyeglasses and contact lenses.
 - a. true
 - b. false
4. Presbyopia develops when the human lens loses its elasticity.
 - a. true
 - b. false
5. Pink eye is an inherited form of color blindness.
 - a. true
 - b. false
6. Cigarette smoking increases the risk of developing glaucoma.
 - a. true
 - b. false

Multiple Choice (7 points)

7. What is the common term for the sclera?
 - a. lower lid
 - b. white of the eye
 - c. tear gland
 - d. eyelashes

8. What is the circular aperture that is formed by the iris?
 - a. pupil
 - b. retina
 - c. cornea
 - d. lens

9. Approximately how many rods and cones does each eye have?
 - a. 6 million rods and 120 million cones
 - b. 60 million rods and 12 million cones
 - c. 12 million rods and 60 million cones
 - d. 120 million rods and 6 million cones

10. What instrument is used to measure the pressure in the eyeball?
 - a. tonometer
 - b. slit-lamp microscope
 - c. phoropter
 - d. ophthalmoscope

11. What is the estimated percentage of the American population that wears glasses?
 - a. 10 percent
 - b. 20 percent
 - c. 30 percent
 - d. 40 percent

12. What is the common term for hyperopia?
 - a. nearsightedness
 - b. farsightedness
 - c. tunnel vision
 - d. cataract

13. What is the most common form of glaucoma?
 - a. acute-angle closure glaucoma
 - b. chronic closed-angle glaucoma
 - c. primary open-angle glaucoma
 - d. idiopathic glaucoma

Short Answer (7 points)

14. What are the three layers of tissue surrounding the internal structures of the eyeball?

15. What is the function of the tarsal glands?

16. What is the choroid?

17. What do the ciliary muscles do?

18. Name the two types of light-sensitive cells in the retina.

19. How does the American Academy of Ophthalmology define an ophthalmologist?

20. What is a phoropter?

Short Essay (2 points)

21. What is stereoscopic vision?

22. What is astigmatism?

Quiz 2 (21 points total)

True/False (5 points)

1. Optometrists are permitted to provide treatment for ocular diseases.
 - a. true
 - b. false
2. Pain can be relied on to alert a worker that there is a foreign body in his or her eye.
 - a. true
 - b. false
3. Harmful exposures to ultraviolet light usually occur in welding operations.
 - a. true
 - b. false
4. Caustic burns are much more injurious to the eyes than acids.
 - a. true
 - b. false
5. Use of water substitutes, such as neutralizing solutions or boric acid solutions, in eyewash fountains is encouraged.
 - a. true
 - b. false

Multiple Choice (4 points)

6. What is the most common industrial test for distance acuity?
 - a. visual field test
 - b. refractive correction
 - c. the Snellen chart
 - d. a tonometer reading

Overhead 5-1.

Steps in a Vision Conservation Program

There are four steps in a vision conservation program:

1. environmental survey
2. vision-screening program
3. remedial program
4. professional fitting and follow-up procedures

Overhead 5-2.

Guidelines for a Vision Conservation Program

1. Make it a 100 percent program; include everyone.
2. Make certain that safety eyewear is properly fitted.
3. Include eye-care stations for first aid and for cleaning lenses.
4. Control eye hazards at the source.
5. Make sure all areas have adequate lighting, are free from glare, and are painted in colors that emphasize depth perception and highlight potential hazards.
6. Post signs such as “All Personnel and Visitors Must Wear Protective Eyewear” in all hazardous areas.
7. All employees should be given preplacement eye examinations, and periodic follow-up examinations should be scheduled.

6

Industrial Toxicology

Quiz 1 (24 total points)

True/False (5 points)

1. A toxic effect is any irreversible harmful effect on the body as a result of contact with a substance via the respiratory tract, skin, eye, mouth, or other route.
 - a. true
 - b. false
2. A good example of a substance that has unique effects on multiple organs is organic lead.
 - a. true
 - b. false
3. Lethal concentration is usually expressed as milligrams per kilogram or ppm.
 - a. true
 - b. false
4. The response to a new chemical can be assumed to be analogous to that produced by contact with a substance having a similar chemical and biological structure.
 - a. true
 - b. false
5. One of the shortcomings of air standards is the difficulty in acquiring a truly representative breathing zone sample.
 - a. true
 - b. false

Multiple Choice (6 points)

6. The health effect of a chemical exposure is considered “acute” if it ____
 - a. appears within a week of exposure.
 - b. is relatively short-lived.
 - c. recurs periodically.
 - d. is irreversible.

7. The total amount of a toxic compound absorbed via respiratory pathways depends on ____
 - a. its concentration in the air.
 - b. pulmonary ventilation volumes.
 - c. the duration of exposure.
 - d. all of the above.

8. Which of the following is considered a central nervous system depressant?
 - a. chlorofluorocarbon refrigerants
 - b. lead
 - c. styrene
 - d. acetone

9. In addition to providing the EPA with test data and other information about the safety of a new chemical, a company is required to notify the EPA ____ before starting to manufacture the chemical.
 - a. 30 days
 - b. 60 days
 - c. 90 days
 - d. 120 days

10. According to the ACGIH’s rating system for carcinogenic substances, a substance with a rating of A4 is ____
 - a. a confirmed animal carcinogen with unknown relevance to humans.
 - b. a suspected human carcinogen.
 - c. not classifiable as a human carcinogen.
 - d. not suspected as a human carcinogen.

11. Which of the following may be detected using either a urine sample or a blood sample?
 - a. zinc
 - b. ethyl benzene
 - c. nickel
 - d. acetone

Short Answer (7 points)

12. The cutaneous absorption rate of some organic chemicals increases when _____ and _____ increase.

13. The dose-response relationship can be expressed as the product of two variables. What are these variables?

14. What is hypersusceptibility?

15. According to NIOSH, when should a substance be considered a suspected carcinogen to humans?

16. If epidemiological data and cases of human exposure are not available for study, what is the preferred method for determining TLVs®?

17. Rates of _____, _____, and _____ determine when it is most appropriate to analyze biological samples in relation to duration and time of exposure.

18. What types of samples are used to determine Biological Exposure Indices®?

Short Essay (6 points)

19. What do toxicologists feel is the difference between *toxicity* and *hazard*?

20. Compare and contrast teratogens and mutagens.

Quiz 2 (24 total points)

True/False (5 points)

1. A toxic substance can enter the body by more than one route depending on its specific properties.
 - a. true
 - b. false
2. Although all substances produce harmful effects at some dose, a toxic substance causes harmful effects at low doses.
 - a. true
 - b. false
3. Irritation from airborne contaminants is generally reversible after short-term exposure.
 - a. true
 - b. false
4. Animal testing is an accurate and easy means of measuring the toxicity of a chemical for humans and determining acceptable Threshold Limit Values[®].
 - a. true
 - b. false
5. If a substance is not included on the Toxic Substances List, the substance is not toxic.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Which of the following factors can be used to determine the degree of hazard of a toxic substance?
 - a. route of entry
 - b. environmental variables
 - c. physiological state
 - d. all of the above

7. Prolonged exposure is typically defined as ____
 - a. less than 24 hours.
 - b. 5 to 7 days.
 - c. 2, 4, or 6 weeks.
 - d. 3 months.

8. Which of the following is *not* a simple asphyxiant?
 - a. methane
 - b. carbon monoxide
 - c. hydrogen
 - d. nitrogen

9. Which of the following types of human epidemiological data identifies a change in prevalence of a disease in a subgroup of a population?
 - a. descriptive
 - b. prospective
 - c. illustrative
 - d. retrospective

10. Air monitoring measures ____
 - a. the amount of a chemical that has been absorbed via the lungs.
 - b. the composition of the external environment surrounding the worker.
 - c. the effects of increased work load resulting in increased air intake of the contaminant.
 - d. the total exposure, both on and off the job, to harmful substances.

11. Which of the following is true of irritation and irritants?
 - a. The degree of local irritation of many liquid irritants is related to their systemic toxicities.
 - b. A primary irritant exerts extensive systemic toxic action.
 - c. Most frequently irritation results from a direct mechanical reaction with constituents in the tissue.
 - d. Irritants are often grouped according to their site of action.

Short Answer (7 points)

12. The toxicity of a chemical depends on ____.

13. If the skin comes in contact with a toxic substance, one of four possible actions will result. What are these four actions?

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3. What are some ways in which biological samples can be analyzed?

Overhead 6-1.

Common Routes of Entry into the Body for Toxic Substances

- inhalation
- skin absorption
- ingestion
- injection

Overhead 6-2.

Federal Regulations Covering Industrial Toxicology

- Occupational Safety and Health Act (OSHAct)
- Toxic Substances Control Act (TSCA)
- NIOSH/OSHA Standards

Other Important Standards

- The Toxic Substances List (a requirement of the OSHAct)
- ACGIH Threshold Limit Values (TLVs®) (voluntary professional guides)

7

Gases, Vapors, and Solvents

Quiz 1 (21 total points)

True/False (6 points)

1. Solvents are good for cleaning materials, but should not be used to transport solutes.
 - a. true
 - b. false
2. In general, there is a high potential hazard for inhaling vapors from aqueous solutions.
 - a. true
 - b. false
3. Water is a highly polar solvent.
 - a. true
 - b. false
4. In the United States, TLVs[®] have been adopted as a legal standard.
 - a. true
 - b. false
5. Benzene is now indicated as a leukemogenic agent, which has greatly increased its use as a solvent.
 - a. true
 - b. false
6. All alcohols are formed by the replacement of one or more hydrogen atoms by one or more hydroxyl groups.
 - a. true
 - b. false

Multiple Choice (6 points)

7. A _____ is a formless fluid that completely fills its container and that exerts an equal pressure in all directions.
 - a. vapor
 - b. gas
 - c. liquid
 - d. solvent

8. Vapor pressure is highly dependent on _____.
 - a. temperature.
 - b. surface area.
 - c. evaporation.
 - d. solubility.

9. Compounds with only carbon and hydrogen atoms are called _____.
 - a. hydrocarbons.
 - b. halogenated hydrocarbons.
 - c. isomers.
 - d. soluble.

10. The _____ of a liquid is the lowest temperature at which it gives off enough vapor to form an ignitable mixture with the air near the surface of the liquid.
 - a. flammability
 - b. flash point
 - c. reactivity
 - d. combustibility

11. Which of the following is most likely to be an upper respiratory tract irritant?
 - a. sulfuric acid
 - b. nitrogen dioxide
 - c. ozone
 - d. phosgene

12. What is the minimum percentage of atmospheric oxygen required to support life?
 - a. 75 percent
 - b. 64 percent
 - c. 32 percent
 - d. 18 percent

Short Answer (8 points)

13. What are the three fundamental states of matter?

14. What are the most commonly used guidelines in the United States to assist industrial hygienists in interpreting the hazard posed by specific concentrations of gases and vapors in the workplace?

15. What is a functional group in an organic molecule?

16. Name at least one reference manual used for classifying and understanding the composition of a solvent.

17. What are the safety concerns posed by a cryogenic liquid? What is the most common cryogenic fluid?

18. What is the flammable range of a liquid or gas?

19. What is the difference between a simple asphyxiant and a chemical asphyxiant?

20. What factors should an industrial hygienist take into consideration when evaluating the degree of risk a volatile chemical will have in the workplace?

Short Essay (1 point)

21. Where a solvent system is in use, three distinct possible routes of exposure must be considered. What are these routes, and which is considered the most important route of exposure and why?

Quiz 2 (21 total points)

True/False (7 points)

1. Organic chemistry is the chemistry of the compounds of oxygen.
 - a. true
 - b. false
2. Esters should never be used as an anesthetic.
 - a. true
 - b. false
3. The greatest safety hazard of saturated and unsaturated alkyl ethers is that they have a tendency to form explosive peroxides.
 - a. true
 - b. false
4. Respirators can be used as the primary or only means of protection against hazardous chemicals.
 - a. true
 - b. false
5. Hydrocarbons are a major factor in the formation of photochemical smog.
 - a. true
 - b. false
6. The ANSI Z87.1 standard has removed the prohibition on contact lenses in eye hazard areas.
 - a. true
 - b. false

7. Barrier creams are every bit as effective as impervious gloves.
- true
 - false

Multiple Choice (6 points)

8. The fire point of a liquid is usually about ____ the flash point temperature.
- 10 F below
 - 5 F below
 - 5 F above
 - 10 F above
9. Which of the following is a chemical asphyxiant?
- nitrogen
 - hydrogen
 - carbon monoxide
 - carbon dioxide
10. Aliphatic compounds take their name from the Greek word *aliphe*, meaning ____
- water.
 - fat.
 - dizzy.
 - round.
11. It is estimated that there are ____ different hydrocarbons in gasoline.
- 150
 - 500
 - 875
 - 1,025
12. Which of the following have been used as anesthetics?
- cyclic hydrocarbons
 - aliphatic hydrocarbons
 - lipophilic solvents
 - none of the above
13. Which of the following is an important solvent for acetate rayon and vinyl resin coatings?
- aldehydes
 - methanol alcohol
 - nitrohydrocarbons
 - ketones

At another one of Cicely Chem's plants, it was discovered that they were releasing large amounts of CO₂ into the environment.

7. What effect can large concentrations of CO₂ have on the atmosphere?

Alfred Weiss, CEO of Cicely Chemical Company, was confronted by reporters as he tried to get into his car. "Mr. Weiss!" one of them shouts. "Aren't you afraid that your company's negligent policies will make the air unbreathable?" Mr. Weiss snarls in reply, "If you're so worried, buy yourself a gas mask."

8. Even if he had been serious in his answer, would a respirator adequately protect one against hazardous chemical vapors? Why or why not?

8

Particulates

Quiz 1 (22 points total)

True/False (6 points)

1. The primary route of exposure for most hazardous particulate is inhalation.
 - a. true
 - b. false
2. The number of asbestos fibers inhaled is not as important as the mass.
 - a. true
 - b. false
3. The relative toxicity of the six forms of asbestos remains in debate.
 - a. true
 - b. false
4. Most particles demonstrate toxicity only when they are deposited in the alveolar region of the respiratory tract.
 - a. true
 - b. false
5. Excess cancer rates have been associated with living in houses with high levels of radon daughters.
 - a. true
 - b. false

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6. Both of the main analytical methods available for free crystalline silica are quite imprecise by industrial hygiene standards.
- true
 - false

Multiple Choice (4 points)

7. What types of particles are found in a polydisperse particle cloud?
- particles in a wide range of sizes
 - particles caused by acid digestion
 - particles that fall within a very narrow size range
 - particles resulting from vaporization and recondensation
8. Why is the aerodynamic equivalent diameter of a particle important?
- It helps to determine what type of personal protective equipment is needed.
 - It determines where in the respiratory tract the particle is most likely to be deposited.
 - It indicates toxicity levels.
 - It is necessary for compliance with OSHA's permissible exposure limits.
9. What is one of the few particulate matters (PMs) that is routinely analyzed by size-selective microscopic counting?
- tobacco smoke
 - asbestos
 - coal dust
 - lead
10. Where are asbestos exposure and monitoring mostly found?
- asbestos mines
 - building maintenance and renovation
 - asbestos manufacturing facilities
 - asbestos mills

Short Answer (10 points)

11. How is *particulate matter* defined in the field of industrial hygiene?
12. Why are particles smaller than about 0.001μ not treated as particulate matter?

13. What are the five primary mechanisms of particle deposition?
14. What makes asbestos fibers particularly hazardous?
15. What are industrial hygienists concerned with rather than the actual diameter of a particle?
16. List three types of particle sampling that are common in industrial hygiene.
17. List four reasons for conducting surface sampling.
18. What are two problems with the optical methods of asbestos analysis?
19. What is the most common method for differential fiber counting in asbestos sampling?
20. What is the basic principle of operation for direct-reading particle detectors?

Short Essay (2 points)

21. What factors contribute to the toxicity of inhaled radiological materials?

22. What are the airborne limits for radioactive particles, and how do they differ from chemical exposure limits?

Quiz 2 (21 points total)

True/False (5 points)

1. The environmental limits for exposure of the general population to particulate matter are generally much lower than the occupational limits.
 - a. true
 - b. false
2. OSHA requires preexposure medical assessment for workers who will be exposed to certain hazardous particulates.
 - a. true
 - b. false
3. The majority of occupational exposure limits are based on the results of air sampling.
 - a. true
 - b. false
4. Diesel exhaust has been shown to be carcinogenic.
 - a. true
 - b. false
5. It is unusual for an industrial hygienist to be asked to sample for infectious airborne bacteria, fungal spores, or viruses.
 - a. true
 - b. false

Multiple Choice (4 points)

6. What is often a primary factor for the toxicity of a material?
 - a. size of particles
 - b. number of particles
 - c. length of exposure
 - d. chemical composition
7. What regulates most U.S. exposure levels for particulate matter?
 - a. OSHA PELs
 - b. NIOSH RELs
 - c. AIHA WEELs
 - d. ACGIH TLVs®

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17. What biological organisms are most often of interest to the typical industrial hygienist?

18. What are general area samples commonly used for?

19. What are radon progeny?

Short Essay (2 points)

20. How is the situation of concurrent exposure to multiple toxic agents addressed?

21. What are two critical factors to consider when sampling PM in a moving airstream?

Overhead 8-1.

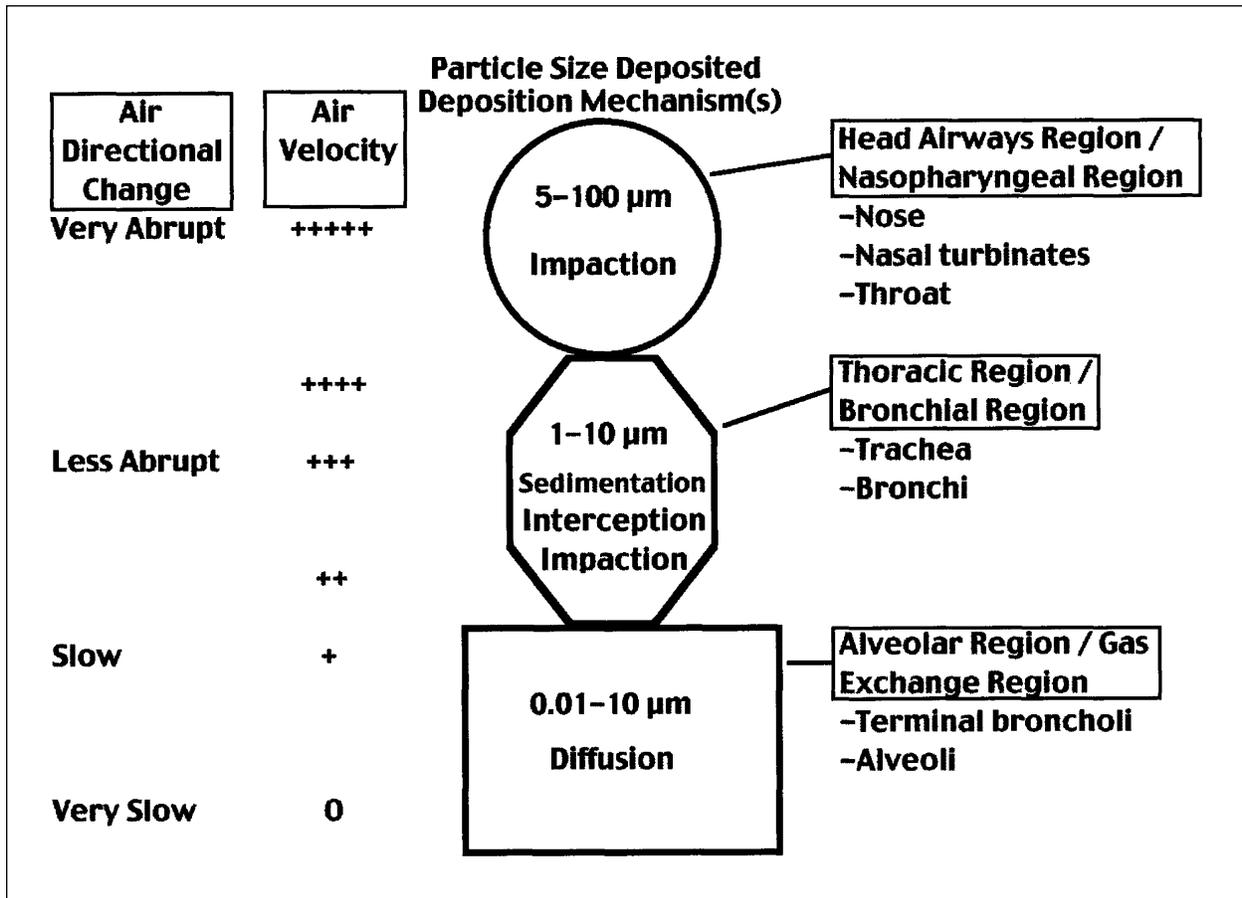
Critical Factors in Determining Acceptable Exposure

The nature of the health problems caused by inhalation of particulate matter is influenced by a number of factors:

- chemical and biological composition of the particles and stability of their nuclei (radioactivity)
- crystalline, structural, and isotopic forms of the particles
- the shape of the particles
- the size of the particles
- the dose, or the concentration of particles in the work environment and exposure duration
- preexisting health or genetic status of the workers
- concurrent exposure to other toxic agents

Overhead 8-2.

Respiratory Tract Particle Deposition as a Function of Aerodynamic Equivalent Diameter



9

Industrial Noise

Quiz 1 (24 total points)

True/False (5 points)

1. Noise does not always have particular physical characteristics that distinguish it from wanted sound.
 - a. true
 - b. false
2. The sound power radiated from a source remains constant even though intensity diminishes as the distance from the source increases.
 - a. true
 - b. false
3. An individual's ability to hear sentences and repeat them correctly in a quiet environment is not satisfactory evidence of adequate hearing ability because it does not demonstrate the person's ability to hear pure tones.
 - a. true
 - b. false
4. Sound can be transmitted to the inner ear by hearing-protective devices, such as earplugs and earmuffs.
 - a. true
 - b. false
5. A hearing conservation program becomes mandatory at an eight-hour TWA exposure of 90 dBA.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Which of the following does *not* apply to frequency?
 - a. Broadband noise can be somewhat more harmful than single frequencies.
 - b. The audible range of frequencies for humans is between 20 Hz and 20,000 Hz.
 - c. Frequency is perceived by the human ear as pitch.
 - d. The frequency composition of a sound is known as its spectrum.

7. What is the answer to the following equation: $75 \text{ dB} + 71 \text{ dB} = \underline{\hspace{2cm}}$
 - a. 73 dB.
 - b. 76 dB.
 - c. 77 dB.
 - d. 79 dB.

8. General guidelines for conducting preliminary noise surveys include which of the following?
 - a. The survey should define areas where hearing protection will be required.
 - b. The information recorded should cover workers' TWA exposures.
 - c. The information recorded should allow another individual to reproduce the measured data.
 - d. The survey should be carried out in areas where workers within 10 feet of one another have to shout to communicate.

9. Most damage-risk criteria are written for $\underline{\hspace{2cm}}$ because it is the easiest to define in terms of amplitude, frequency content, and duration.
 - a. intermittent noise
 - b. continuous noise
 - c. impact noise
 - d. cyclical noise

10. Which of the following protective devices can reduce bone-conducted sound?
 - a. earmuffs
 - b. earplugs
 - c. canal caps
 - d. helmets

11. Which of the following industries is not covered by the Hearing Conservation Amendment?
 - a. agriculture
 - b. gas well drilling
 - c. construction
 - d. all of the above

Short Answer (7 points)

12. What is the definition of occupational hearing loss?

13. What is the root-mean-square (rms) sound pressure used to measure and what units are used for these measurements?

14. Changing the frequency of a sound changes its relative loudness. Why?

15. What is the difference between a source measurement and an ambient-noise measurement?

16. Every noise problem can be broken down into three parts. What are these parts?

17. What are the four categories of personal hearing-protective devices?

18. If an employee has experienced a standard threshold shift (STS), a protective device must reduce his or her level of noise exposure to _____ or below.

Short Essay (6 points)

19. Describe a semireverberant location. How can the sound level be measured in such a location?

20. Who should take preplacement hearing-threshold tests and why are such tests important?

Quiz 2 (24 total points)

True/False (5 points)

1. A wall is not an effective shield against low-frequency sounds, but it can offer more protection against high-frequency sounds.
 - a. true
 - b. false
2. Doubling sound pressure is the equivalent of doubling sound power.
 - a. true
 - b. false
3. The range of greatest interest in most noise measurements is between 20 Hz and 20,000 Hz.
 - a. true
 - b. false
4. OSHA sets specific standards for noise-generating equipment. These standards can be used as one type of administrative control for noise hazards.
 - a. true
 - b. false
5. A biological check of an audiometer is done by testing the hearing of a person whose hearing threshold is known and stable.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Which of the following is true of noise-induced hearing loss?
 - a. It denotes injury to the sensorineural elements of the inner ear.
 - b. It can result from direct trauma to the head or ear.
 - c. It usually affects both ears equally in the extent and degree of loss.
 - d. It can result from one or a few exposures to sudden intense acoustic energy.

7. The threshold of hearing can vary as much as _____ among healthy individuals.
 - a. ± 10 dB
 - b. ± 20 dB
 - c. ± 30 dB
 - d. ± 50 dB

8. Which of the following is a critical factor in the analysis of noise exposure?
 - a. the frequency composition
 - b. the duration of noise exposure
 - c. the A-weighted sound level
 - d. all of the above

9. If the noise level around a workstation is never greater than _____, the employee's noise exposure can be considered satisfactory.
 - a. 75 dBA
 - b. 80 dBA
 - c. 85 dBA
 - d. 90 dBA

10. What is the best hearing-protective equipment for a worker who is only exposed to hazardous noise intermittently?
 - a. earmuffs
 - b. canal caps
 - c. a helmet
 - d. earplugs

11. What is a practical way of measuring the noise exposure of workers who perform a variety of tasks in different locations?
 - a. an octave-band analyzer
 - b. a noise dosimeter
 - c. a sound survey meter
 - d. a tape and graphic level recorder

Short Answer (7 points)

12. Certain effects produced by sounds seem to be universally undesirable for all people. What are these effects?

13. Define the threshold of hearing.

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14. The upper limit of frequency at which airborne sounds can be heard depends primarily on _____ and _____.
15. Why is the A-weighted sound level measurement being used by many agencies to assess overall noise hazard?
16. What is the one serious drawback of earplugs and earmuffs as hearing-protective devices?
17. What are the five components of an effective industrial audiometric program?
18. What is NIOSH's definition of a standard threshold shift (STS)?

Short Essay (6 points)

19. To properly represent the total noise of a noise source when analyzing the source, the total noise generally needs to be broken down into its various frequencies. Why?
20. If an employee is found to have a standard threshold shift (STS), what steps must be taken by the company?

Case Study

(Scoring Guidelines — Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

Over the past several months, the medical personnel at Barsten Products has spoken to a number of employees who have complained about ringing in their ears toward the end of their shifts. Before the complaints started about three months ago, Barsten Products had not had any noise problems at its plant. In reviewing their files with Barsten's industrial hygienist, the medical staff found that first complaint was made shortly after the company purchased a new machine for trimming metal. According to the manufacturer's recommendations, earmuffs should be worn when operating the machine. The industrial hygienist confirmed that employees working with the machine had been fitted for earmuffs; however, he also noted that some of the employees needed to wear protective eyewear at the same time. When the medical personnel and the industrial hygienist discussed the issue with Barsten's management, management was extremely concerned about the complaints leading to determinations of occupational hearing loss. The decision was made to reevaluate the risk factors for hearing loss and the company's testing program.

You are a member of the team assigned to reevaluate the noise levels at the plant and the company's testing program. Before you begin to reassess the testing program, you need to review the following definitions:

1. occupational hearing loss
2. acoustic trauma
3. noise-induced hearing loss
4. Then you need to assess the risk factors for hearing loss and the problems associated with wearing earmuffs and eye protection at the same time.

Overhead 9-1.

The Noise Survey

An effective noise survey answers the following questions:

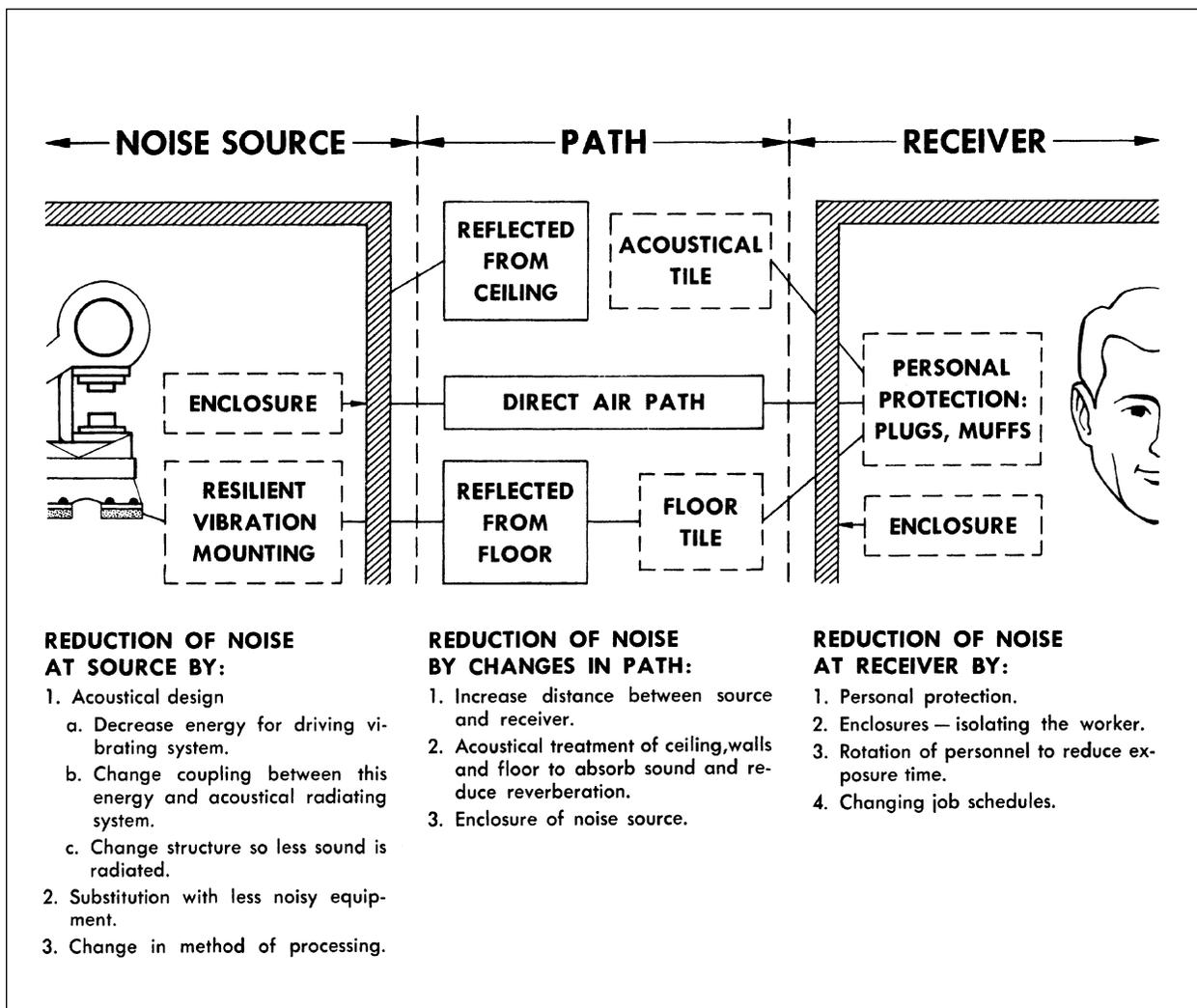
- How noisy is each work area?
- What equipment or process is generating the noise?
- Which employees are exposed to the noise?
- How long are employees exposed?

Three-Step Noise Survey

1. area measurements
2. workstation measurements
3. exposure duration

Overhead 9-2.

The Three Components of a Noise Problem



Overhead 9-3.

The Objectives of Industrial Audiometry

1. Obtain a baseline audiogram that indicates an individual's hearing ability at the time of the preplacement examination.
2. Provide a record of an employee's hearing acuity.
3. Check the effectiveness of noise-control measures by measuring the hearing thresholds of exposed employees.
4. Record significant hearing threshold shifts in exposed employees during the course of their employment.
5. Comply with government regulations.

10

Ionizing Radiation

Quiz 1 (25 total points)

True/False (7 points)

1. Light is a form of radiation energy.
 - a. true
 - b. false
2. Gamma-radiation is produced in the orbiting electron portion of the atom or from free electrons, whereas x-radiation is produced in the nucleus.
 - a. true
 - b. false
3. If a normal atom were to lose one of its orbiting electrons, the atom would become a positive ion.
 - a. true
 - b. false
4. A neutron particle has a negative charge.
 - a. true
 - b. false
5. The term *dose* is used to express a measure of radiation that a body or other material absorbs when exposed to a radiation field.
 - a. true
 - b. false

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6. Neutrons and protons are the smallest particles known to man.
 - a. true
 - b. false
7. A simple molecule such as water can recombine after ionization.
 - a. true
 - b. false

Multiple Choice (8 points)

8. _____ is the number of nuclear disintegrations occurring in a given quantity of material per unit of time.
 - a. Atomic number
 - b. Counter
 - c. Activity
 - d. Quality factor
9. Which unit is used to measure the rate of radioactive decay?
 - a. becquerel
 - b. curie
 - c. electron volt
 - d. roentgen
10. The _____ is the sum of the number of protons and neutrons in the nucleus of an atom.
 - a. atomic number
 - b. atomic weight
 - c. molecule
 - d. ICRP
11. Alpha-emitters are chemically similar to _____ in their action within the human body.
 - a. iron
 - b. vitamin C
 - c. water
 - d. calcium
12. What are beta particles?
 - a. small, electrically charged particles emitted from the nucleus of radioactive atoms
 - b. a class of hazardous, highly penetrating electromagnetic photons emitted from the nucleus of radioactive atoms
 - c. an atom or molecule that carries either a positive or negative charge
 - d. the inner core of an atom

2. Alpha-emitters are considered to be primarily internal radiation hazards.
 - a. true
 - b. false
3. The occupational dose equivalent to people under the age of 18 should be less than 0.1 rem per year.
 - a. true
 - b. false
4. A pocket dosimeter is most often used to detect beta-radiation.
 - a. true
 - b. false
5. Personal electronic alarm dosimeters are used to monitor the presence of gamma-radiation.
 - a. true
 - b. false
6. A Geiger-Mueller counter is accurate only for the type of radiation energy for which it is calibrated.
 - a. true
 - b. false
7. Ionizing radiation can sometimes be detected by taste or smell.
 - a. true
 - b. false

Multiple Choice (8 points)

8. Hydrogen-3 is another name for what element?
 - a. tritium
 - b. uranium
 - c. radium
 - d. plutonium
9. Which of the following is the most sensitive to the effects of radiation exposure?
 - a. bone marrow
 - b. bone
 - c. muscle
 - d. nerve

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10. Which of the following is a man-made, heavy element that undergoes fission under the impact of neutrons?
 - a. uranium
 - b. plutonium
 - c. radium
 - d. strontium-90

11. For cancer and genetic effects, the limiting value is specified in terms of a derived quantity called the effective dose equivalent. The effective dose equivalent received in any year by an adult worker should not exceed _____.
 - a. 2 rem
 - b. 5 rem
 - c. 7 rem
 - d. 9 rem

12. Which of the following is commonly used to produce roentgenograms of dense portions of objects?
 - a. tracer
 - b. gamma ray
 - c. x ray
 - d. ions

13. If two plates or electrodes with an electrical potential between them are placed in a container filled with air, a/an _____ is formed.
 - a. x-ray machine
 - b. ionization chamber
 - c. thermoluminescence detector
 - d. scintillation counter

14. If you double the distance from the source of radiation, the exposure would be decreased to _____ percent of the original amount.
 - a. 10
 - b. 25
 - c. 50
 - d. 75

15. What is the most frequent route of entry of radioactive material into the body?
 - a. absorption through intact skin
 - b. absorption through broken skin
 - c. contaminated food sources
 - d. inhalation

Short Answer (8 points)

16. What is half-life? What is the half-life of U-238?

17. In terms of radiation exposure, what is the latent period?

18. Over the years, the allowable radiation levels for human exposure have been consistently reduced as researchers have obtained more information on the effects of radiation exposure. What sources were used to obtain the pool of health experience data used in this research?

19. What are the three basic safety factors for protection against external radiation hazards?

20. What is meant by “safe distance?”

21. Work with radiation can and should be planned and managed so that radiation exposure to the general public is kept to a minimum. What are the potential avenues of exposure to the public?

22. What is a glove box?

23. What is a radioisotope and what are some of its uses?

3. What are the most common types of ionizing radiation?

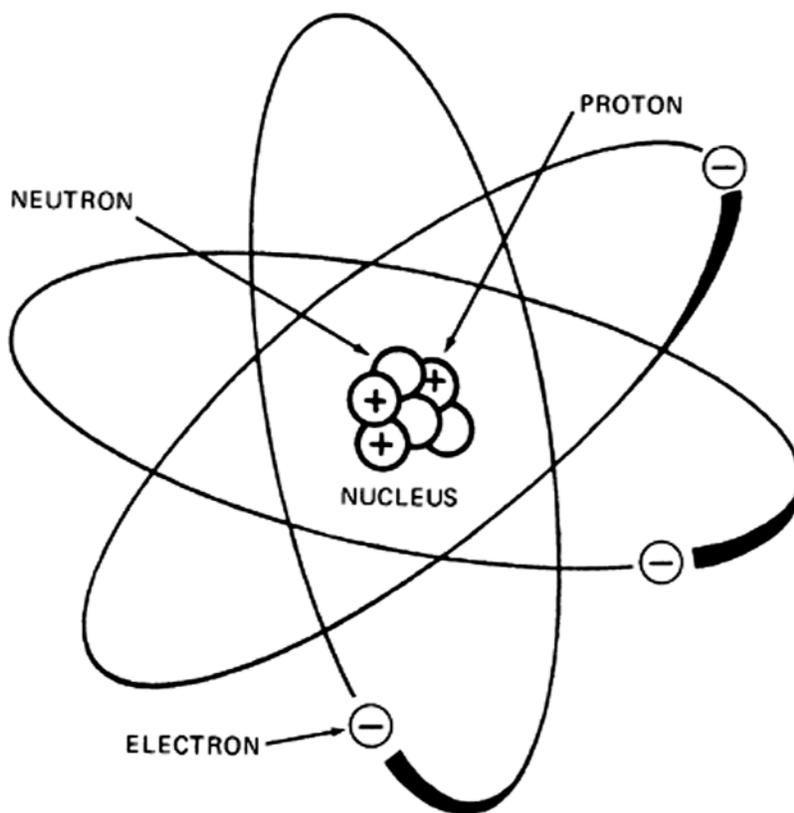
Even with the extensive precautions Artemis Labs takes to protect its employees, accidental exposures can occur.

4. What are the biological effects of ionizing radiation on the human body?

5. How was this health data obtained?

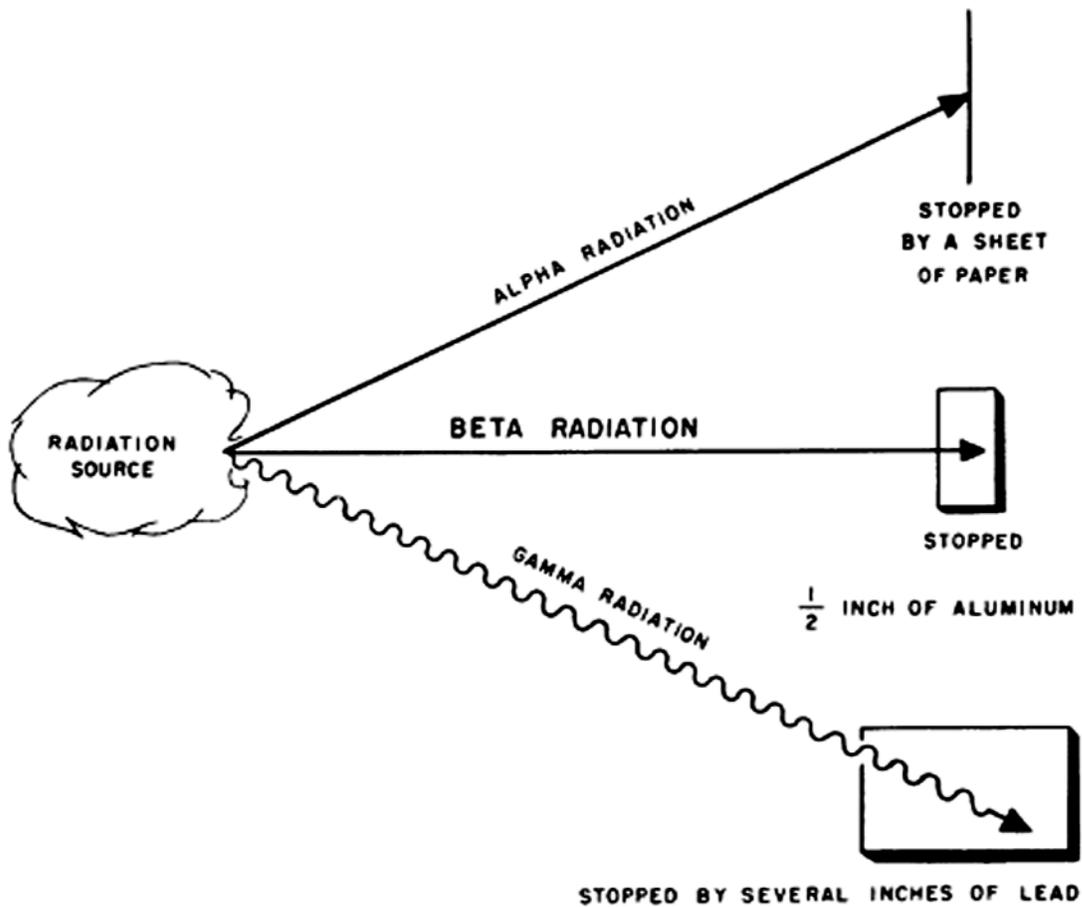
Overhead 10-1.

Basic Model of the Atom



Overhead 10-2.

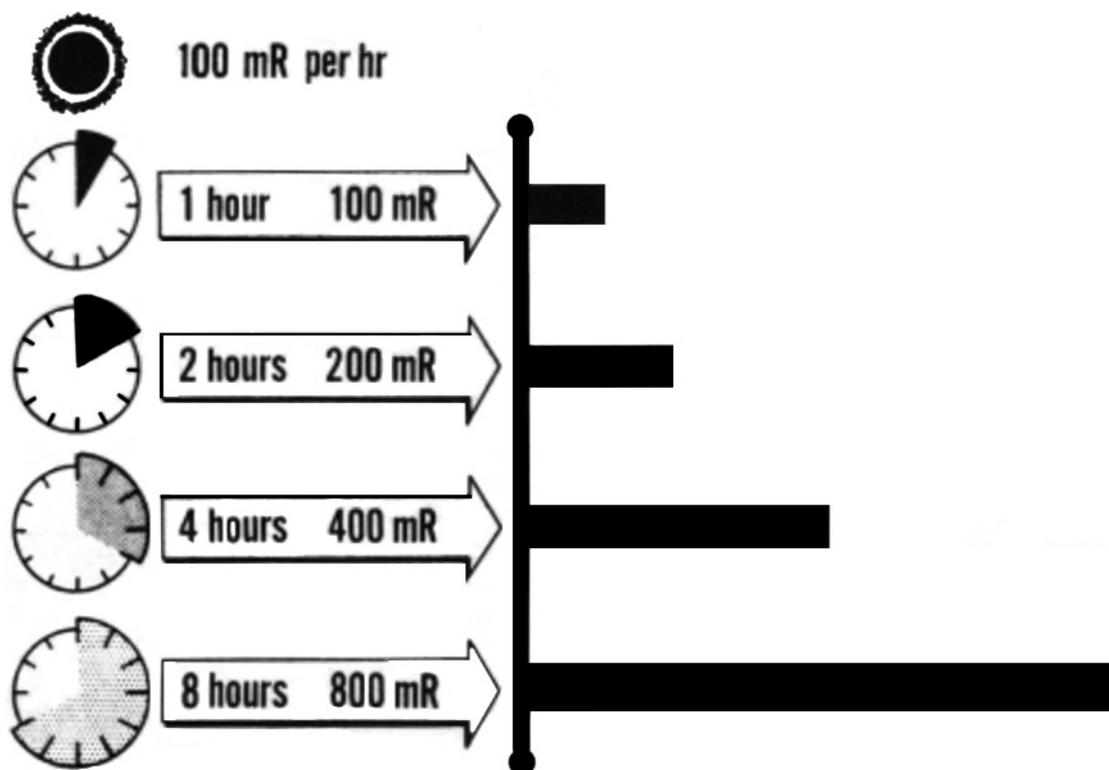
Relative Penetrating Power of Alpha- Beta-, and Gamma-Radiation



(Reprinted with permission from *Atomic Radiation*, RCA Service Co., Inc., 1957.)

Overhead 10-3.

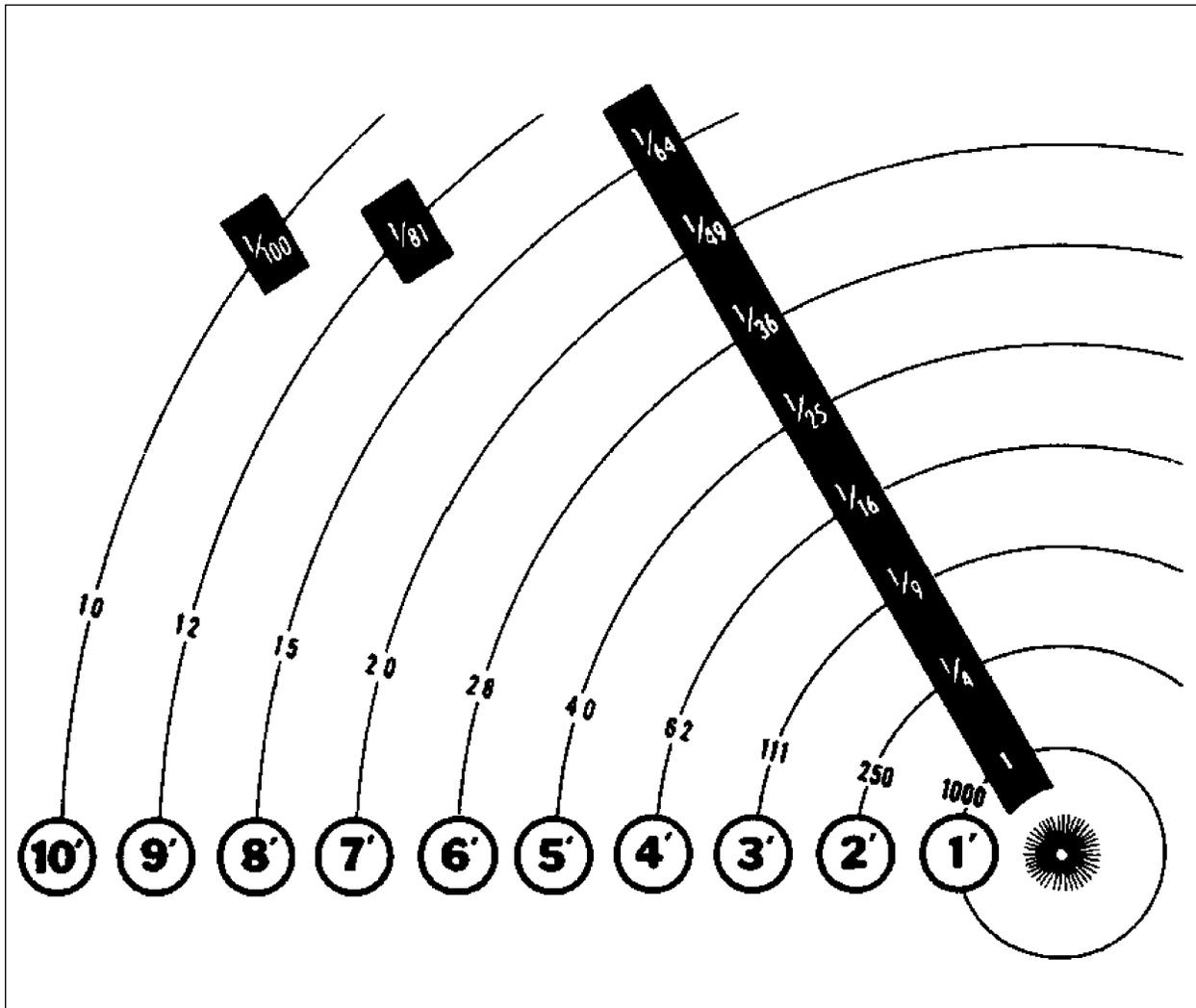
Effect of Time on Radiation Exposure



(Reprinted from U.S. Nuclear Regulatory Commission, *Living with Radiation—Fundamentals*.)

Overhead 10-4.

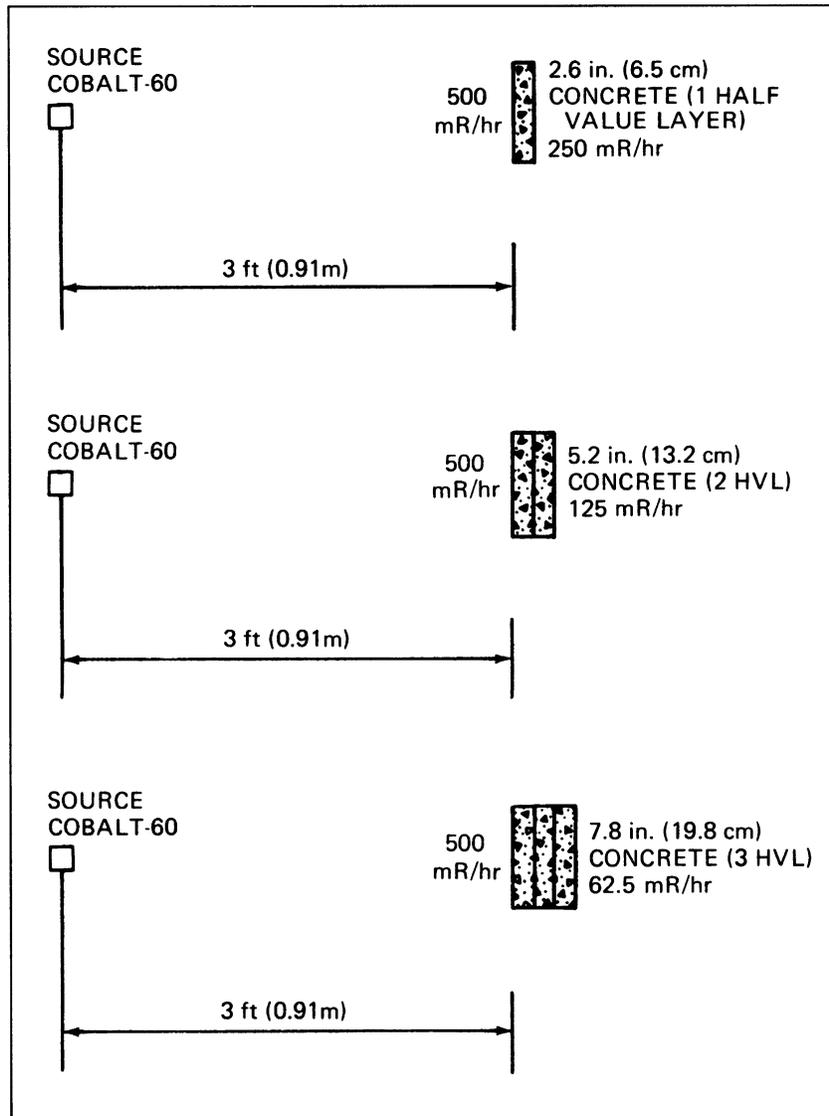
Effect of Distance on Radiation Exposure



(Reprinted with permission from *Safe Handling of Radioisotopes in Industrial Radiography*, Picker X-Ray Corp., 1962.)

Overhead 10-5.

Attenuation of Cobalt-60 Gamma-Radiation by Half-Value Layers of Concrete



11

Nonionizing Radiation

Quiz 1 (23 points total)

True/False (5 points)

1. Stopping electric fields is easy.
 - a. true
 - b. false
2. Licensing is required to use the industrial, scientific, and medical bands of the electromagnetic spectrum.
 - a. true
 - b. false
3. The protons in the nuclei of atoms attract an identical number of electrons, so the atom is neutral.
 - a. true
 - b. false
4. Lead is necessary for RF/MW shielding.
 - a. true
 - b. false
5. Common glass does not offer complete protection against UV-A, although it is very effective against UV-B and UV-C.
 - a. true
 - b. false

Multiple Choice (5 points)

6. In what direction do magnetic fields exist in relation to the direction of the current flow?
 - a. parallel
 - b. perpendicular
 - c. surrounding
 - d. 45 degree angle

7. To what level did the International Commission for Non-Ionizing Radiation Protection raise the TWA exposure limit for static magnetic fields?
 - a. 50 mT
 - b. 100 mT
 - c. 150 mT
 - d. 200 mT

8. What does 1 watt times 1 second equal?
 - a. 1 nanowatt
 - b. 1 joule of energy
 - c. 2 microwatts
 - d. none of the above

9. What are the target organs of optical radiation (more than one answer)?
 - a. eyes
 - b. testes
 - c. lungs
 - d. skin

10. What is the most common skin effect from infrared (IR) and visible light?
 - a. wrinkles
 - b. skin cancer
 - c. sunburn
 - d. excessive levels of vitamin D

Short Answer (10 points)

11. What does the term *alternating current* refer to?

12. How often do polarity changes in the current occur in the United States?

13. What is the basic law of electrical engineering and how is it expressed mathematically?
14. What is the speed of electromagnetic radiation in air and in a vacuum?
15. What is the 2001 Threshold Limit Value (TLV[®]) for DC electric fields from 0 Hz to 100 Hz?
16. What is one medical electronic device that can suffer negative effects from static magnetic fields?
17. How are magnetic fields controlled?
18. What portion of the radiofrequency spectrum is the range for microwaves?
19. How much radiation leakage is allowed under the present emission standard for microwave ovens?
20. What two undesirable effects on the skin are produced by UV-B and UV-C?

Short Essay (3 points)

21. How are magnetic fields often measured?

22. How are electric fields at frequencies ranging up to 100 kHz often measured?

23. Define *dose rate*.

Quiz 2 (23 points total)

True/False (5 points)

1. People who work in strong magnetic fields should avoid unusual shift work that causes them to lose track of day–night cycles.
 - a. true
 - b. false

2. Lasers can be operated in two major modes: pulsed and continuous wave.
 - a. true
 - b. false

3. The main engineering control for lasers is personal protective equipment.
 - a. true
 - b. false

4. Cadmium exposure is a potential hazard for fluorescent tube breakers.
 - a. true
 - b. false

5. The idea that power line fields can influence cell membranes has now been rejected.
 - a. true
 - b. false

Multiple Choice (4 points)

6. What are two common engineering controls for optical radiation, particularly for welding areas?
 - a. copper tape
 - b. baffles
 - c. sight barriers
 - d. a Faraday cage

7. A recent review of laser accidents showed that 37.2 percent of laser accidents occurred _____
 - a. during alignment.
 - b. during initial setup.
 - c. because of inadequate engineering controls.
 - d. due to failure of interlocks.

8. What is the “gauss” being replaced with?
 - a. the tesla
 - b. the orc
 - c. a plasma etcher
 - d. a dipole antenna

9. What dimension is necessary for the mesh openings in metal screens used for RF/MW shielding?
 - a. $\frac{1}{4}$ wavelength
 - b. $< 4\text{nm}$
 - c. $1.5\mu\text{m}-3\mu\text{m}$
 - d. $\frac{1}{2}$ wavelength

Short Answer (11 points)

10. What do optical radiation and laser safety standards use as a measure of angle rather than degrees?

11. In optical radiation and laser safety standards, what angular measure is used to describe portions of the surface of a sphere?

12. What is *laser* an acronym for?

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13. What are the health hazards of lasers, and what are the other hazards of laser use, excluding laser weapons?

14. What are the two basic units of measure for illuminance?

15. At what frequencies is radiation (not just a field) likely to be found?

16. When does an object absorb the most radiation energy?

17. What interval do radiofrequency standards rely on, rather than eight-hour time-weighted averages?

18. What do the Swedish MPR standards apply to?

19. What is a Faraday cage and what is its use?

20. Why are lasers especially hazardous to the eyes?

Short Essay (3 points)

21. What standard on radiofrequency/microwave exposure does OSHA enforce?

22. Basically, how do lasers work?

23. What is the form of retinal damage that is unique to visible and IR-A lasers?

Case Study

(Scoring Guidelines — Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

Amy Fong teaches science at Avondale Middle School. Prior to teaching, Amy was employed at a research laboratory, using sophisticated equipment, including lasers. Of course, her students aren't impressed by lasers. They tell her that laser technology has been around so long and become so common that anybody can buy a laser pointer at an office supply store. Amy now has the perfect opportunity to explain some important points about lasers. She gives a quick history of laser pointers.

1. What type were the first laser pointers and what was the major drawback to them?

Overhead 11-1.

Biological Effects Reported for Radiofrequency and Microwave Radiation

<i>Target Organ/ Overall Effect</i>	<i>Effect</i>	<i>Exposure</i>
Eyes (animals and humans)	Cataracts	Hours at 120 mW/cm ²
	Keratitis	40 mW/cm ²
Behavioral (animals only)	Various test changes Behavioral thermoregulation	≥1.1 W/kg ≥1.1 W/kg
Endocrine (animals only)	Corticosteroid and thyroid increases	>8.3 W/kg
Immune (animals only)	B and T cell activity changes	≥1.4 W/kg
Neurological (animals only)	Tests of blood/brain barrier contradictory	
Mutations	Not found in replicated studies to date	
Cancer	Not found in humans or animals to date	
Reproduction	Temporary male sterility	5.6 W/kg
	Testicular changes	≥15 W/kg
	Leutenizing hormone changes	>2 W/kg
Teratology (animals only)	Malformed offspring	≥31 W/kg
Thermoacoustic/ inner ear (pulsed only)	Observed in radar operators in WWII as perceived clicking sound while in beam	
	Possible cause of neurological effects observed in test animals	0.6 W/kg

Overhead 11-2.

Radiofrequency Hazard Icon



12

Thermal Stress

Quiz 1 (24 total points)

True/False (5 points)

1. The health risk zones for heat and cold stress are located just beyond the comfort zone on the thermal stress continuum.
 - a. true
 - b. false
2. Insulation can reduce heat flow by radiation, convection, and conduction.
 - a. true
 - b. false
3. If the clothing worn by a worker is likely to substantially reduce evaporative cooling, then heat strain monitoring is the most feasible approach for evaluating heat stress.
 - a. true
 - b. false
4. According to NIOSH's Recommended Exposure Limit, as metabolic rate increases, the WBGT threshold increases as well.
 - a. true
 - b. false
5. Reflective clothing may increase heat stress exposure because it reduces sweat evaporation.
 - a. true
 - b. false

Multiple Choice (6 points)

6. If according to the thermal balance equation the value of S is zero, which of the following is true?
 - a. the body is gaining heat
 - b. the body is losing heat
 - c. the body is in thermal equilibrium
 - d. none of the above

7. A pale face, a high pulse rate, and dizziness are signs and symptoms of _____
 - a. heat stroke.
 - b. heat syncope.
 - c. heat exhaustion.
 - d. dehydration.

8. Which of the following factors in the thermal balance equation depends on air temperature and the volume of air inhaled?
 - a. C_{resp}
 - b. R
 - c. E_{resp}
 - d. K

9. If an employee experiences more than a _____ loss of body weight between the beginning and the end of a work shift, then he or she is likely to be excessively dehydrated.
 - a. 0.5-percent
 - b. 1.0-percent
 - c. 1.5-percent
 - d. 2.0-percent

10. A burning sensation, blisters, and tingling are signs and symptoms of _____
 - a. frostnip.
 - b. trench foot.
 - c. Raynaud's disorder.
 - d. frostbite.

11. Which of the following is *not* an engineering control for cold stress?
 - a. redesigning equipment to make it safe to use below 2 C (36 F)
 - b. requiring that mittens be used below -17 C (1 F)
 - c. adjusting ventilation to maintain workers' core temperatures at 36 C (96.8 F)
 - d. providing hand warming for fine hand work below 16 C (61 F)

Short Answer (7 points)

12. What are the three factors that influence the degree of thermal stress a worker feels?

13. Why does increased metabolism result in increased rates of heat gain?

14. What is the equation for local heat storage? What does each term in the equation represent?

15. If workers are exposed to heat stress on an episodic basis, how is their heat stress assessed?

16. Describe three ways of controlling diffuse sources of radiant heat.

17. What are two physiological responses to cold stress?

18. When workers are at risk for cold stress, what general controls should be implemented?

Short Essay (6 points)

19. How does the skin cool the body? What role does sweating play in the process?

20. What causes hypothermia and how does it affect the body? How can first aid be used to treat hypothermia?

Quiz 2 (24 total points)

True/False (5 points)

1. The major emphasis for evaluation and control of thermal stress is focused on the transition from the discomfort zone to the health risk zone for both heat and cold stress.
 - a. true
 - b. false
2. In heat stress, metabolic rate can add 10 to 100 times more heat to the body than radiation and convection combined.
 - a. true
 - b. false
3. The value of E_{req} is positive because it measures the amount of perspiration being produced by the body as heat flows away from it.
 - a. true
 - b. false
4. Acclimation decreases the ability to work under heat stress and increases the risk of heat disorders.
 - a. true
 - b. false
5. The insulating value of clothing generally comes from layering clothes rather than wearing just one garment.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Faintness and blurred vision are signs and symptoms of _____
 - a. heat stroke.
 - b. heat syncope.
 - c. heat exhaustion.
 - d. dehydration.

7. If the average heart rate over an eight-hour day is greater than _____, the work and heat stress may be excessive.
 - a. 80 bpm
 - b. 90 bpm
 - c. 100 bpm
 - d. 110 bpm

8. Which of the following can be a precursor to heat exhaustion?
 - a. heat cramps
 - b. heat syncope
 - c. heat rash
 - d. dehydration

9. Which of the following is not true of heat-balance analysis?
 - a. It uses an empirical model to evaluate heat stress.
 - b. The Heat Stress Index is one type of heat-balance analysis.
 - c. It analyzes heat exchange between a hypothetical person and the environment.
 - d. The accuracy of heat-balance analysis is limited because certain variables cannot be easily measured.

10. Vascular disease can be a factor in all of the following *except* _____
 - a. frostbite.
 - b. Raynaud's disorder.
 - c. hypothermia.
 - d. chilblain.

11. A worker's manual dexterity begins to decrease after 10–20 minutes of uninterrupted work at temperatures below _____
 - a. 15 C (59 F).
 - b. 16 C (61 F).
 - c. 17 C (63 F).
 - d. 18 C (64 F).

Short Answer (7 points)

12. What is the general equation for thermal balance presented in the text? What does each term in the equation represent?

13. What are the three major characteristics of clothing that affect thermal balance?

14. Name the physiological adaptations to thermal stress that are collectively known as heat strain.

15. There are four environmental factors that are central to evaluating heat stress. What are these four factors?

16. What are the main topics that should be covered during periodic heat-stress training sessions?

17. When temperatures fall below _____, steps should be taken to implement workplace monitoring.

18. Where along the continuum of thermal stress are demands on physiological adaptation modest and productivity greatest?

Short Essay (6 points)

19. How can you determine whether workplace conditions should be evaluated for heat stress?

20. Explain the difference between engineering and administrative controls. Give some examples of each in relation to heat stress controls.

Case Study

(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

The parts manufacturing division of Allied World Inc. is located near Detroit. Employees come to work in the heat and humidity in the summer and deal with snow, ice, and wind chills in the winter. The facility generally handles the seasonal changes in temperature without a problem, and employees are able to work in comfortable conditions. In fact, the ventilation system serving the main section of the plant was recently upgraded. Representatives visiting the facility from the main office were pleased with the outcome of the improvements. Nevertheless, they remained concerned about the warehouse portion of the plant, where the air temperature felt significantly different. They noted that some of the workers and truck drivers risked being exposed to heat and cold stress during loading and unloading procedures in an area of the facility that had been converted to a loading dock. In some cases, these employees were also responsible for retrieving supplies stacked outside the warehouse and moving them back into the plant. In preparation for the summer months, the representatives decided to designate a task force to evaluate thermal stress in the warehouse and around the loading docks.

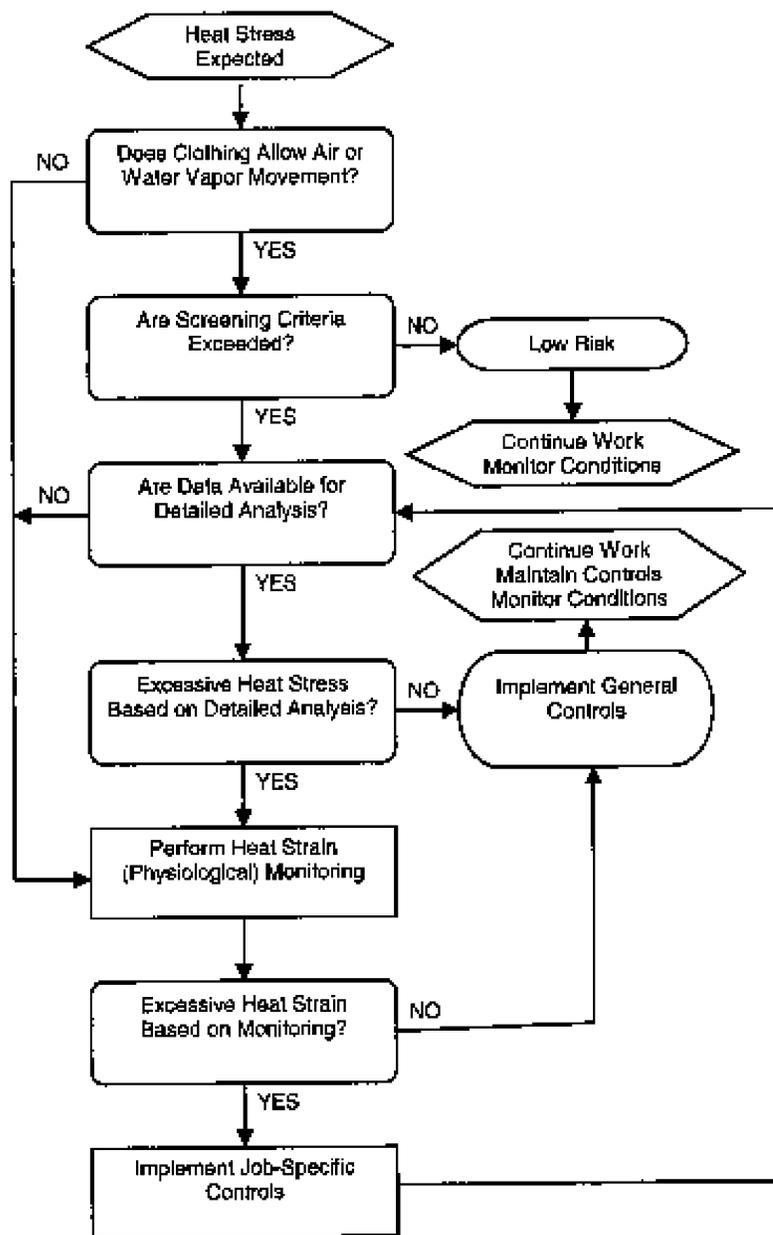
1. You have been asked to brief members of the task force on the risk factors for heat stress and ways they can recognize heat stress without testing workers for temperature, heart rate, or other physiological responses.

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2. What are some heat-related disorders that may affect workers?

Overhead 12-1.

Flow Chart for the ACGIH TLV® for Heat Stress and Strain



Overhead 12-2.

WBGT Adjustment Factors for Different Clothing Ensembles in Degrees C*

<i>Clothing Type</i>	<i>ACGIH</i>	<i>Other Sources</i>
Work Clothes	0	0
Coveralls	3.5	
Double Coveralls	5	
SMS Coveralls		-1
Tyvek® 1422A Coveralls		2
Vapor-Transmitting Water-Barrier		2 – 6
Vapor-Barrier		8
Encapsulating Suit		11

* The adjustment factors are added to the measured WBGT.

13

Ergonomics

Quiz 1 (20 total points)

True/False (5 points)

1. Fitts' Law is used to express motion time.
 - a. true
 - b. false
2. Frequent short rest periods reduce cumulative fatigue better than a few long breaks.
 - a. true
 - b. false
3. Single-percentile constructs are the best method for designing equipment and workstations.
 - a. true
 - b. false
4. The only active action a muscle can take is to contract.
 - a. true
 - b. false
5. Roughly 50 percent of back pain episodes cannot be linked to a specific incident.
 - a. true
 - b. false

Multiple Choice (6 points)

6. The ____ includes the cranial and spinal nerves.
 - a. central nervous system
 - b. peripheral nervous system
 - c. autonomic nervous system
 - d. somatic nervous system

7. Control of voluntary movements, sensory experience, abstract thought, memory, learning, and consciousness is located in the ____
 - a. basal ganglia.
 - b. cortex.
 - c. cerebrum.
 - d. cerebellum.

8. Under optimal conditions, simple auditory, visual, and tactile reaction times are about ____ seconds.
 - a. 0.2
 - b. 0.5
 - c. 0.8
 - d. 1.2

9. All but one of the following functions is addressed by biomechanics. Which one does not fit in this group?
 - a. range of motion
 - b. body posture
 - c. mental processes
 - d. human muscle strength

10. Of the four groups mentioned below, which has the largest reported incidence ratio for compensation claims for back injuries?
 - a. material handlers
 - b. garbage collectors
 - c. construction workers
 - d. nurses

11. In general, women are about ____ as strong as men.
 - a. 25 percent
 - b. 50 percent
 - c. 66 percent
 - d. 75 percent

Short Answer (7 points)

12. What is the difference between “underloading” and “overloading”?

13. What is *affordance*? Use a specific example in your answer.

14. Define *reaction time*, *motion time*, and *response time*.

15. What limits an individual’s capacity for physical work?

16. What is the simplest technique for heart rate assessment?

17. What is anthropometry? What are the two defined postures used in anthropometry?

18. How are Newton’s Second and Third Laws used to assess human muscle strength?

Short Essay (2 points)

19. Define *fatigue*. What is the primary reason for muscle fatigue? How might fatigue be avoided?

20. If all opportunities to automate or mechanize the movement of material have been exhausted and it becomes necessary for people to handle material directly, certain guidelines should be established to enable the operator to perform the work safely and efficiently. Summarize those guidelines here.

Quiz 2 (20 total points)

True/False (5 points)

1. With proper lifting techniques, people can actually increase their muscular strength/endurance and cardiovascular endurance as well as prevent injuries.
 - a. true
 - b. false
2. If people must move material, make sure it is predominantly in the vertical plane.
 - a. true
 - b. false
3. While manipulating a hand tool, the wrist should be pronated.
 - a. true
 - b. false
4. Sitting at a workstation provides more available body strength to the worker than standing.
 - a. true
 - b. false
5. If the 95th-percentile knee height were used to determine the height of a workstation table, nearly everybody's legs would fit under the table.
 - a. true
 - b. false

Multiple Choice (6 points)

6. ____ permits the operator to modify the work environment and equipment so that it conforms to that individual's particular set of physical characteristics as well as to subjective preferences.
- Maximal dimension
 - Minimal dimension
 - Flexibility
 - Adjustability
7. The area in which form and color of objects can be seen by both fixated eyes is the worker's ____.
- visual field.
 - peripheral vision.
 - ear-eye line.
 - none of the above.
8. ____ is the result of compression of the ulnar nerve below the notch of the elbow.
- Carpal tunnel syndrome
 - Cubital tunnel syndrome
 - DeQuervain's syndrome
 - Epicondylitis
9. ____ is a special case of tendosynovitis where the tendon becomes nearly locked so that its forced movement is not smooth but snaps or jerks.
- Trigger finger
 - Ulnar nerve entrapment
 - White finger
 - Ganglion
10. Early symptoms of cumulative trauma disorder may be reversible through ____.
- work modifications.
 - rest breaks.
 - exercise.
 - all of the above.
 - a and b only.
11. A ____ is a small, flat, synovia-filled sac lined with a slippery cushion that prevents rubbing of a muscle or tendon against bone.
- bursa
 - ligament
 - sheath
 - joint

Short Answer (7 points)

12. Material handling is among the most frequent and the most severe causes of injury all over the world and in U.S. facilities. Kroemer identified seven keys as the major ergonomic tools for safe and efficient material handling. What are these keys?

13. Biomechanical research has shown that the straight-back/bent-knees lift is inappropriate for many tasks. Why? What types of lifts have been suggested as a replacement?

14. Define the terms in the following equation. What does this equation represent?
$$RWL = LC * HM * VM * DM * AM * FM * CM$$

15. Why would a person decide to wear a belt while lifting heavy objects? Are they effective at preventing injuries? Why or why not?

16. Five general rules govern the design of a workplace. What are they?

17. What are the most frequent health problems voiced by computer operators? What are the principal causes?

18. What are the work factors that can cause CTDs?

Short Essay (2 points)

19. Light signals are often used on control panels to alert an operator of the system status. What colors are commonly used, and what do each of them mean?

20. Which body components are at risk for CTDs? Describe the type of traumas that can occur.

Case Study

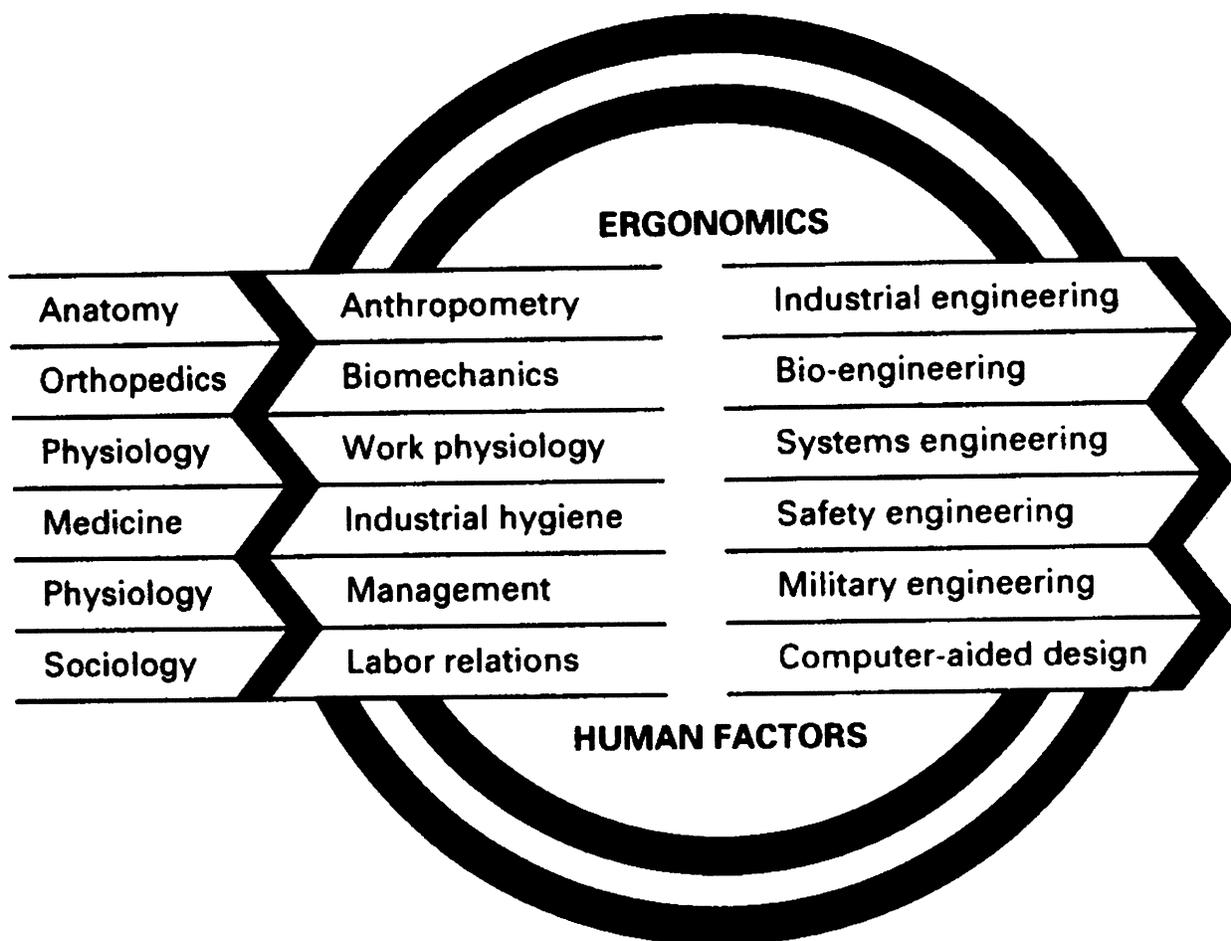
(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

Bruant Books is an academic press with a small staff of dedicated editors. Their office has been located in the same building for more than 75 years, and most of their office furniture is nearly as old. Several employees have recently been complaining of “writer’s cramp,” and have requested that management update their office with human-friendly furniture. Management has agreed that it is long overdue.

1. What is the proper name for the condition the employees are experiencing? Describe, in medical terms, what is happening to them. What can be done to avoid this condition?

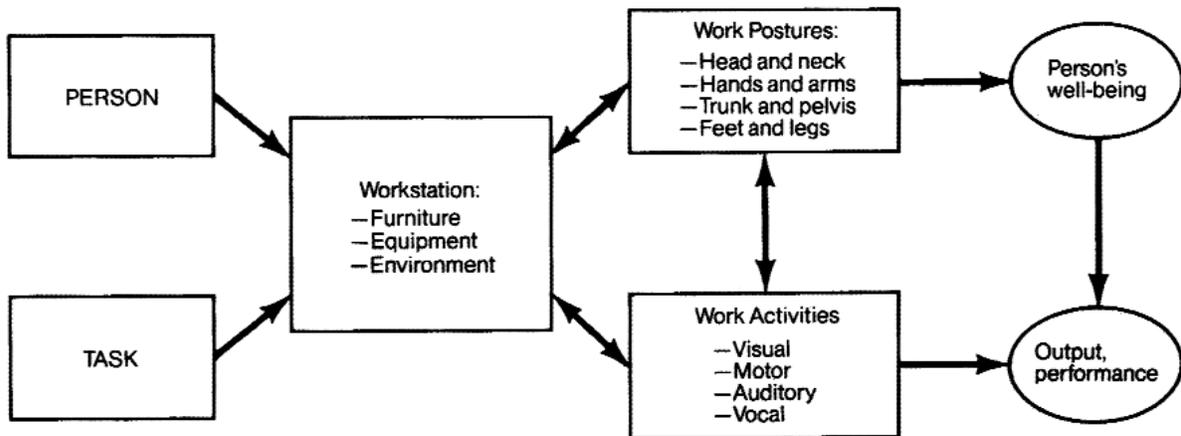
Overhead 13-1.

Origins and Applications of Ergonomics/Human Factors



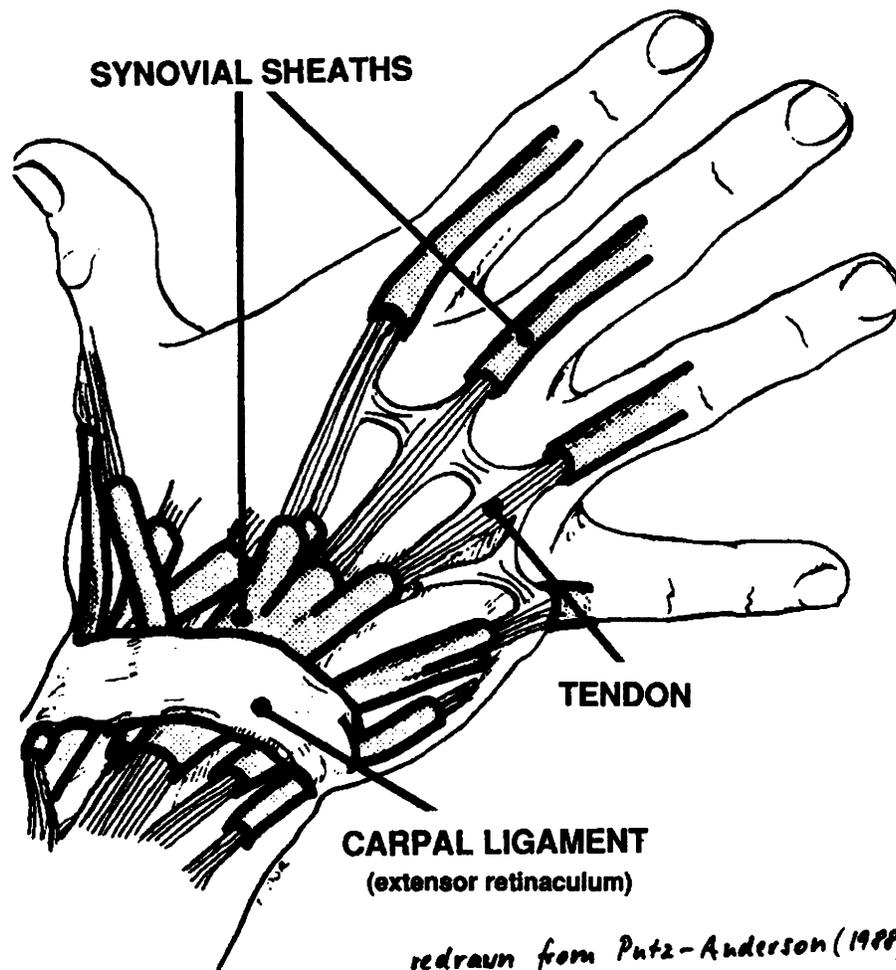
Overhead 13-2.

Interactions among Workstation Design, Work Postures, and Work Activities and Their Effect on the Computer Operator's Well Being and Performance



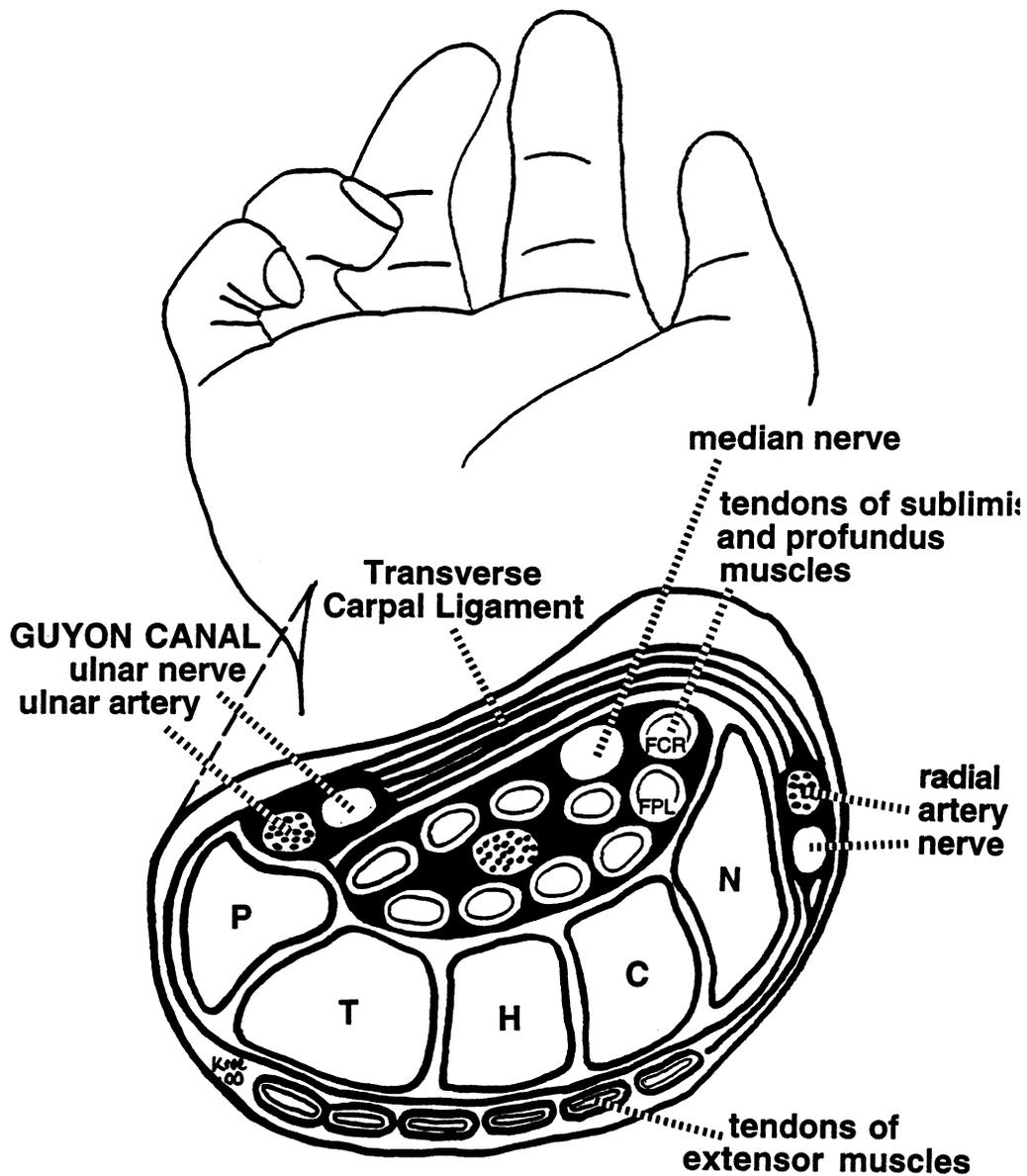
Overhead 13-3.

Tendons and Their Sheaths in the Back of the Hand



Overhead 13-4.

Cross-Section of the Carpal Tunnel



(Adapted from Kroemer 1989.)

14

Biological Hazards

Quiz 1 (23 points total)

True/False (6 points)

1. Viruses are totally dependent on their hosts for replication.
 - a. true
 - b. false
2. Viruses only infect higher plants and animals.
 - a. true
 - b. false
3. Direct contact of an infected person with another person is common in the laboratory environment.
 - a. true
 - b. false
4. Because of the stringent requirements associated with BSL-4 containment, only a few facilities that meet this standard have been built and are operational.
 - a. true
 - b. false
5. Decorative plants are restricted from use at BSL-3 and higher.
 - a. true
 - b. false

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6. Personal habits such as nail biting must be avoided because they offer an excellent means of ingesting pathogens.
- true
 - false

Multiple Choice (4 points)

7. What are the two categories of microorganisms?
- prokaryotes
 - eukaryotes
 - gram-negative
 - gram-positive
8. What is the most frequently used and effective example of laboratory containment equipment?
- biological safety cabinet
 - vertical-flow clean benches
 - controlled access
 - directional one-pass airflow
9. What two serious hazards can be presented by centrifugation?
- electrical sparks
 - excessive noise
 - dispersion of aerosols
 - mechanical failure
10. Which of the following terms implies complete elimination or destruction of all forms of microbial life?
- decontamination
 - disinfection
 - sterilization
 - purification

Short Answer (10 points)

11. What prompted OSHA to establish the bloodborne pathogens standard in 1991?
12. Define *infection*.

13. What are four occupations in which workers are exposed to animal-related allergens and to infectious agents or their toxins?
14. What control measures should be used for the zoonotic diseases considered to be a hazard for agricultural workers?
15. What biosafety guidelines are most commonly used in the United States for containment of biohazardous agents in the workplace?
16. What is one of the most critical workplace controls used to minimize exposure to HIV, HBV, and HCV?
17. What is the infection control concept of universal precaution?
18. What are the four components of an epidemiological investigation of any disease outbreak (natural or artificial)?
19. What health effects are consistent with endotoxin exposure?
20. What appears to cause organic dust toxic syndrome?

Short Essay (3 points)

21. What are three ways that infectious airborne particles can be generated?

22. What is primary containment and how is it achieved?

23. What is secondary containment and how is it attained?

Quiz 2 (25 points total)

True/False (5 points)

1. Work-associated infections are underreported in the scientific literature.
 - a. true
 - b. false
2. OSHA's bloodborne pathogens standard applies only to the health care community.
 - a. true
 - b. false
3. Hepatitis B virus is transmitted by parenteral inoculation and airborne transmission.
 - a. true
 - b. false

4. Decontamination of persons exposed to agents associated with bioterrorism is less important than decontamination of persons exposed to chemicals.
 - a. true
 - b. false

5. Humans have long coexisted with legionellae, the bacteria that cause Legionnaires' disease.
 - a. true
 - b. false

Multiple Choice (5 points)

6. In what species do viroids cause diseases?
 - a. fish
 - b. birds
 - c. plants
 - d. humans

7. What are zoonotic diseases?
 - a. diseases common to wild animals in captivity
 - b. diseases limited to animals
 - c. diseases acquired from spores
 - d. diseases that affect both humans and animals

8. What is the most common chronic bloodborne infection in the United States?
 - a. HIV
 - b. hepatitis C virus
 - c. hepatitis B virus
 - d. tuberculosis

9. How much of the world's population is tuberculosis estimated to affect?
 - a. one-tenth
 - b. one-quarter
 - c. one-third
 - d. half

10. What are the two clinically and epidemiologically distinct manifestations of legionellosis?
 - a. Legionnaires' disease
 - b. hantavirus
 - c. salmonella
 - d. Pontiac fever

Short Answer (12 points)

11. Name five types of microorganisms.

12. What are exogenous infections?

13. What are three principal modes of transmission for infectious microorganisms and other biological materials?

14. How do vector-borne infections occur?

15. What are the major infectious hazards for women who are pregnant or intend to become pregnant?

16. What conditions must be present before an infection occurs?

17. What are the most frequently used disinfectants in the workplace?

18. How is hepatitis C virus transmitted primarily?

19. To what is much of the current increase in cases of tuberculosis attributed?

20. How is tuberculosis usually transmitted?

Overhead 14-1.

Seven Basic Rules of Biosafety

1. Do not mouth pipette.
2. Manipulate infectious fluids carefully to avoid spills and the production of aerosols and droplets.
3. Restrict the use of needles and syringes to procedures for which there are no alternatives; use needles, syringes, and other sharps carefully to avoid self-inoculation; and dispose of sharps in leak- and puncture-resistant containers.
4. Use protective laboratory coats and gloves.
5. Wash hands after all laboratory activities, after removing gloves, and immediately following contact with infectious materials.
6. Decontaminate work surfaces before and after use, and immediately after spills.
7. Do not eat, drink, store food, apply cosmetics, or smoke in the laboratory.

Overhead 14-2.

Biosafety Containment Level Requirements

Biosafety Level 1 (BSL-1)

- for work involving defined and well-characterized strains of viable microorganisms
- no known or minimal potential hazard to laboratory personnel or the environment
- no special competence is required
- training in the specific procedures should be provided
- should be supervised by a scientist with general training in microbiology or a related science
- laboratory is not separated from general building traffic
- work is conducted on the open bench

Biosafety Level 2 (BSL-2)

- for work with many moderate-risk agents present in the community (indigenous)
- associated with human disease of varying degrees of severity
- agents are usually of moderate potential hazard to personnel and the environment
- should have a level of competency equal to or greater than one would expect in a college department of microbiology
- limited access to the laboratory when work is in progress

Biosafety Level 3 (BSL-3)

- for work with indigenous or exotic agents where the potential for infection by aerosols is real
- disease may have serious or lethal consequences
- partial containment equipment, such as Class I or Class II biological safety cabinets, is used for all manipulations of infectious material
- special engineering design criteria and work practices are associated with BSL-3 containment

Biosafety Level 4 (BSL-4)

- for work with dangerous and exotic agents
- high individual risk of life-threatening disease
- agent has a low infectious dose and poses a danger for the community from person-to-person spread
- BSL-4 containment is appropriate for all manipulations of potentially infectious diagnostic materials, isolates, and naturally or experimentally infected animals
- maximum containment equipment, such as a Class III biological safety cabinet, or partial containment equipment in combination with a full-body, air-supplied, positive-pressure personnel suit is used for all procedures and activities

15

Evaluation

Quiz 1 (24 total points)

True/False (5 points)

1. The 6.2 million occupational work-related injuries and illnesses reported by the U.S. Department of Labor's Bureau of Statistics in 1997 represents the actual number of injuries that occurred in private industry.
 - a. true
 - b. false
2. If during an initial field survey, an industrial hygienist smells a chemical and experiences some eye irritation, it can be assumed that the workers in the plant are being overexposed to one or more chemicals.
 - a. true
 - b. false
3. It is generally assumed that the effects of chemicals acting on different organs should be considered jointly because they may produce additive or synergistic results.
 - a. true
 - b. false
4. The results of personal monitoring should be used to determine the effectiveness of control measures implemented to prevent overexposure.
 - a. true
 - b. false

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5. If windows are kept open during one season and closed during another, regular air sampling only needs to be done during the season when the windows are closed.
- true
 - false

Multiple Choice (6 points)

6. What is the most satisfactory method of cleaning dry, dusty materials without producing excessive amounts of airborne contaminants?
- steam cleaning
 - vacuuming
 - using compressed air
 - wet mopping
7. OSHA recognizes _____ as one method of evaluating the hazards of a process.
- failure mode and effects analysis (FMEA)
 - what-if scenarios
 - fault tree analysis
 - all of the above
8. Which of the following is *not* true of personal monitoring?
- Personal monitoring can be conducted during employee breaks.
 - It is important to interview an individual before, during, and after personal monitoring.
 - Personal monitoring measures the ambient air concentration of a substance in a given area.
 - Personal monitoring is usually done during a specific time period.
9. A Certified Industrial Hygienist (CIH) has met certain educational requirements and has at least _____ years experience in the field.
- 2
 - 3
 - 4
 - 5
10. When a contaminant is released into the atmosphere as a dust, mist, or fume, its concentration can be expressed in all of the following ways *except* _____
- ppm.
 - $\mu\text{g}/\text{m}^3$.
 - oz/1,000 ft³.
 - gcf.

11. If after analysis a sampling result is less than the PEL, it _____
- should be interpreted as a clean bill of health.
 - is considered to be in compliance with the law.
 - guarantees that the workplace is safe for employees.
 - is adequate to protect employees from multiple exposures.

Short Answer (7 points)

12. Required by OSHA's Hazard Communication Standard, 29 CFR 1910.1200, _____ are used to anticipate possible hazards and to ensure these risks are communicated to employers and employees before they are encountered in the workplace.
13. Define *process safety management*.
14. What are the three categories of biological monitoring?
15. If a worker's medical evaluation shows that he is overexposed to lead, what does OSHA require of his employer?
16. What is the definition of *accuracy*?
17. When calculating UCLs and LCLs, OSHA distinguishes between three types of samples. What are they?
18. When analyzing sampling results, what happens if samples were not collected for a one-hour period and existing documentation does not show that exposure levels were constant?

4. The OSHA airborne exposure limits, RELs, and TLVs[®] were developed under the assumption that workers are exposed to chemicals one at a time since this is most often the case.
 - a. true
 - b. false

5. When measuring contaminant concentrations for gases and vapors, it is necessary to know the atmospheric temperature and pressure under which the samples were taken.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Which of the following are also known as ceiling levels and are used to evaluate brief exposure times or peak releases?
 - a. TWAs
 - b. STELs
 - c. RELs
 - d. TLVs[®]

7. Which of the following is true of chemical inventories?
 - a. They classify the degree of risk from exposure to the chemicals listed.
 - b. They specify the quantities of chemicals used in various processes.
 - c. They indicate the point in a process at which employees risk being exposed.
 - d. They identify the chemical hazards that are present in a process.

8. The records to be kept during air sampling include _____
 - a. the total time sampled.
 - b. the use of personal protective equipment.
 - c. the location of general exhaust ventilation.
 - d. all of the above.

9. Which of the following is true of biological monitoring?
 - a. The results of biological monitoring must be reproducible.
 - b. Biological monitoring is not limited by intraindividual variability.
 - c. Laboratory reliability does not affect the outcome of biological monitoring.
 - d. The significance of results from biological monitoring is never open to interpretation.

10. Which of the following affect precision?
 - a. poorly calibrated equipment
 - b. method error
 - c. intraday concentration fluctuations
 - d. incorrect calculations

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11. According to TLV[®] guidelines, short-term exposures may exceed _____ the TLV[®] for no more than a total of 30 minutes during the workday.
- 1.5 times
 - 2 times
 - 2.5 times
 - 3 times

Short Answer (7 points)

12. What is the unequal distribution of risks that industrial hygienists should consider when evaluating workplace hazards?
13. Interviews with workers can provide some of the best information about hazard information. What are four questions workers should be asked?
14. The increased risk of lung cancer that results from smoking and asbestos exposure is an example of a _____.
15. What are two factors that should be considered when determining which employees working in a room run the highest risk of hazard exposure?
16. The number of samples that needs to be collected depends on three factors. What are these factors?
17. What is the formula for calculating the time-weighted average exposure (TWA) for an eight-hour workday?
18. If published standards or guidelines do not exist for a chemical, how can industrial hygienists evaluate sampling results?

Short Essay (6 points)

19. Although area sampling is a good technique for determining the need to develop, implement, and improve control measures, it does have drawbacks. What are some of its drawbacks?
20. In some cases, an industrial hygienist might decide to sample the worst case scenario first, during the time of greatest exposure, at a location known to have posed problems. What are three advantages of this strategy?

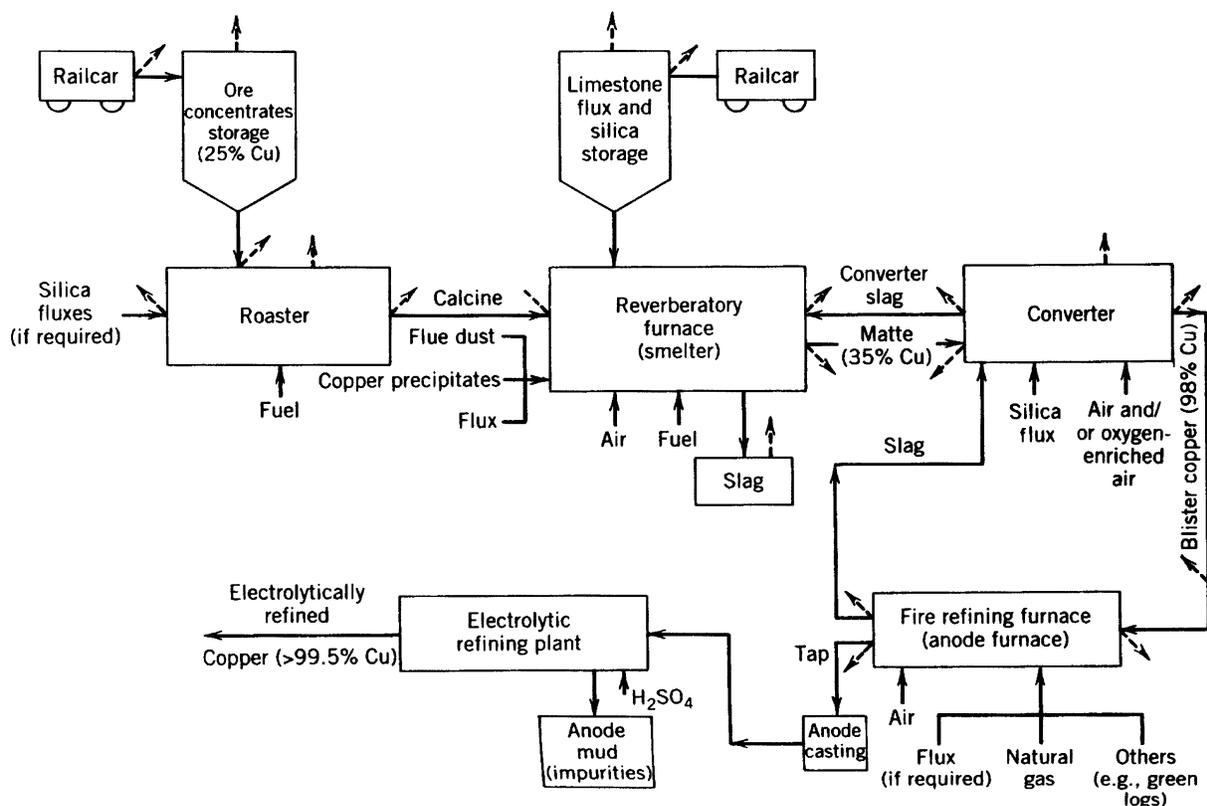
Case Study

(Scoring Guidelines— Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

For the last several years, Fingston Labs has been relying primarily on biological monitoring and medical surveillance to evaluate hazard exposures for its employees. It collects samples based on the worst-case scenario method. In other words, samples are collected during the time of greatest exposure at locations known to have caused problems in the past. As a result, the most highly exposed employees have been tested on a regular basis for some time. Results of the sampling show that exposures do not exceed PELs or STELs, and Fingston management is confident the employees are working in safe conditions. However, industrial hygienists at the company do not feel as confident about the safety of working conditions in the facility. They realize that the results may not be reliable because the sampling periods were not chosen randomly and are not statistically representative of the entire exposed group. They are also concerned because changes have been made to some of the manufacturing processes, but Fingston has been using the same monitoring and sampling process. As an industrial hygienist at Fingston, you would like to propose some alternatives to the worst-case scenario method.

Overhead 15-1.

Sample Process Flow Diagram for Primary Copper Smelting Showing Fugitive Emissions



(Source: EPA 1977.)

Overhead 15-2.

Types of Monitoring

Monitoring is a continuous process of observation, measurement, and judgment.

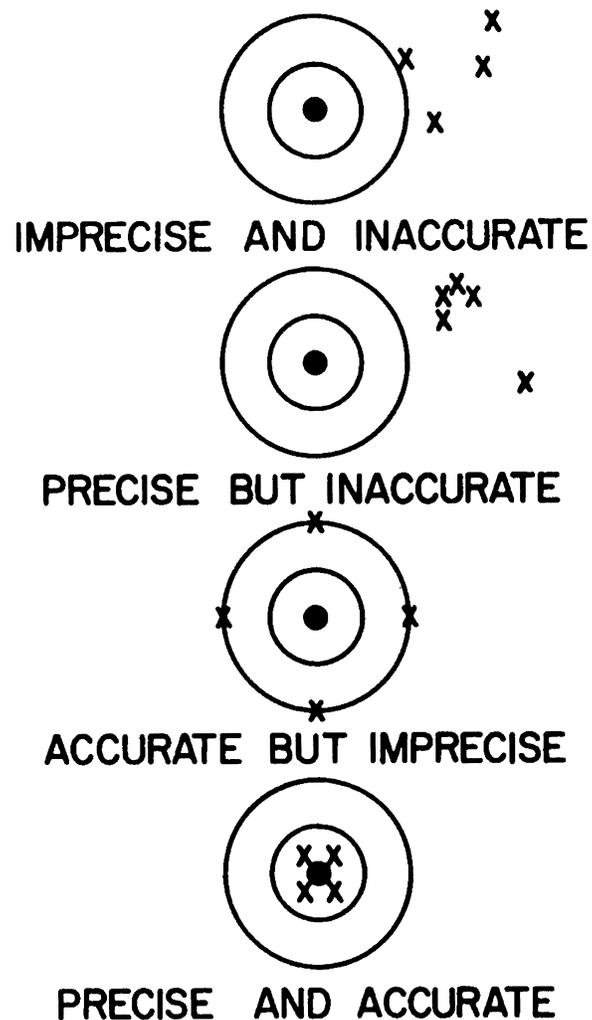
Various types of monitoring include:

- personal monitoring
- environmental, or area, monitoring
- biological monitoring
- medical screening

Overhead 15-3.

Accuracy and Precision

A measurement can be precise, but not accurate. A measurement can also be accurate, but not precise.



(Reprinted with permission from Powell CH, Hosey AD, eds. *The Industrial Environment—Its Evaluation and Control*, 2nd ed. U.S. Public Health Services Pub No. 614, 1965.)

16

Air Sampling

Quiz 1 (16 total points)

True/False (5 points)

1. Since all adsorption is exothermic, adsorption is increased at higher temperatures.
 - a. true
 - b. false
2. The filter is the most common collection device for particulates.
 - a. true
 - b. false
3. Personal air sampling is the preferred method of evaluating worker exposure to airborne chemicals.
 - a. true
 - b. false
4. A vapor is the gaseous phase of a substance that under standard conditions exists as a liquid or a solid in equilibrium with its vapor.
 - a. true
 - b. false
5. The impinger is one of the oldest methods of particulate samplings, but it is little used today.
 - a. true
 - b. false

Multiple Choice (5 points)

6. What is the most commonly used solid sorbent?
 - a. porous polymers
 - b. molecular sieves
 - c. silica gel
 - d. activated charcoal

7. What is the most commonly used filter for aerosol samplers?
 - a. membrane filters
 - b. glass and quartz filters
 - c. polycarbonate straight pore filters
 - d. none of the above

8. Which of the following absorption devices is the easiest to use?
 - a. spiral absorbers
 - b. gas wash bottles
 - c. fritted bubblers
 - d. helical absorbers

9. A/an _____ is used to collect particles of respirable size. Respirable particles are those that are retained in the lung and are generally considered to be of an aerodynamic size below 10 μm .
 - a. electrostatic precipitator
 - b. elutriator
 - c. impinger
 - d. cyclone

10. A/an _____ can be used to determine particle size distribution.
 - a. electrostatic precipitator
 - b. inertial impactor
 - c. suction pump
 - d. elutriator

Short Answer (5 points)

11. What is the definition of "breathing zone?"

12. Air-sample collection devices are made of five basic components. What are these components?

13. What is meant by “breakthrough” in adsorption sampling?

14. Explain how a wet-test meter works.

15. Explain how a precision rotameter works. When it is typically used?

Short Essay (1 point)

16. Explain how a critical-flow orifice works.

Quiz 2 (16 total points)

True/False (5 points)

1. Passive monitors are not often used because they are cost-prohibitive.
 - a. true
 - b. false

2. Low-flow suction pumps are used for filter, cyclone, and impinger sampling.
 - a. true
 - b. false

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3. OSHA regulations do not specify the use of a particular air-sampling method, but only that the method used has been proven accurate.
 - a. true
 - b. false
4. A soap-bubble meter can be used to calibrate a rotameter.
 - a. true
 - b. false
5. As the concentration of contaminant in air increases, breakthrough capacity (mg adsorbed) of a solid sorbent bed increases, but breakthrough volume (L of air sampled) decreases.
 - a. true
 - b. false

Multiple Choice (4 points)

6. The ____ is commonly used for cotton dust sampling. It consists of a large tube through which the direction of airflow is opposite to the direction of gravity.
 - a. vertical elutriator
 - b. horizontal elutriator
 - c. inertial impactor
 - d. impinger
7. Which of the following is an example of a primary calibration device?
 - a. rotameter
 - b. wet test meter
 - c. soap bubble meter
 - d. dry test meter
8. OSHA standard 29 *CFR* 1910.20, Access to Employee Exposure and Medical Records, requires that employee exposure records be kept for ____ year(s).
 - a. 1
 - b. 12
 - c. 25
 - d. 30
9. Background data of air sampling such as lab reports and field notes need to be retained for at least ____ year(s).
 - a. 1
 - b. 12
 - c. 25
 - d. 30

Short Answer (6 points)

10. What are field blanks?

11. What are the advantages and disadvantages of grab sampling?

12. What conditions would call for the use of an electrostatic precipitator?

13. What information is required on the OSHA air-sampling worksheet?

14. What is a thermal desorption tube and when is it used?

15. What are media blanks?

Short Essay (1 point)

16. The selection of an air-sampling method depends on a number of factors. What are these factors?

Case Study

(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

As an industrial hygienist for Mr. Cabaret Cleaning Supplies, you are responsible for the evaluation and control of employee exposure to occupational health hazards, including the risk of exposure to airborne contaminants. For the evaluation and control of inhalation hazards, you compare the measured concentration of an airborne chemical to a recognized exposure limit. You are required to use many different types of air sampling in your work.

1. Briefly define personal air sampling, area sampling, grab samples, and integrated samples.

2. In addition to testing for contaminants, how else might air samples be used?

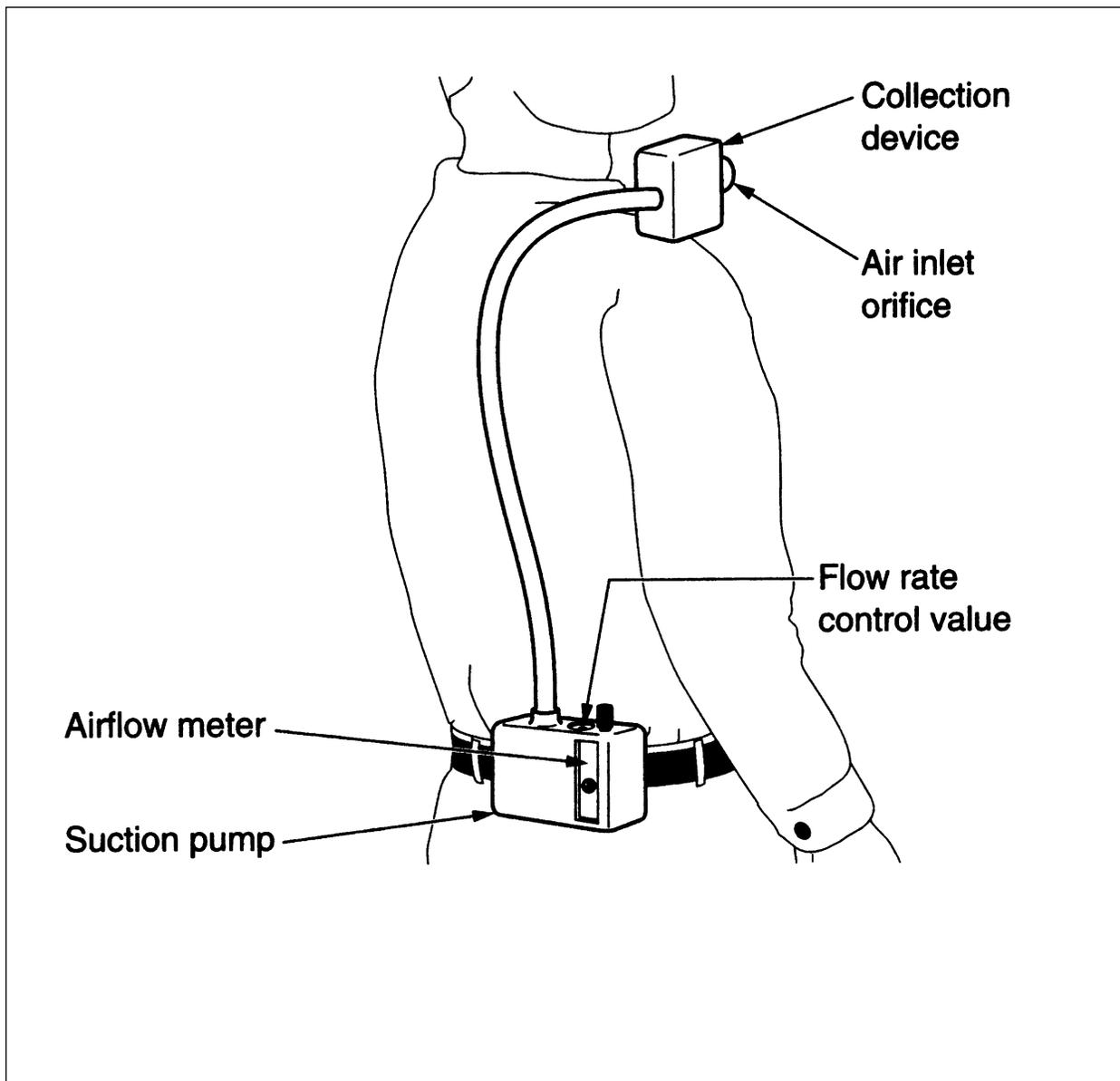
Study Guide: Fundamentals of Industrial Hygiene

6. What other sampling techniques are available?

7. What factors will determine which sampling method you'll use?

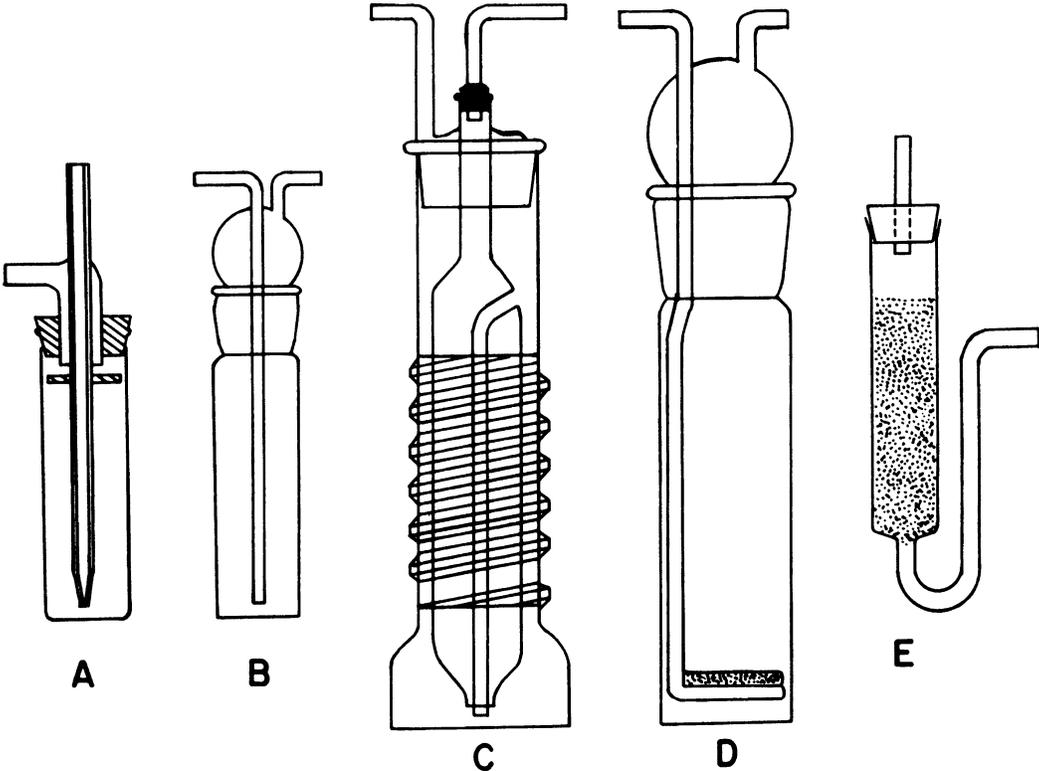
Overhead 16-1.

Components of a Typical Air-Sampling Train



Overhead 16-2.

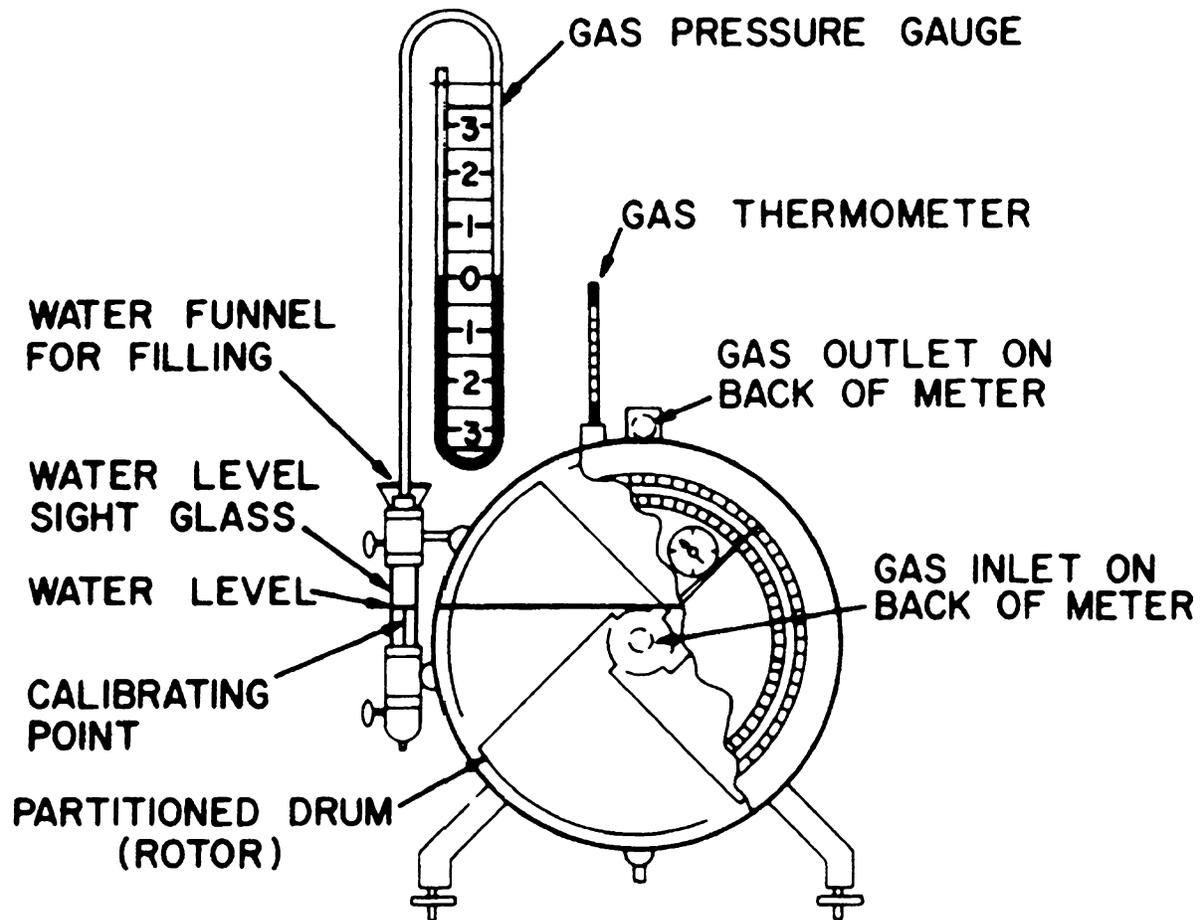
Basic Absorbers



(Reprinted from Powell CH, Hosey AD, eds. *The Industrial Environment—Its Evaluation and Control*, 2nd ed. U.S. PHS Publication No. 614,1965.)

Overhead 16-3.

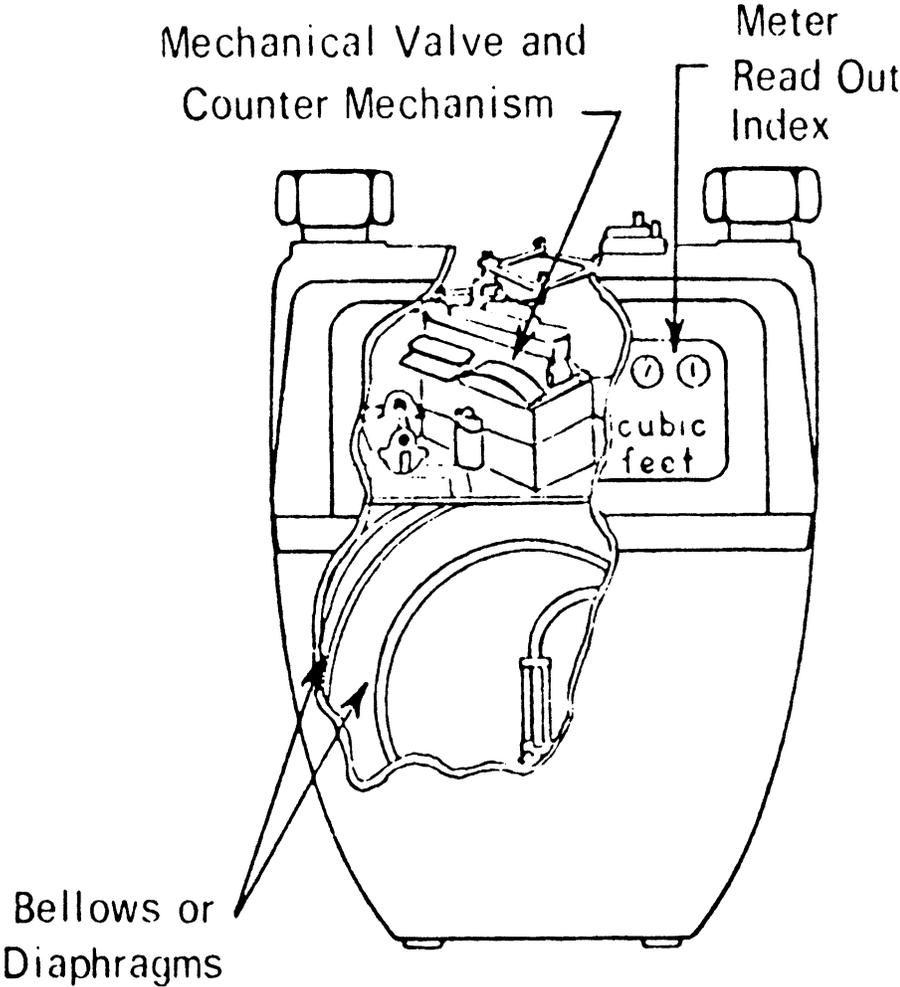
The Working Parts of a Wet-Test Meter



(Reprinted from *The Industrial Environment—Its Evaluation and Control*, PHS Pub. no. 614, 1965.)

Overhead 16-4.

A Dry-Gas Meter



(Reprinted from *The Industrial Environment—Its Evaluation and Control*, PHS Pub. no. 614, 1965.)

17

Direct-Reading Instruments for Gases, Vapors, and Particulates

Quiz 1 (17 points total)

True/False (4 points)

1. The simplest type of combustible gas instrument provides only one sensitivity, usually up to 100 percent of the UEL.
 - a. true
 - b. false
2. Instrument manufacturers often provide calibration curves or tables for a variety of different combustibles.
 - a. true
 - b. false
3. Interchanging tubes and pumps from various manufacturers will lead to erroneous results.
 - a. true
 - b. false
4. Indicator tubes used with hand pumps have been developed for determination of time-weighted average concentrations.
 - a. true
 - b. false

Multiple Choice (3 points)

5. Which of the following is not a type of combustible gas monitor?
 - a. catalytic combustible gas sensor
 - b. thermal conductivity detector
 - c. optical reflector detector
 - d. metal oxide semiconductor detector

15. Why is it advantageous to use a mass spectrometric detector with a portable gas chromatograph?

Short Essay (2 points)

16. Direct-reading instruments for combustible gases are based on one of two principles. What are those principles?

17. What is the basis for infrared analyzers?

Quiz 2 (16 points total)

True/False (4 points)

1. Direct-reading instruments based on biosensors are not yet commercially available.
 - a. true
 - b. false
2. Even oxygen has a specific occupational exposure level.
 - a. true
 - b. false
3. Interfering gases and vapors can seriously affect instrument response.
 - a. true
 - b. false

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4. Few instruments can measure formaldehyde concentrations at the current TLV[®] ceiling level of 0.3 ppm.
 - a. true
 - b. false

Multiple Choice (3 points)

5. Assuming that the instrument is functioning properly, what does the absence of an instrument response mean (more than one answer)?
 - a. little or no combustible gas in the space being tested
 - b. interference from nonexplosive gases
 - c. overloading of a sensitive scale
 - d. concentration above the UEL but insufficient oxygen for combustion
6. What level of oxygen is considered the minimum to support life?
 - a. 29 percent
 - b. 21 percent
 - c. 19.5 percent
 - d. 16 percent
7. What organization certifies that commercial detector tubes comply with established performance specifications?
 - a. NIOSH
 - b. ASSE
 - c. OSHA
 - d. SEI

Short Answer (7 points)

8. How is air typically drawn into a detector?
9. Why should a hot-wire combustible gas indicator not be used in areas where silicone vapors are present?
10. What two parameters do polarographic detectors rely on?

11. What can direct-reading nonspecific detectors be used for?
12. How do flame ionization detectors work?
13. What was the ion mobility spectrometer originally developed for?
14. What is the condensation nuclei counter used for?

Short Essay (2 points)

15. How does one ensure that a reading above the UEL is not misinterpreted as a true zero reading?
16. What is the basic principle for surface acoustic wave detectors?

Overhead 17-1.

Using Colorimetric Indicator Tubes

Performing reliable tests with indicating tubes requires careful use and thorough knowledge of their limitations. Experience has shown that the following measures help to minimize some errors:

- Test each batch of tubes with a known concentration of the air contaminant to be measured.
- Read the length of stain in a well-lighted area.
- Comply with the manufacturer's expiration date and discard outdated tubes.
- Store detector tubes in accordance with the manufacturer's recommendations.
- Refer to the manufacturer's data for a list of interfering materials.

18

Methods of Control

Quiz 1 (24 total points)

True/False (5 points)

1. The best time to integrate engineering controls is during the design phase of a facility.
 - a. true
 - b. false
2. Episodic exposures are easy to control from an engineering point of view.
 - a. true
 - b. false
3. Nonroutine maintenance, repair, and cleaning performed on automated equipment have can pose the greatest exposure risks to employees.
 - a. true
 - b. false
4. Job rotation can keep employee exposure to toxic chemicals below recommended levels while also exposing more employees to the hazard.
 - a. true
 - b. false
5. The best way to remove dust on overhead ledges before it can become airborne as a result of vibration is to use compressed air.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Wherever feasible, _____ should be used as the first line of defense against workplace hazards.
 - a. personal protective equipment
 - b. administrative controls
 - c. engineering controls
 - d. none of the above

7. When a facility is brought on-line, it is recommended that the ventilation system be operated for _____ prior to occupancy to purge construction-related contaminants.
 - a. 12 hours
 - b. 24 hours
 - c. 36 hours
 - d. 48 hours

8. One example of changing a process to reduce environmental hazards is _____.
 - a. replacing white lead in paint pigment with zinc.
 - b. using arc welding to replace riveting.
 - c. removing beryllium phosphors from formulations for fluorescent lamps.
 - d. shotblasting instead of sandblasting.

9. Which of the following is true of general ventilation systems?
 - a. They should be used only when small quantities of air contaminants are being released into the work environment.
 - b. They are more effective and economical in environments where highly toxic dusts and fumes are present.
 - c. They are designed to capture contaminants at their source before they escape into the work environment.
 - d. They should be used when a contaminant cannot be controlled by substitution, changing the process, isolation, or enclosure.

10. The direct flow of a chemical through seams, pinholes, or closures is known as _____.
 - a. degradation.
 - b. permeation.
 - c. penetration.
 - d. infiltration.

11. Which of the following should be considered when selecting proper hearing protection?
 - a. the anatomical characteristics of the wearer
 - b. the noise exposure dose
 - c. environmental conditions
 - d. all of the above

Short Answer (7 points)

12. What are the three categories of methods used to control health hazards in the workplace?

13. When a facility is being designed, plans must follow permissible standards and laws. What happens when more than one standard or agency is involved?

14. Five questions should be asked when addressing airborne hazards during the design process. What are these questions?

15. When isolating toxic materials, the degree of isolation that is required depends on _____, _____, and _____.

16. What is the major disadvantage of general ventilation?

17. What is the difference between an air-purified respirator and an air-supplied respirator?

18. What method do hazard-oriented medical surveillance programs use to monitor the absorption of chemical agents?

Short Essay (6 points)

19. Substituting a nontoxic or less toxic material for a highly toxic one is an effective method of industrial hygiene control. In addition to reducing environmental hazards, what are some other advantages of this method? What are some of its drawbacks?

20. What factors influence the proper design of exhaust ventilation systems? Why can local exhaust systems be difficult to design?

Quiz 2 (24 total points)

True/False (5 points)

1. Vapor from chlorinated solvents interacting with ultraviolet radiation is just one example of an accumulated hazard.
 - a. true
 - b. false
2. Design engineers are usually more familiar with safety hazards because the effects of overlooking these hazards are much more obvious than those resulting from health hazards being overlooked.
 - a. true
 - b. false
3. Isolation is particularly useful method of industrial hygiene control for jobs that involve relatively few workers.
 - a. true
 - b. false
4. According to OSHA carcinogen regulations, a regulated area must be set aside for producing or handling a particular carcinogen.
 - a. true
 - b. false
5. Respiratory protective devices can be substituted for engineering controls, especially in highly toxic environments.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Which of the following is an example of a closed system becoming momentarily open?
 - a. noise emissions caused by ill-fitting lagging
 - b. exhaust hoods that are not completely effective
 - c. a periodic filter change operation
 - d. weakened pump seals

7. For infrequent emergencies or nonroutine events, _____ can be an appropriate solution.
 - a. personal protective equipment
 - b. administrative controls
 - c. engineering controls
 - d. none of the above

8. All of the following are industrial hygiene control methods for reducing environmental hazards *except* _____.
 - a. good housekeeping.
 - b. job rotation.
 - c. local exhaust ventilation.
 - d. dry work methods.

9. Which of the following methods can be the easiest way to prevent hazardous physical contact?
 - a. providing remote controls for equipment
 - b. isolating equipment such as hot water lines
 - c. automating processes to eliminate worker exposure
 - d. isolating workers by enclosing them in control booths

10. Which of the following is true of local exhaust ventilation systems?
 - a. They can reduce heating and air-conditioning costs because they need less airflow than general ventilation systems.
 - b. They are always 100 percent effective in removing contaminants from the work environment.
 - c. Like general ventilation systems, they cannot be used to reclaim reusable materials.
 - d. They can only be used with contaminants of low toxicity.

11. In a typical manufacturing plant, who has the primary responsibility for safe operation and control?
 - a. the team of on-site industrial hygienists
 - b. the line organization of the operations department
 - c. the hazard-oriented medical surveillance personnel
 - d. the employees working in the hazardous environment

Short Answer (7 points)

12. What three basic steps must be followed to determine the extent of exposure to a hazard?

13. Generally employers do not favor administrative controls over engineering controls. Why?

14. Describe a closed system and how it affects employee safety.

15. What are two benefits of locating one or more hazardous operations together in a separate building?

16. Facilities should prohibit their employees from removing particulates from clothing using compressed air. Why?

17. Explain the cradle-to-grave responsibility that companies have to consider when dealing with hazardous waste disposal.

18. What two factors can determine whether disposable or reusable protective clothing should be selected as protective equipment?

Short Essay (6 points)

19. General ventilation should be used only in situations meeting a certain set of criteria. What are these criteria and what is the exception to these criteria?

20. Workers often feel that wearing a respirators for an extended period of time is uncomfortable and inconvenient. How can employers help workers to better cope with using respirators on the job?

Case Study

(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

Mayfield Manufacturing is conducting an annual assessment of its control methods. It has been able to substitute some of the more hazardous chemicals used in its manufacturing processes for less hazardous chemicals. In addition, it has altered processes to make working conditions safer and isolated some of its operations to reduce the number of employees exposed to airborne contaminants. As part of its assessment, Mayfield management also evaluated the need for respiratory protection in a future addition to the facility. When it reviewed the assessment, the safety and health committee agreed that management had done a good job implementing engineering controls to reduce exposure to contaminants. Nevertheless, the committee was still concerned about controlling dust in the facility. It wondered if wet methods might be more effective. The committee also raised questions about the use of personal protective equipment, such as respirators, in the future addition. You have been asked to address the concerns of the safety and health committee.

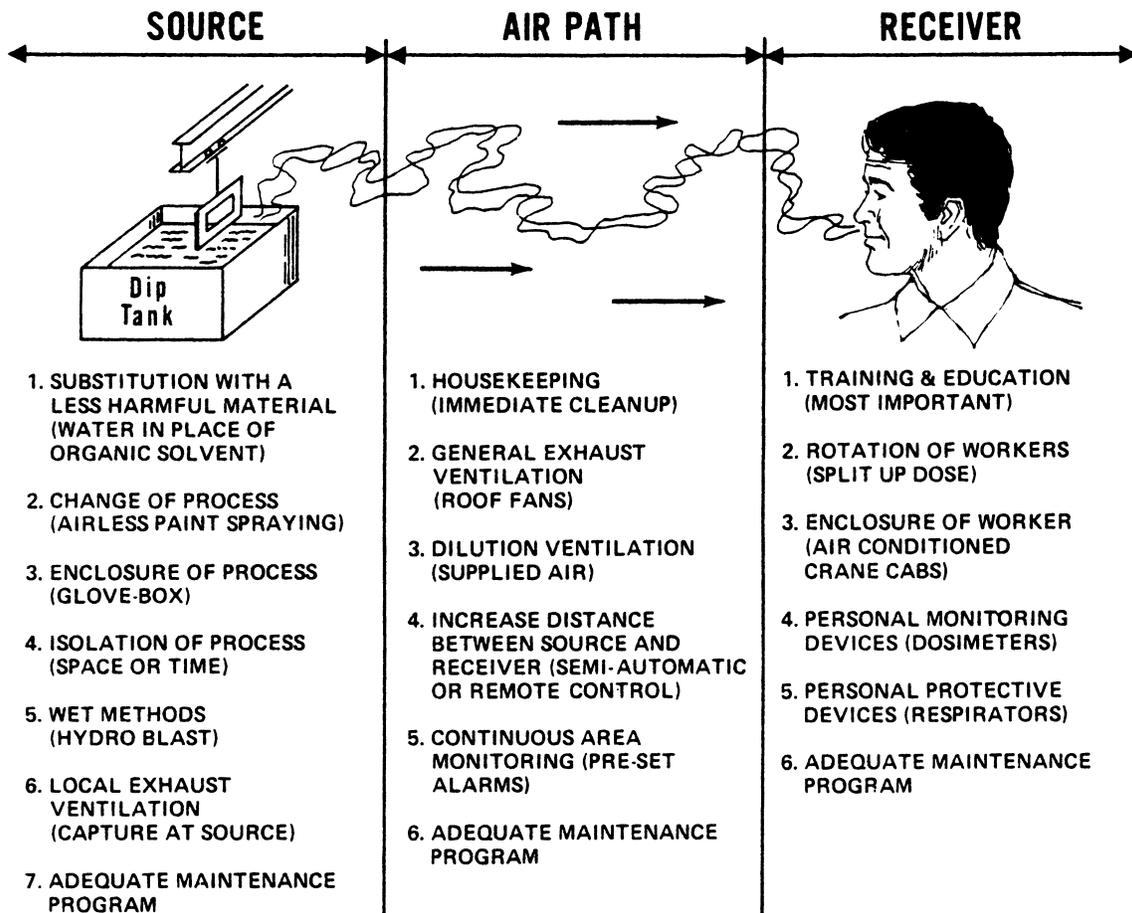
1. What are the drawbacks of personal protective equipment?

Overhead 18-1.

Determining the Extent of Exposure

To determine the extent of exposure, an industrial hygienist locates the contaminant source, finds its path to the employee, and identifies the employee's work pattern and use of protective equipment.

GENERALIZED DIAGRAM OF METHODS OF CONTROL



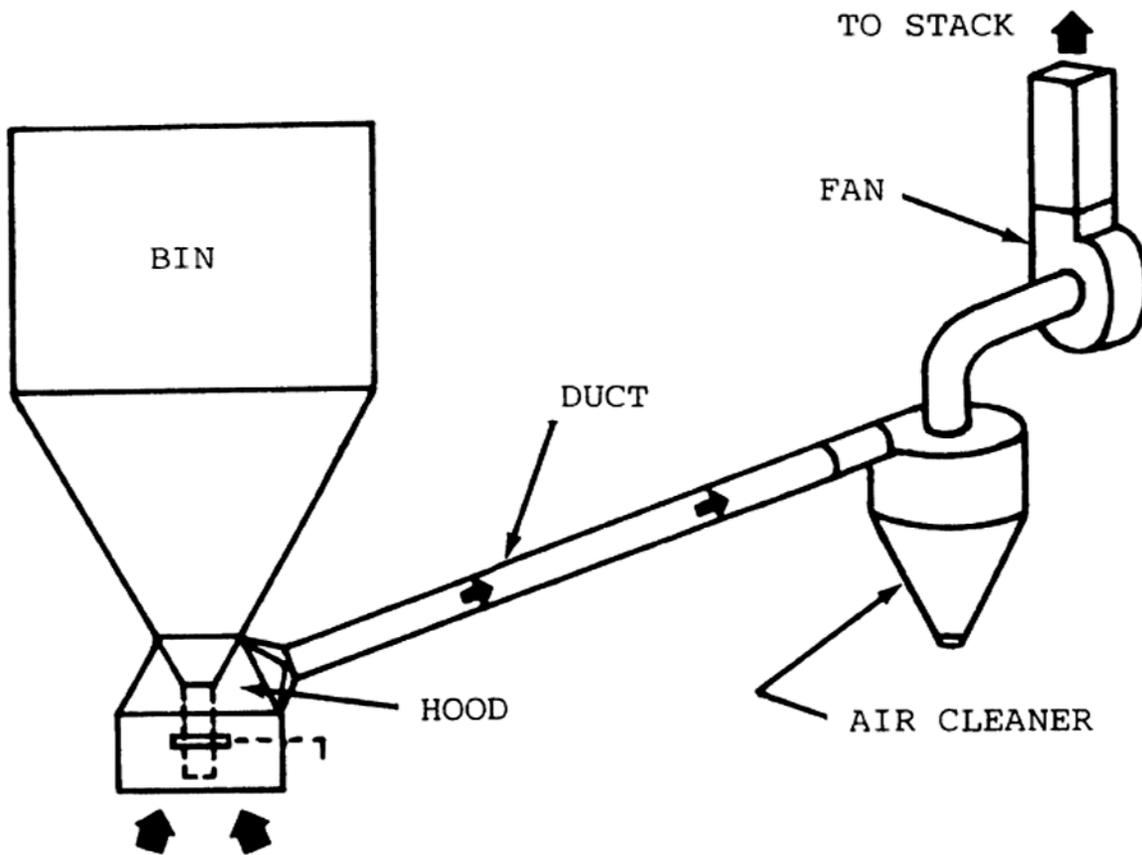
Overhead 18-2.

Principles of Engineering Controls

- substitution: changing the material
- substitution: changing the process
- isolation
- ventilation

Overhead 18-3.

A Typical Local Exhaust Ventilation System



(Courtesy American Conference of Governmental Industrial Hygienists.)

19

Local Exhaust Ventilation

Quiz 1 (20 total points)

True/False (5 points)

1. Canopies for unheated processes must be designed as capturing hoods.
 - a. true
 - b. false
2. Airflow patterns across a roof tend to circulate so they hit the upwind side of the building or the ground.
 - a. true
 - b. false
3. In LEV systems, centrifugal fans are more widely used than axial fans.
 - a. true
 - b. false
4. Air moves because there is a difference in pressure between two points.
 - a. true
 - b. false
5. An LEV reduces the concentration of contaminants into the workroom by mixing with air flowing through the room.
 - a. true
 - b. false

Multiple Choice (6 points)

6. What is the most important part of an LEV system?
 - a. air cleaner
 - b. hood
 - c. makeup air supply
 - d. fan

7. Which type of hood is widely used since it can be placed alongside the contaminant source?
 - a. capturing
 - b. enclosures
 - c. receiving
 - d. slot

8. A paint spray booth is an example of which type of hood?
 - a. capturing
 - b. enclosures
 - c. receiving
 - d. slot

9. ____ impart a circular motion to the exhaust gas that causes particulates to move to the outer part of the airstream where they impact the walls.
 - a. Wet scrubbers
 - b. Cyclones
 - c. Filters
 - d. Electrostatic precipitators

10. Makeup air should be introduced into the “occupied zone” of the plant. In general, the occupied zone is ____ feet from the floor.
 - a. 2-3
 - b. 4-5
 - c. 5-7
 - d. 8-10

11. The ____ contains a paddle that moves according to the velocity of the air passing through the instrument.
 - a. thermo-anemometer
 - b. swinging vane velometer
 - c. smoke tube
 - d. pitot tube device

Short Answer (7 points)

12. Name and describe the two major types of industrial ventilation.

13. How can a health and safety professional make a significant contribution to good hood selection?

14. What is the major limitation of the use of receiving hoods?

15. If corrosion is a concern, what material should you select for your ducts?

16. Spinning or nonuniform flow patterns reduce the fan's air volume and static pressure output. What are some of the major reasons for poor flow patterns?

17. When using an air-cleaning device, what are the three major removal techniques for vapors and gases?

18. What does it mean when a room or plant is "air bound."

Short Essay (2 points)

19. What are the two major categories of filters? Describe some of the materials that filters can be made from, as well as the variety of configurations that are available. What is the advantage of using a filter for particulate removal?

20. A fan generates pressure that causes the air to move through the system. In LEV systems, this fan pressure is called fan static pressure. It is calculated from an equation used by fan manufacturers as part of a standard test of fan performance. Write out this equation, and define each of the input terms.

Quiz 2 (20 total points)

True/False (5 points)

1. Airfoil fans are a modification of the backward-curved blade fan.
 - a. true
 - b. false
2. Adsorption is the process in which a gas or vapor adheres to the surface of a porous solid material.
 - a. true
 - b. false
3. For any given fan, doubling the fan speed will quadruple the volume output.
 - a. true
 - b. false
4. The ideal location to measure hood static pressure is actually three duct diameter from the throat of the hood with a tapered transition into the duct.
 - a. true
 - b. false
5. A pitot tube is a special probe-like device that accurately measures static and total pressures inside a duct.
 - a. true
 - b. false

Multiple Choice (5 points)

6. Which removal device can be used when the air contaminants are combustible?
 - a. adsorption
 - b. oxidation
 - c. absorption
 - d. None of the above are safe to use.

7. The supply rate of makeup air should exceed the exhaust rate by about _____ percent.
 - a. 2
 - b. 5
 - c. 10
 - d. 20

8. The _____ works on the principle that the resistance of a heated wire changes with temperature variations.
 - a. smoke tube
 - b. thermo-anemometer
 - c. electrostatic precipitator
 - d. cyclone

9. The network of piping that connects the hoods and other system components is known as _____
 - a. stacks.
 - b. conveyors.
 - c. ducts.
 - d. hoppers.

10. Which of the following equations is used to determine break horsepower?
 - a. $Q = V \times A$
 - b. $Q = V_x (10X^2 + A)$
 - c. $H_e = (F_d)(VP_d)$
 - d. none of the above

Short Answer (8 points)

11. Why is wind direction important to keep in mind when selecting a stack location?

12. What can occur if there is an insufficient quantity of makeup air in relation to an LEV system?

Study Guide: Fundamentals of Industrial Hygiene

13. The “equation of continuity” is expressed as $Q = V \times A$. What concept does the equation of continuity represent, and what does each symbol stand for?

14. In ventilation work, pressure is expressed in units of “inches of water gauge.” What tool is used to measure that pressure?

15. What factors affect air density?

16. What is a smoke tube, and how is it useful?

17. How do you measure static pressure in a duct?

18. Air flowing through the ductwork meets two forms of resistance. What are these forms, and how do straight ducts and elbows contribute to this resistance?

Short Essay (2 points)

19. Name and describe the elements of a typical local exhaust system.

3. What special room conditions are critical for this type of hood?

4. In general, what are the other types of hoods utilized in a local ventilation system?

An important step in the system design is to determine whether an air cleaner is needed to reduce the amount of contaminants discharged to the environment.

5. What factors determine the type of cleaner needed?

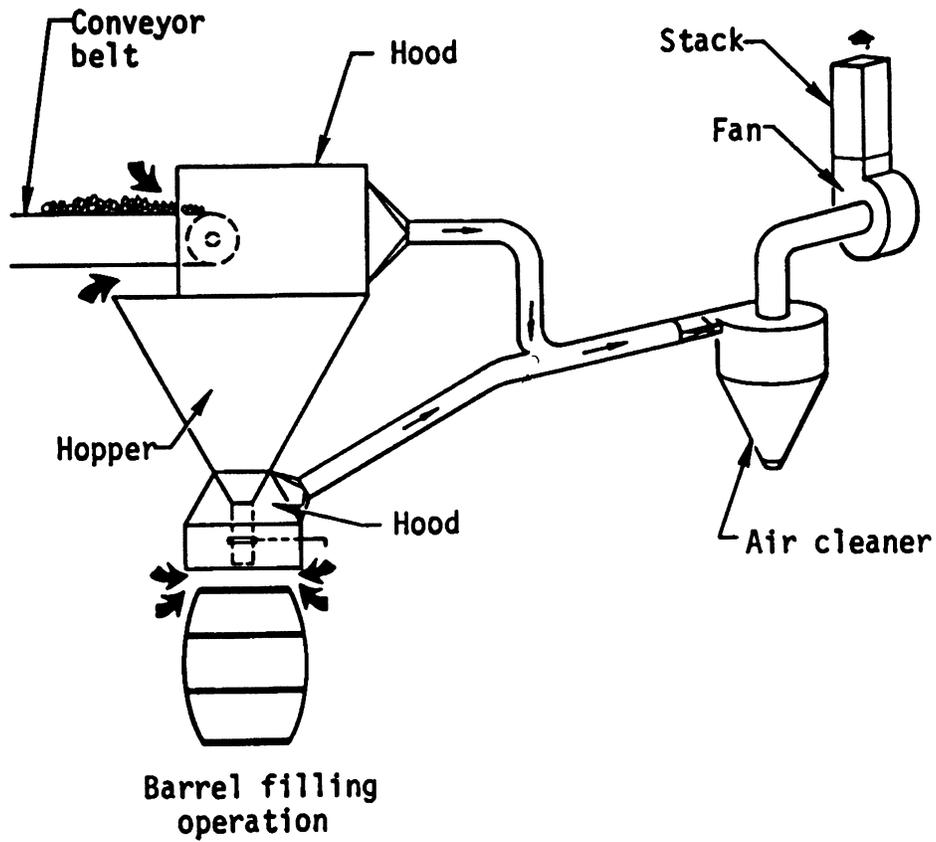
6. What type would you select for the spray painting job?

Management is concerned about their ability to supply adequate makeup air so that they don't become air bound.

7. What are the important features to keep in mind when designing a makeup air system?

Overhead 19-1.

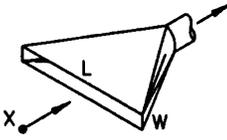
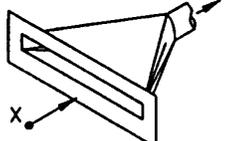
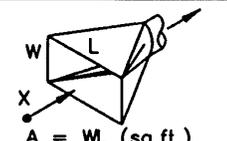
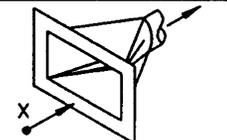
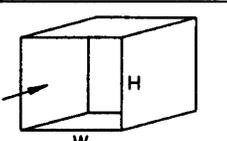
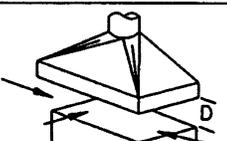
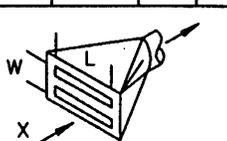
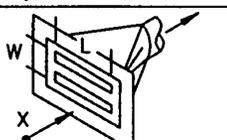
Typical Local Exhaust Ventilation System



(Source: McDermott, 2000.)

Overhead 19-2.

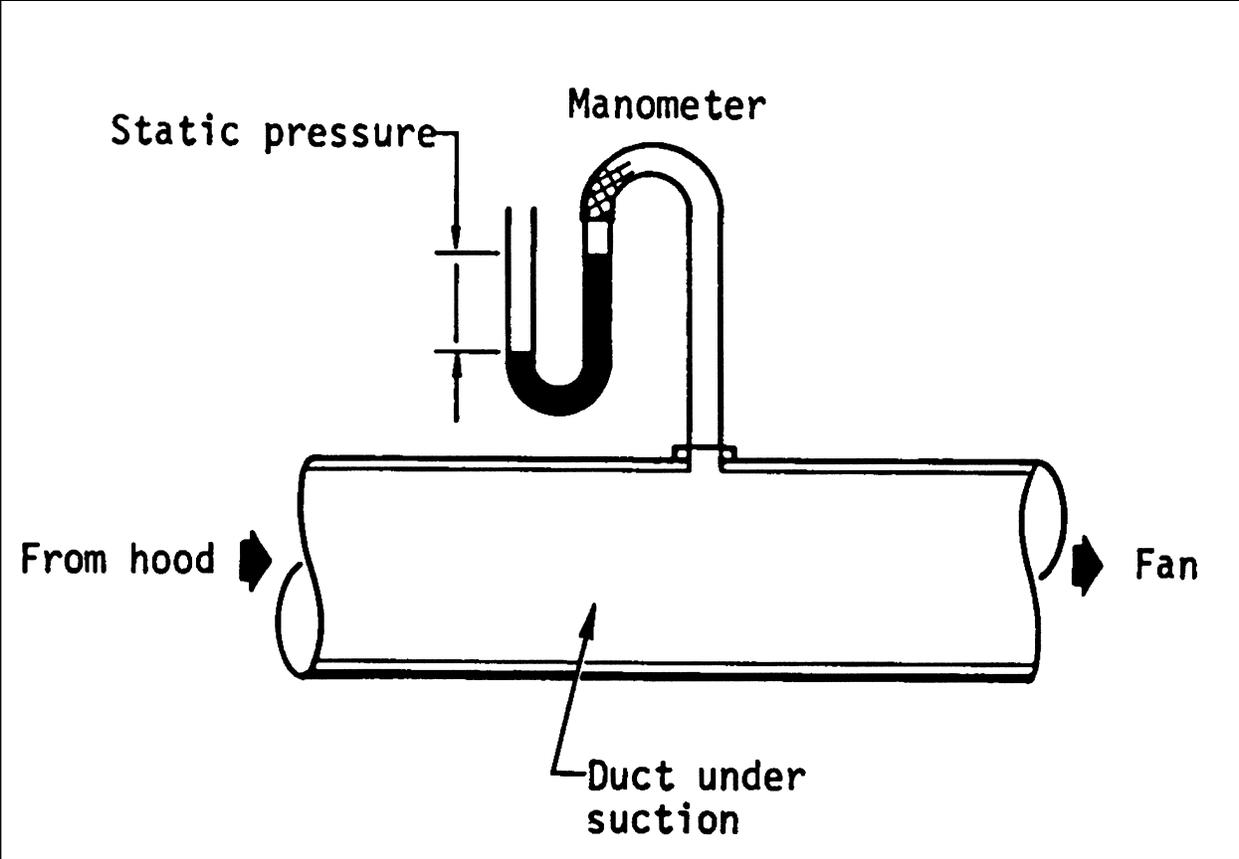
Air Flow (Q) Equations

HOOD TYPE	DESCRIPTION	ASPECT RATIO, W/L	AIR FLOW
	SLOT	0.2 OR LESS	$Q = 3.7 LVX$
	FLANGED SLOT	0.2 OR LESS	$Q = 2.6 LVX$
	PLAIN OPENING	0.2 OR GREATER AND ROUND	$Q = V(10X^2 + A)$
	FLANGED OPENING	0.2 OR GREATER AND ROUND	$Q = 0.75V(10X^2 + A)$
	BOOTH	TO SUIT WORK	$Q = VA = VWH$
	CANOPY	TO SUIT WORK	$Q = 1.4 PVD$ SEE VS-99-03 P = PERIMETER D = HEIGHT ABOVE WORK
	PLAIN MULTIPLE SLOT OPENING 2 OR MORE SLOTS	0.2 OR GREATER	$Q = V(10X^2 + A)$
	FLANGED MULTIPLE SLOT OPENING 2 OR MORE SLOTS	0.2 OR GREATER	$Q = 0.75V(10X^2 + A)$

(Source: From American Conference of Governmental Industrial Hygienists (ACGIH®). *Industrial Ventilation: A Manual of Recommended Practice*, 23rd ed. Copyright 1998, Cincinnati. Reprinted with permission.)

Overhead 19-3.

Measuring Static Pressure with a Water Manometer



(Source: McDermott, 2000.)

20

Dilution Ventilation of Industrial Workplaces

Quiz 1 (11 points total)

True/False (2 points)

1. With dilution ventilation, the contaminants are dispersed from the workroom air and are removed immediately.
 - a. true
 - b. false
2. Velometers are used to determine the velocity through openings.
 - a. true
 - b. false

Multiple Choice (2 points)

3. How should the air inlet and exhaust fans be arranged?
 - a. air movement is from dirtier to cleaner areas
 - b. air movement is from cleaner to dirtier areas
 - c. air movement is from lower to higher levels
 - d. air movement is from higher to lower levels
4. Which of the following is not a factor that affects air density?
 - a. temperature
 - b. altitude
 - c. humidity
 - d. oxygen level

Short Answer (6 points)

5. What is dilution ventilation?

6. What determines the amount of dilution airflow required?

7. What are the two main categories of fans?

8. What are smoke tubes useful for?

9. Describe tubeaxial fans.

10. What is “sensible” heat?

Short Essay (1 point)

11. What is the major disadvantage of dilution ventilation?

Quiz 2 (10 points total)

True/False (2 points)

1. Simple propeller fans provide a reliable flow of air without requiring complex systems.
 - a. true
 - b. false

2. Dilution ventilation is used to reduce concentrations of flammable or explosive gases to safe levels.
 - a. true
 - b. false

Multiple Choice (2 points)

3. Which of the axial fan designs is usually the noisiest?
 - a. propeller
 - b. centrifugal
 - c. vaneaxial
 - d. tubeaxial

4. What is the term for heat released to a room from condensing steam or water vapor?
 - a. latent
 - b. convective
 - c. purged
 - d. sensitive

Short Answer (5 points)

5. Why can air movement due to temperature differences be useful?

6. What are the three different types of axial fans?

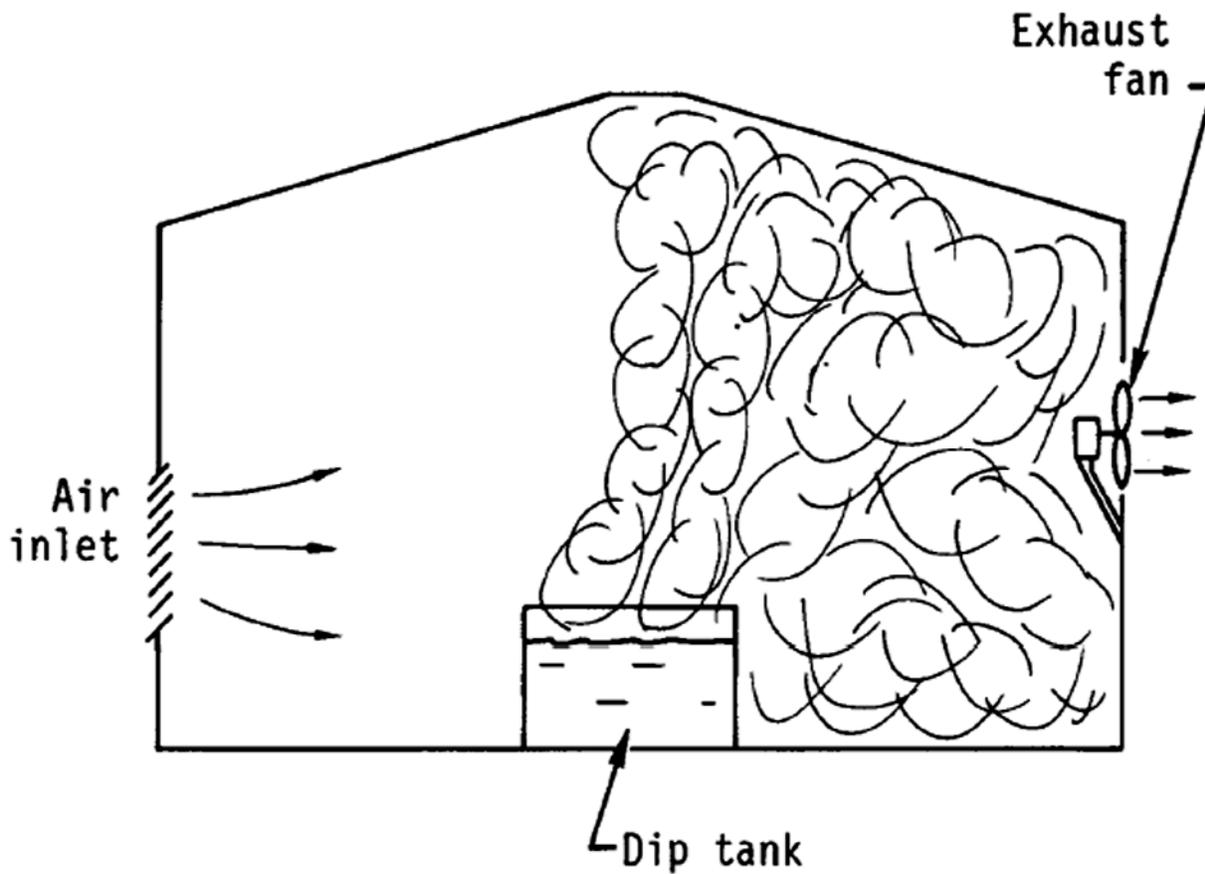
7. What special hazards are presented in confined or enclosed spaces?

8. Why might axial flow fans used for dilution ventilation in enclosed spaces exhibit a severe drop in airflow with added resistance to airflow?

9. Why is dilution used to ventilate workspaces such as tanks and utility vaults that are usually unoccupied?

Overhead 20-1.

Dilution Ventilation



Overhead 20-2.

Criteria for Using Dilution Ventilation

Dilution ventilation is used in situations meeting the following criteria:

- small quantities of contaminants released into the workroom at fairly uniform rates
- sufficient distance from the source to the worker (or source of ignition for fire/explosion hazards) to the contaminant source to allow for dilution to safe levels
- contaminants of relatively low toxicity or fire hazard so that no major problems will result from unanticipated minor employee exposure or concentration exceedances
- no air-cleaning device needed to collect contaminants before the exhaust air is discharged into the community environment
- no corrosion or other problems from the diluted contaminants in the workroom air

21

General Ventilation of Nonindustrial Occupancies

Quiz 1 (24 total points)

True/False (5 points)

1. Outdoor air does not always need to come from outside a building. It can come from a hallway inside the building.
 - a. true
 - b. false
2. Single-zone constant-volume systems are energy efficient, but may cause problems stemming from insufficient outside air.
 - a. true
 - b. false
3. Delivery of air to a space does not guarantee that proper mixing will occur.
 - a. true
 - b. false
4. ASHRAE 55-1992 addresses the environmental factors, such as air quality and contaminant levels, that affect an occupied zone.
 - a. true
 - b. false
5. Outside air reduces indoor contaminants to concentrations that are acceptable to a majority of the occupants in a space.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Acceptable indoor air quality is air in which there are no known contaminants at harmful levels as determined by appropriate authorities, and air with which _____ or more of the people do not express dissatisfaction based on several acceptability criteria.
 - a. 70 percent
 - b. 80 percent
 - c. 85 percent
 - d. 95 percent

7. Air has been perfectly mixed if K_m is equal to _____
 - a. 0.8.
 - b. 1.0.
 - c. 1.2.
 - d. 1.5.

8. Based on its studies of indoor air quality, NIOSH has concluded that _____ of problems are related to some indoor air contaminant, such as solvent vapors or dusts.
 - a. 10 percent
 - b. 20 percent
 - c. 30 percent
 - d. 50 percent

9. Which of the following is *not* covered by ASHRAE 62-1999 on Ventilation for Acceptable Air Quality?
 - a. Inlets and outlets should be located to avoid contamination of intake air.
 - b. AHU shall be easily accessible for inspection and preventive maintenance.
 - c. Where practical, exhaust systems shall remove contaminants at the source.
 - d. Relative humidities should be maintained between 20 and 50 percent.

10. Which of the following is the easiest and most useful tracer gas method for measuring air-exchange rates over short periods of time?
 - a. the concentration-decay method
 - b. the constant-concentration method
 - c. the constant-emission method
 - d. all of the above

11. If an occupant complains about draftiness in his working space, which of the following can be used to assess air movement in that area?
 - a. a thermometer
 - b. indicator tubes
 - c. a smoke tube and a velometer
 - d. a visual inspection

Short Answer (7 points)

12. The recommended quantity of fresh air is commonly written as cfm OA/person. What measurement does cfm OA/person represent?

13. Why is it important that supply air reach terminal velocity before it reaches building occupants?

14. Define mixing factor.

15. What determines the distribution of supply air in the occupied zone?

16. What four simple measurements can indicate CO₂ levels in a room?

17. What is the relationship that forms the basis for estimating airflow using tracer gas methods?

18. How can microbiological growth be kept to a minimum in ductwork?

Short Essay (6 points)

19. What are three ways of achieving a good air mixing in an occupied zone? What is a common cause of poor mixing?

20. What guidelines must be followed when the space above the ceiling is used for returning air?

Quiz 2 (24 total points)

True/False (5 points)

1. The costs of heating, cooling, and ventilating a zone decrease as the size of the zone decreases.
 - a. true
 - b. false
2. Conditioned air in a single-zone constant-volume system travels through ductwork at 1,000–2,000 fpm and slows to 500–1,000 fpm upon entering a room.
 - a. true
 - b. false
3. According to NIOSH, many of the IAQ problems caused by HVAC systems commonly occur in energy-efficient buildings.
 - a. true
 - b. false
4. The ASHRAE Arrestance test uses fine dust as the test medium.
 - a. true
 - b. false
5. Testing and balancing involve periodically assessing the HVAC system for adequate air distribution to the occupied zone.
 - a. true
 - b. false

Multiple Choice (6 points)

6. The occupied zone is generally defined as the region with an occupied space between the floor and 72 inches above the floor and more than _____ from the walls.
- 1 foot
 - 2 feet
 - 3 feet
 - 4 feet
7. Variable air volume systems are primarily used for _____
- controlling air temperature.
 - humidifying outside air.
 - increasing air movement.
 - energy conservation.
8. Inadequate fan capacity, worn fan blades, and an increased number of occupants could all be potential reasons for _____
- insufficient total air delivery to an occupied zone.
 - insufficient outdoor air being delivered to an occupied zone.
 - improper air distribution within an occupied zone.
 - improper mixing of outdoor air and return air.
9. According to IAQ rules proposed by OSHA in May 2000, carbon dioxide levels in places of employment must be kept below _____
- 600 ppm.
 - 700 ppm.
 - 800 ppm.
 - 900 ppm.
10. Most non-HVAC personnel should be able to _____
- become familiar with the characteristics of the HVAC system.
 - perform cursory ventilation checks with smoke tubes and velometers.
 - determine the intended or desired operating parameters.
 - all of the above.
11. Which of the following is *not* true about ductwork?
- Ducts should be replaced if slime is found growing inside them.
 - If ducts have small amounts of dust on their surfaces, they should be cleaned.
 - Ducts should be cleaned if dust is seen coming from supply registers.
 - If debris is restricting the airflow from a duct, it may need to be replaced.

Short Answer (7 points)

12. What is ASHRAE?

13. Why is a single constant volume system that supplies air to multiple zones less energy efficient than other systems?

14. What is the formula for calculating mixing efficiency?

15. What are the three most important consensus standards for indoor air quality?

16. What are the three phases usually involved in troubleshooting a problematic HVAC system?

17. Three tracer gas methods are commonly used to measure airflow. What are these methods?

18. If the air in a workspace smells musty, what might be the reason?

Short Essay (6 points)

19. How can variable air volume systems be energy efficient and lower costs?

20. What is commissioning?

Case Study

(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

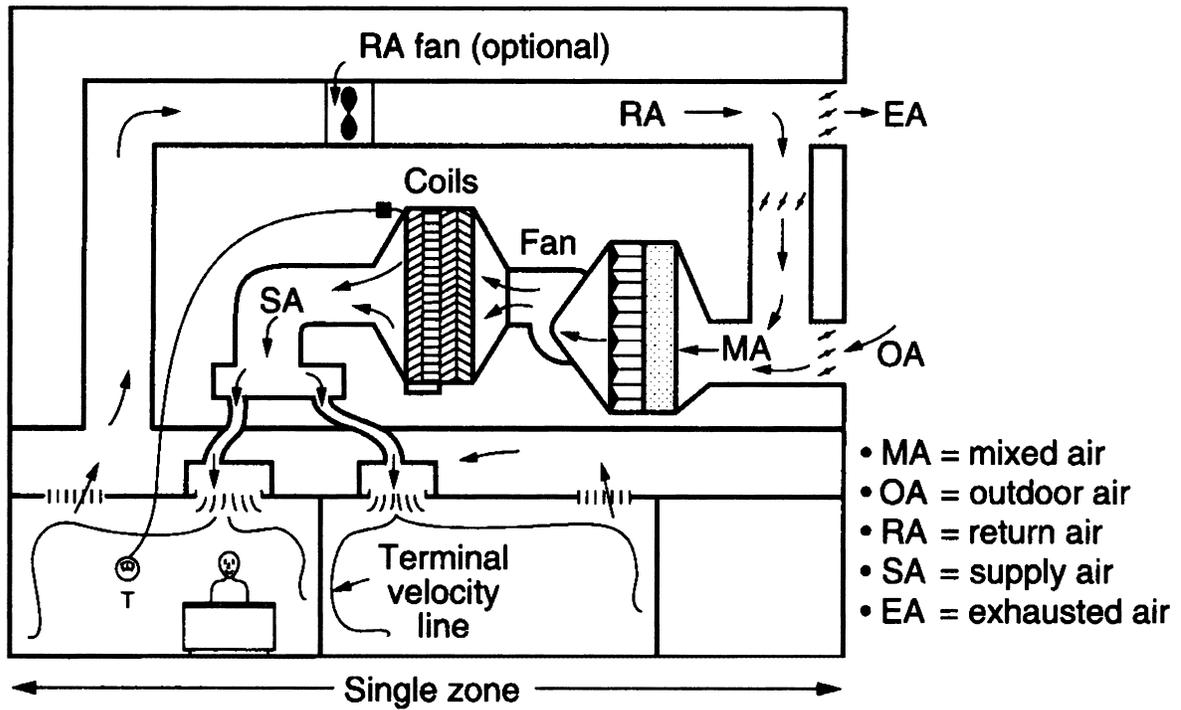
The employees at Ledicot Systems have complained periodically about fluctuating temperatures in their offices since last winter. Last winter employees working on the south side of the building told their supervisors they were too hot, while employees working on the north side said they were too cold. Over the summer, employees felt the offices were stuffy and there was little air movement. The company is located in a building equipped with a variable air volume system that was installed about nine years ago. Energy conservation and lower operating costs were two reasons why Ledicot management chose the system. Management is still happy with the system, but it is concerned about the productivity of employees working in conditions with which they are not satisfied. It would like to know if the company is meeting the standard for thermal quality before making expensive repairs or major changes to the system.

Management has asked you to troubleshoot the HVAC system at Ledicot. Before you begin, you would like to review the standard for thermal quality.

1. How can Ledicot comply with the standard?

Overhead 21-1.

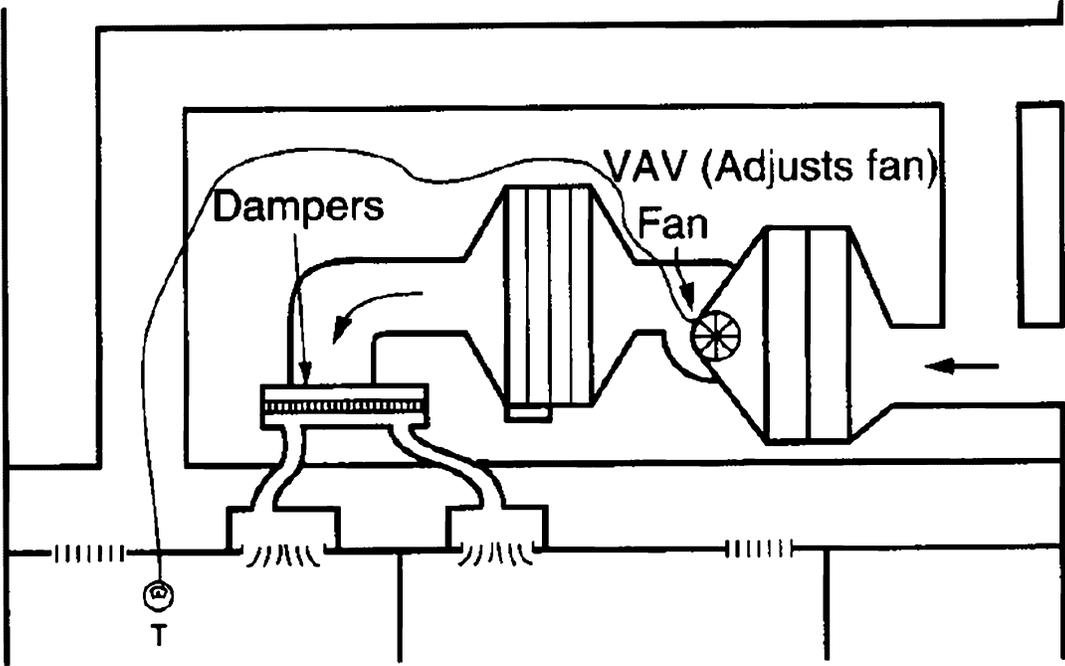
A Typical Single-Zone Constant-Volume HVAC System



(Source: Burton, *IAQ and HVAC Workbook*, 1995.)

Overhead 21-2.

A Typical Variable Air Volume HVAC System



Overhead 21-3.

Simple Checks of the HVAC System in a Room

- Does the room have a supply diffuser? A return?
- Is air moving through diffusers and return grills?
- Are air diffusers and grills open? Blocked? Attached to ductwork?
- Is supply air distributed throughout the occupied space?
- Do people actually feel air moving?
- Are there dead air spaces in the office or room?
- Do printers, copiers, and other equipment have adequate ventilation?
- Are mixing fans or portable heaters used by occupants?
- Does the HVAC system always operate when people are in the building?
- Is the air too hot? Too cold? Too humid? Too dry?
- Do people actually detect odors?
- Do occupants report symptoms that they associate with air quality?
- What contaminates the air?

22

Respiratory Protection

Quiz 1 (20 total points)

True/False (5 points)

1. Respirators are the best means of exposure control against airborne contaminants.
 - a. true
 - b. false
2. Respirators with loose-fitting respiratory inlet coverings should still be fit tested.
 - a. true
 - b. false
3. A loose-fitting helmet is acceptable for workers with beards.
 - a. true
 - b. false
4. An aerosol-removing respirator provides effective protection against gases.
 - a. true
 - b. false
5. In general, large heavy particles are removed by impaction and interception.
 - a. true
 - b. false

Multiple Choice (6 points)

6. In _____ the particles do not deviate from their original streamline of air.
 - a. diffusion
 - b. sedimentation capture
 - c. interception capture
 - d. electrostatic capture

7. An _____ filter is restricted to use in atmospheres free of oil aerosols. They may be used for any solid or liquid airborne particulate hazard that does not contain oil.
 - a. N-Series filters
 - b. P-Series filters
 - c. R-Series filters
 - d. X-Series filters

8. In gas/vapor removing respirators, _____ are used to interact with the gas or vapor molecule to clean the air.
 - a. oils
 - b. acids
 - c. solvents
 - d. sorbents

9. Airborne concentration of asbestos that is greater than 100f/cc (1,000 x PEL) requires the use of _____
 - a. a half-mask air-purifying respirator other than a disposable respirator, equipped with high efficiency filters.
 - b. a full facepiece supplied air respirator operated in pressure demand mode, equipped with an auxiliary positive pressure self-contained breathing apparatus.
 - c. any powered air-purifying respirator equipped with high efficiency filters or any supplied air respirator operated in continuous flow mode.
 - d. a full facepiece air-purifying respirator equipped with high efficiency filters.

10. If an organic vapor's boiling point is greater than 70 C, and its concentration is less than 200 ppm, the organic vapor cartridge should last _____ hours assuming normal breathing rate.
 - a. 3
 - b. 5
 - c. 6
 - d. 8

11. Fit testing should be conducted on all tight-fitting respirator wearers at least once every _____ months.
- a. 2
 - b. 4
 - c. 6
 - d. 12

Short Answer (7 points)

12. Selection of the proper respirator is a very important task. A chosen respirator must be approved for use by which organization?
13. What are the physiological stresses that result from the use of respirators? Who must determine whether or not an employee should be precluded from the use of a respirator?
14. What is a user seal check and who conducts it?
15. Once a respirator has been approved for use, what factors or situations might void that approval?
16. Activated carbon is commonly used for removal of organic vapors. What are the most common starting carbon materials for respirator cartridges?
17. What factors determine the service life of gas/vapor removing respirator cartridges?
18. In the past, warning properties such as odor, eye irritation, and respiratory irritation have been relied on almost completely for indicating when chemical cartridge breakthrough was starting. What are the inherent problems for such a system? What is a better practice?

4. In some cases, chemical absorption through the skin can be more significant than absorption through the respiratory system.
 - a. true
 - b. false

5. The selection of one high-quality make and model of respirator type is suitable for use by the entire work force.
 - a. true
 - b. false

Multiple Choice (6 points)

6. If the TSI Portacount[®] Respirator Fit Tester is used, a worker should not be allowed to smoke within _____ of the fit test.
 - a. 5 minutes
 - b. 30 minutes
 - c. 3 hours
 - d. 24 hours

7. An oxygen deficient atmosphere is one where the oxygen content is below _____ by volume.
 - a. 66 percent
 - b. 28.5 percent
 - c. 19.5 percent
 - d. 13 percent

8. A test subject may not eat, drink, smoke, or chew gum for _____ before a saccharin solution aerosol fit test procedure.
 - a. 15 minutes
 - b. 30 minutes
 - c. 1 hour
 - d. 3 hours

9. A _____ means a pass/fail fit test to assess the adequacy of respirator fit that relies on the individual's response to the test agent.
 - a. qualitative fit test
 - b. quantitative fit test
 - c. user seal check
 - d. oxygen efficiency

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10. A high efficiency particulate air filter (HEPA) needs to be at least _____ percent efficient in removing monodisperse particles of 0.3 micrometers in diameter.
 - a. 89
 - b. 98.60
 - c. 99.97
 - d. 100

11. A _____ means an atmosphere-supplying respirator that admits breathing air to the facepiece only when a negative pressure is created inside the facepiece by inhalation.
 - a. filtering purifying element
 - b. escape-only respirator
 - c. air-purifying respirator
 - d. demand respirator

Short Answer (7 points)

12. The term *oil* has never been defined by a regulatory agency. For purposes of selecting a filter, how would you define oil?

13. OSHA defines IDLH as an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere. In such an environment, there are only two devices that can provide escape provisions for the wearer. Name one.

14. One of the more recent worksites seeing increased respirator usage is health care settings. Why are they used, and what makes the selection of a proper respirator difficult?

15. The qualitative fit-test protocols consist of three steps. What are these steps?

16. What is the proper procedure for cleaning respirators?

17. How do you conduct a facepiece positive pressure check?

18. Name at least one CNP test exercise.

Short Essay (2 points)

19. Name and provide a brief description of the three groups of air-supplying respirators.

20. Respirator selection involves determining the hazard and following a selection logic to choose the correct type or class of respirator that offers adequate protection. What are the steps for hazard determination as outlined in the text?

Case Study

(Scoring Guidelines— Answers should encompass knowledge from text, class discussion, and overheads.

Scoring can be adapted to fit individual classroom use.)

You have just been transferred to the Mica-Bradshaw Manufacturing Plant outside of Raleigh-Durham. After a recent inspection and a hefty fine, it has become necessary for Mica-Bradshaw to chuck their old plan and develop an entirely new respiratory protection program. Because of your years of experience as an independent tester, the job of designing this program has fallen on your shoulders.

Study Guide: Fundamentals of Industrial Hygiene

1. What should your written respiratory protection program include?

Much to your dismay, you realize that Mica-Bradshaw has never established an employee training program for the proper use of respirators.

2. At a minimum, what should the employees know about respirator usage?

3. How often should they be retrained?

During your first training session, you ask the employees about the proper steps toward respirator maintenance to get a feel for how much knowledge they might already possess. They were completely clueless about proper cleaning methods, and only one person knew how to store respirators properly.

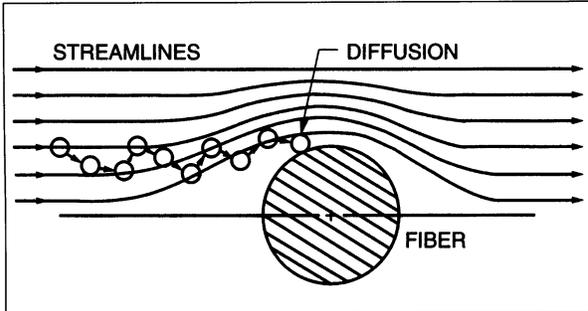
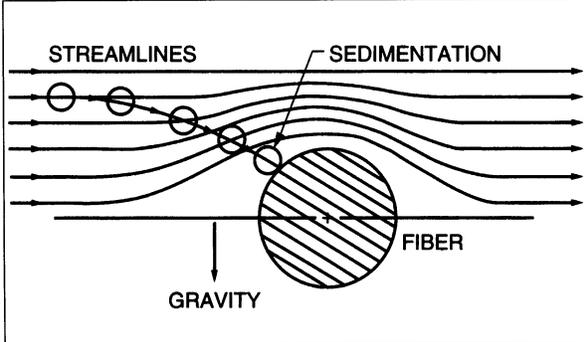
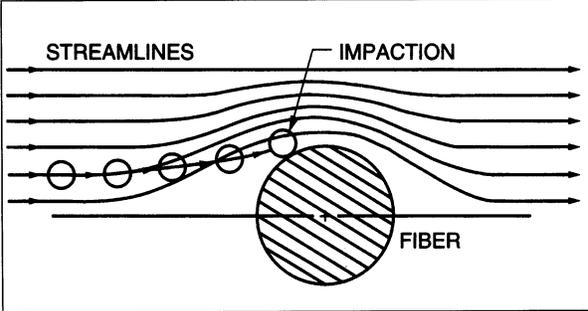
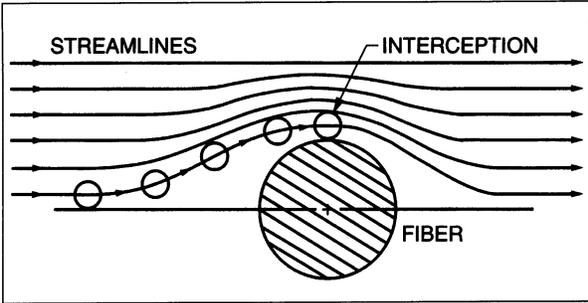
4. What is the proper storage method?

You notice that one of the plant managers is sitting in the back of the room nodding in agreement to everything you say, but not taking any notes. “You should be our new program administrator,” you say to her.

5. What are the duties of a program administrator?

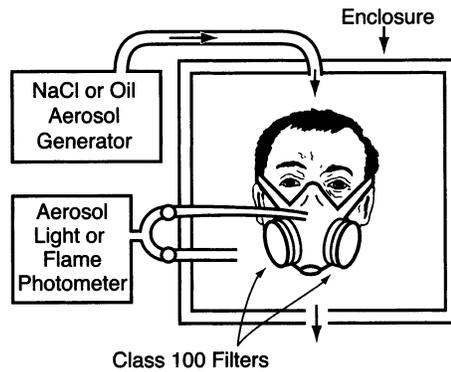
Overhead 22-1.

Capture Mechanisms

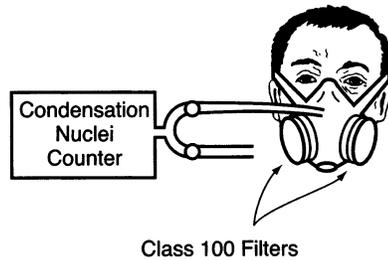


Overhead 22-2.

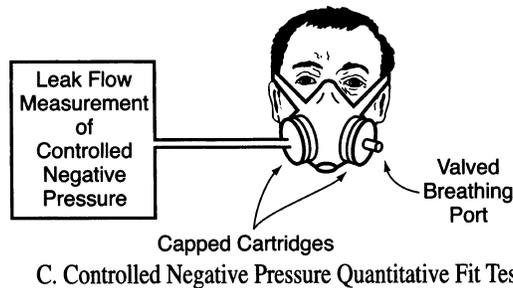
Schematic Representation of Commercially Available Quantitative Fit Tests



A. Generated Aerosol Quantitative Fit Test



B. Ambient Aerosol Condensation Nuclei Counter Quantitative Fit Test



C. Controlled Negative Pressure Quantitative Fit Test

(Adapted from Han DH et al, *AIHA Journal* 58; 219-228, 1997.)

23

The Industrial Hygienist

Quiz 1 (14 points total)

True/False (3 points)

1. Many companies have combined the duties of safety and industrial hygiene manager and even added responsibility for other functions.
 - a. true
 - b. false
2. Few certified safety professionals are also certified industrial hygienists.
 - a. true
 - b. false
3. The IHIT certification refers to Industrial Hygiene Information Technician.
 - a. true
 - b. false

Multiple Choice (2 points)

4. Which organization offers the designation of Certified Industrial Hygienist (CIH)?
 - a. American Industrial Hygiene Association
 - b. American Board of Industrial Hygiene
 - c. American Council of Governmental Industrial Hygienists
 - d. American Academy of Industrial Hygiene
5. Approximately how many active CIHs are there currently?
 - a. 1,200
 - b. 2,400
 - c. 4,000
 - d. 6,400

Short Answer (7 points)

6. In which scientific fields must industrial hygienists be competent?

7. List three examples of the types of health and safety activities that might be performed by Occupational Health and Safety Technologists.

8. What are the functions of an industrial hygiene manager?

9. List three examples of what a certified industrial hygienist can do to earn certification maintenance points.

10. What is the newest industrial hygiene certification being offered?

11. What is the purpose for the Education and Research Centers?

12. What organization accredits baccalaureate and master's level programs in industrial hygiene?

Short Essay (2 points)

13. How does the American Industrial Hygiene Association define industrial hygiene?

14. What is required of candidates to earn the Occupational Health and Safety Technologist (OHST) certification?

Quiz 2 (12 points total)

True/False (2 points)

1. Government industrial hygienists may find that a diplomatic demeanor is among their most important assets.
 - a. true
 - b. false
2. All ERCs are located in universities.
 - a. true
 - b. false

Multiple Choice (3 points)

3. Which two organizations offer the Occupational Health and Safety Technologist certification program?
 - a. Board of Certified Safety Professionals
 - b. American Council of Governmental Industrial Hygienists
 - c. American Board of Industrial Hygiene
 - d. National Safety Council
4. Which of the following is *not* one of the components of OSHA's Office of Training and Education?
 - a. Division of Training and Educational Programs
 - b. Division of Training and Educational Development
 - c. Division of Job Placement
 - d. Division of Administration and Training Information
5. What are ERCs?
 - a. Education and Research Centers
 - b. Employment Resource Councilors
 - c. Evaluation and Remediation Contracts
 - d. Environmental Risk Consultants

Short Answer (5 points)

6. In the civil service sector, how does a senior industrial hygienist differ from the industrial hygienist?

7. What is the purpose of the training program for OSHA compliance safety and health officers that was instituted in 1992?

8. What are the three self-study programs that an OSHA compliance safety and health officer (CSHO) must complete before attending the initial compliance course at the OSHA Training Institute?

9. What kind of continuing maintenance of skills and knowledge is required of CSHOs?

10. Which industrial hygiene organization sets Threshold Limit Values®?

Short Essay (2 points)

11. What is the mission of the OSHA Office of Training and Education?

12. What are two primary responsibilities of the OSHA Training Institute?

Overhead 23-1.

Functions of Industrial Hygienists

The industrial hygienist typically performs the following functions:

- carries out detailed studies of incidents
- prepares recommendations and other reports
- reviews new processes, machinery, and layouts from a health (or safety) viewpoint
- promotes occupational health and safety education
- advises management about health hazards, industrial hygiene practices, procedures, and equipment needs

Overhead 23-2.

Certified Associate Industrial Hygienist (CAIH)

The basic qualifications for certification include:

- a bachelor's degree with at least 30 semester hours of science and math
- industrial hygiene college or professional development courses covering fundamentals, measurements, controls, and toxicology
- four years of post-bachelor, professional-level industrial hygiene experience (at least 25 percent industrial hygiene activities)
- successful completion of a written exam

24

The Safety Professional

Quiz 1 (24 total points)

True/False (5 points)

1. A well-defined safety program furthers the objective of producing high-quality products at the lowest cost.
 - a. true
 - b. false
2. Matters of employee health and fitness to work are the responsibility of medical personnel, not the safety and health professional.
 - a. true
 - b. false
3. The most efficient time to engineer safety and health hazards out of a process is while it is being redesigned.
 - a. true
 - b. false
4. Safety and health inspections should be limited to identifying unsafe physical conditions because such conditions pose more risk than unsafe work practices.
 - a. true
 - b. false
5. A good record-keeping system can promote interest in safety and health among supervisors by providing them with information about the accidents experienced in their departments.
 - a. true
 - b. false

Multiple Choice (6 points)

6. According to the Board of Certified Safety Professionals of the Americas, a safety professional _____
 - a. is engaged in the prevention of accidents, incidents, and events that harm people, property, or the environment.
 - b. makes recommendations to managers, designers, and government agencies about controls.
 - c. evaluates hazards to identify what might occur, the likelihood that it may occur, the severity of results, risk, and cost.
 - d. does all of the above.

7. Which of the following is true about equipment safety?
 - a. When purchasing equipment such as lifting devices, adequate labeling that identifies potential safety and health hazards should be provided.
 - b. A general statement such as “must meet OSHA standards” is all that needs to be provided to a machine manufacturer designing a new piece of equipment.
 - c. A safety and health professional can reasonably expect a purchasing department to maintain information on accident experience with equipment.
 - d. The health and safety hazards for ordinary items such as cleaning rags and paint are insignificant as compared to other hazards and, therefore, do not need to be monitored.

8. Which of the following is an accurate statement about accident investigations?
 - a. Accident investigations should focus on faultfinding because it is important for workers to know when they have been negligent.
 - b. When they conduct an accident investigation, safety professionals should be primarily interested in protecting upper-level management from any liability.
 - c. The consequences of some accidents can be so devastating that any hint of conditions that may lead to such an accident should be investigated.
 - d. Although an investigation may lead to countermeasures that reduce the number of accidents, it can never lead to measures that decrease the severity of accidents.

9. Which of the following is a good recommendation for employee training sessions?
 - a. Train employees in large groups because it is more time efficient and cost-effective.
 - b. Keep records of employee attendance, if possible with their signatures.
 - c. Explain equipment use to employees, but keep practice with equipment to a minimum during sessions.
 - d. Use upper-level managers as trainers. Employees often perceive upper-level managers as having a higher level of credibility.

18. Why do supervisors play a key role in any safety and health program?

Short Essay (6 points)

19. What are three important trends that have emerged in the development of safety professionals?

20. What are the advantages of having a third party conduct a safety inspection?

Quiz 2 (24 total points)

True/False (5 points)

1. In general, a supervisor needs to be trained at a level that is equal to or exceeds the training given to the workers in his or her department.
 - a. true
 - b. false

2. One of the primary responsibilities of the safety professional is to collect and analyze data on illness and accidents in order to determine accident trends.
 - a. true
 - b. false

3. Safety professionals should never be given the authority to order an immediate shutdown, even for potentially hazardous chemical processes. The decision to shut down a process should be made only by a line official.
 - a. true
 - b. false

4. The main purpose behind safety and health inspections is to find out how many things are wrong at a facility.
 - a. true
 - b. false

5. Employees who have been with an organization for many years need to be involved in training sessions so they have the same information about products, policies, and equipment as new employees.
 - a. true
 - b. false

Multiple Choice (6 points)

6. What is the most effective and the preferred method for addressing accident prevention?
 - a. prescribe personal protective equipment to shield personnel from the hazard
 - b. train operating personnel to be aware of the hazard
 - c. eliminate the hazard from the machine or process
 - d. contain the hazard by enclosing it at its source

7. Full staff responsibility for safety activities should be assigned to _____ since it is a key position in any safety program.
 - a. one person
 - b. a team of two people
 - c. a team of three people
 - d. a team of four people

8. A safety professional should be familiar with _____.
 - a. standards approved by the American National Standards Institute (ANSI).
 - b. lists of approved devices published by Underwriters Laboratories, Inc.
 - c. safety practice recommendations made by the American Industrial Hygiene Association (AIHA).
 - d. all of the above.

9. The process of collecting information about an injury or illness generally begins with the _____.
 - a. supervisor's accident report.
 - b. first-aid report.
 - c. employee's injury or illness record.
 - d. safety professional's assessment of working conditions.

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10. Estimating the amount an organization could lose under the most adverse conditions falls under which step in a risk management program?
 - a. maximum possible loss
 - b. hazard identification
 - c. loss retention
 - d. hazard protection

11. To meet the personal safety experience criteria established by the Board of Certified Safety Professionals, the prior professional safety function of a CSP candidate must have accounted for at least _____ of the position's duties.
 - a. 50 percent
 - b. 60 percent
 - c. 75 percent
 - d. 80 percent

Short Answer (7 points)

12. What are the responsibilities of the Board of Certified Safety Professionals (BCSP) with respect to certifying safety professionals?

13. How is a loss control representative involved in the safety industry?

14. Safety policies generally begin with a purpose statement. What information often follows the purpose statement?

15. The number of safety professionals and inspectors needed for adequate safety inspection activities primarily depends on three factors. What are these factors?

16. What are the five main benefits of conducting a job safety analysis?

17. Spot-checking, reporting by repair control centers, and auditing are the three basic elements of _____.
18. How can an individual qualify for the title of Certified Safety Professional?

Short Essay (6 points)

19. What are two reasons for the increased number of full-time safety professionals?
20. How can management use safety inspections to show employees that it is concerned about their safety and health in the workplace?

Case Study

(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

The older machines at Jackson Metals have been experiencing problems since the beginning of the company's latest production cycle. In the past, worn or broken parts on the machines were replaced or repaired, returning the production schedule at the facility to normal. Recent incidents, however, have nearly resulted in injuries to employees. Investigations into the incidents have revealed failures in the company's record-keeping practices and raised questions about whether the incidents could have been prevented. As the situation has become more urgent, the management at Jackson Metals has realized it needs to take action. It would like to start by doing a cost-effectiveness analysis of the systems at the facility, and then address the issue of replacing or repairing the failing equipment. The purchasing department has concerns about

Overhead 24-1.

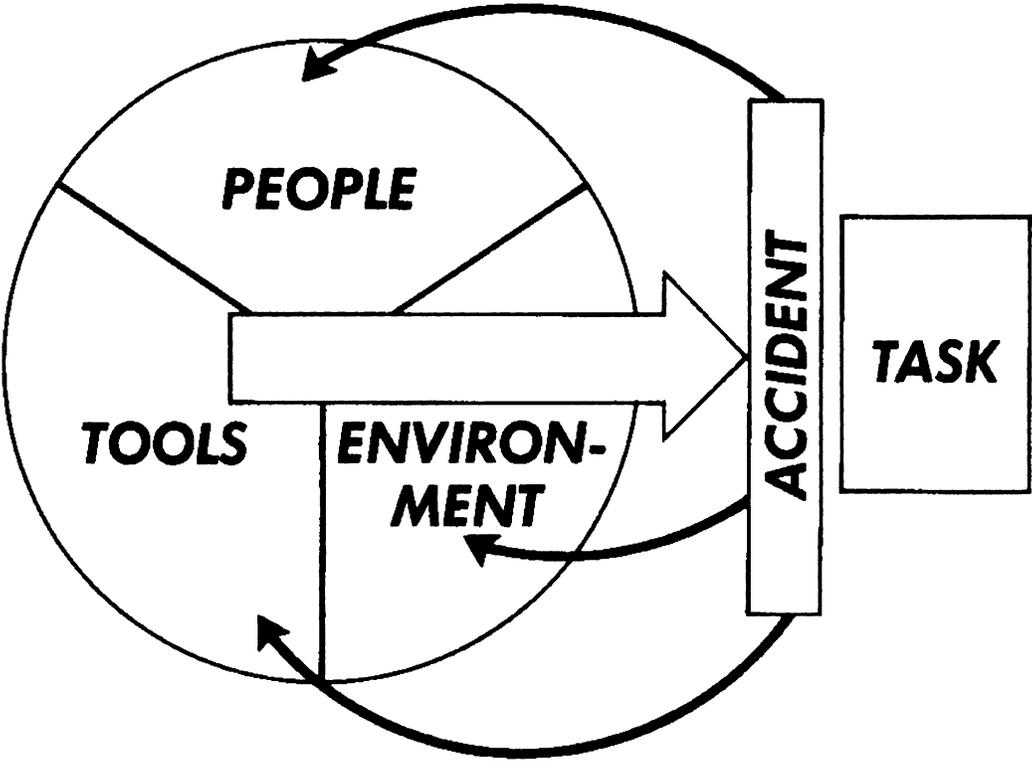
A Five-Step Risk Management Program

1. hazard identification
2. hazard elimination
3. hazard protection
4. maximum possible loss
5. loss retention

Overhead 24-2.

Analyzing a System

A system analysis can show how people, tools, and the environment can combine to produce an accident.



Overhead 24-3.

General Qualifications for Becoming a Certified Safety Professional

- apply to the Board of Certified Safety Professionals (BCSP)
- meet an academic requirement
- meet a professional safety experience requirement
- pass the Safety Fundamentals Examination
- pass the Comprehensive Practice Examination

25

The Occupational Medicine Physician

Quiz 1 (12 total points)

True/False (3 points)

1. Before 1900, many doctors had no formal training.
 - a. true
 - b. false
2. Physicians who graduated before 1984 are not eligible for the Occupational Medicine Board examination.
 - a. true
 - b. false
3. An occupational medicine physician working in a multi-specialty group practice or hospital-based program has a relatively light patient load of 8-10 patients a day.
 - a. true
 - b. false

Multiple Choice (4 points)

4. The post- _____ industrial boom brought thousands of new chemicals into existence for which neither human beings nor our Earth's ecology had developed any evolutionary defenses.
 - a. WWI
 - b. WWII
 - c. Korean War
 - d. Vietnam War

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5. As of this printing, approximately _____ physicians graduate each year from occupational medicine residency programs.
 - a. 75
 - b. 175
 - c. 750
 - d. 1,750

6. Who is Bernardino Ramazzini?
 - a. 18th century physician and author of *Diseases of Workers*
 - b. founder of the American Academy of Occupational Medicine
 - c. scientist who first described the use of anesthesia
 - d. inventor of the x-ray machine

7. Unions have developed relationships with occupational medicine physicians, industrial hygienists, and epidemiologists since the _____.
 - a. 1920s.
 - b. 1940s.
 - c. 1970s.
 - d. 1990s.

Short Answer (4 points)

8. List three of the breakthroughs in the late 1800s that contributed to the “scientific practice of medicine.”

9. Where might an occupational medicine physician find a job?

10. What are the prerequisites to become eligible for the Occupational Medicine Board Examination?

11. Name at least one professional association for occupational medicine physicians.

Short Essay (1 point)

12. Describe the type of practice an occupational medicine physician would most likely encounter at a freestanding occupational health clinic.

Quiz 2 (12 total points)

True/False (3 points)

1. Staff physicians for policy development and regulatory agencies are rarely involved in clinical work with patients.
 - a. true
 - b. false
2. International occupational health consulting is a rapidly declining sector for occupational medicine physicians.
 - a. true
 - b. false
3. Asbestos is a naturally occurring compound.
 - a. true
 - b. false

Multiple Choice (4 points)

4. In four years of medical school, there is an average of _____ spent on occupational exposure.
 - a. 4 hours
 - b. 8 hours
 - c. 12 hours
 - d. 16 hours
5. Which of the following jobs might require a complete preplacement examination with histories and physicals including cardiac, pulmonary, and strength/endurance testing?
 - a. firefighting
 - b. hazardous waste work
 - c. registered nurse
 - d. both a and b
 - e. all of the above

26

The Occupational Health Nurse

Quiz 1 (13 points total)

True/False (3 points)

1. Occupational health services manage only work-related injury and illness.
 - a. true
 - b. false
2. Manufacturing industries should have one full-time OHN for every 300 employees.
 - a. true
 - b. false
3. Tertiary prevention is the prevention of disability through rehabilitative efforts.
 - a. true
 - b. false

Multiple Choice (2 points)

4. What is the major professional specialty nursing organization that serves occupational health nurses?
 - a. Occupational Health Nursing Association
 - b. American Association of Occupational Health Nurses
 - c. Association of Specialty Nursing Practice
 - d. Society for Occupational and Environmental Health Nursing
5. What size employers predominantly employ OHNs?
 - a. more than 2,000 employees
 - b. more than 1,000 employees
 - c. more than 500 employees
 - d. more than 200 employees

Short Answers (6 points)

6. What is the goal of occupational health nursing?

7. What certifications are offered by the American Board of Occupational Health Nurses?

8. What is required for certification by the American Board of Occupational Health Nurses?

9. Where can an OHN find additional academic preparation as a manager, nurse practitioner, or clinical nurse specialist in occupational health nursing?

10. In addition to the occupational health nurse, who else might be part of the occupational health services team? Name at least three.

11. What is secondary prevention in the occupational health setting?

Short Essay (2 points)

12. At what level of practice are occupational health nurses licensed?

13. What industry variables determine the scope of occupational health services? Name at least four.

Quiz 2 (14 points total)

True/False (3 points)

1. Supervisors create a job analysis for each job class, which the OHN uses in preplacement evaluations.
 - a. true
 - b. false
2. Modified duty programs need support from a panel of health care providers who philosophically support transitional work as a therapeutic intervention.
 - a. true
 - b. false
3. OHNs often maintain OSHA 200 logs, reporting all injuries, even those requiring only first aid.
 - a. true
 - b. false

Multiple Choice (3 points)

4. According to AAOHN recommendations, service industries should have one full-time OHN for how many employees?
 - a. every 500 employees
 - b. every 750 employees
 - c. every 1,000 employees
 - d. every 1,500 employees
5. In what percentage of companies is the occupational health nurse the sole health care provider at the worksite?
 - a. 15 percent
 - b. 30 percent
 - c. 50 percent
 - d. 60 percent

14. What were the four most frequent occupational health nursing activities noted in a 1988 survey of Fortune 500 companies?

Case Study

(Scoring Guidelines—Answers should encompass knowledge from test, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

Peoples Insurance Corporation has about 900 employees at its Midwestern headquarters. Most are office workers. Colleen O’Brady is the occupational health nurse on-site. Although an office environment doesn’t present as many obvious bodily hazards as a manufacturing facility, for example, there are still areas that require expert attention. Colleen has noticed an increase in the number of musculoskeletal complaints. She starts thinking about an ergonomics program.

1. What particular knowledge, skills, and abilities will Colleen need to establish an ergonomics program for the company?

2. What are the basic elements that go into establishing an ergonomics program?

Overhead 26-1.

Occupational Health Nursing Services

Occupational health nursing services include the following:

- clinical and primary care, including assessment, diagnosis, management, and documentation of occupational and nonoccupational illness and injury
- case management for occupational and nonoccupational illness and injury
- health hazard assessment and surveillance of employee populations, workplaces, and community groups
- investigation, monitoring, and analysis of illness and injury episodes and trends, as well as methods to promote and protect employee health and safety
- compliance with laws, regulations, and standards governing health and safety for employees and the environment
- management and administration of occupational and environmental health services
- health promotion and disease prevention strategies using primary, secondary, and tertiary principles
- counseling, health education, and training programs using adult learning approaches
- research related to occupational and environmental health

Overhead 26-2.

Occupational Health Nursing Competencies

The OHN role requires knowledge, skills, and abilities in the following competencies:

- clinical and primary care
- case management
- work force, workplace, and environmental issues
- regulatory / legislative issues
- management
- health promotion and disease prevention
- occupational and environmental health and safety education / training
- research
- professionalism

Overhead 26-3.

Programs Commonly Managed by OHNs

- workers' compensation
- Americans with Disabilities Act
- record keeping
- bloodborne pathogens
- ergonomics
- evaluating outcomes of OHN activities

27

The Industrial Hygiene Program

Quiz 1 (22 total points)

True/False (5 points)

1. One of the benefits of a well-established industrial hygiene program is the increased productivity that results from improved working conditions.
 - a. true
 - b. false
2. An industrial hygiene program that has been detailed in writing can serve as a measurable performance guideline for worker protection.
 - a. true
 - b. false
3. A workplace characterization groups and describes employees with similar work duties.
 - a. true
 - b. false
4. Consulting with employees will probably not make training sessions more effective because employees do not have in-depth knowledge of industry standards for safety hazards.
 - a. true
 - b. false
5. The value of an audit diminishes if regular follow-up audits or other periodic evaluations are not scheduled.
 - a. true
 - b. false

Multiple Choice (4 points)

6. Which of the following is *not* true of a goal?
 - a. A goal should be measurable if at all possible.
 - b. A goal should be realistic.
 - c. A goal is a desired outcome.
 - d. A goal should be static to ensure continuity.

7. The first step in an exposure assessment program is to complete _____.
 - a. a workplace characterization.
 - b. an agent characterization.
 - c. the work force characterization.
 - d. all of the above.

8. OSHA 29 *CFR* 1910.20 requires that exposure records must be maintained for at least _____.
 - a. 15 years.
 - b. 25 years.
 - c. 30 years.
 - d. 35 years.

9. Who has the ultimate responsibility for an industrial hygiene program and the safety of the employees at a facility?
 - a. the general manager
 - b. the supervisor
 - c. the safety and health committee
 - d. the industrial hygienist

Short Answer (7 points)

10. What are the four stages of the Demming cycle?

11. The requirements and procedures outlined in a written industrial hygiene program serve four purposes. What are they?

12. Why are employees organized into SEGs, or similar exposure groups?

13. Explain why it is important to determine whether training can solve a safety problem.
14. Why must the documentation collected from an industrial hygiene program be maintained?
15. A health professional needs to have a good understanding of _____, _____, _____, and _____ to run an effective medical program.
16. How does an organization's purchasing department contribute to workplace safety?

Short Essay (6 points)

17. What are the five steps in the audit process?
18. Explain what a safety and health committee is and describe its role in a safety and health program.

Quiz 2 (22 total points)

True/False (5 points)

1. It costs much less to anticipate and eliminate a hazard in the planning stage than it does to manage it afterward.
 - a. true
 - b. false
2. It is not necessary to reevaluate exposure assessments unless a new process or potentially hazardous agent is brought into the workplace.
 - a. true
 - b. false
3. Well-established industrial hygiene programs have been shown to reduce compensable injuries and illnesses and lower insurance premiums.
 - a. true
 - b. false
4. Process, facility, and equipment design reviews usually result in better protection and generally are the most cost-effective method for controlling potential hazards.
 - a. true
 - b. false
5. Recognition and control are the two phases of any industrial hygiene program.
 - a. true
 - b. false

Multiple Choice (4 points)

6. New industrial hygiene programs typically focus on ____
 - a. the planning phase of the Demming cycle.
 - b. determining voluntary commitments from those involved.
 - c. reactive activities, such as new legal requirements.
 - d. ways to implement continual improvements.
7. Which of the following is the least acceptable method of controlling a potential hazard?
 - a. substitution
 - b. personal protective equipment
 - c. engineering controls
 - d. administrative controls

8. Medical staff should know what is produced in the workplace, how it is produced, potential hazards, and the physical requirements of a job. This information helps the staff ____
 - a. conduct preplacement medical exams.
 - b. detect conditions that might be work related.
 - c. organize health education programs.
 - d. do all of the above.

9. Which of the following is *not* true of safety programs?
 - a. Safety programs tend to be less well established than industrial hygiene programs.
 - b. Effective safety programs build support for all health- and safety-related work at a facility.
 - c. If industrial hygiene resources are limited, safety professionals may implement industrial hygiene activities.
 - d. The goals of an industrial hygiene program and a safety program are the same: maintain a safe and healthful workplace.

Short Answer (7 points)

10. What is the difference between a goal and an objective?

11. How can an industrial hygienist determine which workers should be included in an SEG, or similar exposure group?

12. Why is it important to have a written procedure for sampling methods?

13. What aspect of industrial hygiene programs is addressed by organizing health and safety committees and employee suggestion programs?

14. How do auditors usually prepare to audit an industrial hygiene program?

15. What is an agent characterization?

Study Guide: Fundamentals of Industrial Hygiene

16. An industrial hygiene program usually begins with a policy statement. What are the remaining six components that the program should address?

Short Essay (6 points)

17. Explain the two-step process that should be followed when evaluating the hazards listed for a homogenous group.

18. A supervisor plays a key role in implementing and maintaining safety and health requirements on a daily basis. What are a supervisor's responsibilities?

Case Study

(Scoring Guidelines—Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

Last week Prism Parts completed an evaluation of its industrial hygiene program. For the first time in many years, an independent team of health and safety consultants conducted the audit. The team was very thorough and spent several weeks examining every aspect of Prism's program. In its report to Prism management, the consultants concluded that portions of the company's industrial hygiene program needed to be updated, particularly the policy statement and employee training and education. The hazard recognition, control, and evaluation components of the program, however, were satisfactory. While it was pleased to learn several aspects of its program were successful, management was concerned about the problems with the policy statement since it was designed to communicate Prism's commitment to safety and health. The unsatisfactory assessment of the training program was also worrisome. Management decided to call a meeting with the safety and health committee, general managers, supervisors, and the industrial hygiene team in hopes of addressing these issues as quickly as possible.

Study Guide: Fundamentals of Industrial Hygiene

4. What are some requirements for training programs covered in OSHA standards?

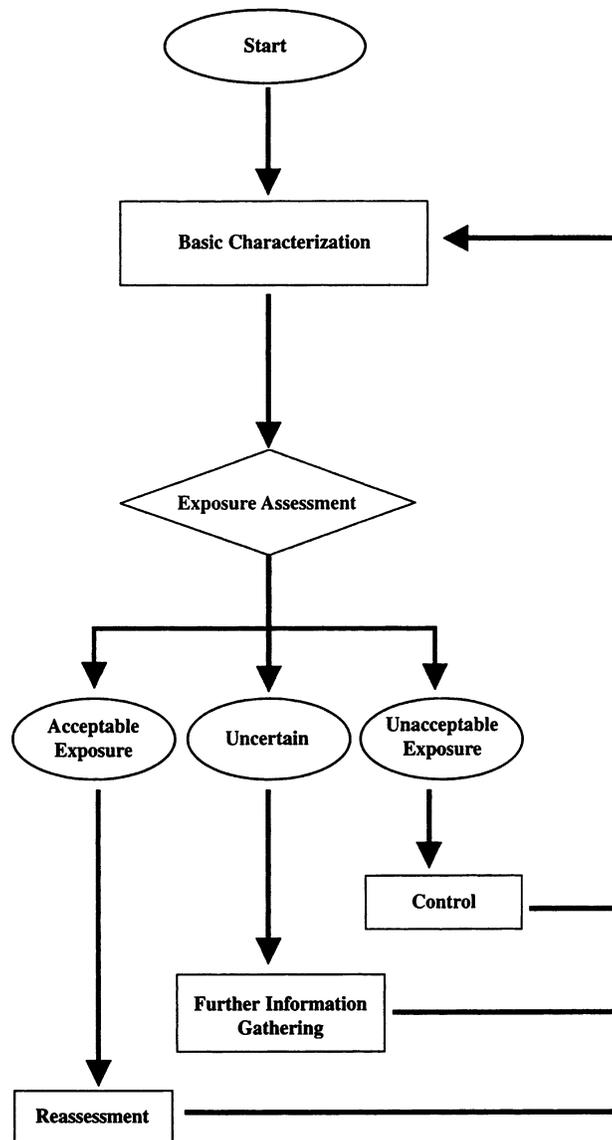
Overhead 27-1.

Basic Components of an Industrial Hygiene Program

- written program and policy statement
- hazard recognition
- hazard evaluation and exposure assessment
- hazard control
- employee training and involvement
- program evaluation
- documentation

Overhead 27-2.

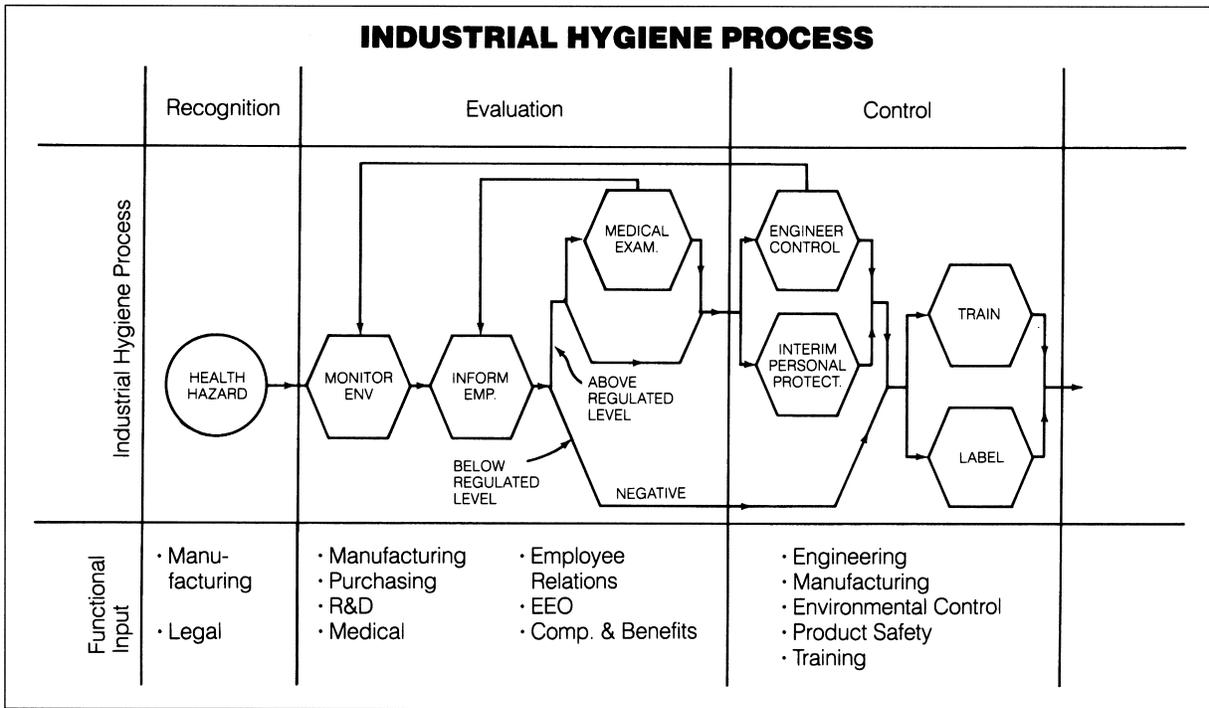
A Strategy for Assessing and Managing Occupational Exposures



(Reprinted with permission from Mulhausen J, Damiano J, eds. *A Strategy for Assessing and Managing Occupational Exposures*. Fairfax, VA: AIHA, 1998.)

Overhead 27-3.

The Industrial Hygiene Process



(Adapted with permission from Bridge DP. Developing and implementing an industrial hygiene and safety program in industry. *AIHA Journal* 40:255–263, 1979.)

28

Government Regulations

Quiz 1 (20 total points)

True/False (5 points)

1. The Occupational Safety and Health Administration (OSHA) was created by the Department of Labor.
 - a. true
 - b. false
2. The solicitor of labor is responsible for providing legal advice and assistance to the secretary and all officers of the Department of Labor in the administration of statutes and executing orders relating to occupational safety and health.
 - a. true
 - b. false
3. The filing of a complaint against a state program's administration (CASPA) is a common occurrence.
 - a. true
 - b. false
4. Most of the safety and health standards for general industry now in force today under OSHA were promulgated in the first year after the law went into effect.
 - a. true
 - b. false
5. OSHA compliance officers who find conditions of imminent danger can demand an immediate shutdown of an operation.
 - a. true
 - b. false

Multiple Choice (6 points)

6. Which of the following groups is covered by the Hazard Communication Standard?
 - a. pesticides
 - b. hazardous wastes
 - c. distilled spirits
 - d. none of the above

7. OSHA schedules inspections on a priority system. Which of the following events has the lowest priority?
 - a. random inspections of high hazard industries
 - b. in response to fatalities
 - c. in response to multiple hospitalization incidents
 - d. in response to employee complaints

8. Which manual, adopted in 1994, contains general instructions and policies on field compliance operations?
 - a. Field Operations Manual
 - b. Field Inspection Reference Manual
 - c. The OSHA Technical Manual
 - d. Everything You Always Wanted to Know About Field Inspections But Were Afraid to Ask, Volume II

9. During an inspection, the TWA concentration must be determined for _____ hour exposures.
 - a. 2
 - b. 4
 - c. 6
 - d. 8

10. If an employer representative is aware of the requirements of the OSHA standard or the existence of an applicable standard or regulation and is also aware of a condition or practice in violation of those requirements, he is guilty of a/an _____ violation.
 - a. imminent danger
 - b. serious
 - c. willful
 - d. none of the above

11. If an employer willfully violates any standard, rule, or order that results in the death of an employee, that employer will, on conviction, be punished by a fine or by imprisonment for not more than _____, or both.
- 3 months
 - 6 months
 - 3 years
 - 6 years

Short Answer (7 points)

12. OSHA sets out two duties for employers and one for employees. What are these duties?
13. What is the significance of the General Duty Provision (section 5(a)) of OSHA?
14. How can a state agency assert jurisdiction under state law over safety and health issues?
15. What are the four categories of OSHA standards?
16. What is the action level concept? What happens when the action level is exceeded?
17. What are the essential elements of an industrial hygiene inspection?
18. What is a "failure to abate" situation?

Short Essay (2 points)

19. The intent of the Hazard Communication Standard (29 *CFR* 1910.1200) is to provide employees with information about the potential health hazards from exposure to workplace chemicals. What specific employee training measures does the standard require?
20. What responsibilities does OSHA grant the secretary of labor?

Quiz 2 (20 total points)

True/False (5 points)

1. During an OSHA industrial hygiene inspection, if the employees are represented by a labor union, they must be notified of OSHA's presence but are not allowed to take part in the inspection.
 - a. true
 - b. false
2. A walk-through inspection is required for all health inspections unless the facility was recently inspected.
 - a. true
 - b. false
3. During an OSHA industrial hygiene inspection, a second closing conference needs to be made in person.
 - a. true
 - b. false

4. Measurements for air pollutants should be taken from the employee's breathing zone.
 - a. true
 - b. false
5. It is not necessary that a compliance violation be committed with a bad purpose or an evil intent to be deemed willful.
 - a. true
 - b. false

Multiple Choice (6 points)

6. The _____ is the principal administering officer of the OSHA Act.
 - a. state governor
 - b. solicitor of labor
 - c. secretary of labor
 - d. secretary of health
7. Of the following, which is the most significant violation that an industrial hygienist might write a citation on?
 - a. imminent danger
 - b. willful violation
 - c. serious violation
 - d. intentional violation
8. Congress has told OSHA that, exclusive of serious violations, it must find more than _____ other violations before any penalty can be imposed against a company.
 - a. 1
 - b. 5
 - c. 10
 - d. 15
9. The _____ is the principal federal agency engaged in research to eliminate on-the-job hazards to the health and safety of American workers.
 - a. Center for Disease Control
 - b. Department of Health, Education, and Welfare
 - c. Occupational Safety and Health Administration
 - d. National Institute for Occupational Safety and Health
10. Which U.S. government agency has jurisdiction of the Federal Mine Safety and Health Amendments Act of 1977?
 - a. Department of the Interior
 - b. Department of Labor
 - c. Department of Health and Human Services
 - d. Mining Enforcement and Safety Administration

Study Guide: Fundamentals of Industrial Hygiene

11. Which act, enacted in 1976, provides the EPA with the authority to require testing of chemical substances entering the environment and to regulate them when necessary?
 - a. Chemical Safety Act
 - b. Coal Mine Health and Safety Act
 - c. Toxic Substances Control Act
 - d. Resource Conservation and Recovery Act

Short Answer (7 points)

12. It has been determined that three key duties should be triggered when an action level is reached. What are these duties?

13. What does GRIP stand for? Describe some of the goals and focuses of GRIP.

14. During an inspection, detailed information regarding an employer's Occupational Health Program is gathered for evaluation. What aspects of the program are of interest to an industrial hygiene inspector? Name four programs.

15. Some compliance standards require the establishment of regulated areas, where concentrations exceed the PELs. What minimum standards should a regulated area meet?

16. Cases under consideration for treatment as egregious must be classified as willful and meet at least one other criteria. There are six criteria an industrial hygienist may use in this case; name one.

17. Define an "other than serious violation" and give an example.

18. Which act established the Superfund Program to handle emergencies at uncontrolled waste sites, to clean up the sites, and to deal with related problems?

5. It is not uncommon for violations to be found during the course of an initial inspection. List the types of violations for which a citation might be issued.

29

History of the Federal Occupational Safety and Health Administration

Quiz 1 (17 points total)

True/False (5 points)

1. President Lyndon Johnson signed the OSHAct into law.
 - a. true
 - b. false
2. The OSHA law as passed has generally been viewed as a stringent regulatory statute.
 - a. true
 - b. false
3. The OSHAct applies to all private employers as well as all federal employees.
 - a. true
 - b. false
4. All OSHA standards are subject to court of appeals review.
 - a. true
 - b. false
5. OSHA's *Compliance Manual* has been a primary means for the agency to advise interested parties of its policies.
 - a. true
 - b. false

Multiple Choice (3 points)

6. Which of the following are means of enforcement of the OSHAct?
 - a. citations
 - b. assessment of civil penalties
 - c. imprisonment
 - d. all of the above

7. Under what circumstances does an employer have the right to refuse a workplace inspection?
 - a. without prior notice
 - b. unless preceded by a warrant
 - c. less than 15 employees
 - d. less than 60 days since last inspection

8. What amount of federal funding do state OSHA programs receive?
 - a. none
 - b. 25 percent
 - c. 50 percent
 - d. 90 percent

Short Answer (6 points)

9. When was the OSHAct signed into law?

10. What was the major disagreement between the Democrats and Republicans concerning the proposed creation of the OSHA legislation?

11. What two elements in the statutory structure are designed to constitute an incentive to employers to abate hazards?

12. What agency was assigned responsibility to develop an effective program of collection, compilation, and analysis of occupational safety and health statistics?

13. Who was the first head of OSHA?

14. What form of administrative structure was established for OSHA?

Short Essay (3 points)

15. What factors contributed to the consensus in 1969 that federal occupational legislation was needed?

16. If a hazard is not covered by a standard, is there any other regulatory control over employers?

17. What are OSHA's four broad categories of inspections?

Quiz 2 (14 points total)

True/False (4 points)

1. Courts have not generally insisted on OSHA's rigorous adherence to procedural requirements on rulemaking.
 - a. true
 - b. false
2. At present, there is no legal requirement on walkaround pay.
 - a. true
 - b. false
3. Many amendments have been proposed throughout the history of OSHA, almost all curtailing the agency's authority, but none has passed.
 - a. true
 - b. false
4. OSHA has no involvement with federal agency workplaces or their safety and health programs.
 - a. true
 - b. false

Multiple Choice (2 points)

5. What does Part 1903 (29 CFR 1903) deal with?
 - a. agency inspection procedures
 - b. compliance manual
 - c. promulgation of standards
 - d. assessment of penalties
6. Who was the first health professional to head OSHA?
 - a. George C. Guenther
 - b. Gerard Scannell
 - c. Joseph Dear
 - d. Morton Corn

Short Answer (6 points)

7. Where did many of OSHA's start-up standards come from?

8. What employee rights are foremost in the OSHA program?
9. What is Congress's real source of influence over OSHA?
10. Which OSHA standard contained the novel provision requiring employers to transfer at-risk employees to lower-exposure jobs?
11. Does the OSHAct allow criminal penalties to be imposed?

Short Essay (2 points)

12. What two overriding issues have been argued and resolved in standards proceedings?
13. Briefly explain what the Kepone Incident refers to and what impact it had on OSHA.
14. What is the "egregious" penalty policy?

Case Study

(Scoring Guidelines — Answers should encompass knowledge from text, class discussion, and overheads. Scoring can be adapted to fit individual classroom use.)

Not so many years ago, Josie Cantrell would have been called a typesetter. Of course, now almost everything is done electronically. But human hands are still involved in turning those words into bits/bytes/or whatever is needed. Josie has been working for FullPage Printing Company for several years and has been satisfied with her job. She has friends doing similar work with other companies, however, who have serious problems. In fact, one of them is considering surgery for carpal tunnel syndrome. That motivated Josie to visit her human resources department to get some facts about ergonomics and what was being done to help employees. Peter Demeter, the HR manager, tried to provide some information.

1. What caused OSHA to recognize that a problem existed?

2. What steps did OSHA take initially?

3. But Josie wants to know what has OSHA done lately to convince employers that ergonomics matters to employees. Has OSHA created a standard?

Overhead 29-1.

OSHA Regional Offices

- Region I: Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont
- Region II: New Jersey, New York, Puerto Rico, and the Virgin Islands
- Region III: Washington DC, Delaware, Maryland, Pennsylvania, Virginia, and West Virginia
- Region IV: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee
- Region V: Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin
- Region VI: Arkansas, Louisiana, New Mexico, Oklahoma, and Texas
- Region VII: Iowa, Kansas, Missouri, and Nebraska
- Region VIII: Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming
- Region IX: American Samoa, Arizona, California, Guam, Hawaii, Nevada, and the Trust Territories of the Pacific
- Region X: Alaska, Idaho, Oregon, and Washington

Overhead 29-2.

States with Approved Plans

Alaska	New York
Arizona	North Carolina
California	Oregon
Connecticut	Puerto Rico
Hawaii	South Carolina
Indiana	Tennessee
Iowa	Utah
Kentucky	Vermont
Maryland	Virgin Islands
Michigan	Virginia
Minnesota	Washington
Nevada	Wyoming
New Mexico	

