

PROCESS TECHNOLOGY
SAFETY, HEALTH AND ENVIRONMENT
Third Edition

ANSWER KEYS FOR REVIEW QUESTIONS
(at the end of each Chapter)

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TABLE OF CONTENTS

Chapter 1	Introduction to Process Safety
Chapter 2	Hazard Classification
Chapter 3	Routes of Entry & Environmental Effects
Chapter 4	Gases, Vapors, Particulates, & Toxic Metals
Chapter 5	Hazards of Liquids
Chapter 6	Hazardous Chemical Identification: HAZCOM, Toxicology, DOT
Chapter 7	Fire and Explosion
Chapter 8	Electrical, Noise, Heat, Radiation, Ergonomic and Biological Hazards
Chapter 9	Safety Permit Systems
Chapter 10	Personal Protective Equipment (PPE)
Chapter 11	Engineering Controls
Chapter 12	Administrative Controls
Chapter 13	Regulatory Overview: OSHA, PSM, and EPA.
Chapter 14	HAZWOPER
Chapter 15	Process System Hazards
Chapter 16	Weapons of Mass Destruction, Hurricanes, and Natural Disasters

CHAPTER 1

INTRODUCTION TO PROCESS SAFETY

LEARNING OBJECTIVES

- After studying this chapter, the student will be able to:
- Describe the chemical processing industry.
- Describe the significant events of the safety movement.
- Classify the safety roles and responsibilities of process technicians.
- Identify the basic principles of safety.
- Describe the general safety rules used in the industry.
- Explain the difference between the terms process safety and occupational safety and health.
- Explain the key elements of safety.
- Describe the basic elements of a hazard analysis.
- Explain the typical permits used by the chemical processing industry.
- List the various types of firefighting equipment.
- Describe the principles associated with production, transportation, and storage of chemicals.
- Describe the Occupational Safety and Health Act.
- Describe Process Safety Management.
- Identify the key elements of HAZCOM.
- Explain the principles of hazard classification and recognition.
- Explain the key aspects of personal protective equipment.
- Describe administrative and engineering controls.
- Explain the key issues associated with weapons of mass destruction, hurricanes, and natural disasters.

CHAPTER 1: REVIEW QUESTIONS

1. Describe the importance of process safety. The primary purpose of process safety is to prevent injuries, fatalities, fires, explosions, or unexpected releases of hazardous materials. Process safety focuses on the individual chemical processes and operational procedures associated with these systems.
2. Explain the key elements of occupational health and safety. Occupational safety and health deals with items like personal protective equipment, HAZCOM, permit systems, confined space entry, hot work, isolation of hazardous energy, and so on. Process technicians are required to work with existing systems and programs. Understanding the key elements of process safety, and occupational safety allow technicians to contribute significantly to the reduction of risks and hazards associated with the chemical processing industry.
3. What is the definition of the term process technology? Process technology is defined as the study and application of the scientific principles associated with the operation and maintenance of the chemical processing industry.
4. What are the significant differences between industrial worker safety in the past versus the present? During the early days of industrialization, management was not concerned about the deplorable conditions their people worked in, much less the safety and health of individual employees. Modern manufacturers are concerned about work conditions and individual safety.
5. List the roles and responsibilities of process technicians. The roles and responsibilities of process technicians include working on equipment and systems, instruments, electrical devices, minor maintenance, operation of equipment, utilizing math and science, and operating advanced computer technology.

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6. List five general safety rules used in the operation and maintenance of a typical chemical plant or refinery.
- Do not go to a fire, explosion scene, accident, or vapor release unless you have specific duties or responsibilities.
 - Obey all traffic rules.
 - Do not park in designated fire lanes.
 - Report injuries immediately.
 - Stay clear of suspended loads.
 - Smoking and matches are not permitted in most sections of a plant.
 - Drink from designated water fountains and potable water outlets.
 - Use the right tool for the right job.
 - Report to the designated equipment owner before entering an operating area.
 - Stay in your assigned area.
 - Illegal drugs and alcohol are not permitted in the plant.
 - Firearms and cameras are not allowed in the plant.
 - Take steps to remove hazardous conditions.
 - Review and follow all safety rules and procedures including: personal protective equipment, hazard communication, respiratory protection, permit system, hazardous waste operations and emergency response, housekeeping, and fire prevention.
 - Know and understand the following alarms and rules associated with them: vapor release, fire or explosion, evacuation, and all clear.
7. List the most important events in the safety movement from 1960 to the present. The 1960s brought about a number of changes that directly affected the safety movement; the Equal Pay Act 1963, the Civil Rights Act 1964, and the Age Discrimination in Employment Act of 1968. The 1970s brought sweeping changes to the industrial safety movement with the passage of the Occupational Safety and Health Act of 1970, the Resource Conservation and Recovery Act of 1976, Clean Water Act, the Safe Drinking Water Act, the Refuse Act, and the Toxic Substances Control Act. Under the Occupational Health and Safety

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Administration (OSHA), inspectors were allowed to enter and inspect the workplace, cite violations, and set deadlines.

In 1983, OSHA's Hazard Communication (HAZCOM) Standard was implemented. HAZCOM increased plant worker awareness of chemical hazards and gave instructions on appropriate safety measures for handling and working with these chemicals. In the early 1990s, Process safety management (PSM) provided the fangs that HAZCOM had needed. In response to a number of catastrophic events that had occurred in the process industry, OSHA and the Environmental Protection Agency (EPA) implemented the PSM standard, which was designed to keep the process in the pipes and not in the environment. PSM targets highly hazardous chemicals and its objective is to prevent catastrophes from these chemicals. In response to this standard, the chemical processing industry, government, business, and education communities joined forces to better educate the technical workforce. Chemical Technology/Technician college programs formally provided the platform for Apprentice Training programs for process technicians, laboratory technicians, and engineering technicians. The Bureau of Apprenticeship inside the Department of Labor still works with many of the leading manufacturers in the chemical process industry.

The 1980s and 1990s saw the introduction of the personal computer (PC), video cassette recorder (VCR), microwave oven, and the Internet into most U.S. homes. Rapid changes in technology, coupled with enhanced environmental regulations characterized this period. Prior to 2000, a number of major company mergers began to take place as many smaller companies were forced out of the market. New technology and a smaller, more technically educated workforce began to replace the baby-boomers. Never at any period of time has modern technology controlled such vast arrays of equipment and systems. Process safety is an essential aspect of operation in the chemical processing industry.

8. Why did industrial workers in the 1870s believe their jobs were hazardous? Workers in the 1870s believed their jobs were very hazardous. A brass finisher identified metallic dusts and dangerous machinery. A carriage painter was afraid

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of lead poisoning. Most workers were concerned about noise, heat, burns, dusts, and proper ventilation.

9. What is phossy jaw and how was it contracted? Phossy jaw was a disease workers contracted from breathing the fumes of white or yellow phosphorus. This disease appeared to flourish among workers in match factories. Phossy jaw was characterized by a painful swelling of the jaw that produced severe scarring and disfigurement. In severe cases, the jaw or portions of the face were removed.
10. How will understanding the key elements of process safety and occupational safety allow chemical technicians to contribute significantly to the reduction of risks and hazards associated with the chemical processing industry? Process safety is described as the application of engineering, science, and human factors to the design and operation of chemical processes and systems. The primary purpose of process safety is to prevent injuries, fatalities, fires, explosions, or unexpected releases of hazardous materials. Process safety focuses on the individual chemical processes and operational procedures associated with these systems. Occupational safety and health deals with items such as personal protective equipment, HAZCOM, permit systems, confined space entry, hot work, isolation of hazardous energy, and so on. Understanding the key elements of process safety and occupational safety allows technicians to contribute significantly to the reduction of risks and hazards associated with the chemical processing industry.
11. Why is the Pittsburgh Survey of 1906 a significant part of the safety movement? As the Pittsburgh Survey expanded outside the Pittsburgh area, the investigation revealed that there had been over 30,000 fatalities from industrial accidents across the United States during 1906. As news of this report became known, industry, government, and the public recognized a need for change. The Russell Sage investigators had unknowingly opened a new chapter for the safety

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movement. This new safety climate ushered in the development of organized safety programs and workers' compensation benefits.

12. Describe the relationship OSHA, HAZCOM, and PSM have to the Safety movement? In 1983, OSHA's Hazard Communication (HAZCOM) Standard was implemented. HAZCOM increased plant worker awareness of chemical hazards and gave instructions on appropriate safety measures for handling and working with these chemicals. In the early 1990s, Process safety management (PSM) provided the fangs that HAZCOM had needed. In response to a number of catastrophic events that had occurred in the process industry, OSHA and the Environmental Protection Agency (EPA) implemented the PSM standard, which was designed to keep the process in the pipes and not in the environment. PSM targets highly hazardous chemicals and its objective is to prevent catastrophes from these chemicals. In response to this standard, the chemical processing industry, government, business, and education communities joined forces to better educate the technical workforce.
13. Describe the fire classification system. The fire classification system is designed to simplify the selection of fire-fighting techniques and equipment.
 - Class A fires involve the burning of combustible materials such as wood, paper, plastic, cloth fibers, and rubber.
 - Class B fires involve combustible and flammable gases, liquids, and grease.
 - Class C fires are categorized as electrical fires.
 - Class D fires cover combustible metals.
14. Describe the different types of fire extinguishers. The carbon dioxide extinguisher is composed of a cylinder filled with compressed carbon dioxide. CO₂ extinguishers are effective on Class B and C fires because they displace oxygen. Dry chemical fire extinguishers are composed of a cylinder, dip tube, pressure gauge, hose and nozzle, BC or ABC dry chemical agent, carrying handle, operating lever, locking pin, and a compressed nitrogen or carbon

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dioxide cartridge. Foam fire extinguishers are used to control flammable liquid fires. The foam forms an effective barrier between the flammable liquid and the oxygen needed for combustion. Water fire extinguishers are composed of a cylinder, dip tube, pressure gauge, carrying handle, locking pin, operating lever, and overfill tube. Portable, hand-held water-filled fire extinguishers are designed for use on Class A fires only

15. Explain how hurricanes are classified. Hurricanes are powerful, swirling storms with tentacles reaching out from a singular eye. These storms are characterized with having pulsing wind gusts from 74 to over 155 mph, heavy rainfall and flooding, tremendous storm surges from 4 to 18 feet, spin-off tornados, downed trees and broken limbs, damaged homes, loss of electricity, utilities, and basic commodities.

Cat-1	74-95 mph: Dangerous winds will produce some damage
Cat-2	96-110 mph: Extremely dangerous winds will cause extensive damage
Cat-3	111-130 mph: Devastating damage will occur
Cat-4	131-155 mph: Catastrophic damage will occur
Cat-5	155+ mph: Catastrophic damage will occur

16. Describe the scale used to rate a tornado. Tornados are classified as extremely violent, turbulent, rotating columns of air that maintain contact with the cumulonimbus cloud and the surface of the earth. Tornados produce wind speeds between 40 and 110 mph and tend to gather or collect debris, rocks, and dust (flying projectiles). These destructive forces of nature are around 250 feet across and travel for several miles on the ground before dissipating. Some tornados have achieved wind speeds of over 300 mph and have been measured at more than a mile wide while wrecking destruction and death over several states before jumping back into the clouds only to re-emerge somewhere else. The CPI utilizes the Fujita scale to classify Tornados.

F0	Gale Tornado	40-72 mph
F1	Moderate Tornado	73-112 mph
F2	Significant Tornado	113-157 mph

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

F3	Severe Tornado	158-206 mph
F4	Devastating Tornado	207-260 mph
F5	Incredible Tornado	261-318 mph

17. List the different types of permits found in the CPI. Three permit systems are common in the industry: the control of hazardous energy (lockout/tagout), confined space entry, and hot work. Examples of a permitting system could include:
- Hot work permit—any maintenance procedure that produces a spark or excessive heat, or requires welding or burning.
 - Energy isolation procedure, lockout and tagout—isolates potentially hazardous forms of energy: electricity, pressurized gases and liquids, gravity, and spring tension. (The standard is also designed to shut down a piece of equipment at the local start or stop switch, turn the main breaker off, attach a lockout adapter and process padlock, try to start the equipment, and tagout and record in lockout logbook.)
 - Confined space entry, permit to enter—designed to protect employees from oxygen-deficient atmospheres, hazardous conditions, power-driven equipment, and toxic and flammable materials.
 - Opening or blinding permit—removing blinds, installing blinds, or opening vessels, lines, and equipment.
 - Unplugging permit—barricades area, clears lines for unplugging, informs personnel, issues opening blinding permit, and issues unplugging permit.
 - Routine maintenance permit—general maintenance and mechanical work that does not involve hot work or opening up a vessel.
18. Explain the hazards associated with the use of weapons of mass destruction. The use of weapons of mass destruction can have a catastrophic affect on the chemical processing industry and the communities that surround them. Weapons of mass destruction can be classified as biological agents, chemical agents, and bombings.

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Potential Risks include:

- Terrorist flies an airplane into a chemical plant or refinery
- Terrorist enters CPI workforce
- Use of conventional bomb
- Use of nuclear weapon
- Suicide bomber
- Use of chemical weapons
- Use of biological weapons
- Use of military weapons

19. List the steps associated with conducting a job hazard analysis. A job hazard analysis is often referred to as a process used to assess risk. The basic steps include the identification of unacceptable risks and the process used to eliminate or control these risks. A hazard is defined as a condition or practice that could contribute to an undesirable or unplanned event or as the potential for harm. A hazard analysis reviews and analyzes an operating process from start to finish. The primary focus is on the identification of hazards associated with each job task. Other areas include the work environment, required tools, and relationship between the technician and the task.

In order to conduct a job hazard analysis the following detective work is required:

- List what can go wrong.
 - Identify the consequences.
 - Explain how it could arise or occur.
 - Select the contributing factors.
 - Determine the frequency with which the hazard occurs.
20. List the key elements of HAZCOM. In 1983, OSHA's Hazard Communication (HAZCOM) Standard was implemented. HAZCOM increased plant worker awareness of chemical hazards and gave instructions on appropriate safety measures for handling and working with these chemicals. Chemical manufacturers are required by the HAZCOM standard to:

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- analyze and assess the hazards associated with chemicals
- develop written procedures for evaluating chemicals
- document hazards and develop material safety data sheets (MSDSs) and warning labels
- disseminate the information to affected individuals
- label, tag, and attach warning documentation to chemicals leaving the workplace

Employers are responsible for:

- preparing a written HAZCOM program
- organizing a hazardous chemical inventory list
- designing individual MSDSs

CHAPTER 2

HAZARD CLASSIFICATION

LEARNING OBJECTIVES

- Describe the hazard classification system.
- Apply the methods of hazard recognition and classification.
- Describe common industrial hazards found in the plant.
- Compare acute and chronic hazards.
- Describe the physical hazards associated with chemicals.
- Explain the activities that are associated with ergonomic hazards.
- Explain how biological hazards affect chemical technicians.
- Explain the principles of accident prevention.
- Analyze the principles of accident investigation.
- Describe the various types of ionizing radiation.

CHAPTER 2: REVIEW QUESTIONS

1. What are the physical hazards associated with chemicals? Physical hazards are categorized as combustible liquid, compressed gas, explosive, flammable gas, flammable liquid, organic peroxide, oxidizer pyrophoric, unstable, and water reactive.
2. Describe the hazard classification system. The first step includes the proper instruction in the identification, handling, and use of hazardous substances. The second step, a critical one, includes the use of safety procedures in working with any of these substances.
3. Compare acute and chronic hazards. Acute hazards have an immediate effect on workers, while chronic hazards has a delayed effect. Acute (immediate) poisons may be ingested, inhaled, injected, or absorbed. Chronic (delayed) hazards include asbestos fibers, coal dust, and toxic metals such as lead or

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

manganese. Chronic hazards are cumulative and frequently occur over an extended period of time

4. Describe biological hazards found in chemical plants and refineries. Biological hazards are described as any living organism capable of causing disease in humans. This includes insects, bacteria, fungi, and molds.
5. Describe ergonomic hazards found in chemical plants and refineries. Ergonomic hazards are activities that require chemical technicians to work in unusual or awkward positions for extended periods of time. This may include repetitive motions, monotony, work pressure, inability to match the standard of performance, console operations, or equipment and systems operation.
6. Describe physical hazards found in chemical plants and refineries. Physical hazards are classified as electrical, noise, radiation, or temperature. Physical hazards associated with chemicals are categorized as a combustible liquid, a compressed gas, explosive, a flammable gas, a flammable liquid, organic peroxide, oxidizer, pyrophoric, unstable, and water reactive.
7. Describe chemical hazards found in chemical plants and refineries. Chemical hazards are often referred to as health hazards by process technicians and can be categorized as carcinogens, mutagens, teratogens, reproductive toxins, asphyxiation, anesthetic, neurotoxic, allergic response, irritants, sensitizers, corrosives, toxic, highly toxic, and target organ effects.
8. The key to accident prevention is linked to what? The basic principles of accident prevention include a safe working environment, safe work practices, and effective management. If management does not support the safety program, if process technicians do not follow the rules of a safety program, or if the environment is riddled with unidentified hazards, the system will not work.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

9. Accident investigation is designed to do what? Accident investigation is designed to identify the point of failure and prevent recurrence.
10. How is the National Fire Protection Association's standardized system used? (chemical hazard identification)
11. Describe an unsafe condition. (any act that increases a person's chance of having an accident)
12. Describe the basic principles of accident prevention. (includes a safe working environment, safe work practices, and effective management.)
13. List the radioactive substances found in the chemical processing industry and describe the effects of exposure on the human body. Of the 102 known elements listed on the periodic table, 50 are known to be radioactive. Ionizing radiation cannot be detected by any of the five human senses. It is classified as alpha particles, beta particles, gamma rays, x-rays, and neutron particles. Alpha particles are the least penetrating and provide little threat to human tissue; however, these high-energy, high-velocity particles can damage specific internal organs if exposed. Beta particles are emitted from radioactive materials and penetrate much deeper than alpha particles. These particles can be ingested, inhaled, or absorbed through the skin. Energy from these hazardous particles is completely released in soft human tissue.

Unlike alpha and beta particles, gamma rays are not made up of atomic particles. Gamma rays are aggressively penetrating energy waves that can be stopped only by thick layers of concrete or lead and are extremely hazardous even from great distances.
14. List the chemicals typically associated with acute hazards and (immediate) poisons and describe common entry into the human body. Acute (immediate) poisons may be ingested, inhaled, injected, or absorbed; examples of these

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

chemicals include chlorine, acids, and caustics.

15. Describe the term “ionizing radiation,” and explain detection and classification methods. Ionizing radiation cannot be detected by any of the five human senses, classified as: alpha particles, beta particles, gamma rays, x-rays, and neutron particles. Alpha particles are the least penetrating and provide little threat to human tissue; however, these high-energy, high-velocity particles can damage specific internal organs if exposed. Beta particles are emitted from radioactive materials and penetrate much deeper than alpha particles. These particles can be ingested, inhaled, or absorbed through the skin. Energy from these hazardous particles is completely released in soft human tissue.

Unlike alpha and beta particles, gamma rays are not made up of atomic particles. Gamma rays are aggressively penetrating energy waves that can be stopped only by thick layers of concrete or lead and are extremely hazardous even from great distances.

X-rays are used in medical diagnostics and treatments, medical photographs, and to inspect vessels, packages, equipment, and piping. X-rays penetrate deeply and can change the molecular structure of tissue; therefore, extreme caution must be exercised through monitoring and shielding.

Neutron particles penetrate deeply and can be stopped only by heavy shielding. Neutron particles have no practical application; however, the military and certain research groups are experimenting with future uses.

Radiation is indirectly measured by the ionization footprint produced as it passes through a medium. Units for measuring radiation include rad (energy absorbed in a substance), rem (amount of biological injury), rep (radiation in human tissue), or roentgen (X or gamma radiation unit measurement). These four units refer to the energy, the charge, or biological effect.

16. Explain the risks associated with “electrical hazards.” Process technicians work with a variety of electrical energized equipment and systems. Electrical motors are used to drive pumps, compressors, generators, mixers, conveyors, fans,

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

blowers, large valves, and a wide variety of other systems. Motor control centers (MCCs) are frequently used to turn equipment on and off. These substations have a variety of voltages coming in and out of local transformers. The chemical processing industry has initiated special procedures for the control and isolation of hazardous energy. Isolating and safely tagging and locking out process equipment is part of a process technician's job.

17. Describe the decibel range associated with "industrial noise hazards." Industrial noise is described as valueless or unwanted sound that is measured in decibels. The trigger point for hearing protection is 85 decibels. Noise over 140 decibels can cause permanent hearing loss. When hearing loss occurs, it can never be recovered. Industrial equipment produces noise at a variety of decibel levels. Hearing protection is provided and required in areas where exposure will exceed recommended levels.
18. How many elements on the periodic table are known to be radioactive? Of the 102 known elements listed on the periodic table, 50 are known to be radioactive.
19. List the categories used to describe toxic hazards. Toxic hazards include fuels, metal fumes, solvents, products, and byproducts. Flammable substances catch fire or explode easily.
20. List the elements of effective safety management. Process technicians ensure that the rules of the safety program are maintained by all of the people entering the facility. Technicians are the backbone of any safety program because they are responsible for
 - good housekeeping
 - hazard recognition
 - safe work practices
 - safe work environment

CHAPTER 3

ROUTES OF ENTRY AND ENVIRONMENTAL EFFECTS

LEARNING OBJECTIVES

- Identify the attitudes and behaviors for safe and environmentally sound work habits.
- Contrast safety, health, and environmental issues with the performance of job tasks.
- Explain how hazardous chemicals can enter the human body.
- Discuss the dose response relationship.
- Describe key elements of environmental awareness training.
- Identify the primary reasons for air pollution control.
- Explain the importance of water pollution control.
- Describe solid waste control.
- Explain how the toxic substances control standard protects chemical technicians.
- Describe the Resource Conservation and Recovery Act (RCRA).
- Explain the purpose of the Toxic Substances Control Act.
- Contrast the clean up of chemical waste and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Superfund Law.
- Describe the role and responsibilities of the Environmental Protection Agency (EPA).

CHAPTER 3: REVIEW QUESTIONS

1. What is solid waste technically defined as? Defined as a non-liquid, non-soluble material ranging from municipal garbage to industrial waste that contains complex and sometimes hazardous substances.
2. What is the community right-to-know principle designed to do? Increases community awareness of the chemicals manufactured or used by local chemical

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- plants and businesses, involves community in emergency-response plans, improves communication and understanding, improves local emergency response planning, and identifies potential hazards.
3. Describe the purpose of the Resource Conservation and Recovery Act (RCRA). enacted as public law in 1976. The purpose of the RCRA is to protect human health and the environment. A secondary goal is to conserve our natural resources. RCRA completes this goal by regulating all aspects of hazardous waste management: generation, storage, treatment, and disposal (a concept referred to as "cradle to grave").
 4. Vapor releases, chemical spills, explosions, fires, equipment failure, hurricane, high winds, loss of power, and bomb threats fall under which main program? Emergency Response.
 5. "Cradle-to-grave" is a term associated with which government act? Describe how this applies to local chemical plants and refineries. Resource Conservation and Recovery Act (RCRA)—enacted as public law in 1976. The purpose of the RCRA is to protect human health and the environment. A secondary goal is to conserve our natural resources. RCRA completes this goal by regulating all aspects of hazardous waste management: generation, storage, treatment, and disposal (a concept referred to as "cradle to grave"). Chemical plants and refineries are responsible for the products they produce and can be fined and penalized.
 6. After how many minutes should smoking flares be reported? What are the penalties for not reporting? Smoking flares in excess of 5 minutes should be reported. Failure to report results in severe penalties. . Penalties for civil and criminal abuses of the clean air act range from \$25,000 a day to \$250,000 and 2 to 15 years in jail.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

7. What must be obtained for any project that has the possibility of producing air pollutants? Permits must be obtained for any project which has the possibility of producing air pollutants. The Air Control Board will place limits on emissions and will need about 3 to 8 months to complete the permit process. After the ACB issues the permit a yearly inspection will be scheduled.
8. What was the significance of the Exxon Valdez incident? The Valdez incident was the largest tanker oil release in U.S. history. Approximately 11 million gallons of North Slope crude oil gushed out of the ruptured hull contaminating the coastlines of the Alaska Peninsula, lower Cook Inlet, the Kenai Peninsula, the Kodiak Archipelago, and Prince William Sound. Oil from the Valdez was found over 600 miles southwest of the spill.
9. List the harmful products produced by air pollution. Include how they are produced. Modern factories, office buildings and homes produce smoke that contains sulfur dioxide and nitrogen dioxide. Sulfur dioxide and nitrogen dioxide are known to have harmful effects on the human respiratory system. As sulfur dioxide travels higher into our atmosphere it turns into sulfur trioxide that mixes with rain to form sulfuric acid. As nitrogen dioxide rises it combines with hydrocarbons and sunlight to form smog. Smog is an irritant that damages the eyes, the respiratory tract and plants. Motorized vehicles produce unburned hydrocarbons, carbon monoxide and nitrogen dioxide. This is bad for our environment because hydrocarbons injure plant life, human life and helps form smog. Carbon monoxide produces headaches and dizziness in humans. Low concentrations of carbon monoxide can kill. Incineration units and wide scale burning concentrates high levels of mercury and small particles in the atmosphere. This reduces visibility, injures the respiratory tract and nervous system and affects the climate.
10. In your opinion, list the importance of CERCLA. Please defend your answer. The clean up of waste sites is regulated by the Comprehensive Environmental

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

Response Compensation and Liability Act CERCLA. This Act is frequently referred to as the superfund law. Under CERCLA a number of large companies have been required to provide money for clean up activities for materials dumped by them or their parent companies years ago. This effort supports the “cradle-to-grave” concept and forces chemical manufacturers to develop long range procedures for the handling, storage and disposal of chemicals. The State Water Commission is the primary regulating agency charged with enforcement of solid waste disposal generated within their boundaries.

11. Describe the typical routes of entry a chemical uses to enter a body. Inhalation—airborne chemicals enter the body through the mouth or nose and may irritate the nose throat, bronchi, and deep lung tissue. Inhalation of a hazardous agent is the most common route of entry in the workplace. Some gases or vapors will not irritate the respiratory tract but will be absorbed into the blood system through the lungs. This process can affect the blood, brain, bone, liver, fatty tissue, kidney, and colon.

Hazardous chemicals can alter healthy cells and they may become cancerous. Airborne chemical particulates may be retained in the respiratory tract and cause allergic reactions, lung scarring, cancer, or fibrosis.

Absorption (skin contact)—Only a small number of chemicals are known to have serious impacts upon skin contact. These chemicals should be identified quickly if they are in your unit. When a hazardous chemical comes into contact with skin, there are four possible results:

1. Nothing will occur.
2. The chemical will react with skin and cause primary irritation.
3. The chemical will penetrate the skin and cause sensitization.
4. The chemical will penetrate the skin and enter the blood.

Ingestion—a process in which a hazardous chemical is transmitted to food, liquid, or cigarettes and then swallowed. Airborne chemicals may also be taken in through the respiratory system and then swallowed in the saliva or mucus.

Typically, large quantities of hazardous chemicals are not ingested; however,

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

small quantities of arsenic, lead, or mercury can be highly toxic over a period of time.

Injection—a process in which a toxic or hazardous material is injected into the body by a needle or sharp object, or through cuts in the skin.

12. Describe the effect that the Exxon Valdez spill had on the local community and economy. The spill had catastrophic effects on five state parks, three national parks, one state game sanctuary, a national forest, four national wildlife refuges, and four state critical habitat areas.
13. When was the Resource Conservation and Recovery Act (RCRA) passed? Was enacted as public law in 1976.
14. What was the TSCA inventory (75,000) established to do? The TSCA inventory (75,000) was established to trace and record all products manufactured, imported, sold, processed, or used for commercial purposes. Exemptions include research and development chemicals and byproducts without commercial purpose. TSCA also controls pre-manufacture review of new chemical substances, risk assessment by testing and information gathering, record keeping and reporting on health and environmental effects associated with chemical substances, and restrictions on known hazardous chemicals. The Toxic Substances Control Act has severe penalties for those who break the law. Yearly penalties for current violations are estimated at over \$40,000,000. The Environmental Protection Agency is the primary agency charged with enforcing toxic substance control.
15. Describe the purpose of the Toxic Substances Control Act. Toxic Substances Control Act (TSCA)—a federal law enacted in 1976 intended to protect human health and the environment. TSCA was also designed to regulate commerce by (1) requiring testing and (2) necessary restrictions on certain chemical substances. TSCA imposes requirements on all manufacturers, exporters,

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

importers, processors, distributors, and disposers of chemical substances in the United States.

16. Describe how smog is formed. Modern factories, office buildings and homes produce smoke that contains sulfur dioxide and nitrogen dioxide. Sulfur dioxide and nitrogen dioxide are known to have harmful effects on the human respiratory system. As sulfur dioxide travels higher into our atmosphere it turns into sulfur trioxide that mixes with rain to form sulfuric acid. As nitrogen dioxide rises it combines with hydrocarbons and sunlight to form smog. Smog is an irritant that damages the eyes, the respiratory tract and plants. Motorized vehicles produce unburned hydrocarbons, carbon monoxide and nitrogen dioxide. This is bad for our environment because hydrocarbons injure plant life, human life and helps form smog.
17. In what year was the Federal Clean Water Act passed and what was it designed to do? The federal clean water act was passed in 1898. The water control act of 1965 took a "water quality" approach and initiated close examination of receiving waters. States were required to establish standards for water quality.
18. Describe the dose-response relationship and the term toxicology. Dose is defined as the amount of chemical entering or being administered to a subject. Response is defined as the toxic effect the dose has upon the subject. This may be expressed under the following categories:
 - Ingestion—as the amount per unit of body weight
 - Injection—as the amount per unit of body weight
 - Absorption—as the amount per body surface area
 - Inhalation—as the amount per unit volume breathed

From Chapter 6: Toxicology—is the science that studies the noxious or harmful effects of chemicals on living substances

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

19. Explain the purpose of the “Federal Railroad Administration.” It regulates railroad traffic, including the transportation of hazardous materials.

20. Describe the purpose of the “Nuclear Regulatory Commission (NRC).”
Established in 1974 to regulate the nuclear devices used in the chemical processing industry. This includes x-ray and measuring devices used to inspect vessels and equipment.

CHAPTER 4

GASES, VAPORS, PARTICULATES, AND TOXIC METALS

LEARNING OBJECTIVES

- Describe the physical and health hazards associated with gases and vapors.
- Describe the physical and health hazards associated with particulates.
- Describe the physical and health hazards associated with toxic metals.
- Identify common poisonous metals and describe the hazards associated with each.
- List the metals that are fire hazards
- Describe the hazards associated with toxic metals.
- Explain the hazards associated with toxic metal compounds.
- Describe the hazards associated with compressed gas cylinders.
- List the flammable gases that will mix easily with air.
- Describe the hazards associated with dust explosions.
- List special precautions used when working with particulates, dust, and gases.
- Describe the Bhopal India vapor release.
- Explain how to work safely with asbestos.
- Describe the background and history of asbestos.

CHAPTER 4: REVIEW QUESTIONS

1. Some gases are known to interfere with the supply of oxygen to the body, this process is referred to as asphyxiation. List the simple asphyxiants identified in this chapter and describe how to safely work with these gases. Simple asphyxiants include gases like Nitrogen, helium, hydrogen, carbon dioxide, and methane that will displace the oxygen content in air.

To work safely with these chemicals it is important to use the correct respirators or avoid being exposed to the asphyxiants.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

2. Carbon monoxide and hydrogen cyanide are described as chemical asphyxiants. Describe how these chemicals work. Chemical asphyxiants like carbon monoxide and hydrogen cyanide prevent cells from using oxygen or prevent the blood from supplying oxygen.
3. Describe the effect an anesthetic gas will have on an exposed technician. Anesthetic gases have a numbing effect and will cause the loss of sensation and unconsciousness. Affected workers will become dizzy, lose coordination and fall asleep because the central nervous system has been chemically depressed. Death may occur from respiratory paralysis. All organic liquids in the gaseous state are considered anesthetics: methane, ethane, ethylene, acetylene, methyl alcohol, ethyl alcohol, methyl and ethyl ether, carbon tetrachloride, toluene, benzene, and xylene.
4. List the steps required to extinguish a flammable metal fire. Class D fire extinguishers are used in areas where a flammable metal fire hazard is present. Magnesium and zinc burn at extremely high temperatures (1,000 °F/ 540 °C), and are difficult to put out once started. Potassium is submerged in oil to reduce air contact and sodium is stored in a dry, moisture-proof container. Class D fires cover combustible metals such as aluminum, magnesium, zinc, potassium, sodium, titanium, and zirconium. It is important to mention that other types of fire extinguishers may make the fire worse.
5. Describe the hazards associated with asbestos. When an abrasive, irritating, asbestos fiber enters the human lung it activates the natural body defense system by encapsulating it. This process creates scar tissue that will remain inside the lung for life. Over time, the scar tissue causes the lungs to lose their ability to move oxygen in and out of the lungs and supply oxygen to the blood stream. This condition is referred to as asbestosis. Because asbestos is classified as a cancer-causing agent, asbestosis is considered serious.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

6. Explain why flammable gases are a serious concern in the chemical processing industry. Flammable gases mix readily with the air and quickly form mixtures that will explode or burn. This family of explosive and flammable gases includes acetylene, hydrogen, methane, ethane, butane, and propane.
7. List the hazards associated with working around compressed gas cylinders. When cylinders are heated up the compressed gases expand rapidly, increasing pressures. Direct flames will weaken the exposed side of the cylinder. Gas cylinders can rupture with catastrophic effects. The cylinder head or hoses could be damaged or knocked off, releasing the contents of the cylinder.
8. Explain how a dust explosion occurs. Dust explosions occur when particle concentrations are detonated from a single spark. Coal dust, grain dust, and fine saw dusts are typically associated with catastrophic dust explosion hazards.
9. A compound is described as a substance formed by the chemical combination of two or more substances in definite proportions by weight. What are the hazards associated with a compound that has lead oxide, mercuric nitrate, cadmium salts, chromates, or manganese oxide as a major component. A compound is described as a substance formed by the chemical combination of two or more substances in definite proportions by weight. Hazardous metallic compounds combine one or more of the known toxic metal(s) in the chemical compound. These substances include; lead oxide, mercuric nitrate, cadmium salts, chromates, and manganese oxide. Hazardous metallic compounds can be as dangerous as the purer form of the toxic metal and can be more dangerous depending on how the chemical is introduced into the human system.
10. Describe the effects of beryllium, copper, lead, manganese, mercury, and zinc on an unprotected technician. Beryllium is an extremely light and hazardous metal commonly found in the chemical processing industry. Beryllium is used in the manufacture of electronic parts, specialty light-weight alloys, and x-ray tubes.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

Initial exposures can irritate the skin, eyes, and lungs, provoking spasmodic coughing, tightness in the chest, pain, and difficulty in breathing. Beryllium has a catastrophic effect on the liver, gall bladder, and upper respiratory system. A single acute exposure may take four to six months to recover from. Technicians exposed to chronic levels of beryllium will experience constant pain in the joints, bones, and lungs and may develop cancer in the affected areas.

Toxic metallic substances include systemic poisons like, lead, manganese, and mercury. As mentioned earlier these poisons collect in specific organs and cause significant damage. This type of poisoning frequently occurs from inhaling dusts and vapors composed of toxic metals. Figure 4-6 shows a list of toxic metals and their harmful effects. A short list of toxic metals would include beryllium, copper, lead, manganese, mercury, and zinc.

Manganese is a rare metal known to cause brain damage. This element forms scar tissue on the brain and may develop into insanity. Symptoms include weakness, blank facial expressions, strange speech patterns, spasmodic laughter, and instability.

Mercury is a dangerous protoplasmic poison that destroys biological tissue.

Acute Lead poisoning may induce the following symptoms; anemia, paralysis, loss of higher level motor skills and stomach problems. Long-term chronic lead exposures accumulate in the brain, kidneys and liver and cause permanent damage. Symptoms of chronic lead exposure include depression, irritability, loss of coordination, and uncontrollable tremors or shaking.

11. Describe the pressure relief devices found on a compressed gas cylinder.
Pressure relief devices are used to control excessive pressures. These devices include safety relief valves and fusible plugs.
12. List the nine different types of dusts that pose a hazard for process technicians.
See Figure 4-4

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

13. Describe the Bhopal, India vapor release in one or two paragraphs. On December 3, 1984 the chemical processing industry was rocked as a large vapor cloud composed of methyl isocyanate (MIC) escaped from the Union Carbide India Limited (UCIL) plant and drifted over the sleeping town of Bhopal, India. The toxic vapor cloud became a nightmare from which nearby residents did not wake. By the time the sun came up 1,400 people had died. Seven years later the official body count had risen to 3,800 and those with disabling injuries reached 11,000. Some estimates indicate that over 200,000 people were hurt during this incident. For the first time in modern chemical manufacturing history an event had taken place near a populated area that demonstrated how vulnerable a community is to the hazards that exist inside the chemical processing industry.
14. List the most critical mistakes made in the events that led up to and through the Bhopal, India release.
- The vent gas scrubber and flare system was undersized and not operational because of a management decision.
 - The refrigeration system was dismantled.
 - Tk-610 alarms and instrumentation were faulty.
 - Jumper line was installed.
 - Stainless steel was not used in areas where it was specified.
 - Plant lay-offs and lack of training caused deficits.
 - A safe zone around the plant had not been established. The government and company allowed a densely populated shanty town to grow up around the plant by deeding land to their citizens. Most of these people were in the direct path of the release and died first.
 - Communication between Union Carbide and Union Carbide India Limited, and the Indian government broke down. The initial meeting with the press was short. Many questions were asked with few answers given.
 - The Indian government seized control of the plant and arrested the leader of the Union Carbide Corporation investigation team. The team was denied access to the plant and employees.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Many of the employees moved after the plant shut down and left no forwarding address.
 - Official plant documents were altered after the vapor release.
 - The amount of \$5 million dollars sent to the victims of the release was withheld by the government and sent back to Union Carbide.
 - A \$2 million project funded by Union Carbide to aid the victims of the release was bulldozed by the Indian government.
 - Samples of the MIC drum were difficult to obtain and delayed the analysis phase of the project by the Union Carbide Corporation.
 - The Indian government filed a suit against the Union Carbide Corporation and was awarded \$470 million. The government wanted \$3 billion but settled with Union Carbide. A few months later, the government changed hands and the court's first ruling was thrown out.
15. List the generic health hazards associated with working with gases, vapors, particulates, and hazardous metals. There are several health hazards associated with gases, vapors, particulates, and toxic metals. Health hazards are listed as: carcinogens, mutagens, teratogens, reproductive toxins, asphyxiation, anesthetic, neurotoxic, allergic response, irritant, sensitizer, corrosive, toxic, highly toxic, and target organ effects.
16. List the generic physical hazards associated with working with gases, vapors, particulates, and hazardous metals. A physical hazard associated with gases, vapors, particulates and toxic metals is described as a chemical that falls into one of the following categories: compressed gas, explosive, flammable gas, oxidizer, pyrophoric, or unstable. Gaseous airborne contaminants can affect unprotected technicians as irritants, asphyxiants, anesthetics, and as systemic poisons.

Physical hazards of gases include:

- a compressed gas—has a gauge pressure of 40 psig at 70 °F (21.1 °C).

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- explosive—a chemical characterized by the sudden release of pressure, gas, and heat when it is exposed to pressure, high temperature, or sudden shock.
- flammable gas—forms a flammable mixture with air at ambient temperature.
- an oxidizer—a chemical that promotes combustion in other materials through the rapid release of oxygen, usually resulting in a fire.
- pyrophoric—a chemical that ignites spontaneously with air at temperatures below 130 °F (54.4 °C).
- unstable—a chemical that will react (condense, decompose, polymerize, or become self reactive) when it is exposed to temperature, pressure, or shock.

Some gases are known to interfere with the supply of oxygen to the body, this process is referred to as asphyxiation. Simple asphyxiants include inert gases such as nitrogen, helium, hydrogen, carbon dioxide, and methane that will displace the oxygen content in air. Chemical asphyxiants such as carbon monoxide and hydrogen cyanide prevent cells from using oxygen or prevent the blood from supplying oxygen. Anesthetic gases have a numbing effect and will cause the loss of sensation and unconsciousness. Affected workers will become dizzy, lose coordination and fall asleep because the central nervous system has been chemically depressed. Death may occur from respiratory paralysis. All organic liquids in the gaseous state are considered anesthetics: methane, ethane, ethylene, acetylene, methyl alcohol, ethyl alcohol, methyl and ethyl ether, carbon tetrachloride, toluene, benzene, and xylene.

Systemic poisons are formed when toxic gases enter the bloodstream through the lungs and migrate toward specific body organs and tissues. A partial list of these gaseous systemic poisons include:

- Arsine—Blood cells and liver
- Benzene—Bone marrow
- Carbon tetrachloride—Liver and kidneys
- Ethylene dichloride—Liver and kidneys
- Hydrogen selenide—Liver and spleen
- Hydrogen sulfide—Respiratory system

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Mercury—Nervous system, kidneys, glands
 - Methyl alcohol—Nervous system and optic nerve
 - Methyl chloride—Kidneys and heart and nervous system
 - Phosphorous—Bone
17. A chemical that reacts violently when it comes into physical contact with another chemical is referred to as incompatible.
18. When the concentration of an airborne chemical reaches the level at which it kills 50% of the test animals, it is referred to as the Lethal Concentration 50 (LC50).
See Chapter 6.
19. The lowest concentration at which a vapor or gas will produce a rich enough vapor concentration in air to ignite in the presence of an ignition source is referred to as the Lower Explosive Limit (LEL).
20. A chemical that affects the dermal layer of the body is referred to as an irritant.

CHAPTER 5

HAZARDS OF LIQUIDS

LEARNING OBJECTIVES

- Describe the physical and health hazards associated with liquids.
- Describe the physical and health hazards associated with solvents.
- Describe the safety precautions used when spray painting is in progress.
- Describe the hazards associated with paints and adhesives.
- Compare and contrast acids and caustics.
- Explain the PPE used in handling acids and caustics.

CHAPTER 5: REVIEW QUESTIONS

1. Describe the hazards associated with paints and adhesives. Adhesives contain chemicals like toluene and xylene that can cause permanent damage when inhaled in sufficient quantities. Some adhesives, like instant glues contain cyanoacrylates that are toxic when inhaled, injected, ingested, or absorbed through the skin. Most industrial painting projects should be considered as a breathing hazard. Acrylic paints, oil-based paints, and epoxy paints contain a variety of hazardous components. Two important safety procedures include adequate ventilation and the use of respiratory and personal protective equipment. Fine mists that are inhaled allow paint particles to build up on the inner surface of the lung, reducing respiration. If the paint contains a toxic substance this is the most rapid method of acute or chronic poisoning. It should also be noted that the propellant used in many spray cans is toxic. Paints that are used for rust prevention contain chromates, an alkaline chemical that can lead to chronic poisoning. Lead is another product commonly found in paints that are used for rust prevention. The hardeners used in epoxy paints is also hazardous when absorbed through the skin and can produce an acute or chronic effect.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

2. Compare and contrast the differences between acids and bases. Acids and caustics are typically referred to as chemical opposites since they are used to neutralize each other. When acids and caustics come into contact with human tissue they tend to dissolve or eat away any exposed area. Mists and vapors inhaled by the respiratory system will cause chemical burns and destroy soft throat and lung tissue. An acid produces H_3O^+ (hydronium) ions in an aqueous solution, while a base produces OH^- (hydroxyl) ions in an aqueous solution.
3. List and describe the hazards associated with light-ends. The explosive characteristics of light-ends are very violent. Light-ends are hydrocarbons that are heavier than air and will quickly evaporate at room temperature and pressure. They typically have low boiling points and a Reid vapor pressure (RVP) of 18 psi or higher. For this reason light-ends are often handled and stored as liquids. Examples of light-ends include methane, ethane, propane, butane, and pentane. A common liquid mixture of propane and butane is often referred to as liquefied petroleum gas or LPG. Light-ends are difficult to contain in pipelines and equipment because of their low viscosity and density characteristics. Since most of these hydrocarbons exist as a gas under normal conditions, pressure is added and in some cases temperatures are lowered to keep them in a liquid state.
4. List the specific hazards associated with solvents. Most solvents have varying toxic effects they each appear to attack specific organs in the human body that are often irreversible. Many industrial applications frequently use paints and adhesives in preventive maintenance programs and new construction. These products contain a hazardous substance called a solvent. Solvents are flammable, volatile, highly toxic, and produce large volumes of vapor. For a process technician this presents a serious fire hazard. In addition to being a fire hazard paints and adhesives containing solvents have harmful effects when inhaled, ingested, injected, or absorbed into the human system. Solvents should be handled carefully and stored properly.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

5. Describe the effects of static charge. Electrostatic generation occurs when petroleum products are pumped through a pipeline. This process is closely associated with the velocity of the product being pumped and the amount of water present in the mixture. Under the right conditions a static spark can ignite the mixture and rupture the line. Petroleum products should be kept free of water to avoid creating this hazardous condition.
6. Describe the hazards associated with water. The widespread use and application of water in the chemical processing industry creates a number of potential hazards. When water flashes to steam at 100 °C it expands 1,500 to 1,600 times its original size. One gallon of water can produce 1,600 gallons of steam. Hazards associated with water are typically associated with uncontrolled mixing, however, a number of other areas can be identified. This would include environmental topics like the weather, equipment operations, and displacement procedures.
7. List the hazards associated with steam. The most common hazards associated with steam include; physical exposure to live steam, contact with heated equipment, non-uniform heat transfer, equipment over-pressuring. High pressure steam discharged from a small opening has enough energy to cut through solid materials. Many exposed lines provide heat sources that can easily burn an unprotected technician.
8. List and describe common oxidizers. An oxidizer is described as a substance that enhances the ability of oxygen to combine with fuel. Under these conditions very little heat is needed to initiate a combustion reaction, in some cases room temperature is adequate. Common oxidizers include; ammonium nitrate, chlorine, potassium nitrate, and pure oxygen. Common combustible items like petroleum grease products and oils react violently, ignite and occasionally explode when brought into contact with an oxidizer.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

9. Explain the scientific principles associated with spontaneous combustion.
Spontaneous combustion is the result of a slowly developing chemical reaction that produces its own heat. Oily rags and coal piles have the ability to spontaneously combust. In the case of oily rags an oxidation reaction occurs that uses the fibers of the rags, the oil, and oxygen to start an exothermic reaction.
10. Describe flammable liquid storage. Small quantities of flammable liquids are often kept inside metal cabinets or in fire-resistant rooms. A number of operations require flammable liquids to be kept under pressure. An inert gas like nitrogen is frequently used to increase the pressure in a tank. Closed tanks will respond to temperature variations. The vapor pressure exerted by a liquid increases as the temperature rises. In an enclosed space, a flammable liquid will expand and the vapor pressure will increase as the temperature rises.
11. Describe the key elements of a process system. A process system is a collection of equipment that works together to perform a specific function.
12. List the primary variables a process technician works with. The primary variables a process technician works with are (1) temperature, (2) flow, (3) level, (4) analytical, and (5) pressure.
13. Define the term mutagen. Mutagen—a chemical that is suspected to have the properties required to change or alter the genetic structure of a living cell.
14. Describe and list physical hazards. A physical hazard associated with liquids is a chemical that falls into one of the following categories: combustible liquid, flammable liquid, organic peroxide, corrosive, toxic, and an unstable liquid.
15. Describe and list chemical hazards. Chemical hazards for liquids include carcinogens, mutagens, teratogens, reproductive toxins, asphyxiation,

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

anesthetic, neurotoxic, allergic response, irritants, sensitizers, corrosives, toxic, highly toxic, and target organ effects.

16. List and describe biological hazards. Biological hazards are associated with liquids that contain any living organism capable of causing disease in humans, this includes insects, bacteria, fungi, and molds.
17. Compare and contrast the terms, “nephrotoxin and neurotoxin.” The term “Nephrotoxin” is a chemical suspected of causing kidney damage while the term “Neurotoxi” is a chemical suspected of causing nerve damage; some links exist between this chemical type and behavioral and emotional abnormalities.
18. Define the term, “acute effect.” Acute effect is best described as an immediate adverse effect on biological tissue.
19. Compare and contrast the terms, “flashpoint and flammable liquid.” A flammable liquid has a flashpoint below 100 °F (37 °C). while Flashpoint is the lowest temperature at which a flammable liquid will produce a rich enough vapor concentration to ignite in the presence of an ignition source.
20. Explain the best way to safely handle, store, and transport hazardous chemicals. Transporting, storing, and handling chemicals requires that process technicians understand the systems, equipment, and technology they are working with, the physical hazards associated with chemicals in their facility, the health hazards associated with chemicals in their facility, chemical routes of entry into the human body, using the material safety data sheets (MSDSs), and proper labeling, signs, and tags usage.

CHAPTER 6

HAZARDOUS CHEMICAL IDENTIFICATION: HAZCOM, TOXICOLOGY, and DOT

LEARNING OBJECTIVES

- Describe the Hazard Communication standard.
- Identify the physical properties and hazards associated with handling, storing, and transporting chemicals.
- Describe physical and health hazards associated with exposure to chemicals.
- Describe the key elements of a material safety data sheet.
- Describe a hazardous chemical inventory list.
- Explain the purpose of a written Hazard Communication program.
- Identify methods used to protect process technicians from hazardous chemicals.
- Identify safety signs, tags, and warning labels utilized by process technicians.
- Describe toxicology and the terms associated with it.
- Describe the material classification system for DOT.
- Describe the Hazardous Materials Identification System.
- Describe the National Fire Prevention Association labeling system.

CHAPTER 6: REVIEW QUESTIONS

1. How do hazardous chemicals enter the human body? Ingestion, injection, absorption, inhalation. See Chapter 3.
2. Define toxicology. Toxicology is the science that studies the noxious or harmful effects of chemicals on living substances.
3. Describe a hazardous chemical. A chemical that has been determined to be a physical hazard to humans.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

4. What is a health hazard? A chemical that has been statistically proven by one or more scientific studies to have acute or chronic health risks for humans. See Chapter 3.
5. Describe a physical hazard. Physical hazards include substances that are compressed, explosive, flammable, an oxidizer, pyrophoric, or unstable.
6. List the typical personal protective equipment worn by a process technician. See Chapter 10. Safety hats, glasses, fire retardant clothing, safety shoes, hearing protection, gloves, goggles, face shield, respirators, and radio.
7. What is a fundamental principle of the chemical hazard communication program? The purpose of the Hazard Communication Standard is to ensure that the hazards associated with the handling, transport and storage of chemicals in a plant are evaluated and transmitted to affected personnel. According to the Hazard Communication Standard, chemical manufacturers and employers are required to; analyze and assess the hazards associated with the chemical and develop written procedures for evaluating chemicals, document the hazard and develop material safety data sheets and warning labels, disseminate the information to effected individuals, label, tag, attach warning documentation to chemicals leaving workplace.
8. What is a physical hazard? Physical hazards of gases include:
 - a compressed gas—has a gauge pressure of 40 psig at 70°F (21.1 °C).
 - explosive—a chemical characterized by the sudden release of pressure, gas, and heat when it is exposed to pressure, high temperature, or sudden shock.
 - flammable gas—forms a flammable mixture with air at ambient temperature.
 - an oxidizer—a chemical that promotes combustion in other materials through the rapid release of oxygen, usually resulting in a fire.
 - pyrophoric—a chemical that ignites spontaneously with air at temperatures below 130 °F (54.4 °C).

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- unstable—a chemical that will react (condense, decompose, polymerize, or become self reactive) when it is exposed to temperature, pressure, or shock.
9. What are chemical manufacturers required by the HAZCOM standard to do?
Chemical manufacturers are required by the HAZCOM standard to:
- Analyze and assess the hazards associated with the chemical.
 - Develop written procedures for evaluating chemicals.
 - Document the hazard and develop material safety data sheets and warning labels
 - Disseminate the information to effected individuals.
 - Label, tag, and attach warning documentation to chemicals leaving workplace.
10. What are employers required by the HAZCOM standard to do? Employers are responsible for:
- Preparing a written Hazard Communication Program
 - Organizing a hazardous chemical inventory list
 - Designing individual material safety data sheets
11. Describe the composition of a chemical hazard communication program.
HAZCOM is composed of eight sections, chemical manufacturers requirements, chemical lists, material safety data sheets, target critical operations, physical hazards, chemical hazards, personal protective equipment, and release detection.
12. Who develops the material safety data sheet (MSDS)? The development of the material safety data sheet “MSDS” is the responsibility of the chemicals manufacturer.
13. Describe the Hazard Communication standard. The HAZCOM standard is frequently referred to as, the workers right to know act. The chemical processing

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

industry initiates the delivery of HAZCOM training upon initial assignment to the plant. Training focuses on the physical and health hazards associated with exposure to chemicals. Additional information is provided on the toxicology, physical properties and hazards associated with handling, storing and transporting chemicals. New technicians are required to review company procedures used to protect employees from hazardous chemicals and specific operations are identified that may expose an employee to a chemical. The training section also includes the selection and use of personal protective equipment “PPE” and the methods and observations utilized to detect the release of hazardous chemicals.

14. Identify the physical properties and hazards associated with handling, storing, and transporting chemicals.

Physical hazards associated with chemicals include:

- a combustible liquid
- a compressed gas
- explosive
- flammable gas
- flammable liquid
- an organic peroxide
- an oxidizer
- pyrophoric
- unstable
- water reactive

Health hazards associated with chemicals include:

- Carcinogens
- Mutagen
- Teratogen
- Reproductive toxin
- Asphyxiation
- Anesthetic
- Allergic response
- Irritants
- Sensitizers
- Corrosives
- Toxic
- Highly toxic

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Neurotoxic
- Target organ effects

15. Describe the key elements of a material safety data sheet.

1. SECTION ONE Product Identification and Emergency Information—chemical name, chemical family, formula, trade name, company code, manufacturer address, emergency telephone number 24 hours a day.
2. SECTION TWO Hazardous Ingredients—Chemical component percentages and OSHA hazard.
3. SECTION THREE Health Information and Protection or Hazards Identification—Nature of hazard and first aid; eye, skin contact, inhalation, ingestion. Exposure limits, precautions, personal protective equipment.
4. SECTION FOUR Fire and Explosion Hazard—flashpoint, flammable limits, auto-ignition temperature, general hazards, fire fighting procedures, hazardous combustion products.
5. SECTION FIVE Physical Data and Chemical Properties—Vapor pressure, boiling point, evaporation rate, appearance and odor, specific gravity, solubility in water, percent volatile, density, freezing, melting point.
6. SECTION SIX Spill Control Procedure—Land spill procedure, water spill procedure, vapor release. Methods to control and to protect yourself.
7. SECTION SEVEN Regulatory Information—Department of transportation shipping description, flash point, TSCA information, Comprehensive Environmental Response, Compensation and Liability Act CERCLA information, Superfund Amendments and Reauthorization Act information “SARA.”
8. SECTION EIGHT Reactivity Data—Stability of material, conditions to avoid instability, materials and conditions to avoid incompatibility, hazardous decomposition of product, hazardous polymerization.
9. SECTION NINE Storage and Handling—electrostatic accumulation hazard, storage temperature, storage, transport pressure, loading, unloading temperature, viscosity at loading, unloading temperature.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

10. SECTION TEN Personal Protective Equipment—Respiratory protection, clothing and gloves, face shield, goggles, ventilation, etc.

16. Describe a hazardous chemical inventory list. Fundamental information that must be provided to a process technician includes the key elements of the HAZCOM standard, their plants written Hazard Communication program, a detailed hazardous chemical inventory list and associated material safety data sheets “MSDS” along with warning labels, tags and signs. Information should be included on how to access the HAZCOM system. The chemical inventory list includes all of the chemicals used in a plant.
17. Explain the purpose of a written Hazard Communication program. The purpose of the Hazard Communication Standard is to ensure that the hazards associated with the handling, transport and storage of chemicals in a plant are evaluated and transmitted to affected personnel.
18. Identify methods used to protect process technicians from hazardous chemicals. The methods used to protect process technicians include, the Hazard Communication program, DOT, Toxicology, Safety signs and labels, Hazardous materials identification system, and the National fire protection association.
19. Describe toxicology and the terms associated with it. Toxicology is the science that studies the noxious or harmful effects of chemicals on living substances. The fundamentals of toxicology include a relationship between dose and response. Dose is defined as the amount of chemical entering or being administered to a subject while response is defined as the toxic effect the dose has upon the subject.
20. Describe the following terms: HMIS, DOT, NFPA. Shipments of hazardous materials are regulated by the U.S. Department of Transportation (DOT). These regulations contain specific information on how hazardous materials are

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

identified, placarded, documented, labeled, marked and packaged. HMIS is another labeling system frequently used by industrial manufacturers to identify the hazards associated with chemicals. The HMIS communicates its information to process technicians by listing five essential topics; the chemical name, health hazard, flammability hazard, reactivity hazard and personal protective equipment requirements. A third hazard communication labeling system is the NFPA. This system utilizes the four small diamonds arranged so they form one large diamond. Each small diamond is color-coded and has its own severity rating from one to four. The four color coded topic blocks are; blue for health hazards, red for fire hazards, yellow for reactivity hazards, and white for specific hazards

CHAPTER 7

FIRE AND EXPLOSION

LEARNING OBJECTIVES

- Describe the principles of fire prevention, protection, and control.
- Review the chemistry of fire.
- Describe the fire classification system.
- Evaluate the different types of fire extinguishers.
- Analyze the different fire stages.
- Identify the various types of fire-fighting equipment.
- Respond to a fire emergency.
- •Describe flammable and explosive materials.
- Contrast the Monsanto chemical plant Texas City explosion 1947 with the Union Carbide Bhopal, India vapor release 1984.
- Evaluate the impact of the Phillips, Houston TX. vapor release and explosion 1989 and the ARCO, Houston TX. explosion 1990 on the development of the process safety management standard.

CHAPTER 7: REVIEW QUESTIONS

1. In your own words describe the explosion of the SS. Grandcamp. See Chapter 7. On a cool spring morning, shortly after 8 a.m., April 16, 1947, Texas City residents experienced one of the worst industrial accidents to occur in the United States as the S.S. Grandcamp, a French ship anchored in Galveston Bay, loaded with ammonium nitrate exploded killing 600 people and injuring thousands.
2. Describe the hazards of handling, storing and transporting ammonium nitrate. See Chapter 7. Ammonium nitrate is an ingredient used in TNT and is very

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

volatile if exposed to an open flame. It should be handled with extreme care. It should never be exposed to an open flame. Water should be used to put out the fire. Snuffing systems should not be used. Orange vapors given off during a fire indicate an impending explosion. Explosions are very violent.

3. Describe the special conditions required to safely handle Methyl isocyanate. What could have been done to prevent this accident before it happened? All operational equipment and instruments should be in good condition. This includes process instruments, gauges, rupture disks, safety valves, the refrigeration unit, the scrubber unit, and the correct size flare. MIC should never be mixed with water and should be kept in liquid state.
4. Why were so many people killed during the SS. Grandcamp explosion? See Chapter 7. Lack of knowledge about the hazards associated with handling, storing, and transporting ammonium nitrate.
5. What were the major causes of the Phillips explosion? Attempt to bypass safety procedures complicated by using contractors to change out a valve while the unit was running.
6. What were the major causes of the ARCO explosion? Ignoring rumbling in waste water tank, blocking out the gauge, and ignoring high pressure readings.
7. List the mistakes that occurred during the Bhopal, Texas City, Phillips, ARCO incident. What is common between them? Lack of knowledge and willingness to ignore safety rules.
8. List the three sides of the fire triangle? Fire, Fuel, Air
9. Your computer console has just caught on fire. Please list the steps you would take. Identify the type of extinguisher you would use. CO₂ or halon would be the

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

preferred fire extinguisher since it does not leave a residue and will not damage electrical components.

- Identify the type of material involved in the fire.
- Select the appropriate fire extinguisher.
- Test the extinguisher. Severe burns could result if you get to the fire and find an empty or defective extinguisher in your hand.
- Approach upwind of the fire. This will keep the heat, smoke and extinguishing agent from blowing back on you.
- Aim at the base of the flames and use a sweeping motion to extinguish the fire.
- Back away from the fire before the extinguisher is emptied. Never turn your back on a fire.

10. The motor on pump 102 has just caught on fire. Please list the steps you would take. Identify the type of extinguisher you would use. Dry chemical. Ensure the affected breakers are off.

- Identify the type of material involved in the fire.
- Select the appropriate fire extinguisher.
- Test the extinguisher. Severe burns could result if you get to the fire and find an empty or defective extinguisher in your hand.
- Approach upwind of the fire. This will keep the heat, smoke and extinguishing agent from blowing back on you.
- Aim at the base of the flames and use a sweeping motion to extinguish the fire.
- Back away from the fire before the extinguisher is emptied. Never turn your back on a fire.

11. A liquid spill from tank 102 has just caught on fire. Tk-102 is empty. Please list the steps you would take. Identify the type of extinguisher you would use. Foam would be a good choice and should smother the fire.

- Identify the type of material involved in the fire.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Select foam fire extinguisher system.
 - Test the extinguisher. Severe burns could result if you get to the fire and find an empty or defective extinguisher in your hand.
 - Approach upwind of the fire. This will keep the heat, smoke and foam from blowing back on you.
 - Foam will cover the flames and extinguish the fire.
 - Back away from the fire. Never turn your back on a fire.
12. Fire Monitors—are used to cool exposed facilities and equipment and limit the spread of the fire. The fire monitor is equipped with an adjustable 500 gallon per minute.
13. The nozzle on a fire monitor has three settings; name them. The fire monitor nozzle has three settings, fog, straight stream and power cone.
14. List the four stages a fire goes through. The Incipient Stage (no smoke or flame, little heat, combustion begins), Smoldering Stage (increased combustion, smoke, no visible flame), Flame Stage (flames become visible), and Heat Stage (excessive heat, flame, smoke, toxic gases).
15. When Reporting a Fire you should? (1) give name and phone number, (2) fire location and extent of fire, (3) products involved in fire.
16. Describe three principles of fire prevention, protection and control.
- Analyze the physical layout of the plant or facility and surrounding structures.
 - Ensure fire fighting equipment is available and strategically placed.
 - Design engineering systems that allow for the safe handling, storage and shipment of flammable and combustible materials.
 - Establish written procedures and emergency response plans.
 - Develop structured safety training programs.
 - Design and implement early fire detection systems.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Prevent the outbreak and spread of fires.
17. In two or three paragraphs describe the fire classification system. The fire classification system is designed to simplify the selection of fire-fighting techniques and equipment.
- Class A fires involve the burning of combustible materials like wood, paper, plastic, cloth fibers, and rubber.
 - Class B fires involve combustible and flammable gases and liquids and grease.
 - Class C fires are categorized as electrical fires. This involves energized equipment and class A, B and D materials that are located near the fire.
 - Class D fires cover combustible metals like aluminum, magnesium, potassium, sodium, titanium and zirconium.
18. Describe the hazards associated with fighting a fire that has the potential to produce a “bleve.” BLEVE a physical explosion involving "a boiling liquid expanding vapor explosion, involving the release and ignition of an expanding vapor." A bleve is a severe, violent explosion that can have wide spread consequences for fire fighters and technicians. Most fire departments will evacuate an area where a potential bleve could occur, rather than fight the fire. Bleves occasionally occur with train derailments. As flames come in contact with the outside of a rail car the chemical inside begins to heat up and expand. When the rail car ruptures the rapid release of the volatile chemical creates a tremendous explosion, sending jagged fragments and flames out over a great distance. Fire fighters will frequently evacuate an area where a potential bleve could occur.
19. List the five most common fire extinguishers used in the chemical processing industry. CO₂, Dry chemical, Water, Foam, and Halon.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

20. Describe the evolution of a detonation and chemical explosions. Detonations are a special type of explosion that are extremely destructive because they travel at high velocities, through plant pipe work and process equipment, and produce high internal pressures. A detonation wave for air-hydrocarbon mixtures expands at a high velocity: 4,000 to 8,000 feet per second. The pressures created in a detonation wave can be more destructive than normal explosions. A chemical explosion can be described as a rapidly building, self-contained fire that generates gases and vapors capable of exceeding the pressure ratings of the equipment it is in. Chemical explosions can be described five different ways: thermal explosions, combustion explosions, condensed phase explosions, physical explosions, and nuclear explosions. Other terms used to describe this type of phenomenon include: detonation, fire-ball, overpressure damage, and unconfined vapor cloud explosions.

A thermal explosion is the result of two or more chemical compounds combining and reacting violently. This type of explosion has been identified as the most common in the chemical processing industry. Combustion explosions include unconfined vapor cloud explosions (UVCE), gas, dust, mists, and backdrafts. Condensed phase explosions are rapid chemical component reactions that occur between liquids and solids. The term nuclear explosion is used to describe fission and fusion of matter. Nuclear power is used in electrical power generation facilities.

CHAPTER 8

ELECTRICAL, NOISE, HEAT, RADIATION, ERGONOMIC, AND BIOLOGICAL HAZARDS

LEARNING OBJECTIVES

- Describe the hazards associated with electricity.
- List the hazards associated with the operation and maintenance of electrical equipment.
- Describe the hazards of bonding and grounding.
- Describe the hazards of working with noise, heat, and radiation.
- List the ergonomic hazards found in the chemical processing industry.
- Analyze the hazards connected to confined space entry.
- List the hazards associated with industrial lifting.
- Identify the biological hazards found in a chemical facility.
- Describe the primary concerns about bloodborne pathogens. Bloodborne Pathogens—CFR 1910.1030
- Describe the hearing conservation standard. Occupational Noise Exposure 29 CFR 1910.95
- Explain the effects of noise on hearing.
- Review the purpose of hearing protection devices.
- Describe the selection, use, fit, and care of hearing protection.
- Explain the purpose of audiometric testing.

CHAPTER 8: REVIEW QUESTIONS

1. Describe the various hazards associated with working with electricity. The hazards of working with electricity include; (1) sparks and arcs, (2) static electricity, (3) lightning, (4) stray currents, (5) energized equipment, and (6) electric shock.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

2. Compare and contrast the terms “bonding” and “grounding.” Bonding is described as physically connecting two objects together with a copper wire. Grounding is described as a procedure designed to connect an object to the earth with a copper wire and a grounding rod.
3. Explain how the National Electrical Code (NEC) classifies a chemical plant or refinery. The National Electrical Code (NEC) classifies a typical refinery or chemical plant as Class 1, Group D. A Class 1 area has flammable gases or vapors in high enough concentrations to produce explosive or ignitable mixtures. Class 1 facilities are also divided into Division 1 or Division 2 depending on if they are always hazardous (Div 1) or rarely hazardous (Div 2). Atmospheres containing alcohol, benzene, butane, gasoline, hexane, lacquer solvent vapors, naphtha, or natural gas are classified as Group D. Most refineries and chemical plants are classified as Class 1, Group D, Division 2. The National Electrical Code requires all Class 1, Group D, Division 1 sites to have explosion-proof housings on all energized equipment.
4. Describe the key features of OSHA regulation 29CFR 1910.95. requires all process technicians who are exposed to over 85 decibels (dB) over an eight-hour “TWA” period be placed in a hearing conservation program.
5. List the physiological effects of industrial noise. The psychological effects of noise include; being easily startled, annoyed, inability to concentrate, relax or sleep, communicate. It can also interfere with job performance and safety
6. Explain how Hepatitis B and Human immunodeficiency virus (HIV) and Legionnaires’ disease can be transmitted in the plant. Other process related illnesses include Legionnaires’ disease. This biological hazard is a form of pneumonia caused by inhaling Legionellae bacteria. This strain of bacteria has been found in cooling towers and heat exchangers. Biological hazards are found in; microorganisms, insects, allergens and toxins, and protein allergens from vertebrate animals. This

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

type of exposure is rare in the chemical industry, however, with the advent of bloodborne pathogens like Hepatitis B and Human immunodeficiency virus (HIV) exposure is possible.

7. Describe the ergonomic hazards found in a refinery or chemical plant.

Ergonomic stresses or hazards can be initiated by:

- repetitive or forceful work
- improper work techniques
- poorly designed tools and workplaces

Process related hazards include; lifting, material handling, sitting at computer console for long periods of time, shift work, work teams, using wrong tools for the job, working at heights, working in confined spaces.

8. What are the hazards associated with operating electrical equipment? When electricity jumps a gap it is called a spark. Sparks and arcs occur during the normal operation of electrical equipment. The insulation on older equipment breaks down over a long time period. A spark can be as hot as 1500F and may ignite a flammable mixture. Modern facilities are pre-engineered with explosion proof equipment that do not allow arcs or sparks out of a confined area. Static electricity has been discussed in earlier chapters and can lead towards a deadly situation. Examples of this problem include, pumping, filtering, or moving flammable materials from one place to another. An accumulated static charge has enough voltage to ignite a flammable mixture. To prevent this problem a procedure called grounding is used. Lightning strikes are difficult to predict, however, tall vessels in an electrical storm can attract this phenomenon. Lightning can ignite flammable and combustible materials in tanks and vessels. Lightning has an electrical discharge equivalent to 1,000,000,000,000,000 hp. Most industrial equipment is grounded to prevent static charges and lightning strikes from damaging equipment and personnel. Stray currents in a plant are considered to be power line leakage or battery action of soils and metals. Two hazards associated with stray currents includes; currents flowing through

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

grounded piping which causes the metal to corrode. Typical electrical equipment found in the industry include; motors, switches, heaters, lighting, breakers, motor control centers MCC, ovens, control panels, alarms, thermocouples, etc. Electric shock is always a hazard when working with electrical equipment since some equipment is exposed to the elements and a lot of older equipment has not been replaced.

Over 1,000 people die each year as a result of electrical shock. The direct cause of death appears to be ventricular fibrillation and paralysis of the respiratory system. If the amount of the current and the current path are correct a person's breathing will stop and death results from asphyxiation. In accidental electrocutions the amount of current can vary and is determined by voltage, contact area, and body resistance. Dry surface areas provide high resistance, however, if a process technician is wet and standing in water the contact area is increased and body resistance is lowered. This is how most accidental electrocutions occur. The amount of voltage a process technician can tolerate is very low and is typically measured in milliamperes mA. The hazards of working with electricity include; (1) sparks and arcs, (2) static electricity, (3) lightning, (4) stray currents, (5) energized equipment, and (6) electric shock.

9. Describe the symptoms of heat exhaustion. dizziness, weak pulse, cool, moist skin, painful heat cramps.
10. Describe the correct procedure for lifting and object. Proper lifting techniques require a technician to keep the load close to the body. Bend at the knees and lift with the legs keeping the heels on the ground. Keep feet about shoulder-width and turned out. Avoid twisting by turning the entire body in the direction you want to move. Bend knees and squat down carefully when setting down loads. Older employees should recognize the effect of age on their physical abilities and limit some of the activities they used to be able to do.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

11. What are the ergonomic symptoms of working in confined spaces. Confined space ergonomic stresses include; repetitive movement, exposure to potentially hazardous environments, and fear of enclosed or tight spaces. A variety of visible symptoms include; anxiety, muscle pain, sweating, nausea, dizziness, loss of consciousness, vertigo, inability to communicate, and inability to communicate effectively.
12. Describe the three ways hearing protection is classified. Hearing protection can be classified in three ways:
 - a. Engineered noise abatement—reducing noise through new equipment design and innovation.
 - b. Administrative noise abatement—reduce employee exposure time to industrial noise.
 - c. Personal hearing protection—earplugs, ear muffs. Expandable ear plugs are commonly used by process technicians. The earplug must be rolled between the thumb and forefinger and compressed before they can be inserted into the ear canal. The foam ear plugs will expand and form a seal between the noise and the ear drum. Earmuffs provide the same protection as ear plugs. The sealing area must be kept clear of hair, ear rings and glasses in order to provide protection. Ear muffs and ear plugs (110 dBA) can be used together to provide maximum protection from noise. Hearing protection is typically selected by availability, intensity of noise, and personal comfort.
13. Describe the hazards associated with working with noise, heat, and radiation. OSHA regulation CFR 29 1910.95 requires all process technicians who are exposed to over 85 decibels (dB) over an eight-hour, time weighted average (TWA) period be placed in a hearing conservation program. A decibel is not a linear unit; it is more closely identified as points on a sharply rising curve. The standard requires that each process technician receive initial training and refresher training on the
 - effects of noise on hearing

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- purpose of hearing protection devices
- selection, use, fit, and care of hearing protection
- purpose of audiometric testing

Noise is loosely defined as valueless or unwanted sound. Ambient noise is defined as the composite of all-encompassing noise found in an -environment. The physiological effects of noise include: hearing loss, fatigue, speech problems, nausea, circulatory problems (prolonged exposure), heart attack (prolonged exposure), aural pain, tinnitus (ringing of ears), nerve damage, and structural damage to the ear drum. Hearing loss occurs slowly and painlessly. Once a process technician has experienced hearing loss due to industrial noise, it is unlikely they will ever recover. Approximately 10 million United States and Canadian workers suffer from noise-induced hearing loss. The psychological effects of noise include being easily startled or annoyed and the inability to concentrate, relax, sleep, or communicate. It can also interfere with job performance and safety.

Heat & Radiation. Summer heat and relative humidity in the Gulf Coast area stays in the 90°-plus range. Heat exhaustion is a primary concern for chemical and refinery workers in these areas. Industrial equipment is typically hot and noisy. Temperature extremes seriously affect how much work a person can do. The human body produces heat that must be removed in order to -maintain a temperature range between 96°F and 99°F. Sweating is the primary way the body removes heat. Body sweat is composed of salt and water and accounts for around 1 liter per day under resting conditions. Heavy work schedules can push this to over 4 liters within a four-hour work period. Both the water and salt must be replaced in order to ensure good health.

Radiant heat from the sun produces electromagnetic waves that are absorbed into objects and human tissue. Radiant heat transfer is line of sight and can be prevented only by staying indoors or wearing heat-reflective clothing. The effects of high temperatures include: heat exhaustion; dizziness; weak pulse; cool, moist skin; and painful heat cramps. High temperatures can result in heatstroke, a dangerous condition in which the body is no longer able to cool

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

itself. When this happens, the internal body temperature rises sharply and constitutes a real medical emergency.

14. Describe the hazards connected with confined space entry. Occasionally process technicians are required to work in confined spaces. This may include excavations, opened vessels and equipment, tank cars, distillation columns, reactors, or large tanks. Confined space ergonomic stresses include repetitive movement, exposure to potentially hazardous environments, and fear of enclosed or tight spaces. A variety of visible symptoms include anxiety, muscle pain, sweating, nausea, dizziness, loss of consciousness, vertigo, inability to communicate, and inability to communicate effectively.
15. Identify the biological hazards found in the chemical processing industry. Biological hazards include any living organism capable of causing disease in humans. The purpose of biological safety is to minimize exposure to biological hazards through anticipation, control, evaluation, and recognition. Biological hazards are found in microorganisms, insects, allergens and toxins, and protein allergens from vertebrate animals. This type of exposure is rare in the chemical industry, however, with the advent of blood-borne pathogens such as hepatitis B (HBV) and human immunodeficiency virus (HIV) exposure. Other process-related illnesses include -Legionnaires' disease. This biological hazard is a form of pneumonia caused by inhaling Legionellae bacteria. This strain of bacteria has been found in cooling towers and heat exchangers. Another form of biological hazard comes from the spores found in pigeon droppings and another, meningitis, is carried by mosquitoes.
16. Explain the primary concerns associated with blood-borne pathogens. The blood-borne pathogens standard became effective in March of 1992. The standard is designed to protect employees who come into contact with blood or infectious materials that are suspected of containing HIV and HBV. The Occupational Safety and Health Administration implemented the -standard to

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

eliminate or reduce exposure through engineering controls, administrative guidelines, PPE, medical vaccinations and surveillance, -employee training, and signs and labels.

HIV causes acquired immunodeficiency syndrome (AIDS). The virus can survive only in the blood or body fluids environment. Transmission of HIV is through physical contact with this medium. Process technicians can come into contact with this infected medium through sexual contact, puncture wounds, blood, or body fluid splash onto open injuries or the lips, mouth, nose, or eyes. The hepatitis B virus causes inflammation of the liver and is a major contributor of acute and chronic hepatitis. Over 300,000 people are infected with HBV. Transmission of HBV and its flu-like symptoms is the same as for HIV.

Process technicians should use recommended personal protective equipment (PPE) when they are in situations in which exposure could occur. Examples of PPE used in this case are safety glasses, chemically resistant gloves, pocket masks, and lab coats. Decontamination of soiled PPE is typically through careful and cautious disposal.

17. List the key elements of the “Hearing Conservation Standard.”
 - Maximum noise exposure
 - Actions that employers must take if the limits are exceeded
 - reduce noise by using engineering and administrative controls
 - provide hearing protection for employees
 - implement a hearing conservation program (HCP)
 - monitor sound levels
 - conduct audiometric tests
 - provide hearing protection
 - provide training
18. Describe the term, “audiometric testing.” Audiometric testing is performed on each employee annually. When a process technician is first hired, a baseline audiometric test is run. Hearing in each ear is tested and recorded. Annual hearing tests are then

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

performed and compared to the baseline results for the rest of the technician's career. Audiometry is a term described as the science of testing, measuring, and recording hearing ability.

19. Define the term, "anacusis." Anacusis is described as total hearing loss.
20. Compare and contrast the terms, "heat exhaustion and heat stroke." Heat exhaustion is best described as dizziness, weak pulse, cool, moist skin, and painful heat cramps. Heatstroke is a dangerous condition in which the body is no longer able to cool itself. When this happens the internal body temperature rises sharply and constitutes a real medical emergency.

CHAPTER 9

SAFETY PERMIT SYSTEMS

LEARNING OBJECTIVES

- Describe the different types of permit systems found in the chemical processing industry. Describe hot work permits (CFR 29 1910.119).
- Describe energy isolation and lockout/tagout (CFR 29 1910.147).
- Analyze the confined space entry procedure (CFR 29 1910.146).
- Review opening and blinding permits.
- Utilize a permit to enter.
- Describe an energy isolation permit.
- Recognize an unplugging permit.
- Describe cold work permits.

CHAPTER 9: REVIEW QUESTIONS

1. Describe the key points associated with preparing a hot work permit. Typical roles and responsibilities: Example only!

The process technician

- inspects area and ensures housekeeping
- blinds, isolates, and clears equipment, vessels, tanks, and piping
- immobilizes power-driven equipment (lockout/tagout procedure)
- determine PPE required
- fills out permit, posts at job site, and signs

The first line supervisor

- delegates responsibilities to process technician and ensures all established procedures are completed
- The person performing the work
- inspects job site
- gathers information from process representative and mechanical supervisor about potential hazards, special procedures, or conditions

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- selects and dons appropriate safety equipment
- performs work (other permits may be required)

The mechanical supervisor

- inspects area and ensures it is ready for safety inspector
- ensures equipment, vessels, and piping are cleared
- ensures safety equipment is located near job site
- reviews procedure with person performing the work
- confirms PPE required
- signs permit

The safety permit inspector

- inspects area and ensures it is safe
- performs gas test, determines oxygen level
- ensures equipment, vessels and piping are cleared
- confirms PPE required
- signs permit and sets time limit

The standby

- ensures the person performing the work is safe
- has received special standby training
- wears personal protective equipment required to perform the job
- warns the person performing the work if a hazardous condition develops (Klaxon horn, sign language, radio)
- Note: The standby does not go into the confined space until help arrives.

2. List the steps a technician takes when preparing a motor for energy isolation or lockout/tagout. The purpose of the hazardous energy standard is to protect employees from the hazards associated with the accidental release of uncontrolled energy. The lockout/tagout procedure is a standard designed to isolate a piece of equipment from its energy source. OSHA has established a six-step procedure for locking out a piece of equipment. The first step is the preparation for shutdown phase. During this phase the type of energy being isolated must be identified and the specific hazards controlled. Phase two

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

involves shutting down the equipment. Phase three is the isolation step, which involves closing valves, shutting down main disconnects and circuit breakers, and disconnecting pneumatic, electric, hydraulic and compressed gas and liquid lines. Phase four is the application of lockout/tagout devices (see Figure 9-4) to breakers and disconnect switches, valves, and energy isolating devices. Phase five is directed at the control of stored energy. Pressure must be relieved, grounding cables connected, elevated equipment supported, and moving parts stopped. Phase six is the verification step. The term lock-tag-try is applied when the electrically disconnected equipment is checked by attempting to start the equipment at the local start-stop switch. If the procedure has been performed correctly, the equipment will not start.

3. Explain the hazards associated with confined space entry. A confined space may contain a hazardous atmosphere, chemical, or asphyxiate.
4. Describe the procedure associated with preparing a system for completing the opening and blinding permit. The purpose of the opening blinding permit is to limit accidents through improved communications and structured guidelines for removing blinds, installing blinds, or opening vessels, lines, and equipment. To initiate an opening and blinding permit the process technician performs a safety inspection, secures the area for work, isolates the equipment, and fills out the opening and blinding permit. After the permit is filled the technician speaks with the craftperson about the work to be performed, reviews the hazards, and hangs a hard copy of the permit near the unit with the craft-person's signature. The soft copy of the permit is displayed in the control room.
5. Describe the steps associated with an unplugging permit. Barricades area, clears lines for unplugging, informs personnel, issues opening blinding permit, and issues unplugging permit

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

6. Define the term, “cold work permits.” Cold work is also referred to as “routine maintenance.” The process technician’s responsibilities include:

- Perform safety inspection prior to issuing permit.
- Fill out routine maintenance permit.
- Speak with craftsperson about the work to be performed.
- Review hazards.
- Hang hard copy of permit near unit with craftsperson’s signature.
- Post soft copy of permit in control room.
- Extend permit if necessary.

The mechanical craftsperson’s responsibilities include:

- Initiate the cold work permit.
- Perform safety inspection.
- Sign cold work permit.
- Perform authorized work.
- Secure permit extension.
- Perform housekeeping after job.
- Complete work, sign card, and return it to process representative.
- Secure process approval and update of permit board.

7. Define the term, “CFR.” Code of Federal Regulations.

1. A permit to enter is designed to protect a technician from what hazards?
Designed to protect employees from oxygen-deficient atmospheres, hazardous conditions, power-driven equipment, and toxic and flammable materials.
2. Explain the purpose of the hot work permit. The purpose of a hot work permit is to protect personnel and equipment from explosions and fires that might occur from hot work performed in an operational area. Hot work is defined as any maintenance procedure that produces a spark or excessive heat, or requires welding or burning.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

3. List examples of work that is covered by opening or blinding permits.
Examples of work covered under opening and blinding permits includes the installation and removal of blinds, removal of hatch covers, and opening equipment.
4. Explain the relationship and responsibilities of a process technician and the mechanical technician performing the work. Process Technicians and Maintenance technicians work closely with each other to see that the work is safely completed. See Question 4 for individual responsibilities.
5. List examples that would require a hot work permit. Examples of hot work include portable grinders, open fires, welding equipment, energized electrical circuits, internal combustion engines, electric motors, hot plates, Coriolis meters, turbine meters, concrete busters, soldering irons, dry sandblasting, and so on.
6. List examples that would require a confined space permit. This includes: excavations, sewers, pits, reactors, boilers, furnaces, distillation columns, strippers, absorbers, vessels, tanks, silos, blenders, drums, piping, pumps, compressors, heat exchangers, extruders, or any space that restricts entry or allows the head of the worker to go below the top of the confined space. Entry occurs when the technician's body breaks the plane of the opening. A confined space is defined as a space large enough so a person can enter, has restricted entry, and is not designed for continuous occupancy.
7. List examples that would require the use of a lockout/tagout procedure.
Pump motor, compressor motor, fan motor, etc.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

8. Safe oxygen concentrations must be between what two ranges. Oxygen concentrations must be between 19.5% and 23.5%. Flammable gas concentrations must be less than 10% of their lower flammable limit. Airborne contaminants must fall into correct guidelines or work cannot be performed.
9. List the symptoms associated with oxygen deficiency. For example, oxygen deficiency can cause breathing difficulty, loss of muscle control, ringing in the ears, feelings of well being, mental confusion, and death.
10. Define the term, "inerting." Inerting is a process designed to remove excess oxygen. Typically, nitrogen is used for this procedure.
11. List the people associated with the hot work procedure. The process technician, first-line supervisor, the person performing the work, mechanical supervisor, safety inspector, and the standby.
12. Identify which permits could be associated with the term, "vapor pressure." Confined Space Entry, Cold work, and Opening Blinding.
13. Describe the concerns and responsibilities of a process technician when preparing a permit. Inspects area and ensures housekeeping, blinds, isolates, and clears equipment, vessels, tanks, and piping, immobilizes power-driven equipment (lockout/tagout procedure), determine PPE required, fills out permit, posts at job site, and signs.

CHAPTER 10

PERSONAL PROTECTIVE EQUIPMENT (PPE)

LEARNING OBJECTIVES

- Identify personal protective equipment found in a plant.
- Describe when and how to use personal protective equipment.
- Identify typical workplace hazards.
- Discuss the methods of hazard exposure prevention.
- Contrast emergency response and PPE.
- Describe the four levels of personal protective equipment.
- Describe the principles of hearing protection.
- Identify PPE outerwear worn by technicians.
- Explain the general limitations of PPE equipment.
- Contrast engineering/environmental controls and PPE.
- Explain the purpose of respiratory protection.
- Describe air-purifying respirators.
- Describe air-supplying respirators.
- Describe air purifying, half-face respirators.
- Describe air purifying, full-face respirators.
- Describe an air supplying self-contained breathing apparatus (SCBA)
- Describe an air supplying hose line respirator
- Explain the steps required to take care of and use a respirator.
- Analyze and contrast the limitations of each type of respirator.
- Review the procedures for donning and doffing air purifying respirators.

CHAPTER 10: REVIEW QUESTIONS

1. Identify personal protective equipment found in a plant. Examples could include: hard hats, safety glasses, flame retardant clothing, safety shoes, hearing protection, radio, faceshield, etc
2. Describe when and how to use personal protective equipment. Personal protective equipment provides an effective means for protecting technicians from hazardous situations. Engineering and environmental controls provide another layer of protection. PPE is designed by nature to be used in environments that place technicians in contact with a hazardous situation. The primary purpose of PPE is to prevent exposure to hazards when engineering or environmental controls can not be used.
3. Identify typical workplace hazards. Hazards in the chemical processing industry can be classified as unplanned situations that can injure or kill a process technician. Examples of hazards include burning, exploding, cutting, electrocution, impaling, tripping, falling, slipping, crushing or loud noises or exposure to a chemical.
4. Discuss the methods of hazard exposure prevention. Some of the methods used by industrial manufacturers to prevent exposure include; engineering or environmental controls, personal protective equipment, safe work practices, good housekeeping and training.
5. Contrast emergency response and PPE. Emergency response has four levels of personal protective equipment Level(s) A, B, C, D.
Describe the four levels of personal protective equipment. Level A requires the highest level of PPE protection by requiring a technician to don a Totally Encapsulating Chemical Protective suit. Level B deals with chemical exposures that are not considered to be extremely toxic unless they are absorbed through the skin. In this case a non-air tight chemical protective suit may be worn. Level C is used when the hazard is determined to not adversely affect exposed skin.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

6. Level D provides the minimal amount of protection to a process technician. Level D protection is determined by individual companies since the standard personal protective equipment is the work uniform
7. Describe the principles of hearing protection. Hearing protection protects technicians from noise that can permanently damage the inner ear. Ear plugs and ear muffs are commonly used to keep exposures below 82 decibels for 12 hours or 85 for 8 hours. Ear plugs and muffs are only as effective as the technicians knowledge about correctly using them. If they are installed incorrectly they will not provide enough protection.
8. Identify PPE outerwear worn by technicians. Examples could include: hard hats, safety glasses, flame retardant clothing, safety shoes, hearing protection, radio, faceshield, etc.
9. Explain the general limitations of PPE equipment. Engineering controls, safety procedures and PPE provide an effective blanket of protection from hazards in the workplace. Some general limitations should be mentioned; burning, exploding, cutting, electrocution, impaling, tripping, falling, slipping, crushing, loud noises or exposure to a chemical can get through the most effective safety shield. Technicians should always be aware of this stand-off.
10. Contrast engineering/environmental controls and PPE. Engineering controls include reduction of noise through the use of noise or sound absorbing material, new technology automate the processes, etc. Safe work practices include written procedures and effective employee training. Engineering controls and safe work practices are the preferred method of hazard prevention by OSHA. When these two methods can not be used, personal protective equipment should be used to prevent exposure.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

11. Air purifying respirators come in two basic types. Please list both. Air purifying & Air supplying
12. Air supplying respirators come in several different types. Please list both. Half-mask and Full mask
13. Describe the limitations of air-purifying respirators. Will only remove specific contaminants or organic vapors from the air. These concentrations may range from 5 to 50 times the normal exposure limit allowed by law. Will not work in oxygen deficient environment. Must have cartridges replaced.
14. Describe the advantages of using an air-supplying respirator. Air supplying respirators are used in environments that are suspected of having toxic concentrations of chemicals or are oxygen deficient. The full mask provides maximum protection for eyes, nose, throat, and lungs. The self contained breathing apparatus "SCBA" is relatively light weight and portable. Hose line operations provide a continuous supply of air to the technician.
15. Please define IDLH. Immediately dangerous to life and health.
16. Please define the term "filter life." The filter life of a respirator is determined by two factors; service time and contaminate concentration.
17. Define "overpowering." The term overpowering is used to describe atmospheric conditions that exceed the design limitations of a respirator.
18. Air purifying respirators will work only in atmospheres that exceed: 19.5% Oxygen or greater
19. Contrast the terms selectivity and respirators. Selectivity is a term that applies to the specific compound or contaminate that a respirator is designed to remove.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

Air purifying respirators are selective because of the filtering media they use. Air supplying are not selective since they provide a constant supply of fresh air.

20. Contrast the terms "don" and "doff" on a respirator. Put on a respirator(don), take off a respirator(doff).
21. Describe fit testing. Provides respirator training for the new technician, matches respirators to technician face structure, identifies specific chemical hazards in assigned area and provides information on how to locate and dispose of filters, cartridges, and respirators.
22. Contrast negative and positive fit testing. Positive and negative fit testing takes place shortly after the technician has donned the face mask. By placing your hand over the disconnected breathing tube and breathing in (negative fit) or by blowing into the face piece, (positive fit). Air leaks can be detected coming into the mask or blowing out of the mask.

CHAPTER 11

ENGINEERING CONTROLS

LEARNING OBJECTIVES

- Describe the key elements of risk evaluation.
- Describe the different types of alarms and indicators used in the CPI.
- Explain how floating roof tanks work.
- Discuss how closed-loop sampling systems work.
- Describe the term, “noise abatement.”
- Describe interlocks and automatic shutdown devices.
- Explain the principles of process containment.
- Describe the principles of effluent and waste control.
- Illustrate and explain how a flare system works.
- Describe deluge and explosion suppression systems.
- Identify basic pressure relief devices.

CHAPTER 11: REVIEW QUESTIONS

1. Describe how interlocks are used in automatic shutdown. An interlock is a device that will prevent an operational action unless a specific condition has been satisfied. An interlock will prevent damage to equipment and personnel. This is accomplished by stopping or preventing the start of certain equipment functions unless a preset condition has been met.
2. Identify the equipment used in noise abatement. There are a number of devices in the process industry that produce noise. Noise abatement is an engineering procedure designed to reduce or limit this noise through the use of modern technology. Examples of this technology include mufflers or silencers, noise reducing insulation, equipment designed to produce less noise, and heavily insulated doors.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

3. Identify the standard pressure relief devices. Pressure relief devices come in three different forms: safety valves for gases, relief valves for liquids, and rupture discs for both.
4. Describe the three elements in controlling process containment.
 - Reduction in hazardous materials storage inventory
 - Storage of liquefied gases and the conditions under which these should be stored
 - Plan for a design that provides total containment
5. Describe the term “process redundancy” and how it is used to protect equipment and personnel. Operating a large chemical complex requires the use of redundant systems that provide emergency shutdown and warning protection. Redundancy is a process that uses two or more devices to shut down a system. Redundant alarm and shutdown devices are required in certain hazardous situations where it has been determined that a specific condition poses a threat to the safety of the operation. This may include multiple (2) electric signals sent to a computer system that is programmed to activate an alarm or shutdown. It may include two separate switches or detection devices connected to multiple alarms. It may include the use of pressure relief devices and shutdown equipment. The purpose of automatic shutdown devices is to protect personnel and equipment. These devices typically respond to the primary variables controlled by a process technician and measurements that are considered high or low.
6. Describe the basic components of risk evaluation. Some of the primary steps in the design and operation of a new chemical facility is a process called “risk evaluation.” There are many risk factors to consider in a chemical process, some that are not readily apparent, that could possibly lead to a major disaster. The risk evaluation system includes six parts:
 - Hazardous Materials Evaluation
 - Chemical Process Evaluation

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Physical Operations Evaluation
 - Equipment Design Evaluation
 - Plant Location and Layout Evaluation
 - Operator Practices and Training Evaluation
7. Explain how alarms and indicators are used in the chemical industry. One of the most effective tools used by a process technician in the operation of a large chemical facility are alarms and indicators. Control rooms are the central hub for the location of most alarms and indicators, however, smaller operations can have these devices located near the equipment. Critical alarms are attached to panels that will flash and emit an audible alarm. This will always generate an immediate response by operating personnel. The primary variables controlled by a process technician include: pressure, temperature, flow, level, and analytical variables. In addition to the panel alarms, advanced computer systems are used to monitor the process. These control systems provide a picture of the process that is not clearly visible from the field.
8. Identify the basic equipment used in a flare system and explain how the system works. One of the most important systems in a chemical processing system is a flare system that is designed to: burn waste gases and control pressure generated by process upsets. A flare system is connected to every system in the plant. This elaborate system is composed of numberless safety and relief valves, rupture discs, small and large piping, and one central header that leads to the flare. In some flare systems a knockout drum is provided with a water seal to separate liquids and vapors. The flare is a hollow pipe that allows the vapors to rise and burn cleanly at the flare tip. Figure 11-8 illustrates the basic components of a flare system. A fan may be installed at the base of the flare to increase airflow through the flare. Steam is used to disperse the hydrocarbons as they burn. More steam is used during periods of high discharge. A small pilot light burns continually at the tip of the flare and is used primarily to ignite the vapors.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

9. Explain the reason for using a floating roof design. A floating roof tank is designed to literally float on the surface of the liquid. The seal between the floating roof and liquid prevents vapors from leaving and entering the atmosphere. The primary purpose of a floating roof is to reduce vapor losses. Some tanks are designed with a nitrogen purge that fills the void between the seal and the liquid. These type of systems are employed when hazardous materials are involved and hazardous vapors are formed. Internal floating roofs are used in areas of heavy snowfall since the weight of the snow would affect the seal on an external floating roof.

10. Describe the stages of effluent control and wastewater treatment. Wastewater treatment is an important function in the plant. New technicians are typically assigned to this area in order to train on a variety of complex systems. Surface water is brought into the chemical or refinery complex in large quantities and stored in large settling basins. Suspended solids are allowed to drop out and the water is sent into the plant for further treatment. Raw water is sent to filtering systems and then to a variety of areas including cooling towers, boilers, firewater, industrial, and so on. Additional water treatment is taken care of at or near the units that will be using the water. After this water has been used in industrial processes it needs to be cleaned up for discharge. This may include removing heat and impurities from the process. Figure 11-6 shows an example of a clarifier, a device used to clean up water. Aeration basins are used with microorganisms to eat the hydrocarbons contained in wastewater. Retention time, a good supply of bugs, aerators to agitate the water, and a little phosphoric acid keeps the system operating effectively. Sewer systems in the plant are connected to the wastewater treatment center. This area is often called the environmental control unit. Contaminated water is sent to the aeration basin for treatment. Excess water is held up in retention ponds or lagoons. Plant design should include proper control of all water run-off systems. Figure 11-7 shows how a settling basin works as raw water enters the plant.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

11. Describe the term, “engineering controls.” Engineering controls is a term used to describe how risk evaluation, safety design and plant operation, modern alarms and indicators, fire alarms and detection systems, toxic gas alarms and detection systems, redundant alarm and shutdown devices, interlocks and automatic shutdown devices, process containment and upset controls, closed systems/closed-loop sampling, floating roof tanks and ventilation systems, effluent control and waste treatment, noise abatement, pressure relief and flares, deluge systems and explosion suppression systems and many other engineering controls.
12. List the key elements of plant location and layout evaluation. The key elements of this evaluation include: drainage and runoff control, climatic conditions, effects of uncontrolled releases, community capability and emergency response, plant accessibility, available utilities, gate security, hazardous unit placement, and spacing of equipment. Additional elements to this evaluation include: NEC regulated electrical installations, clearly marked exits, building ventilation, fire walls, fire spread considerations, foundation and subsoil loadings, and administrative building location.
13. List the essential parts of “operator practices and training evaluation.” The essential parts of this section include: operational procedures, training for operating technicians and supervisors, startup and shutdown procedures, permit system, housekeeping and inspection, chemical hazard recognition, emergency response, use of PPE, and auditing.
14. List the integral parts of “equipment design evaluation.” The equipment design evaluation is an integral part of hazard prevention. Equipment systems are designed so that the failure of one or more devices will not result in a disaster. Process equipment must comply with safety codes, government regulation, standards, and current industry practices. New construction and installation must be completed using the strictest guidelines. Emergency shutdowns and

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

safeguards should be installed to provide adequate protection. Equipment and system modifications should not violate original design requirements. New unit construction should have equipment to safely handle any temperatures or pressures generated by the process. A failsafe analysis of electrical and control loop systems ensures that all systems will fail in the safe mode. An inspection and maintenance program is required to be in place prior to starting up the system.

15. List examples of the “physical operations evaluation.” Examples of this include: distillation, absorption, agitating, centrifuging, crushing and grinding, crystallization, evaporation, extraction, filtering, granulation, leaching, spraying, mixing, and milling. These processes have the ability to introduce hazards that are not present before the material changes state. Areas of specific concern include:
- dusting—dispersion of toxic and combustible solids
 - heat transfer—heating up of unstable chemicals
 - pressure—generated by mixing of unstable chemicals
 - vaporization—diffusion of toxic and flammable liquids and gases
 - spraying—atomizing flammable, toxic, or combustible liquids
 - mixing—oxidizing agents with combustible materials
 - separation—of protective dilutants and inertants from hazardous materials
 - generation—static charge
16. Provide a detailed analysis of the “hazardous materials evaluation.” Hazardous materials evaluation includes a detailed analysis of all the properties of the materials handled, stored, and processed in the plant. This process looks at: (1) quantities, (2) physical properties, (3) toxicity, (4) stability hazards, (5) corrosiveness, and (6) impurities. Examples of this process include:
- quantities evaluation—production, storage, handling, determine if loss of containment could result in a fire, explosion, toxicity, corrosion, environmental

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- physical properties evaluation—flashpoint, boiling point, melting point, explosive limits, vapor pressure
 - toxicity evaluation—threshold limit values
 - stability hazards evaluation—reactivity, self-polymerization, spontaneous combustion of amounts found in the plant
 - corrosiveness evaluation—assign level of PPE
 - impurities evaluation—considers the effects on materials. Determine if it could enhance fire, explosion, stability, toxicity, or corrosion of plant materials
17. Explain the primary purpose of toxic gas alarms and detection systems. The purpose of toxic gas detection and alarm systems is to detect the presence of a toxic or hazardous gas in sufficient concentrations PPM to be potentially dangerous to personnel. These alarms may be located on the outside perimeter of a plant or in areas where certain hazardous chemicals exist. These devices are frequently checked and periodically replaced. Toxic gas alarm systems may include an audible signal, a water sprinkler system, or a deluge system to suppress the toxic release. Examples of hazardous gases include: H₂S, hydrogen fluoride, phosgene, chlorine, and so on.
18. Describe the importance of fire alarms and detection systems. Early warning fire detection systems provide the first critical minutes needed to respond to a fire. Most fires start out small and can be controlled and extinguished easily.
19. List the three types of automatic fire alarm systems. Automatic fire alarm systems come in three types: fixed-temperature type, rate-of-rise type, and nuclear detector device. A fixed-temperature type alarm is activated when the temperature reaches a predetermined value. This type of alarm may sound when the temperature reaches: 150 °F, 175 °F, or 200 °F. Rate-of-rise fire alarms activate when there is a rapid temperature increase in the area. Nuclear detector alarms are sensitive to the by-products of combustion and do not require heat to activate. These automatic systems eliminate the risk that a fire will go

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

undetected. This type of system should emit a reliable signal, reach all personnel, and be easily recognized.

20. Describe closed-loop sampling. Closed systems/closed-loop sampling is a procedure where a bypass loop is installed that allows a small part of the stream to be diverted from the main flow. In this type of a system an inline analyzer, container, or small sample port is installed. Figure 11-4 shows an illustration of a closed-loop sampling system. Closed-loop sampling offers a number of advantages that include waste reduction and environmental release control.

CHAPTER 12

ADMINISTRATIVE CONTROLS

LEARNING OBJECTIVES

- Describe the key elements of administrative control.
- Explain the steps used in performing a job safety analysis.
- Describe Responsible Care® and Community Awareness and Emergency Response.
- Identify the essential parts of the Hazards and Operability Study (HAZOP)
- Compare and contrast a comprehensive process hazards analysis PHA system and HAZOP.
- Describe government-mandated training for process technicians.
- List the three things required to become a qualified first aid provider.
- Describe the importance of good housekeeping.

CHAPTER 12: REVIEW QUESTIONS

1. Explain the steps in becoming a qualified first aid provider. A qualified first aid provider is described as an employee qualified by a certified medical group to administer first aid. Plant management is responsible for coordinating certified training programs, documenting recordable injuries, and supplying medical supplies. In order to qualify as a First Aid Provider a technician must:
 - complete the Red Cross Standard first aid, multimedia, eight-hour course.
 - complete the Cardiopulmonary Resuscitation (CPR) eight hour course.
 - attend their company's First Aid Administrator lecture/seminar.Recertification is needed in CPR and Red Cross in one year and three year intervals.
2. Describe how safety is impacted by good housekeeping. New process technicians are taught early in their work career about the importance of housekeeping.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

Housekeeping prevents accidents and increases productivity. Process technicians can prevent accidents by removing items that clutter-up the work-site. Trash, debris, tools, and other items should be moved to the correct place. Water-hoses are used to wash down the concrete mat and prevent dirt and debris from accumulating. A janitorial staff works with operating personnel to complete some required housekeeping tasks. Excess oils and greases that accumulate on equipment and floors should be cleaned-up quickly. Chemical spills should be cleaned up and reported according to procedure. Good housekeeping improves the image of the company and the morale of plant employees.

3. List the various types of monitoring equipment. Industrial monitoring comes in two monitoring systems: industrial hygiene and fugitive emissions.
4. Compare and contrast Responsible Care® with Community Awareness and Emergency Response. The Chemical Manufacturing Association organized Responsible Care® in 1988 in order to address the public's concern about the use and distribution of chemicals. This program is frequently referred to as Community Awareness and Emergency Response (CAER). The guiding principles of Responsible Care® include:
 - Respond to community concerns about chemicals and operations
 - Produce chemicals that can be disposed of safely
 - Report health, chemical, and environmental hazards and required PPE
 - Infuse safety, health, and environmental considerations into new products and processes
 - Operate an environmentally safe plant
 - Conduct safety, health, and environmental research on products
 - Work with customers on the transportation, storage, and disposal of chemicals
 - Resolve handling and disposal problems
 - Create responsible laws, regulations, safeguards, and standards
 - Promote the principles of Responsible Care®.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

Community Awareness and Emergency Response (CAER) programs—designed to respond to the communities concerns about the manufacture and use of chemicals.

The Chemical Manufacturing Association organized Responsible Care® in 1988 in order to address the publics concern about the use and distribution of chemicals. There are a number of techniques used to develop safe work practices and procedures for jobs that have been identified as hazardous.

5. Describe how a job safety analysis is conducted. A job safety analysis or JSA is the most common approach used by operations personnel. The primary steps used in this procedure includes: (1) Observe the people doing the job, (2) Document the steps in the procedure, (3) Validate the procedure with subject matter experts.
6. List the two major monitoring systems used in industrial monitoring. Industrial monitoring comes in two systems: industrial hygiene and fugitive emissions. Industrial hygienists collect samples from the work environment to determine hazardous conditions. Examples of these activities include: ergonomic studies, noise monitoring and toxic substance sampling. Fugitive emissions monitoring compares samples taken in the field to company, EPA and government regulations. Testing equipment used for process monitoring includes: gas detection equipment, LEL, O₂ meters, and personal monitoring devices (Dosimeters).
7. Identify the primary objective of a safety inspection. The primary objective of an audit and safety inspection is to identify unsafe work conditions and to comply with plant and government regulations. Inspections are frequently conducted by local personnel who are familiar with the operation and maintenance of the facility. Audits are typically conducted by outside groups from corporate or regulatory agencies. Engineering and management should establish a system for inspecting operating units and facilities. Inspectors are specifically looking at emergency equipment and critical systems that pose a serious hazard should

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

they fail. Local inspections should include: a record keeping system, inspection training, removal system for defective equipment, and a follow-up system.

8. List the most essential, mandated training topics covered in mandated training. Government mandated training for process technicians covers a variety of topics and includes formal classroom and hands-on training that takes place upon initial assignment to a process unit and training that takes place annually, every two years or every third year. The following list includes most of the essential, mandated training topics and reference numbers. This is not the entire list, however, it does include most of the common topics taught between industrial facilities.
- Hazard Communication HAZCOM—29 CFR 1910.1200 —required upon initial assignment
 - Hazardous Waste Operations and Emergency Response—HAZWOPER, 29 CFR 1910.120, Awareness, Operations, required upon initial assignment and annually each year after.
 - Bunker Gear 29 CFR 1910.120, required upon initial assignment and annually each year after.
 - Respiratory Protection—29 CFR 1910.134, required upon initial assignment and annually each year after.
 - Personal Protective Equipment—29 CFR 1910.133 and 135, required upon initial assignment.
 - The Control of Hazardous Energy (Lockout/Tagout)—CFR 1910.147, required upon initial assignment and every two years after.
 - Process Safety Management (Hot Work)—CFR 29 1910.119, required upon initial assignment.
 - Permit Required Confined Spaces—29 CFR 1910.146 , required upon initial assignment.
 - Fire Extinguisher—29 CFR 1910.157 , required upon initial assignment and annually each year after.
 - Department of Transportation DOT 49 CFR 171-177

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Occupational Noise Exposure—29 CFR 1910.95 , required upon initial assignment and audiometric testing each year after.
 - Scaffold User Safety Inspections—29 CFR 1926.450—.454 , required upon initial assignment.
 - Benzene—CFR 1910.1028 , required upon initial assignment.
 - Electrical Training for Unqualified Persons—CFR 1910.332 , required upon initial assignment and every 2 years thereafter.
 - Asbestos Awareness and Gasket Removal—1910.1200/1001 and 1926.59/1101, required upon initial assignment and annually each year after.
 - Specifications for Accident Prevention Signs and Tags—29 CFR 1910.145, required upon initial assignment.
 - Bloodborne Pathogens—CFR 1910.1030 , required upon initial assignment.
 - Powered Industrial Trucks—1910.178 , required upon initial assignment.
9. Compare and contrast industrial audits and inspections. The primary objective of a safety inspection is to identify unsafe work conditions and to comply with plant and government regulations. Audits and safety inspections are proactive in nature and design. Engineering and management should establish a system for inspecting operating units and facilities. Inspectors are specifically looking at emergency equipment and critical systems that pose a serious hazard should they fail. The frequency of the inspections should be determined by past experiences with the systems. Local inspections should include: a record keeping system, inspection training, removal system for defective equipment, and a follow-up system. Process technicians assigned to the inspection team should perform inspections on schedule, record results, ensure the problems cited are corrected, and document any defects. Inspections are frequently conducted by local personnel who are familiar with the operation and maintenance of the facility. Audits are typically conducted by outside groups from corporate or regulatory agencies. Both systems use inspection and audit checklists during the process.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

10. Describe the term “administrative controls.” Administrative controls can be described as the programs and activities used to control industrial hazards. This includes the policies, procedures, plans, principles, rules, agreements, and systems used in administrative control. Mutual Aid Agreements are an example of a written agreement between industry and outside emergency response organizations in the event of a catastrophic release or situation. Examples of written programs include:
 - Hazard Communication Program (HAZCOM) 29 CFR 1910.1200
 - Community Awareness and Emergency Response (CAER)
 - Hazards and Operability Study (HAZOP)
 - Operator Training
 - Audits and Inspections
11. Identify the essential parts of the Hazards and Operability Study (HAZOP). The Hazards and Operability Study (HAZOP) is a comprehensive process hazards analysis (PHA) system designed to identify hazards to technicians, equipment, operations, and environment. There are several benefits to using this type of study, including product optimization, productivity, profitability, and the identification of operational hazards. These benefits indirectly influence company morale, project improvements, and schedules.
12. Define the term, First Aid. First aid is the immediate, temporary care given to an accident victim.
13. Describe mutual aid agreements. Mutual Aid Agreements provides a formal accord between industry and outside emergency response organizations in the event of a catastrophic release or situation.
14. List 13 written programs influenced by the government and regulatory guidelines, company-specific guidelines, and unit specific requirements. Written programs are influenced by government and regulatory guidelines, company-specific

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

guidelines, and unit-specific requirements. Examples of written programs include:

- Hazard Communication Program (HAZCOM) CFR 29 1910.1200
- Community Awareness and Emergency Response (CAER)
- Process Hazards Analysis (PHA)
- Hazards and Operability Study (HAZOP)
- Incident command systems (ICS)
- Plant permit systems
- Operator training
- Housekeeping
- Audits and inspections
- Mutual Aid Agreements
- Accident investigations
- Industrial hygiene monitoring
- Fugitive emissions monitoring

Hazard control utilizes evaluation, recognition, and removal of workplace hazards. The basic techniques used to remove industrial hazards can include the application of engineering controls, administrative controls, or the use of personal protective equipment (PPE).

15. Describe the terms, training and mandated training. Government-mandated training for process technicians covers a variety of topics and includes: formal classroom and hands-on training that takes place upon initial assignment to a process unit, and training that takes place annually, every two years, or every third year.
16. List each of the mandated training requirements. The following list includes most of the essential, mandated training topics and reference numbers. This is not the entire list; however, it does include most of the common topics taught at industrial facilities.
 - Asbestos awareness and gasket removal—required upon initial assignment and annually each year after (CFR 1910.1200/ 1001 and CFR 1926/1101)
 - Benzene—required upon initial assignment (CFR 1910.1028).

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Blood-borne pathogens—required upon initial assignment (CFR 1910.1030)
- Bunker gear—required upon initial assignment and annually each year after (CFR 29 1910.120)
- Control of hazardous energy (lockout/tagout)—required upon initial assignment and every two years after (CFR 1910.147)
- Department of Transportation (DOT)—CFR 49 171-177
- Electrical training for unqualified persons—required upon initial assignment and every two years thereafter (CFR 1910.332)
- Fire extinguisher—required upon initial assignment and annually each year after (CFR 29 1910.157)
- Hazard Communication (HAZCOM)—required upon initial assignment (CFR 29 1910.1200)
- Hazardous Waste Operations and Emergency Response (HAZWOPER) Awareness, Operations—required upon initial assignment; annually required annually thereafter (CFR 29 1910.120)
- Occupational noise exposure—required upon initial assignment; audiometric testing required annually thereafter (CFR 29 1910.95)
- Permit required for confined spaces—required upon initial assignment (CFR 29 1910.146)
- Personal protective equipment (PPE)—required upon initial assignment (CFR 29 1910.133 and 135)
- Powered industrial trucks—required upon initial assignment (1910.178)
- Process safety management (hot work)—required upon initial assignment (CFR 29 1910.119)
- Respiratory protection—required upon initial assignment and annually each year after (CFR 29 1910.134)
- Scaffold user safety inspections—required upon initial assignment (CFR 29 1926.450–454)
- Specifications for accident prevention signs and tags—required upon initial assignment (CFR 29 1910.145)

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

17. Explain the purpose of Fugitive emission monitoring. Fugitive emissions monitoring compares samples taken in the field to company, EPA, and government regulations.
18. Describe the testing equipment used for process emissions monitoring. Testing equipment used for process monitoring includes: gas detection equipment, lower explosive limit (LEL) monitors, O₂ meters, and personal monitoring devices (dosimeters). This equipment is used to ensure a safe work environment, detect leaks, and measure a process technician's exposure to hazardous substances. LEL monitors are used to monitor and detect leaks. This device works by drawing in a sample and heating it up. LEL monitors measure process samples in three unique ways: metal oxide semiconductor (MOS), oxidized, and thermal conductivity. MOS detectors are designed to absorb combustible gases that generate a change in electrical conductivity that can be measured. Oxidized detectors measure the heat released by burning combustible gases. Thermal conductivity detectors vary from the other devices by measuring variations in thermal conductivity in combustible atmospheres.

O₂ detectors are classified as coulometric and polarographic detectors. Coulometric detectors take a sample of the atmosphere and pass it over a coulometric cell that reacts with any contaminants producing an electrical current. Polarographic oxygen detectors measure oxygen and carbon monoxide in the atmosphere.

A short list of these detectors includes:

- mercury vapor monitors—ultraviolet analyzers designed to measure mercury vapor concentrations
- direct-reading colorimetric tubes and badges
- flame ionization detectors
- photonionization detectors
- infrared analyzers
- ultraviolet analyzers
- gas chromatographs

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- ion mobility spectrometers
 - particulate monitors
19. Explain the purpose of LEL monitors and MOS detectors. LEL monitors are used to monitor and detect leaks. This device works by drawing in a sample and heating it up. LEL monitors measure process samples in three unique ways: metal oxide semiconductor (MOS), oxidized, and thermal conductivity. MOS detectors are designed to absorb combustible gases that generate a change in electrical conductivity that can be measured.
20. O₂ detectors are classified as coulometric and polarographic detectors. How do these devices work? O₂ detectors are classified as coulometric and polarographic detectors. Coulometric detectors take a sample of the atmosphere and pass it over a coulometric cell that reacts with any contaminants producing an electrical current. Polarographic oxygen detectors measure oxygen and carbon monoxide in the atmosphere.

CHAPTER 13

REGULATORY OVERVIEW: OSHA, PSM, EPA, NFDA, DOT

LEARNING OBJECTIVES

- Describe the process safety management (PSM) standard.
- Explain the written procedures requirement of the PSM standard.
- Identify the critical components of PSM action plans.
- Review the employee training issues contained in the PSM standard.
- Describe the process requirement of PSM.
- Review the three management Issues covered under the PSM standard.
- Describe the audit section of PSM.
- Explain the Occupational Safety and Health Act.

CHAPTER 13: REVIEW QUESTIONS

1. Explain the purpose of the Process Safety Management standard. The purpose of the PSM standard is to prevent the catastrophic release of toxic, hazardous or flammable materials that could lead to a fire, explosion or asphyxiation.
2. What is emergency response? Emergency response is a complex plan that identifies how plant personnel respond to emergencies. Additional information can be found in chapter nine, "HAZWOPER."
3. Define the term "hot-work." Hot-work is defined as welding, cutting, or using a spark producing device
4. In your opinion, what is the most important section of the PSM standard? See the standard in chapter 13 for comparison to the student's response.
5. Please describe the PSM standard and list in order of importance each section. The PSM standard is designed to prevent the catastrophic release of toxic,

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

hazardous or flammable materials that could lead to a fire, explosion or asphyxiation.

- | | |
|-------------------------------|-------------------------------|
| a. Process Safety Information | f. Hot Work Permit |
| b. Operation Procedures | g. Management Of Change |
| c. Employee Training | h. Pre-Startup Safety Review |
| d. Employee Participation | i. Emergency Plan. & Response |
| e. Process Hazard Analysis | j. Incident Investigation |

6. Please describe the impact the PSM standard has had on process technicians and secondly on the chemical processing industry. Process safety information covers topics that are typically found in a comprehensive process technology program at a local college or university. A new employee without an educational credential would not have the foundation to address this section of the PSM standard. Items b” through j” deal with topics that are within the daily operation of a process technician. Mechanical integrity , trade secrets, compliance audits, and contractors are more closely associated with management, engineering and service groups.

The PSM standard has changed the educational requirements for work as a process technician in the chemical processing industry. Many technicians who were hired before 1994 will find it difficult to obtain a job as a process technician if they are displaced by their existing employer. The four year degrees that are required for engineers and chemists has been joined by the two year degree in process technology.

7. Define the term, “Code of Federal Regulations (CFR). Contains all of the permanent rules and regulations of OSHA and is produced in paperback format once a year.
8. Explain the importance of compliance audits conducted by OSHA auditors. Conducted by OSHA auditors to ensure compliance with governmental rules and regulations.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

9. Describe an emergency response plan. A written plan that documents how specific individuals should respond during an emergency situation.
10. Describe the “Environmental Protection Agency (EPA), identify when it was established and it’s primary purpose. Established in 1970 to develop environmentally sound policies and national standards, support research and development, and enforce environmental regulations.
11. Explain the purpose of the Federal Register. A publication that (1) produces information on current OSHA standards, and (2) shows all adopted amendments, deletions, insertions, and corrections to government standards.
12. Explain the importance of community college safety, process, and engineering programs in preparation for reading and understanding “FLOW DIAGRAMS.”
Since 1992, industrial manufacturers have initiated partnerships with their local community colleges and universities. The traditional apprentice training function has gravitated from industrial training managers toward the regionally accredited halls of academia. This transition has saved the chemical processing industry millions in training-budget dollars. Only a handful of colleges have pilot plant facilities and bench-top units.
This transition can be documented all across the United States as certain elements of the PSM standard require a higher level of certification. This higher educational credential and need for some training redundancy has changed the occupation of the process technician from one who has little, if any, formal training to one who has the preferred status of a two-year process technology A.A.S. degree. A standardized college curriculum exists in at least one state with several other states positioning themselves for educational standardization. The process safety information section of PSM includes information on the accidental mixing of chemicals and the products they produce, potential hazards, and safe handling procedures. This section provides an accurate assessment of the physical data associated with chemicals: toxic, reactive, corrosive, and explosive

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

limits of specific substances. A simplified flow diagram of the process should be included in this section of the standard so a new person can easily see the various steps of the process. The complete list of the items that should be included in the process safety information include:

- process flow diagram
- equipment and process description
- operational limits of equipment
- consequences of deviations
- safety and relief system design
- electrical classifications
- physical characteristics of chemicals: toxic, reactive, corrosive, explosive, limits
- process chemistry
- inadvertent mixing of chemicals under a variety of conditions: temperature, pressure, flow rates

13. Describe the term, mechanical integrity. A term that applies to the soundness of a plant process.
14. Describe the "Occupational Safety and Health Act of 1970—the purpose of this act is to (1) remove known hazards from the workplace that could lead to serious injury or death and (2) ensure safe and healthful working conditions for American workers. The Occupational Safety and Health Act applies to four broad categories: agriculture, construction, general industry, and maritime. There are three primary agencies responsible for the administration of the Occupational Safety and Health Act: National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), and Occupational Safety and Health Review Commission (OSHRC).
15. Describe the Occupational Safety and Health Administration. One of the three primary agencies created under the Occupational Safety and Health Act.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

16. Describe the primary purpose of NIOSH. One of the three primary agencies created under the Occupational Safety and Health Act.
17. Explain how the Occupational Safety and Health Review Commission works. Independent agency, conducts hearings for situations on noncompliance that are contested, can assess penalties, conduct investigation, and support modify, or overturn OSHA findings.
18. List the key steps in conducting a process hazard analysis.
 - List what can go wrong
 - Identify the consequences
 - Explain how it could arise or occur
 - Select the contributing factors
 - Determine the frequency that the hazard occurs
19. Describe the employee training section of the PSM standard. The Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) believe that the key to preventing catastrophic emergencies inside of the chemical processing industry is to provide adequate employee training. This was the conclusion of the governmental groups that investigated the Phillips Chemical Company and ARCO vapor release and explosions. The employee training aspect of the PSM standard includes seven sections:
 1. Process overview
 2. Training records and method used to administer training (You must document attendance and competency achieved.)
 3. Chemicals used in the process
 4. Description of how access to and from the process unit is controlled
 5. Training materials that reflect current work practices
 6. Refresher training provided
 7. Contractors must inform and train their employees and document that training

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

20. Describe the Comprehensive Environmental Response, Compensation and Liability Act of 1980. The EPA is most noted for its management of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (Superfund). In 1983 they came under severe criticism from Congress for their handling of Superfund. The synergy created by Congress and special interest groups made it clear that the public opinion about a clean environment vetoed the interests of the chemical processing industry. The enforcement of these new, tough environmental regulations put many industrial manufacturers out of business.

Initially the EPA focused on recycling and cleaning up open dump sites. Today the government has passed over 12 environmental laws that impact air, water, and land. These laws go from cradle-to-grave, or in other words, they hold chemical manufacturers responsible from the time the chemical is created until it is disposed of. The EPA regulates water quality pesticides used on farms, oil spills, everything that goes into the ground, and many other things.

CHAPTER 14

HAZWOPER

LEARNING OBJECTIVES

- Describe the operating hazards found in the chemical industry.
- Describe the HAZWOPER first responder, awareness level.
- Describe the HAZWOPER first responder, operations level.
- Describe emergency response.
- Identify potential hazards encountered during an emergency situation and the impact each could have.
- Describe the Incident Command System.
- Describe a fall protection system
- Describe the equipment used in fall protection.
- Identify safe work practices used with fall protection.
- Complete a fall protection inspection checklist.
- Describe the proper cleaning and storage procedures associated with fall protection

CHAPTER 14: REVIEW QUESTIONS

1. Describe the terms cutting, welding, and brazing. Are processes that take place frequently in the chemical processing industry. Process technicians are responsible for controlling and minimizing any potential hazards. Cutting, welding, and brazing produce toxic fumes, generate ultraviolet radiation, electricity, and can easily start a fire. Cutting is described as a process that severs or removes metal using heat from the combustion of hot fuel gases to generate a chemical reaction between the metal, oxygen and flame. Welding is the process of connecting metals using heat and allowing the metals to flow together. Brazing is defined as a process of soldering using an infusible alloy. Adequate ventilation and preparation are needed before any brazing, cutting, or welding occurs.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

2. Explain the hazards of working with hoisting systems. Hoisting systems are used to safely raise, lower, and move loads that are too heavy to be moved manually. Process technicians should receive the correct training prior to operating the hoist. Improperly installed hoists can bind-up and fall from the ceiling mount. If a load is not centered correctly the entire mechanism can collapse and fall to the mat. Load capacity should be clearly specified on the hoisting equipment. The most difficult aspect of the job is estimating the load. Prior to use the hoist system should be carefully inspected. The load should be carefully balanced and all personnel cleared from the area. Hoisting lifts should be smooth and made in small increments. Loads should be suspended no longer than necessary. Tension should be removed from the suspension cables as soon as the load is down. Plant maintenance and the engineering staff should periodically inspect the system and ensure structural integrity. A preventive maintenance program should keep the hoisting system in good working order for many years.
3. What is the purpose of HAZWOPER? The term HAZWOPER is used to describe OSHA's Hazardous Waste Operations and Emergency Response standard. The standard covers two important parts of a plants operation; emergency response and hazardous waste operations. The 29 CFR "Code of Federal Regulations" 1910.120 requires that all individuals who respond to an emergency situation have at least 24 hours of training.
4. Describe why a process technician needs to have emergency response training. The chemical manufacturing industry defines emergency response as a loss of containment for a chemical or the potential for loss of containment that results in an emergency situation requiring an immediate response. Examples of emergency response situations include, fires, explosions, vapor releases and reportable quantity chemical spills. The levels of response have been determined by the chemical processing industry to be:

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- First responder awareness level—individuals who are trained to respond to a hazardous substance release, initiate an emergency response, evacuate the area, and notify proper authorities.
- First responder operations level—an individual that has been trained to respond with an aggressive posture during a chemical release by going to the point of the release and attempting to contain or stop it.
- Hazardous Materials Technician Level
- Hazardous Materials Specialist
- On Scene Incident Commander

Refinery and petrochemical plant employees who are likely to discover or witness a chemical release fall under the scope of the awareness level while those employees who take preventive measures to control and secure the release fall under the guidelines of the operations level. Emergency response procedures are applied to every individual working for a company. The chemical processing industry typically has the following groups working in and around their facilities:

- process and lab technicians
- maintenance technicians—instrument, electricians, mechanics, etc.
- construction and janitorial technicians
- engineers and chemists
- management and administrative staff
- safety and security

Each of these groups are trained to respond to an emergency situation. During an emergency situation, process technicians who fall into the first responder awareness level are required to complete specific procedures. By definition PT's are trained to respond to a hazardous substance release, initiate an emergency response, evacuate the area, and notify proper authorities.

5. The chemical processing industry has five basic levels of emergency response; name them.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- First responder awareness level—individuals who are trained to respond to a hazardous substance release, initiate an emergency response, evacuate the area, and notify proper authorities.
 - First responder operations level—an individual that has been trained to respond with an aggressive posture during a chemical release by going to the point of the release and attempting to contain or stop it.
 - Hazardous Materials Technician Level
 - Hazardous Materials Specialist
 - On Scene Incident Commander
6. Contrast the first responder awareness and operations levels.
- First responder awareness level—individuals who are trained to respond to a hazardous substance release, initiate an emergency response, evacuate the area, and notify proper authorities.
 - First responder operations level—an individual that has been trained to respond with an aggressive posture during a chemical release by going to the point of the release and attempting to contain or stop it.
7. How does the incident command system work for minor, medium, and major vapor releases and fires? Hazardous waste operations in the chemical processing industry involves the use of a complex incident command system I.C.S. The I.C.S coordinates all emergency response activities. Under the I.C.S, a scene safety and control system is coordinated. Decontamination, spill control and containment, and an emergency termination program also fall under the incident command system.
- The I.C.S. is led by an incident commander. The incident commander is responsible for organizing and coordinating response activities, is surrounded by a formal organization with defined lines of authority and responsibility that provide information and carry out orders.
- Hazardous waste operations is typically classified into three different categories:
- hazard is small and does not affect the whole unit.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- medium size hazard that impacts one or more operating units.
- large hazard that impacts on the plant and community.

The organizational structure for a typical incident command system is:

- Incident Commander—direct on-scene activities.
- On-scene Commander—establish command post, first response activities.
- Scene Specialist—conducts risk assessment.
- Planning Chief—coordinates unit operations.
- Operations Chief—directs HAZMAT, fire fighting.
- Medical Chief—provide industrial hygiene, medical first aid.
- Employee Welfare Chief—provides financial and material assistance to community.
- Logistics Chief—refuels vehicles, delivers supplies.
- Security Chief—secures scene and maintains order.
- Communications Chief—initiates radio, telephone and communications.
- Public Affairs Chief—provides information to media.
- Spill Containment, Clean-up Chief—coordinates containment and clean up.
- Safety Chief—assess hazard and prevent unsafe acts.

8. Define Emergency Response. A procedure initiated by the loss of containment for a chemical or the potential for loss of containment that results in an emergency situation requiring an immediate response. "Emergency response" drills are carefully planned and include preparations for worst case scenarios. Examples: Vapor releases, chemical spills, explosions, fires, equipment failure, hurricane, high winds, loss of power, bomb threats, etc.
9. Describe Hazardous Waste Operations. Hazardous waste operations is typically classified into three different categories:
 - hazard is small and does not affect the whole unit.
 - medium size hazard that impacts one or more operating units.
 - large hazard that impacts on the plant and community.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

10. Describe the difference between bunker gear and the typical uniform and safety equipment worn by a process technician. Bunker gear personal protective equipment consists of:
- gloves—special heat-resistant gloves
 - boots—special heat-resistant material
 - coats—special heat-resistant material, comes in small, medium, large, extra large, all latches are engaged, none can be left open, the collar should be pulled up straight and the strap fastened
 - helmet—special heat-resistant material with a face shield, inner liner should be pulled down over the ears, and the chin strap secured (A rotary adjustment knob is located on the back of the helmet to ensure the helmet sits snugly on the head.)

PPE typically worn by technicians include; fire retardant clothing, boots, and hard hat.

Note: Several years ago a fire broke out in a plant that required the process technicians to call in a firefighting team to assist. After a short time an explosion occurred which resulted in a huge fire ball that engulfed several technicians and firefighters. The heat from the fire immediately killed the technicians but inflicted only minor injuries on the firefighters. Upon closer investigation it was determined that the bunker gear the fire fighters were wearing provided superior protection over the flame retardant clothing (FRC) that the technicians were wearing.

11. Describe Draeger pumps and explosimeters. Draeger pumps are portable vacuum-type devices used to collect a representative gas or vapor sample to determine if a known contaminant is present. The Draeger pump has a bellows to draw air into a glass tube filled with a chemically treated sorbent. The activated media in the glass tube will change color if the suspected chemical is present in the air. Each glass tube is scaled or graduated so it can be read in parts per million. Process technicians need specialized training in order to operate a Draeger vacuum pump properly.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

Explosimeters commonly called combustible gas meters are used to determine whether there are sufficient concentrations of a combustible gas mixture to produce a fire or explosion. Explosimeters operate by drawing in an air sample into a combustion chamber and igniting it. If the air sample ignites, combustion level registers.

12. Describe the principles of spill control and containment. Chemical spills and vapor releases require different containment procedures. Most operating units have been designed with spill control or containment in mind. Absorbents, adsorbents, curbing and diking, segregated sewers, earthen dams, fire monitors are devices used to control chemical spills and releases.
13. Describe the physical characteristics of pyrophoric materials. Solids, liquids, or vapors that ignite spontaneously in air below 130 °F.
14. Explain the oxygen requirements for human life and the hazards associated with the low and high ends of the scale. Atmospheres with less than 20% oxygen.
15. List the steps of hazard recognition. Process technicians play a key role in the operation and maintenance of chemical plants and refineries. Due to their close proximity to the operation and the chemicals found in the process they are very likely to be the first to witness a release. The first responder—awareness level is directed at individuals who witness or discover a hazardous chemical release and who have received emergency response training. Properly trained technicians know how to recognize a hazardous chemical release, the hazards associated with this release, how to initiate the emergency response procedure, and how to notify appropriate personnel. Hazards that will initiate an emergency response have been determined by the chemical processing industry to be any of the following: (1) explosion, (2) fire, (3) vapor release, (4) toxic chemical release, (5) large product or chemical spill, and (6) loss of containment for radioactive material.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

16. List the command structure for incident command (ICS). The organizational structure for a typical incident command system is:
- Incident Commander—direct on-scene activities
 - On-scene Commander—establish command post, first response activities
 - Scene Specialist—conducts risk assessment
 - Planning Chief—coordinates unit operations
 - Operations Chief—directs HAZMAT, firefighting
 - Medical Chief—provide industrial hygiene, medical first aid
 - Employee Welfare Chief—provides financial and material assistance to community
 - Logistics Chief—refuels vehicles, delivers supplies
 - Security Chief—secures scene and maintains order
 - Communications Chief—initiates radio and telephone communications
 - Public Affairs Chief—provides information to media
 - Spill Containment, Cleanup Chief—coordinates containment and cleanup
 - Safety Chief—assesses hazard and prevents unsafe acts
17. Describe scene safety and control. In order to reduce the possibility of accidental spread of hazardous chemicals into areas outside of the affected unit, a three-zone system has been established.
- hot zone—the area around the incident where contamination has occurred (Emergency response activities that occur in the hot zone require the appropriate PPE and the buddy system.)
 - warm zone—used to decontaminate technicians leaving the hot zone
 - cold zone—a staging area where the incident command post is established
18. Define the term, “safe haven.” A designated area that is safe from vapor releases, explosions, fires, or other disasters.
19. Describe the “Fall Protection” program. The essential elements of a fall protection system include:

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Written fall protection program.
- Basic fall protection equipment:
- Full body harness—a safety device designed to evenly distribute the forces of an accidental fall to the strongest muscles in the body. This protects vital organs and limits the possibility of a serious injury.
- Lanyard—a tie-off rope that is attached to a full body harness. It is designed to support a minimum of 5,000 pounds. The fall protection standard requires that the lanyard be a maximum of 6 feet long, have double locking snap hooks on each end, and include a shock-absorbing device that is attached to the harness D-ring.
- Anchor point—a tie-off connection device used to secure the free end of a full body harness lanyard. Examples of anchor points include: pre-engineered eye bolts, cable, slide rail, structural steel, or pipe. The anchor point should be strong enough to support 5,000 pounds.

Employee training—all employees should be given training on the fall protection program, donning and doffing fall protection equipment, and inspecting the equipment.

Inspection and audit program—visually inspect equipment for damage. Knotted lanyards cannot be used because their tensile strength is reduced by 50%.

Harnesses should be inspected for wear at the buckles and D-ring. If fiber wear is detected or a cut or tear is found in the harness material, it should be replaced immediately. Check D-rings and buckles for sharp edges, cracks, dents, burrs, or corrosion. Check snap hooks and ensure they operate correctly.

After a full body harness and lanyard has been used, it should be returned to its appropriate location. Harnesses can be cleaned with a wet soapy sponge.

A typical procedure used to don a full body harness includes:

1. Remove harness from container and visually inspect.
2. Hold harness by D-ring and shake so straps will fall into place.
3. Put the harness on like you would a jacket.
4. Secure leg straps.
5. Adjust straps so weight is transferred to the designated locations.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

6. Visually inspect and secure the lanyard to the D-ring double locking hook and shock-absorbing device.
 7. Secure lanyard to anchor point with double locking hook as soon as you reach your work location.
20. List the steps you would take if you noticed a severe vapor release in your plant.
Example: On July 4, 2010 a process technician was completing a routine checklist when she noticed a large vapor cloud escaping from the top of a nearby unit's loop reactor. The chemicals escaping from the reactor were composed of an extremely flammable and explosive material. The technician recognizes the potential hazard and the need to initiate her plant's emergency response plan. The following steps are typically followed during an emergency situation:
1. The technician immediately radios her supervisor about the release.
 2. The first line supervisor (FLS) notifies the FLS at the loop reactor about the problem. They are already aware of the situation because of process instrumentation and are responding. They confirm that the situation is serious. The loop reactor FLS initiates the emergency response situation. The plant alarm system for a vapor release is sounded. The emergency response teams mobilize.
 3. Process technicians from each unit begin the evacuation of their units to the designated safe havens.
 4. Roll is taken and reported to a central incident commander. All plant personnel are accounted for.
 5. Technicians trained to respond to the release are mobilized.
 6. When the release is contained and dispersed the "all clear" is sounded.

CHAPTER 15

PROCESS SYSTEM HAZARDS

LEARNING OBJECTIVES

- Describe the operating hazards found in the chemical industry.
- Describe key terms and definitions used in basic process principles.
- Describe and apply the basic principles of pressure.
- Define fundamental chemistry terms.
- Describe the fundamental principles of chemistry.
- Describe and use a chemical equation and periodic table.
- Describe these chemical reactions:
 - Exothermic
 - Endothermic
- Analyze the scientific principles of heat, heat transfer, and temperature.
- Perform simple temperature conversions between °F, °C, K and °R.
- Examine the principles of fluid flow in process equipment.
- Compare the hazards associated with pump and compressor system operations.
- Describe the safety hazards associated with a heat exchanger and cooling tower system.
- List the hazards associated with steam generation and furnace operation.
- Explain the relationship of science and chemistry to hazard recognition.
- Compare the hazards associated with the principles of reaction and distillation.

CHAPTER 15: REVIEW QUESTIONS

1. Describe the various operating hazards found in the chemical processing industry. Operating hazards can be classified as equipment- and system-related, weather-related, and chemistry- and chemicals-related. The types of equipment and systems that can cause an operating hazard include valves, piping, pumps, compressors, turbines, heat exchangers, cooling towers, boilers, furnaces, reactors, and distillation columns. This list could also include electrical items,

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

instruments, rotating equipment, plastic plant equipment, and many other devices. Weather-related hazards such as lightning, tornadoes, hurricanes, hail, snow, rain, heat, and other phenomena may cause serious damage inside a chemical complex. The operating hazards associated with chemicals include the basic chemistry of how various components mix to form new products under a wide variety of temperatures, pressures, and other variables.

2. Explain how shift work affects a process technician. Shift work and the hazards associated with fatigue have been studied for a number of years. A technician's greatest nemesis is fatigue and mental stress associated with a variety of reasons. Most of the biggest industrial disasters have taken place between the hours of 1:00 a.m. and 4:00 a.m. Most large chemical complexes have between 15% and 25% overtime.

As more studies are conducted over the human body's circadian rhythms, new rotating shift schedules have been developed. The new rules for safe shift design recommend clockwise or forward shift rotation, days to night to evening for 8-hour rotating shifts. A large number of plants use the popular 12-hour rotating shift model. In the United States, over 15 million people work rotating shifts. Shift workers suffer from more stress-related illnesses than those in other occupations. Some research indicates that shift worker performance problems have cost the global industries over \$700 billion per year.

Some companies provide classes for shift workers' families to help them understand the job pressures and health hazards. Some of these organizations are providing 24-hour day care and transportation services for children and elderly parents. Other options include cross-training, opening an ownership of safety program, team building, opening communication to daytime management, staggered work shifts, opening facilities to family members, and company-sanctioned napping.

3. Describe the hazards associated with a pump system. Problems associated with centrifugal pumps include:

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- cavitation
- vapor lock
- improper line-up
- high discharge pressure variations or NPDH
- variations in suction pressure or NPSH
- feed composition changes
- gear box problems
- seals and bearings problem
- broken suction and discharge gauges
- breaker trips on motor
- motor problems
- gasket leaks
- seal flush tubing plugs ups

Other hazards associated with a simple pump system include the buildup of static electricity in moving fluids. Accidental ignition of flammable gases may occur if equipment and piping is not correctly grounded or bonded. In pump systems that include heat exchangers, product contamination is possible if a tube ruptures or breaks. In situations like this, hydrocarbons show up in the cooling tower basin or product streams.

In general, any rotating equipment provides the risk of a serious injury if a process technician does not exercise respect and caution. Loose clothing, long hair, and exposed human tissue can be seriously injured in rotating equipment. Safeguards are typically placed around these potential hazards to prevent injury. These devices should never be removed during operational conditions. Examples of rotating equipment are pumps, compressors, fans, blowers, turbines, agitators, blenders or mixers, extruders, drills, feeders, and conveyors.

1. Explain the safety hazards associated with the operation of a compressor system.
 - Noise hazards
 - High-pressure hoses blowing loose

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Hazards associated with compressed gas systems
 - Hazards associated with rotating equipment.
 - Mixing air and hydrocarbons into flammable or explosive concentrations
 - Avoiding high pressure releases; eyes, ears, nose, skin
 - Fires or explosions
 - Incorrect line-up
 - Loss of cooling water or lubrication
 - Lifted safety
5. Explain how the principle of pressure applies to compressors and pumps.
Pumps and compressors are devices that are designed to increase the pressure of a fluid or liquid through mechanical means. Pumps are designed to be used with liquids while compressors are associated with gases. Liquids are generally considered to be non-compressible, while vapors and gases experience significant decreases in volume during compression cycles. Pressure is defined as force or weight per unit area ($\text{Force} \div \text{Area} = \text{Pressure}$).
6. Describe the hazards associated with cooling towers. The safety aspects of the cooling tower system include the following areas:
- Chemical additives Liquids, Solid & Gas (See Chemical list and MSDS)
 - Rotating equipment.
 - Hazards of hot water
 - Equipment failures (Tube leak on condenser.
 - Working at heights
 - Hazards of working with acid (See MSDS)
 - Confined Space Entry (Water basin empty)
 - Hazardous Energy
 - Rotten Wood
 - Poor visibility due to vapor & foam
7. Describe the safety hazards associated with heat exchangers. The safety

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

aspects associated with the operation of a heat exchanger system include all of the following:

- Chemical hazards associated with spills and leaks (See Chemical List and MSDS)
- Hazards associated with burns
- Hazards associated with fires
- Hazards associated with explosions and Bleve
- Confined Space Entry; larger exchangers with tube bundles removed
- Equipment failure; tube leak, gasket leak, shell puncture or leak
- Error with valve line up resulting in explosion or fire
- Pump failure resulting in over heating in heat exchanger
- Gauge failures
- Sampling, purging, or venting the shell.
- Exceeding pressure and temperature ratings on heat exchanger code stamp for tubes and shell
- Utilizing incompatible materials with chemicals
- Working with hot materials under pressure

8. List the operational hazards associated with boilers and furnaces.

- Flameout
- Tube or coil rupture (over firing, high heat loads, flame impingement and erosion)
- Burns
- High-velocity steam can cut through solid objects.
- The rapid increase in temperature as thermal energy is quickly transferred through the metal.
- Non-uniform heating of piping and equipping can cause expansion problems that will rupture equipment.
- Thermal warp, water hammer, and thermal expansion are all natural phenomena of which a process technician should be aware.
- Hazards associated with this is piping and equipment under pressure.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

9. Explain the safety features associated with reactor operation. Reactors are equipped with a number of safety features:
- Pressure control and relief system
 - Quench system
 - Process variable alarms
 - Automatic shutdown controls
 - Flow control
 - Temperature control
 - Level control
 - Speed control
 - Analytical or compositional control
10. Describe the safety hazards associated with distillation operation. Operational hazards associated with distillation include:
- Fires & Explosions
 - Leaks- Gasket, valve, instruments, piping, pumps
 - Pressure surges- composition changes
 - Loss of cooling water- results in flaring
 - Steam valves sticks in open position- overheats tower
 - Feed valve fails in open position- floods trays or column
 - Lightning strikes column
 - High winds, tornado, hurricane
 - Tube leak mixes hydrocarbon with water
 - Exothermic reaction occurs in column
 - Object strikes column and damages structural integrity
 - Water in feed causes rapid expansion problems
 - Computer failure
 - Power failure
 - Instrument failure
 - Feed tank ruptures

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

11. Describe the most common cause for industrial accidents. Human error has been identified as the most common cause of industrial accidents.
12. Explain the relationship between chemicals and the periodic table. Chemical elements found in nature are listed on the periodic table. These elements can be described as the building blocks of all substances. Each element is composed of atoms from only one kind of element. Chemists describe elements with letters from the alphabet. The letter symbol for hydrogen is H. The letter symbol for carbon is C. A list of all known chemical symbols can be found on a periodic table.
13. List the methods and scientific principles associated with heat transfer. Heat is transmitted through conduction (heat energy is transferred through a solid object; e.g., a heat exchanger), convection (requires fluid currents to transfer heat from a heat source; e.g., the convection section of furnace or economizer section of boiler), and radiation (the transfer of energy through space by the means of electromagnetic waves; e.g., the sun).
14. List the four states of matter. Matter is anything that occupies space and has mass. The four physical states of matter are solid, liquid, gas, and plasma. Plasma can be found in powerful magnetic fields.
15. Compare the following terms, "mixture, solution, and compound." Solutions are a type of homogenous mixture. The term homogenous refers to the evenly mixed composition of the solution. A common example of a homogenous solution is red dye and water. As the contents of the red dye come into contact with the water it is evenly dispersed throughout the solution. Mixtures do not have a definite composition. A mixture is composed of two or more substances that are only mixed physically. Because a mixture is not chemically combined, it can be separated through physical means, such as boiling or magnetic attraction. A

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

compound is defined as a substance formed by the chemical combination of two or more substances in definite proportions by weight. A molecule is the smallest particle that retains the properties of the compound.

16. Define the term, “chemistry.” Chemistry is described as the study of the characteristics or structure of elements and the changes that take place when they combine to form other substances.
17. Describe “cavitation” and the hazards associated with it. Cavitation is defined as the formation and collapse of air pockets inside the pumping chamber. It can also be described as boiling, a process which can be very violent, with rapid pressure increases and decreases. Cavitation can damage the impeller, shaft, casing, or wear rings. This phenomena can break the pump loose from the piping or foundation and sounds like marbles being agitated in a large blender. Cavitation can be prevented by simply increasing the NPSH or pinching down on the discharge valve. It appears to be caused when the pump out runs the liquid entering the suction eye, forming a serious vacuum, reducing the boiling point of the liquid to a point where it violently expands and then collapses as the pressure builds.
18. Explain the principles of distillation. Distillation is a process that separates a substance from a mixture by its boiling point. During the distillation process a mixture is heated until it vaporizes, then is recondensed on the trays or at various stages of the column where it is drawn off and collected in a variety of overhead, sidestream and bottom receivers. The condensed liquid or overhead product is referred to as the distillate while the liquid that does not vaporize in a column is called the residue or bottoms product.
19. Explain how a cooling tower operates and transfers heat energy. Heat transfer in a cooling tower is primarily through evaporative heat transfer (80-90%) and 10 to 20% sensible heat transfer. Hot water enters the top of the cooling tower and

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

cascades over a series of boards or fill allowing for greater surface area and air contact. The cooler water collects in the basin and is pumped back to the plant.

20. Explain the hazards associated with working with acids or bases. Acids and Bases can have a harmful effect on human tissue.

CHAPTER 16

WEAPONS OF MASS DESTRUCTION, HURRICANES & NATURAL DISASTERS

LEARNING OBJECTIVES

After studying this chapter, the student will be able to:

- Describe the hazards associated with the use of weapons of mass destruction on the chemical processing industry.
- Identify the potential risks and hazards facing the chemical processing industry.
- Review the use of nuclear, conventional, and dirty bombs on civilian and industrial facilities.
- Describe the use of chemical weapons by terrorist.
- Describe the hazards associated with chemical asphyxiates.
- Explain the hazards associated with the use of biological weapons.
- Compare the hazards associated with biological toxins and viruses.
- Describe the destructive forces and hazards associated with tornados.
- Review the Fujita Scale for tornado wind speed, F-scale, intensity phrase, and type of damage.
- Describe the hazards associated with hurricanes and the Saffir-Simpson Hurricane Wind Scale.”
- Describe the hazards associated with the use of military weapons on the CPI by terrorists.

CHAPTER 16: REVIEW QUESTIONS

1. Describe the hazards associated with fast forming hurricanes in the waters around the United States. Speed at which the storm forms, heavy rain, severe wind gusts, lack of preparation, loss of utilities and communication.

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

2. List the wind speeds, classifications, and hazards associated with tornadoes. See Fujita Scale.
3. Explain the things a terrorist would need to know in order to inflict severe damage on the chemical processing industry. The key to attacking one-or-more of these companies is in the area of strategic knowledge about vital nerve centers. Many of these companies store raw materials in liquid state that at atmospheric pressure will turn into a vapor. Some of these chemicals will explode violently when exposed to an ignition source. Others are extremely hazardous to humans. Terrorist would need to know the:

- location
- quantity of materials
- physical and chemical hazards
- direction of the wind
- safety instrumentation
- potential for catastrophic effects
- domino effect with other industries
- economic effect on community

In order to gather this type of information a terrorist would need to work in the intended target company and have a sound understanding of engineering and process operations. Specific safety controls would need to be removed and GPS coordinates provided. In light of changing demographics in the gulf-coast area and the need for better-trained employees to replace the baby-boomers, this scenario is a strong possibility.

4. List examples of terrorist type activities in the United States that could indicate possible future activities. Potential Risks include:
- Terrorist flies an airplane into a chemical plant or refinery
 - Terrorist enters CPI workforce
 - Use of Conventional bomb

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

- Use of Nuclear weapon
 - Suicide bomber
 - Use of chemical weapons
 - Use of biological weapons
 - Use of military weapons
5. Describe the Saffir-Simpson Hurricane Wind Scale. The Saffir-Simpson Hurricane Wind scale uses categories 1-5, corresponding “sustained winds”, and “Type of Damage Done” to classify hurricanes. See Saffir-Simpson Hurricane Wind Scale. For example, Cat-1, 74-95 mph, Dangerous winds. The scale tops out at a Cat-5 with sustained winds of 155+ mph.
6. Describe the Fujita scale and explain how it works. The Fujita Scale is broken down into 4 categories; F-Scale Number, Intensity Phrase, Wind Speed, and Type of Damage Done. For example, F1, moderate tornado, 73-112 mph, peels surface off roofs. The scale tops out at an F6 with wind speeds between 319-379 mph.
7. Describe how terrorist could infiltrate the chemical processing industry. There are a number of ways that terrorists could infiltrate the chemical processing industry. Some of these include:
- direct hire into the company as engineer, technician, contractor
 - illegally cross Mexico-US border
 - visit family living in or near chemical plants, refineries, power generation, etc.
 - terrorist would need to work in the intended target company and have a sound understanding of engineering and process operations
 - cut through fences or barricades
 - drive through plant entry check points
 - fly a plane into a critical process
 - obtain educational visas to attend local schools

PTAC-1308 Textbook: Answer Keys for Chapter Review Questions

8. Explain what would happen if an airplane was randomly crashed inside a chemical plant or refinery. If a plane was flown into a chemical plant or refinery, or an oil rig in the Gulf of Mexico, the potential for catastrophic effects is possible, however, the plane would need to hit a crucial nerve center.
9. List the steps that are taken when a bomb threat occurs inside an operating chemical facility.
 - if the threat is considered real the bomb threat alarm is sounded
 - the authorities are notified
 - cell phones should not be used
 - a quick visual check is made of the area
 - the operating unit is placed in a safe condition
 - return after the all clear is sounded
10. Explain the events that would take place in our community if a suicide bomber set off a dirty bomb. The blast zone is over 300 feet in all directions, scattering or pulverizing the ground up radioactive material. The wind will help in spreading the lethal fallout. When small particles are inhaled the long-term effects can be serious.
11. Describe the effects of a nuclear bomb going off inside a major city. A one megaton nuclear bomb is capable of destroying the largest city in the world. When a nuclear bomb is detonated, it releases 35% of its energy as heat, 50% in the initial blast, and 15% as nuclear radiation. One kilogram of nuclear fission fuel is 20,000,000 times more powerful than the same amount of TNT. If a nuclear bomb exploded, it would kill or seriously injure everyone within 3-30 miles. Typical temperatures in a nuclear explosion exceed 300,000°C. The shock wave from this type of explosion produces firestorms and hurricane type winds that blows down everything in its path.

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12. Explain how chemical weapons are classified. Chemical weapons are identified by how they affect the body and whether they are nerve toxins, chemical asphyxiants, respiratory irritants, skin irritants, and burning agents.
13. Describe the following terms; nerve toxins, chemical asphyxiants, respiratory irritants, skin irritants, and burning agents.
14. List specific chemicals in our community that could be used by terrorist as chemical weapons. In areas with large concentrations of chemical plants and refineries, terrorist may choose other chemicals to accomplish their goals. Examples of this could include; railroad cars, tractor-trailer trucks, or bulk storage of industrial chemicals. Specific chemicals that may be targeted include, chlorine, anhydrous ammonia, LPG, hydrocyanic acid, hydrogen fluoride, and sulfur dioxide. There are hundreds of other chemical combinations.
15. Describe the physical properties associated with nerve agents. The most widely known nerve agents or organophosphate compounds are; Sarin, Tabun, Soman, and VX which have properties similar to industrial grade pesticides. Most of these agents are hazardous to the respiratory system.
16. Describe the risks and hazards associated with biological weapons. Biological toxins can be classified as chemical compounds produced by poisonous microbes, animals or plants. Microorganisms are living bacteria and viruses, that have the ability to establish hazardous infections in humans that are easily spread from one population group to another. Biological terrorists have the ability to cultivate, harvest, and introduce these microorganisms into populated areas.
17. Explain what the results would be if a Category 5 hurricane made land fall in the Houston Texas area. Cat-5, 155 mph +, Catastrophic damage will occur. People, pets, and livestock are at high risk of injury or death from flying debris, even if indoors in framed home, mobile home, or barn. Large amounts of windborne debris.

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A high percentage of industrial buildings and apartments destroyed. Most unprotected windows will be damaged or blown out of homes and high-rise buildings. Human suffering will be at a very high level as heat and humidity returns with mosquitoes, and no modern conveniences. Storm surge: 19 plus feet above normal. Barometric Pressure: < 27.17 in.Hg. <920.1 mb. <91.7 kPa.

18. Explain what the consequences would be if a F5 tornado made a direct hit on a large chemical plant and refinery. Total destruction, explosions, fires, the area would be unrecognizable.
19. Describe the damage a terrorist using military weapons on a chemical plant or refinery could inflict and explain how he/she would be captured or stopped. The damage would be severe under this type of scenario. Local police, swat teams, would be ill equipped to handle. In reviewing the number of scenarios available for hazard preparation, it would be difficult to prevent the use of a military weapon, or weapons on facilities operated by the CPI. Weapons can be grouped into four areas; air force, navy, marines, and army weapons. It would be very difficult to stop or capture terrorists so armed.
20. List examples of biological toxins. Examples of biological toxins include:
 - Botulism- Botulinum toxins
 - Ricin
 - SEB- Staphylococcal Enterotoxin B
 - T2- Tricholthecene Mycotoxins

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