Wastewater & Drinking Water Operator Certification Training

Module 30: Safety

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Gannett Fleming, Inc.
Dering Consulting Group
Penn State Harrisburg Environmental Training Center

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Unit 1 – Introduction

Learning Objectives

- Define basic safety terms.
- Identify six sources of supplemental safety information.

Overview

Treatment plant operators face a variety of workplace safety and health hazards ranging from physical injuries associated with maintenance work to hazardous materials exposure associated with chemical use. Your employer is responsible for providing you with a workplace that is free of recognized safety and health hazards. As an employee, however, you also have a responsibility for workplace safety by:

- Complying with established safety rules, procedures, and policies.
- Recognizing and reporting potential safety hazards.
- Becoming knowledgeable about the unique hazards associated with your job as a treatment plant operator.
- Protecting yourself, co-workers, and visitors from workplace accidents/incidents.

Effective safety and health management focuses on identifying, evaluating, and controlling hazards.

A **hazard** is an existing or potential workplace condition that can result in death, injury, illness, property damage, or other loss (such as environment damage or degradation). Hazards are categorized as those dealing with safety and injuries (physical hazards) and those dealing with health and illness (health hazards).

It is important to remember that hazards are **caused**, they do not occur randomly. A thorough examination of an accident will show that the root cause of an accident, whether direct or indirect, can be attributed to one or more of the following basic factors[1]:

- Oversight, omission, or malfunction of the management system. Examples include: inadequate training and education, improper assignment of responsibility, unsuitable equipment, or inadequate budgets.
- Situational work factors such as facilities, tools, equipment, and materials. These often involve design defects, poor construction, improper hazardous materials storage, and inadequate planning, layout and facility design.
- Human factors involving a worker or other person. Typically associated with action(s), or failure to act, by a person, which results in a deviation from standard job procedures. Examples are: using equipment without authority, operating equipment improperly, removing safety devices, using defective tools, and deviating from standard procedures.
- Environmental factors that include physical, chemical, or biological elements. Examples include: noise, vibration, illumination, temperature extremes, hazardous fumes, vapors, mists, dust, bacteria, viruses, and other micro-organisms.

As a Treatment Plant Operator, you can prevent accidents by:

- Using common sense.
- Applying established safety rules and procedures.
- Becoming knowledgeable about the hazards associated with your job.

This can be accomplished by keeping the above four basic factors in mind prior to and during the performance of your work activities. Addressing these four factors in terms of identifying potential hazards, evaluating each hazard, and applying the appropriate hazard control will provide you with a systematic way to protect yourself and others.

Training and Instructions

This module provides a basic resource for treatment plant safety and should be used in conjunction with more comprehensive safety training specific to your operations. This module provides you with a safety awareness that you can take back to your plant and use for identifying safety training and instruction needs. Additional safety training in specific operations, tasks, hazards, and regulatory requirements will be necessary at the facility level. Additional training and instruction topics are listed below.

- Confined space entry
- Hazard communication
- Excavation safety
- Lockout/Tagout
- Fall protection
- Respiratory protective equipment
- Materials handling
- Laboratory safety and chemical hygiene
- Process safety management
- Forklift Safety
- Electrical Safety
- Portable Fire Extinguisher Use

Each of these items has specific training requirements that must be met in order for you to perform your job safely and in accordance with applicable requirements. Consult your supervisor about safety training and the instruction that you will need to perform your job.

The following are definitions of key safety terms that you should be familiar with:

- **ACGIH** is the American Conference of Governmental Industrial Hygienists.
- **Acute** refers to a severe, often dangerous, health effect or symptom associated with an exposure to high concentrations of a contaminant for a short duration of time.
- **Action Level** is the concentration of a contaminant at which specific actions or countermeasures are to be taken to protect workers. Action levels are generally set at 50% of the Permissible Exposure Limit (PEL).
- **AIHA** is the American Industrial Hygiene Association.
- **ASSE** is the American Society of Safety Engineers.
- **Breathing Zone** refers to the area surrounding a worker's nose and mouth from which breathing air is drawn over the course of the work period. The zone generally encompasses a radius of about 10 inches centered at the worker's nose.
- **Chronic** is used to describe persistent, prolonged, repeated exposure to a contaminant and the associated effects.
- **A decibel (dB) is** a unit for expressing the relative intensity of sounds.
- **Flash Point** is the temperature at which sufficient vapor is produced above a container of volatile liquid to form a combustible mixture with air.
- **IDLH** means Immediately Dangerous to Life and Health. It is the maximum concentration of a contaminant from which one could escape within 30 minutes without escape-impairing symptoms or irreversible health effects.
- **Lower Explosive Limit (LEL)** or **Lower Flammable Limit (LFL)** is the minimum concentration, as a percentage, of flammable gas or vapor mixed with air that can be ignited.
- **NIOSH** is the National Institute for Occupational Safety and Health, which is the research arm for Federal OSHA that recommends standards.
- **Nonsparking tools** are tools made of non-ferrous metal that reduce the potential for creating a spark. Typically used when flammable atmospheres or explosion hazards are possible.

OSHA is the Occupational Safety and Health Administration, a. Federal Government agency responsible for establishing and enforcing workplace safety and health regulations.

Permissible Exposure Limit (PEL) is established by OSHA. It is the time weighted average permissible concentration in air of a substance to which nearly all workers may be repeatedly exposed 8 hours per day, 40 hours per week, for 30 years without adverse effects. These are legally enforceable by OSHA.

Recommended Exposure Limit (REL) is established by NIOSH. It is an exposure limit recommended by NIOSH as being protective of workers over a working lifetime. It is typically expressed as a time-weighted average exposure for up to 10 hours per day over a 40 hour work week. These are not legally enforceable.

Threshold Limit Value (TLV®) is established by the ACGIH. It is an exposure level below which most people can work consistently for 8 hours a day, day after day, without harmful effects.

Time Weighted Average (TWA) is the average exposure for an individual over a given work period (typically 8 hours) as determined by sampling at given times, or continuously, during that period.

Upper Explosive Limit (UEL) or Upper Flammable Limit (UFL) is the maximum concentration, as a percentage by volume, of a flammable vapor or gas at which ignition will occur.

Resources

A great deal of safety and health information is available to supplement the materials presented in this module. This supplemental information is provided in various forms such as reference materials, internet web sites, professional organization journals, courses and conferences and regulatory agency outreach.

Listed below are examples of supplemental safety and health information sources.

- Federal OSHA at www.OSHA.gov
- Federal EPA at www.epa.gov
- The Center for Disease Control (CDC) at www.cdc.gov
- The National Institute for Occupational Safety and Health (NIOSH) at www.cdc/NIOSH.gov
- The American Society of Safety Engineers (ASSE)
- The American Industrial Hygiene Association
- The National Safety Council

Below are listed a number of the Pennsylvania State Universities that offer undergraduate and graduate degrees in occupational safety and health and can be potential sources of information and assistance relative to safety and health.

- Indiana University of PA (IUP)*
- Slippery Rock University
- Millersville University
- Pennsylvania State University
- IUP also runs the OSHA Consultation program for the State of Pennsylvania

OSHA Enforcement Offices

Allentown Area Office
850 North 5th Street
Allentown, Pennsylvania 18102-1731
(610) 776-0592
(610) 776-1913 FAX

Erie Area Office
3939 West Ridge Road, Suite B12
Erie, Pennsylvania 16506-1857
(814) 833-5758
(814) 833-8919 FAX

Harrisburg Area Office
Progress Plaza
49 North Progress Avenue
Harrisburg, Pennsylvania 17109-3596
(717) 782-3902
(717) 782-3746 FAX

Philadelphia Area Office
US Custom House, Room 242
Second & Chestnut Street
Philadelphia, Pennsylvania 19106-2902
(215) 597-4955
(215) 597-1956 FAX

Pittsburgh Area Office
Federal Office Building, Room 1428
1000 Liberty Avenue
Pittsburgh, Pennsylvania 15222-4101
(412) 395-4903
(412) 395-6380 FAX

Wilkes-Barre Area Office
The Stegmaier Building
Suite 410
7 North Wilkes-Barre Boulevard
Wilkes-Barre, PA 18702-5241
(570) 826-6538
(570) 821-4170 FAX

[1]*Accident Prevention Manual for Industrial Operations, Administration and Programs*, 9th Edition, (National Safety Council, 1988), p. 45.

- Treatment plant operators face a variety of workplace safety hazards ranging from physical injuries to hazardous material exposure.

- A great deal of safety and health information is available to supplement the material presenting in this module.

Unit 2 – Chemical Hazards at Treatment Plants

Learning Objectives

- For each of the eleven examples of chemicals used at treatment plants:
  - Describe the chemical.
  - Explain its properties.
  - Explain the health hazards and symptoms associated with the chemical.
  - Identify the exposure limits for the chemical.
  - Explain the hazard control requirements for the chemical.
- List four categories of chemical associated with laboratory reagents and explain their potential hazards.
- List four sources of chemical hazards associated with maintenance of a Treatment Plant and explain their potential hazards.
- Identify the potential chemical hazards generated by chemical reactions.
- List and describe four types of injuries/illnesses associated with chemicals.
- Identify a Material Safety Data Sheet (MSDS), its major components, and explain its importance.
- Describe three means of chemical hazard control.
- List and describe four categories of protective equipment used when working with hazardous chemicals.

The onset of health effects or illnesses resulting from occupational exposure to chemicals depends on the amount of exposure, or dose.

The **dose** is the amount of a chemical substance taken into the body. It is expressed in terms of the chemical concentration and the length of exposure time, or, D= C x T, where:

D = dose
C = chemical concentration that an employee is exposed to
T = length of time that the employee is exposed to C

The relationship between the dose and the response is shown in the following graphic:

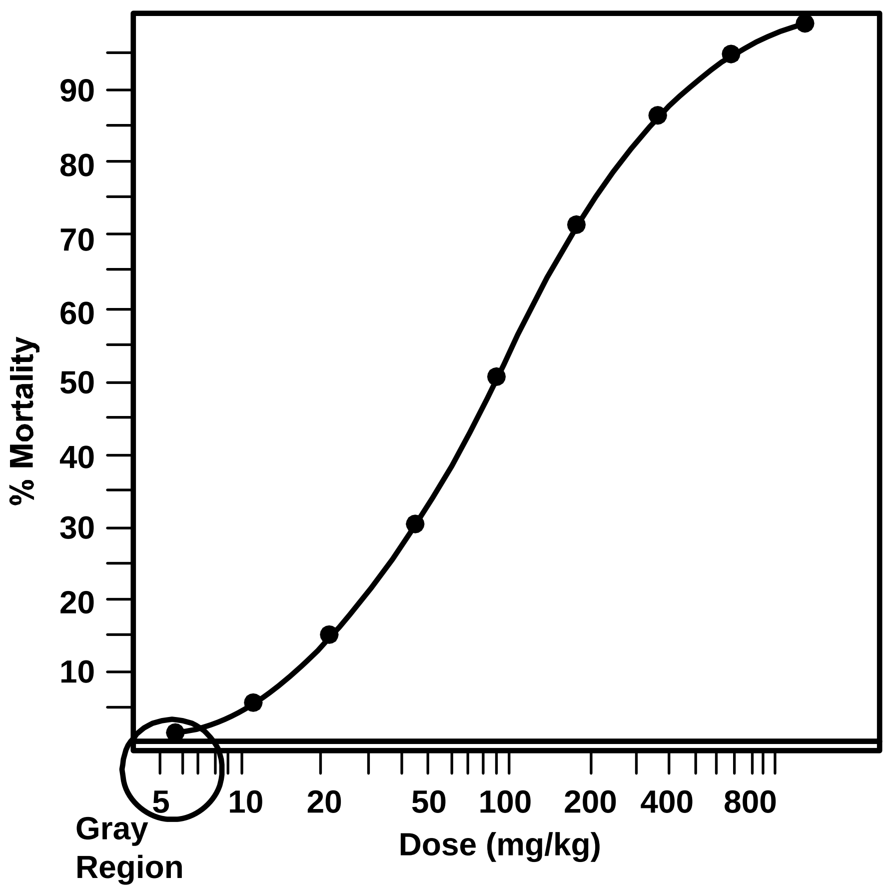

Figure 2.1 Standard Dose Response Relationship[1]

Chronic vs. Acute

Chemical exposures are expressed in terms of acute or chronic and the associated health effects are acute or chronic health effects.

Acute exposures refer to exposure to a high concentration of a chemical over a short period of time, usually minutes or hours.

- This is more easily expressed as a large dose in a short time.
- An acute exposure often produces health effects such as eye, nose, throat and lung irritation; dizziness; fatigue; and nausea that usually go away some time after exposure to a chemical stops.

Chronic exposures are persistent, prolonged, repeated exposures over a long period of time (several years), often to low concentration.

- This is more easily expressed as a small dose over a long time.
- Chronic health effects are usually disease related and develop over a long period of time. Examples include cancer, liver damage, kidney damage, central nervous system damage and reproductive problems.

Respiratory

The following are a few examples of respiratory system affects that can result from excessive inhalation exposure to chemicals:

- Irritation.
- Pneumoconiosis (a disease of the lungs caused by the habitual inhalation of irritants).
- Obstruction.
- Restrictive lung disease.
- Lung cancer.
- Asphyxiation (a loss of consciousness due to the presence of noxious agents).

Dermal

Skin contact with chemicals can result in the following adverse effects:

- Dermatitis (inflammation of the skin).
- Photosensitization (a severe dermatitis resulting from a reaction to sunlight).
- Allergic response.
- Corrosion (chemical burns).
- Systemic toxicity (absorption through the skin).
- Cancer.

Physical

Physical injuries that occur as a result of chemical exposure typically consist of burns. Burns can be the result of a chemical burn caused by the chemical itself or by the temperature of the chemical in process. Chemical burns are usually associated with acidic (pH less than 7.0) or basic chemicals (pH greater than 7.0) that chemically “attack” body tissue and cause tissue damage. Thermal burns are associated with chemicals at high or very low temperatures that physically destroy tissue because of extreme temperatures.

Chemical properties that can produce physical injury, typically from a release of energy, include:

- A **flammable** substance is capable of being easily set on fire or support combustion with a flashpoint below 100°F. Example, Gasoline.
- A **flash point** is the minimum temperature of a liquid at which sufficient vapor is given off to form an ignitable mixture with air.
- A **combustible** material is capable of burning with a flashpoint of 100°F but below 200°F. An example of a combustible is fuel oil.
- An **explosive** substance is one that, when exposed to sudden shock, pressure or high temperature, causes a sudden release of pressure, gas and heat. An example of an explosive is nitroglycerin.

- **Compressed gas** refers to substances in gas form under high pressure. An example is chlorine gas in a cylinder.

- An **oxidizer** is a material that starts or contributes to combustion of other materials by providing oxygen. Examples of oxidizers include strong fertilizers and nitric acid.

- A **pyrophoric** chemical is one that will spontaneously ignite when exposed to air. Examples include white or yellow phosphorus.

- A **reactive, or unstable,** material is one that reacts with air, water or other chemicals and releases energy in the form of heat, pressure and/or harmful byproducts. Some unstable substances will decompose or become self-reactive. Reactive materials include certain types of explosives.

- A **water-reactive** chemical is one that reacts with water and produces a gas that is flammable or poses a health hazard. Examples of water-reactive chemicals include alkali metals such as sodium, and acid chlorides.

These materials must be properly stored, handled and used to prevent the potential for fire, explosion and/or chemical reaction that can result in serious physical injury and property damage. It is important to review the Material Safety Data Sheet (MSDS) for chemical safety information and to receive chemical safety training for the materials used at your facility to ensure proper storage, handling and emergency response procedures.

The three principal approaches for hazard control are similar for both chemical hazards and physical hazards and consist of:

- Engineering Controls
- Administrative Controls
- Personal Protective Equipment

Engineering Controls

Engineering controls can focus on controlling the source of the hazard, the work environment or contact with the worker. These controls are accomplished via the following methods:

Design Phase Safety Review

- The design phase safety review allows the integration of safety into the plant operation from the start. During the design phases of a new plant or process or the addition of a new piece of equipment, safety reviews are conducted to identify and eliminate potential safety hazards prior to construction or installation.
- This process eliminates the hazard and is more economical than retrofitting control measures after the fact. It is also important during the design safety review to consider potential safety concerns associated with maintenance activities.[2]

Substitution

- This involves replacing a hazardous piece of equipment, process or material with a less hazardous alternative.
- Typically, equipment substitution is the most common and least expensive followed by hazardous material substitution, and lastly entire process substitution.
- When substituting one material for another it is important to find a material that meets all of the process requirements while reducing the current hazard and not creating a new hazard.
- Material substitution can also take the form of reducing the concentration or form of a hazardous substance. In other words, use a dilute solution or a liquid form instead of gaseous form.[3]

Isolation

- Isolation establishes a barrier between the potential hazard and personnel that might be affected by it.

Ventilation

- This is the most common method of hazard control for airborne contaminants. There are two types of ventilation: local exhaust ventilation and general (dilution) ventilation.
  - Local exhaust ventilation consists of hoods, ducts and fans to capture the hazardous material at its source of generation and remove it from the work area. This type of system must be properly designed to capture and transport the hazardous material and must be properly maintained.
  - General or dilution ventilation can either provide air to or remove air from the work area to control airborne contaminants. General ventilation may take the form of open windows and doors, roof ventilators, fans, blowers or wall/roof exhaust fans. This type of ventilation is limited to situations where small amounts of a contaminant are produced at a constant rate, the distance between the worker and the source of contamination is enough to allow dilution, the contaminant has relatively low toxicity, the exhausted air does not have to be filtered or treated and the contaminant is not corrosive.

Administrative Controls

Administrative controls can take many forms, such as those listed below.

Housekeeping

- This includes the removal of dust accumulations, spill cleanup, equipment decontamination, equipment maintenance and general cleanliness.

Hazardous Materials or Transfer Procedure

- This ensures that chemicals are stored, transported and used appropriately.

Leak Detection Programs

- These provide early warning about potential leaks or process upsets. These are usually in the form of visual inspections or automatic sensors that allow for process shut down and timely corrective action prior to significant worker or public exposure.

Training

- Training is one of the most common administrative controls and is an effective method for reducing the risks of injury or illness. Workers should be trained to understand the potential hazards associated with their activities and what protection methods or devices are available.

Work Schedule Modification

- Worker schedule modification is sometimes used to reduce worker exposures to hazardous materials by limiting the amount of time the worker works with that material so that the OSHA Permissible Exposure Limit (PEL) or other exposure guideline is not exceeded.

Personal Hygiene

- Personal hygiene is a procedural approach aimed at removing chemical substances from exposed skin and clothing either caused by routine work activities or from an accidental spill or release. Personal hygiene practices involve the provision of appropriate and convenient cleaning facilities such as showers, locker rooms, cleaning agents and emergency eyewashes and showers.

Medical Surveillance

- Medical surveillance is useful for evaluating employees and assessing the effectiveness of your hazard control program. It entails the use of a qualified physician familiar with your workplace, tasks and potential hazards. Regulatory requirements require medical surveillance of employees who have to wear respiratory protection or work with certain substances such as lead, asbestos or methylene chloride.

Personal Protective Equipment

Personal Protective Equipment (PPE) consists of the following:

Respiratory Protection

- This is used to control worker exposure to airborne hazardous materials whenever engineering controls are not feasible or are not being implemented. It is important the respirator selected and given to the employee is appropriate for the type and severity of the hazard. The use of respiratory protection should be done in accordance with a comprehensive respiratory protection program that includes fit testing, medical evaluation, respirator selection and respirator maintenance.

Protective Clothing

- Protective clothing typically includes gloves, coveralls, suits and aprons to protect against a variety of hazards including chemical, electrical and thermal.

Head, Eye, Hand and Foot Protection

- This is required whenever there is a potential for physical injury and includes hard hats, safety glasses/goggles, work gloves, chemical resistant gloves and safety shoes.

Exercise

1. The three principal approaches to hazard control are: engineering controls, administrative controls and ____.

2. An individual inhales a high concentration of chlorine gas and develops an irritation of the eyes, nose, and throat, followed by coughing, wheezing, and chest pain. This is an example of __________________ exposure.

In the State of Pennsylvania, two laws govern the occupational use of hazardous materials:

- The Federal Occupational Safety and Health Administration (OSHA) Standard 29 CFR 1910.1200 – Hazard Communication (Haz Com), which covers all private and public sector employers.
- The Pennsylvania State Worker and Community Right-to-Know Act (RTK), which covers all state employers and establishes similar requirements provided in the Federal Haz Com Standard, with slight variations.

Identifying and Inventorying Hazardous Material

The first step in developing a facility hazard communication program is to identify and inventory all of the materials used in everyday plant operation, laboratory work and maintenance activities. It is also important to consider materials that might be brought on-site by contractors and the potential for local industries to accidentally discharge chemicals to the waterways that feed your intake system. Once a complete chemical inventory has been developed, the materials should be categorized by hazard.

The PA State RTK Law requires public sector employers to list all hazardous materials on the Hazardous Substance Survey form.

Obtaining Information and Determining Potential Hazards

The second step is to obtain information about each of the chemicals identified in your chemical inventory. This information is generally provided by the chemical manufacturer or distributor and commonly takes the form of a Material Safety Data Sheet (MSDS).

A MSDS is a document produced by the chemical manufacturer and provided to the users in accordance with the Federal and State requirements. The MSDS provides useful information about the chemical and can be developed in a variety of formats; however, it should include the following complete information:

- The chemical manufacturer's name, address, contact number, emergency number and the date of preparation.
- The chemical name, common name and synonyms.
- Identification of the hazardous ingredients of the substance and its composition.
- A summary of the recommended exposure limits or OSHA PEL.
- Fire and explosion hazard data.

- Reactivity data.
- Health hazard data.
- Precautions for safe handling and use.
- Hazard control methods.

Chemical substances should not be received at your facility without a complete MSDS. The purpose of the MSDS is to provide readily available safety information for the operators. Therefore, you should be aware of the location of your facilities MSDS file and be trained to review and understand the information provided on the MSDS and implement the appropriate control procedures. MSDS's should be stored in convenient location at your facility so that they are readily available for use.

A generic MSDS produced by OSHA as a guideline is included in Appendix A.

Labeling Hazardous Materials

Following the development of a complete chemical inventory and hazard assessment, a labeling and training program must be implemented to ensure that hazards are communicated to facility employees and visitors.

- Containers with chemical substances must be labeled in order to identify the containers contents and potential hazards. Chemical manufacturers and distributors are required by law to label all containers shipped to your facility and each label must contain the following minimum information:
  - Identity of the chemical and the hazardous constituents.
  - Appropriate hazard warnings such as: flammable, toxic or corrosive.
  - Symptoms of exposure.
  - Precautions against exposure.
  - Emergency response and treatment.
  - Safe use conditions.
  - Name and address of the chemical manufacturer or responsible party.
- Containers that are received at your facility without appropriate labels should be returned to the supplier.
- Chemical containers, process equipment and piping at your facility must be provided with appropriate labels that identify the hazardous material and hazard warnings.
- There are a variety of acceptable labeling methods. Most are standardized methods that rely on a combination of color-coding for hazard levels, numbering systems, and pictographs.
- The most common labeling systems include:
  - The National Fire Protection Association (NFPA) 704 system
  - The Hazardous Material Identification System (HMIS)
  - Other private labeling systems such as J.T. Baker Chemical Company and SIGNMARK.

The following are examples of some of the different types of labels you might encounter.

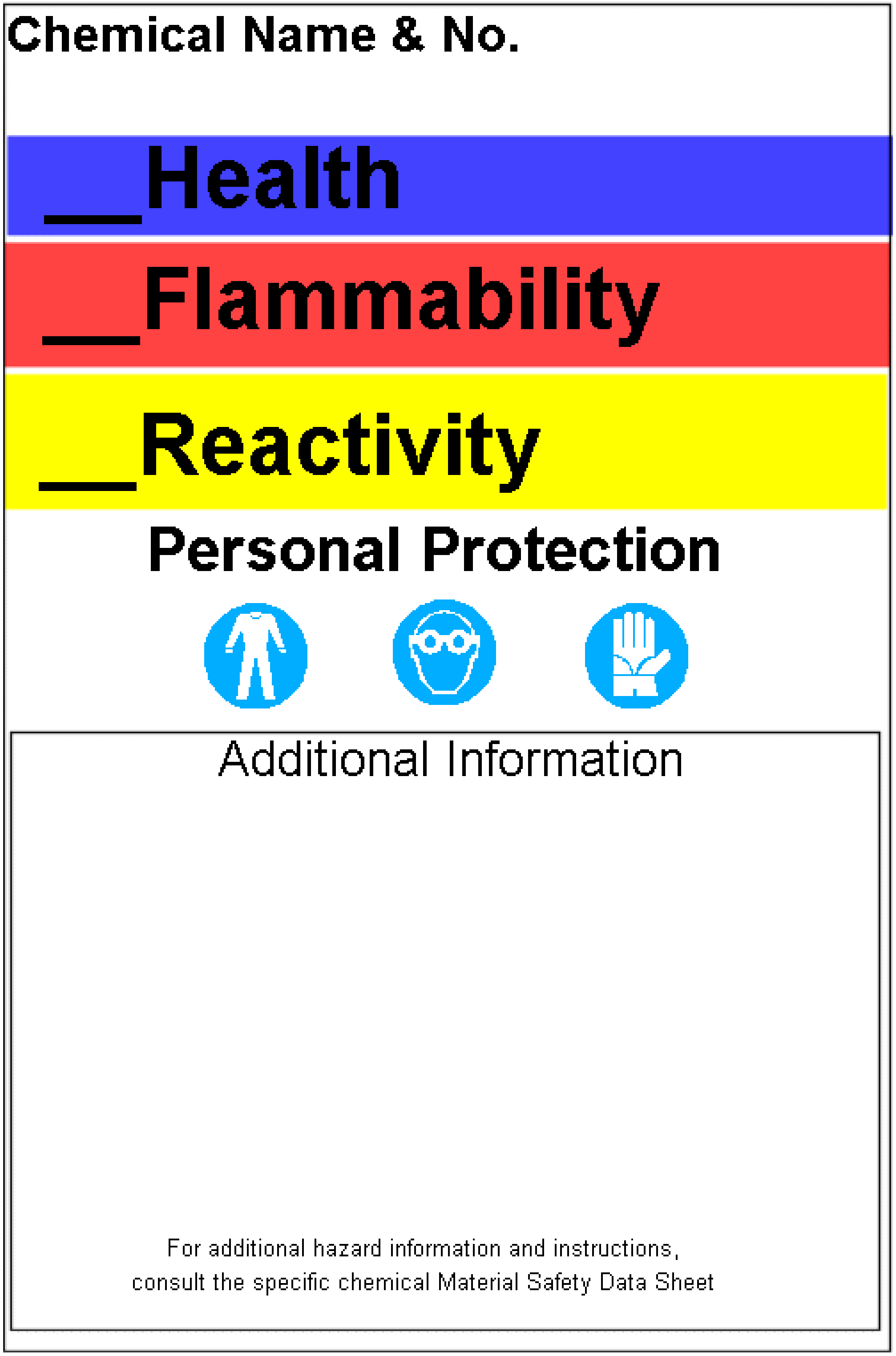

Figure 2.2 Hazardous Materials Information System Label[5]

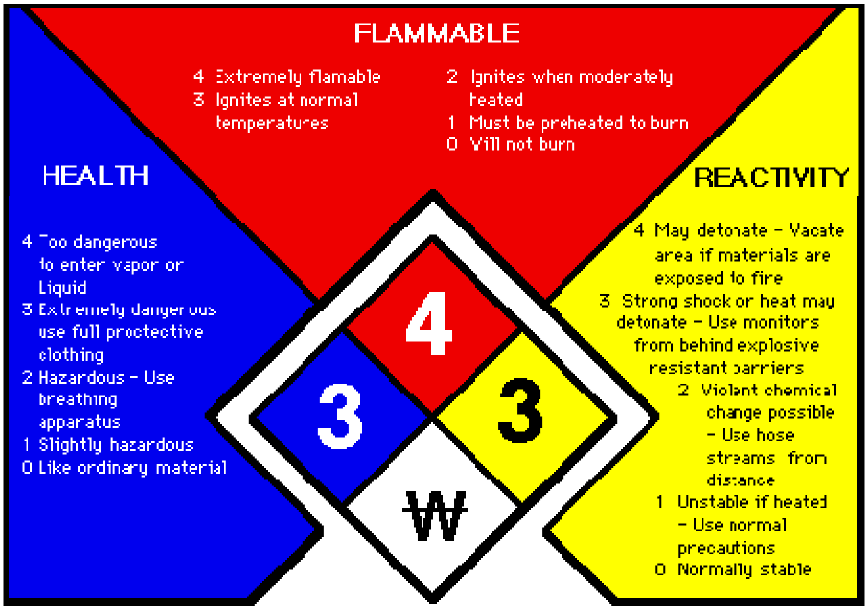

Figure 2.3 National Fire Protection Association Label[6]

Training Employees

The final step in implementing a hazard communication program is to provide training to plant employees. Hazard communication training must be provided to employees under the following circumstances:

- Prior to their working with hazardous materials.
- If any changes are made to the process.
- If new hazardous materials are introduced.
- Periodically as needed.
- The PA RTK Law requires that public sector employees receive training on an annual basis.

Employee training should be based on the specific chemical substances that you will be using during the course of plant operation and maintenance. Minimally, the training should accomplish the following:

- Identify the Hazardous Communication and PA State Right-To-Know requirements.
- Identify the potentially hazardous operations and substances that you may be exposed to during plant operation and maintenance.
- Provide emergency response procedures for handling non-routine situations.

- Identify the MSDS file, its location and teach you how to read and interpret the MSDS information.
- Identify the labeling format to be used at the facility.
- Document that you have completed the appropriate training.

This training is extremely important for you and your coworkers to ensure that you know the hazards associated with your job and the methods to control them.

Also, contractors that come on plant property to perform work should be provided with training on the hazardous materials on site, their location, how to avoid exposure and emergency procedures. Contractors should also provide you with copies of the MSDS for any material they bring onto your site.

Chemicals Used in Treatment

Exercise

Using Table in Appendix B, answer the questions asked by your facilitator.

The OSHA Process Safety Management Standard (29 CFR 1910. 119) was enacted to provide for the safe handling and use of highly hazardous materials such as chlorine and sulfur dioxide if used in quantities over a certain threshold. Consult your supervisor about your facility's Process Safety Management Program if applicable.

It is important to remember that each chemical has different requirements and therefore it is important to review all of a chemical's safety information prior to working with it.

Laboratory Reagents

Laboratory technicians must be trained in the proper storage and handling of the materials used in the laboratory and how to respond in the case of an emergency. They must also receive training on the selection and use of PPE necessary for laboratory work. At a minimum, laboratory personnel should wear safety goggles and disposable chemical resistant gloves. Also, each laboratory must be equipped with safety equipment such as laboratory fume hoods, fire extinguishers, eyewash, safety shower, spill response kit and the appropriate PPE.

The OSHA Laboratory Chemical Hygiene Standard (29 CFR 1910.1450) establishes the requirements for laboratory operations.

Chemicals Used in Maintenance

The following hazardous materials are commonly used during plant maintenance activities and consideration should be made for safety:

Pipe Grouts

- Pipe grouts used in pipe construction and repair contain a number of potentially hazardous materials that produce health hazards and are also flammable.

- Two common components of pipe grout are considered toxic: acrylamide and 2-nitropropane.
  - Acrylamide has an OSHA PEL of 0.03 mg/m^3, an IDLH of 60 mg/m^3, and is considered a skin hazard due to its ability to absorb through the skin. The most significant health effects of acrylamide exposure include central nervous system damage, cancer and reproductive effects. Therefore, it is imperative that exposure to acrylamide be controlled by using adequate ventilation in conjunction with appropriate PPE. PPE should include gloves (e.g. butyl rubber), body protection, safety glasses/goggles and if necessary, respiratory protection.
  - 2-nitropropane, in addition to its irritating effects, can cause heart, liver and kidney damage; bleeding of the gastrointestinal tract; and cancer. OSHA has established a PEL of 25 ppm and the IDLH is 100 ppm. Again, adequate ventilation is necessary to prevent inhalation exposure as well as PPE in the form of chemical gloves, body protection, safety glasses/goggles and appropriate respiratory protection.

- It is important that you review the MSDS for pipe grouts prior to their use and that all safety precautions have been considered and implemented.

Paints and Coatings

- Pipes, chambers, tanks and facilities require different types of paints and coatings. These paints and coatings and their associated solvents and thinners give off potentially hazardous vapors from a health and flammability standpoint.

- Acute health effects may include dizziness, euphoria, fatigue, central nervous system depression, and unconsciousness.

- Chronic exposures can result in liver damage, lung damage, central nervous system disorders, and cancer. Hazard controls involve the use of adequate ventilation and respiratory protection for organic vapors.

- An additional consideration when removing old paint is the potential for lead-containing paint. The removal of lead paint can produce dangerous airborne concentrations of lead dust, and in the case of torch cutting, lead fume. Paint should be tested for lead content prior to its disturbance. If lead is present, control measures must be established. These can take the form of lead paint abatement by a licensed contractor or the development of lead paint disturbance procedures by in-house personnel. The OSHA Lead in Construction Standard (29 CFR 1926.62) establishes hazard control requirements for working with lead.

Welding and Cutting

- Welding and cutting occur routinely throughout the facility and can pose physical hazards associated with compressed gasses, flammable gases, hot welding slag and heat, which can ignite surrounding materials. It is important to remove combustible materials from welding locations and to observe strict gas cylinder safety procedures.

- Gas cylinders should never be brought into a confined space in case a cylinder leaks and creates an oxygen deficient or flammable atmosphere.

- If you are performing welding and cutting make sure that you have the appropriate PPE in the form of leather gloves, welding coat, and welding hood with the correct lens shade for the type of welding that you are performing.

- Hazardous fumes and gases can be produced depending on the type of welding being performed, the base metal, coatings or contamination of the base metal (greases, oils, solvents) and the welding rod. These fumes and gases evolve from the materials being welded, the base metal, coatings and chemical reactions with the surrounding air.

- Welding can present a number of hazards that include UV radiation, nitrogen dioxide, mild steel, stainless steel, galvanized steel and flux coating.

Ultraviolet (UV) Radiation

- UV radiation can cause conjunctivitis and retina damage in the eyes. UV radiation can also react with chlorinated solvents such as 1,1,1-trichloroethane to produce phosgene gas, which is a very irritating and toxic gas. Phosgene gas can be very deadly in low concentrations (OSHA PEL = 0.1 ppm, IDLH = 2.0 ppm) and therefore, welding areas should be kept free of chlorinated solvents. The welding arc should be shielded and the welder should wear the appropriate lens shade for eye protection.

  Ozone is also produced as a result of UV reaction with oxygen in the surrounding air. Ozone is an eye, nose, and throat irritant and can result in chronic pulmonary disease, premature aging, and the growth of lung tumors. Sufficient ventilation is necessary to control the hazards associated by ozone build-up.

Nitrogen Dioxide

- This is a reddish brown gas produced around electric arc welding. It can cause nose and throat irritation and lead to more serious illnesses such as emphysema and pulmonary edema (lungs fill up with fluid). High concentrations can build up quickly in confined spaces and cause death. The OSHA PEL is 5 ppm with an IDLH of 20 ppm. Proper ventilation and personal protective equipment is essential.

Mild Steel

- Welding on mild steel will produce iron oxide fume, which is not particularly hazardous. However, in sufficient concentration iron oxide fume can produce bronchitis and “metal fume fever” which is a short-term health effect similar to the flu.

Stainless Steel

- Stainless steel, which contains cadmium and nickel, which are lung carcinogens. Cadmium has an OSHAL PEL of 0.005 mg/m^3 and an IDLH of 9 mg/m^3 and is covered under the OSHA Cadmium Standard (29 CFR 1910.1027). Cadmium produces significant respiratory system problems, kidney and blood disorders, as well as lung and prostate cancer. Nickel has an OSHA PEL of 1 mg/m^3 and an IDLH of 10 mg/m^3 and can produce lung and nasal cancer in addition to dermatitis and allergic asthma. Welding on stainless steel should only be performed when sufficient local exhaust ventilation is supplied and/or the welder is equipped with an air-purifying respirator with a high efficiency particulate cartridge.

Galvanized Steel

- Galvanized steel contains zinc that can be produced as zinc oxide fume when welding, brazing or cutting is performed. The inhalation of zinc oxide fumes can produce symptoms called zinc chills or metal fume fever. This condition manifests itself in the form of chills, fever, nausea, muscular pain, dryness of the mouth and throat, headache and fatigue. These symptoms usually abate within 12 to 24 hours of exposure.

Flux Coatings

- Flux coatings are a typical component of welding rods and serve the purpose to protect the weld from deteriorating while it cools. However, welding fluxes can produce an irritating fume when heated. Some fluxes contain fluoride, which can burn the eyes and skin on contact. Excessive inhalation of fluoride fumes can result in fluoride buildup in the bones.

Fuels

- Fuels inherent in plant operations to power vehicles, equipment and generators and to provide heat.
- Fuels include gasoline, diesel fuel, heating fuel, and acetylene for welding and cutting operations.
- Primarily the fuels are composed of petroleum hydrocarbon based compounds that pose significant flammable and combustible hazards.
- Fuels must be stored and handled properly in order to prevent fire or explosion. Fuel containers must be approved for their use and transfer of fuels from one container to another should be performed using appropriate grounding and bonding procedures.
- Petroleum based fuels contain a variety of hydrocarbon compounds that pose potential health hazards. Gasoline, for example, contains benzene, toluene, ethyl benzene and xylenes, which can cause dizziness, euphoria, irritation of the mucous membranes, dermatitis, central nervous system disorders, liver damage, blood disorders and in the case of benzene, leukemia.
- Acetylene gas is used in compressed gas cylinders and presents a significant fire hazard especially in combination with oxygen. Compressed cylinder safety is a must when dealing with oxygen/acetylene welding and cutting and safe use procedures must be established and followed. Cylinders must be in good condition and constructed and maintained in accordance with US DOT requirements. The cylinders should be stored upright, with the valve caps on when not being used, and secured to prevent tip-over. Acetylene should be stored in a dry, well-ventilated area, protected from heat, sparks, flame, electric current and direct sunlight. Oxygen cylinders must be stored at least 20 feet away from acetylene or other flammable gases or separated by a five-foot high fire resistant partition with a fire rating of at least 30 minutes. Acetylene gas also poses an asphyxiation hazard. Leaking cylinders should be removed to the outside immediately and the supplier contacted. Compressed gas cylinders should not be brought into a confined space.

Respiratory Protection Equipment

Respiratory protection consists of two categories: air purifying respirators and air supplying respirators. In simple terms air purifying respirators filter or "clean" the ambient air that you breath and require sufficient ambient oxygen, typically >19.5%. Air supplying respirators supply contaminant free breathing air either through an air compressor, air tank and supply line, or in the form of a Self Contained Breathing Apparatus (SCBA).

Air Purifying Respirators

The following summarizes the major types of air purifying respirators.

Nuisance Dust Masks

- Nuisance dust masks are loose fitting, surgical-type masks used primarily for protection against nuisance dusts such as saw dust or gypsum board dust.
- A dust mask offers minimal protection and is not effective in providing protection against hazardous materials or in oxygen deficient atmospheres (<19.5% oxygen).
- They usually do not require a fit test, however, some models do and it is important to check with the manufacturer.

Figure 2.7 Nuisance Dust Mask[7]

Air Purifying Respirators (APRs)

- These come in either a half-face piece or full-face piece depending on the desired protection level.
- APRs are negative pressure respirators that rely on the wearer to draw ambient air through a cartridge.
- APRs are made of malleable materials that provide a tight fit to the face to provide a seal and prevent contaminants from entering into your breathing zone.
- The face piece is equipped with cartridges or canisters that filter, absorb/adsorb, or neutralize contaminants to prevent them from entering the breathing zone. These cartridges are specific to certain contaminants and it is important to make sure that the appropriate cartridge is being used.
- APRs do not supply breathing air and are not effective in oxygen deficient atmospheres or when contaminant concentrations exceed the respirators protection factor.
- Typically half-face piece APRs have a protection factor of 10 while full-face piece APRs have a protection factor of 50 and also provide eye protection.
- The protection factor (PF) is defined as the concentration of contaminant outside of the respirator divided by the concentration inside the respirator.
- APRs provide excellent respiratory protection when contaminants and their concentrations are known and there is sufficient oxygen. They require that employees be medically qualified to wear them and that the employees be fit tested on the specific respirator model that they are assigned.
- PAPRs are similar to regular APRs except that they are equipped with a small motor that draws ambient air through a filtering cartridge and delivers positive pressure air to the facepiece.

Figure 2.8 Air Purifying Respirators[8]

Air Supplied Respirators

Air supplied respirators provide a contaminant-free breathing atmosphere (at least Grade D breathing air as specified in the ANSI/Compressed Gas Association Commodity Specification for Air, G-7.1-1989) to the user.

They are available in various combinations but typically fall into two categories: airline respirators and self contained breathing apparatus (SCBA). Personnel using air-supplied respirators must receive specific training and be provided with sufficient support personnel when using the equipment in order to monitor air supplies.

Airline Respirators

- These are equipped with a face piece similar to an APR except that the face piece is connected by an airline to a stationary breathing air supply, typically an air compressor or air tank. No filtering cartridges or canisters are used.

- Airline respirators provide a protection factor of about 2,000 but limit the mobility of the wearer since they are tethered by the airline to the air supply.

Figure 2.9 Airline Respirators[9]

SCBAs

- SCBAs offer the greatest protection against airborne contaminants and are required equipment for emergency response activities especially when dealing with unknown contaminants, unknown contaminant concentrations and/or IDLH atmospheres.

- SCBAs offer a protection factor of about 10,000 and provide the wearer with free mobility as the air supply is in a tank worn by the user. The SCBA is limited to the amount of air the tank can hold. Therefore, time limitations are placed on the user.

Proper Use of Respiratory Equipment

A respiratory protection program in accordance with the OSHA Respiratory Protection Standard, 29 CFR 1910.134, should be in place at your facility if respirators are used. The program must include the following elements:

- Procedures for selecting respirators.
- Medical evaluations for employees required to wear respirators.
- Fit testing procedures for tight fitting respirators.
- Procedures for the proper use or respirators in routine and reasonably foreseeable emergency situations.
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding and maintaining respirators.
- Procedures to ensure adequate air quality, quantity and flow of breathing air for air supplying respirators.
- Training of employees in the respiratory hazards to which employees may be exposed during routine and emergency situations.
- Training of employees in the proper use of respirators, including putting on and removing them, the limitations on their use and respirator maintenance.
- Procedures for the regular evaluation of the respiratory protection program.

As part of the respiratory protection program, respirator users must be trained, medically qualified and properly fit tested. Fit testing procedures are established in the OSHA Respirator Standard and can be either qualitative or quantitative. Qualitative fit testing involves the use of a challenge agent such as irritant smoke, banana oil or saccharin to ensure that the respirator fits appropriately. A qualitative fit test utilizes a computer model that computes a numerical fit factor for the specific individual.

Respirator selection must be made by a qualified person who is familiar with the potential atmospheric hazards at your facility. Respirators must be selected based on the hazard posed and the protection offered by the respirator. Also, chemical cartridges for APRs must be selected based on their protection against a particular contaminant.

All respirators must be stored so that they are protected against damage, contamination, dust, sunlight, extreme temperatures, excessive moisture and damaging chemicals.

Gloves

Examples of glove materials most suitable for some of the materials that you will be working with are listed in the following table.

Table 2.1 Glove Materials

Chemical	Glove Material
Chlorine and Chlorine Dioxide	neoprene, butyl rubber, nitrile rubber, and teflon.
Sodium Hypochlorite	natural rubber, neoprene, nitrile rubber, polyvinyl chloride
Acids	butyl rubber, natural rubber, neoprene, nitrile rubber, polyvinyl chloride, Teflon
Bases	butyl rubber, natural rubber, neoprene, nitrile rubber, polyethylene, polyvinyl chloride, teflon, and viton
Polymers	butyl rubber, teflon
Resins	polyvinyl alcohol, Teflon, viton
Gasoline and diesel	nitrile rubber, polyvinyl alcohol, Teflon, viton

The following concepts are also important to understand when selecting a suitable glove:

- **Permeation** is the molecular diffusion through a chemical protective material, which is not noticeable by the naked eye.

- **Breakthrough time** is the time a chemical takes to pass through a protective material and detected by an analytical instrument.

- **Permeation rate** is the rate at which a material passes through a material after it has broken through.

- **Degradation** is the physical change in a protective material caused by the chemical. This can range from no effect to completely dissolving the material.

- **Penetration** occurs as the chemical flows through a protective material at tears, pinholes, rips and other defects.

- Ensure that the protective gloves provided to you are inspected regularly and kept in good condition.

- Gloves that show signs of degradation, defects, rips, tears or punctures should be discarded.

- Gloves should be routinely washed (unless disposable) and stored in a dry location away from sunlight, chemicals and heat.

Footwear

- Protective footwear should conform to the requirements of ANSI Z41-1991, American National Standard for Personal Protection-Protective Footwear.

- Safety footwear is available for chemical protection and should be used when foot contact with materials is anticipated.

- Rubber boots, latex and polyvinyl chloride booties and disposable Type® shoe covers should be used to protect your feet from chemical exposure and to prevent your regular shoes from being contaminated, thereby bringing that contamination home to your family.

Body Protection

Typically, body protection at your facility will include a splash apron, basic cotton or polyester blend coverall, a disposal Type® suit or a polyethylene coated Type® suit.

- Basic coveralls are primarily used to prevent other clothes or your skin from becoming soiled. They do not offer much protection from chemical exposure and are not water resistant.

- Disposable suits such as those made of Type® material offer protection against dirt and hazardous dusts such as lead and asbestos. They are relatively porous and offer limited protection against hazardous liquids, gases, mist or vapors. Some disposable suits are coated with a polyethylene material (e.g. polycoated Tyvek®) to provide added protection against hazardous liquids; however, their protection against vapors and gases is limited.

- Emergency response personnel may be required to don extensive chemical protection in the form of chemical resistant suits and fully encapsulated suits. These suits are made of various materials, similar to the chemical resistant gloves that are designed to protect against specific chemical substances. The same concepts of permeation, breakthrough time, permeation rate, degradation and penetration used for gloves apply to chemical resistant suits. These suits, in conjunction with gloves, footwear, respiratory protection, safety eyewear and hearing protection complete the full ensemble of emergency response PPE. Only those specifically trained in emergency response procedures and the use of emergency response PPE should respond to emergency situations and/or wear emergency response PPE.

[1] Michelle M. Schaper, PhD and Michael S. Bisesi, PhD, CIH, "Environmental and Occupational Toxicology", in *The Occupational Environment – Its Evaluation and Control*, (Fairfax, VA: American Industrial Hygiene Associateion, 1997), p.64.

[2] S.Z. Mansdorf, *Complete Manual of Industrial Safety* (Prentice Hall, 1993), pp. 254-257.

[3] Mansdorf, pp. 254-257.

[4] www.OSHA.gov

[5] www.safetyinfo.com

[6] www.safetyinfo.com

[7] www.safetyinfo.com

[8] www.safetyinfo.com

[9] www.safetyinfo.com

Unit 3 – Other Hazard Sources at Treatment Plants

Learning Objectives

- List and explain the sources of mechanical hazards and electrical hazards at a Treatment Plant.
- Describe the Lockout/Tagout Program and eye protection requirements as they relate to mechanical hazards in a Treatment Plant.
- Describe the sources and exposure limits for noise in a Treatment Plant and explain the role of a hearing conservation program, noise reduction and hearing protection.
- Name four sources of slip, trip and fall hazards in a Treatment Plant and explain what can be done to minimize or prevent those hazards.
- List six safety considerations when excavating.
- Explain the importance of inspections in regards to excavations.
- Explain the protective systems used for excavations.
- List and explain four soil classifications.
- Describe the characteristics of a Permit-Required Confined Space and the elements of a Confined Space Entry Program.
- List four classes of fire and describe the proper methods for storing and handling flammable material.
- Describe a typical Fire Response Plan and list three sources of reference information related to fire hazard prevention.
- Explain manual lifting limits, proper lifting procedure and the NIOSH lifting equation.
- Describe the Pennsylvania requirements for traffic safety and work zone isolation.

Rotating Equipment

Rotating equipment such as fans, blowers, motors, drive belts, gears, pulleys, blades and shafts pose a significant hazard for fingers, clothing and tools to be caught in the rotating parts, resulting in serious injury.

Guarding

- Rotating shafts, drive belts, couplings, etc. must be guarded and guards should not be removed for any reason other than maintenance.

- OSHA has established machine-guarding requirements in its Machine Guarding Standard (29 CFR 1910.212) and has published a reference booklet, *Concepts and Techniques of Machine Safeguarding* (publication No. 3067), that establishes methods of machine guarding.

- Workers should not wear loose fitting clothing, rings or jewelry when working around this equipment. Also, if you have long hair it should be secured.

- Prior to working on rotating equipment, you must ensure that the equipment is shut down and all energy sources have been locked out in accordance with your facilities lock out/ tag out program. Upon completion of the work and prior to restarting the equipment after a shutdown, follow appropriate restart procedures to include:
  - Removing all tools and materials.
  - Replace all guards.
  - Ensure that all personnel are clear of the equipment.
  - Restart.

Centrifugal Force

- During restart it is important to keep people away from the area as centrifugal force caused by the rotating equipment can throw dusts, oils, loose metal, materials and tools from rotating shafts and couplings.

Crushing

Conveyor Rollers

- Crushing hazards are usually associated with conveyors, presses, hoisting equipment and moving machinery such as trucks and backhoes.
- Again, machine guarding should be employed where practical and extreme caution must be used when working around heavy equipment and hoists. Most conveyors are equipped with an emergency stop—you should be familiar with this device.

Equipment Movement

- Heavy equipment operators must be appropriately trained and authorized for the type of equipment they are operating and they must ensure that the machinery is in good working condition by performing daily inspections.
- Hoisting equipment should be appropriate for the material being lifted or lowered and within the safe lifting limits of the hoist and lifting devices (chains, slings, cables).
- Areas where potential crush hazards exist should be barricaded to prevent people from accidentally being struck.
- Lock out/tag out must be used whenever equipment is to be worked on.

Lockout/Tagout Program

Standard operating procedures should be established for all equipment that has the potential for accidental startup or movement caused by an energy source such as electricity, hydraulics, pneumatic, rotating equipment, gravity, stored energy, pressure and water flow.

Purpose

These procedures usually are in the form of a lockout/tagout program. The purpose of a lockout/tagout program is to ensure that all personnel follow standardized shutdown and startup procedures to prevent accidental equipment start up, energization or release of stored energy and personal injury or property damage.

OSHA has established requirements for energy isolation, lockout/tagout in the Control of Hazardous Energy Standard, 29 CFR 1910.147 and the Electrical Safety Standard, 29 CFR 1910.333(b).

A lockout/tagout program should include the following basic elements:

- An energy control program that consists of energy control procedures for each piece of equipment, employee training and periodic inspections to ensure that the appropriate procedures and energy isolation is being performed.

- Lockout/tagout must be used to provide full protection for workers when performing maintenance or repair on equipment. If the energy isolating device for a piece of equipment is capable of being locked out then the energy control procedure should use a standardized lockout device similar to those shown in the figures below. A lockout device uses a positive means such as a lock, chain, blank flange, wedge, block or slip blind to prevent the energizing of a machine or equipment.

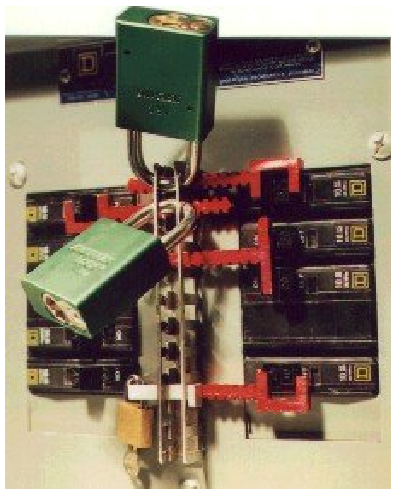

Figure 3.1 Lockout Device for Circuit Breakers[1]

Figure 3.2 Typical Lockout Device[2]

- A standardized tagout system must be used if an energy-isolating device is not capable of being locked out.

A **tagout device** is a prominent warning, such as a tag, which can be securely fastened to an energy-isolating device to indicate that the energy isolating device and equipment are not to be operated until the tag is removed.

- The tags should have appropriate warning language such as: *Do Not Start, Do Not Open, Do Not Close, Do Not Energize, Do Not Operate.* The following two figures are examples of tagout devices.

Figure 3.3 Warning Tags[3]

A combination of both a lockout device and tagout device is recommended when possible to ensure the most protection.

Energy Control

- Energy control procedures should be developed, documented and used.
- The procedures should state the intended use of the procedure; the steps and responsibility for the placement, removal and transfer of lockout or tagout devices; and the requirement for testing a machine or equipment to ensure that the lockout/tagout devices are effective in controlling the hazardous energy.

Training

- Training should be provided to all employees that will be performing maintenance or may be affected by the maintenance.

- The training should include the purpose and function of the energy control program and the procedures for the safe application, use, and removal of the energy controls such as locks or tags.

Sample Lockout/Tagout Procedure

A sample lockout/tagout procedure at your facility might look something like this:

- An authorized employee who knows the type and extent of energy a piece of equipment uses and the associated hazards will notify all affected employees that a lockout or tagout system is going to be used and the reason why.

- Shut down the equipment by the normal shut down procedure.

- Operate the switch, valve or other energy-isolating device to ensure that the equipment is isolated from its energy source.

- Ensure that stored energy that may be in springs; elevated equipment parts (gravity); rotating flywheels; hydraulic systems; pneumatic systems; or gas, steam or water pressure is dissipated or controlled by venting, bleeding, blocking or repositioning.

- Apply the lockout or tagout device in accordance with your procedures.

- Perform a final energy isolation test by operating the start button or normal operating controls as a check to make sure that the energy source is isolated. This should only be done after making sure that no personnel are exposed and all tools and equipment are out of the area of operation. After completing the test make sure that all operating controls are reset to the neutral or off position.

- Proceed with the necessary maintenance or repair work.

- Upon completion of the work, remove all tools, reinstall the guards, and clear the area of all personnel.

- Remove the lockout or tagout device and restore energy to the equipment.

How does the lockout/tagout procedure at your plant differ from the sample procedure above?

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Outside Contractors

- It is extremely important that any contractors brought into your facility to perform work be familiar with that lockout/tagout program and procedures at your facility.

- Communication and coordination must be established between your facility and contractors when shutting down or restarting energized equipment. Prior to the start of any contractor work at your facility a meeting should be held to review the equipment to be shutdown, the schedule, the lockout/tagout procedures to be used, the restart time and the restart procedures.

Never remove a lock or tag unless it is your own and you have followed the appropriate procedures.

Eye Protection

Requirements

- Eye protection should be worn whenever there is a potential for flying objects, debris or exposure to chemicals or hazardous light radiation from welding or cutting.

- Eye protection should conform to the requirements of ANSI Z87.1 – 1989, American National Standard Practice for Occupational and Educational Eye and Face Protection.

Welding Lens Shades

- Lens shades used for protection against radiant energy during welding or cutting should be appropriate for the type of activity being performed and in accordance to guidelines established in OSHA standards.

Serious injury from electrical shock often occurs to personnel who attempt to repair or troubleshoot electrical equipment when not qualified or authorized to perform work on the equipment.

It is important to keep in mind that all electrical systems are considered to be energized until a qualified electrician verifies that it is de-energized and, therefore, you must not perform work on electrical equipment unless you are qualified and authorized to do so.

A qualified person is one who has specific training in the following:

- Distinguishing live exposed parts from other parts of electrical equipment.
- Determining the nominal voltage of exposed live electrical parts.
- Determining the clearance distances required for working with or near various voltage lines.

The most common shock-related injury is a burn. Electrical accident burns take three forms and can occur simultaneously.

- Electrical burns result from electric current flowing through body tissue or bone. The heat generated by the current flow through the body causes the tissue damage. Electrical burns are one of the most serious injuries and should be given immediate attention.
- Arc burns, or flash burns, result from high temperatures near the body caused by an electric arc or explosion.
- Thermal contact burns occur when the skin contacts hot surfaces of overheated electric conductors, conduits, or other energized equipment. This can also cause clothing to ignite and produce additional thermal burns.

Electric shock can also cause secondary injuries such as bruises, bone fractures and death as a result of falls or striking objects caused by electric shock induced involuntary muscle contractions.

Electrical Hazard Control

Electric arcs caused by short circuits can cause injury or start a fire. High-energy arcs can damage equipment and cause fragmented metal to fly in all directions. Even low energy arcs are capable of causing violent explosions in atmospheres containing flammable gases, vapors or combustible dusts.

Electrical accidents are typically the result of unsafe equipment or installation, environmental effects and unsafe work practices.

Electrical hazards can be controlled by:

- **Insulation**
  Insulation such as glass, mica, rubber and plastic is used on conductors to prevent shock, fire, and short circuits. Before you work with electrical equipment, especially power tools and extension cords always check the insulation before connecting to a power source to be sure that there are no exposed wires.

- **Guarding**
  Guarding against accidental contact must be provided on the live parts of electrical equipment at 50 volts or more. Guarding is usually achieved by: 1) location in a room, vault or enclosure accessible only to qualified persons, 2) using permanent partitions or screens to keep unqualified personnel away, 3) location on a balcony or platform elevated and arranged to exclude unauthorized personnel, or 3) elevation of 8 feet or more above the floor or work surface. Also, entrances to rooms or other guarded locations with exposed live parts must be posted with conspicuous warning signs.

- **Grounding**
  This is a secondary means of protection in which an intentional conductive connection is made between an electrical circuit and the ground or ground plane. By grounding a tool or electrical system a low-resistant path to the earth is created to prevent the buildup of voltages that may cause a hazard. It is important that all electrical service and equipment be appropriately grounded.

- **Electrical Protective Devices**
  These are designed to automatically limit or stop the flow of electricity in the event of a ground-fault, overload or short circuit in a wiring system. These devices include fuses, circuit breakers and ground-fault circuit interrupters (GFCI). Fuses and circuit breakers are over-current devices that are used in circuits to limit the amount of current a circuit will carry. When the amount of current flow becomes unsafe they automatically break the circuit. A GFCI is designed to shutoff electric power within about 1/40 of a second by comparing the amount of current going to the equipment to the amount of current returning. If there is a difference of more than 6 milliamperes, the GFCI interrupts the current in time to prevent electrocution. GFCIs should be used in wet locations, on extension cords and during construction activities.

- **Safe Work Practices**
  These must be employed by all plant personnel when working with or around electrical equipment. Work practices may include deenergizing electric equipment before inspecting or making repairs, using only tools that are in good repair, using good judgment when working near energized lines and using the right protective equipment.

- **Deenergizing Electrical Equipment (Lockout/Tagout)**
  Deenergizing is essential prior to performing any inspection or repair on electrical equipment, even on low voltage circuits. The current must be turned off at the source and locked in the off position. Also, the switch or controls of the equipment or machine being serviced should be locked out or tagged. Only qualified electricians familiar with lockout/tagout procedures should be authorized to work on electrical equipment.

- **Tools**
  Tools such as electric drills and saws must be regularly maintained and in proper working order to maximize your safety. Inspect the tool prior to use and remove it from service if any defects, such as broken insulation, frayed wires, broken plug, no ground plug or cracked casing are found. Tools used for electrical safety protection such as lineman's gloves, insulating blankets and hot sticks must be maintained, inspected routinely and designed to handle the voltage and stresses to which they will be exposed.

- **Overhead/Underground Power Lines**
  These must only be worked on by qualified electricians. The lines must be deenergized and grounded by the owner or operator of the lines or other protective measures such as guarding or insulting must be provided. Unqualified workers must keep themselves, tools and equipment (e.g. backhoe) at least 10 feet away from overhead/underground power lines. If the voltage is over 50,000 volts then the safe distance must be increased 4 inches for each additional 10,000 volts.

- **Protective Equipment**
  Protective Equipment must be used if your job requires you to work directly with electricity. This equipment includes rubber insulating gloves, hoods, sleeves, matting, blankets, line hose,and protective helmets, all of which must be rated for the particular voltage to be worked on.

- **Good Judgment**
  Good judgment and common sense is your best defense against electrical hazards. Make sure that you are familiar with safety procedures for your particular job. Make sure you maintain a safe distance form energized electrical equipment. When you must work around electrical equipment keep in mind these basic procedures:
  - Have the equipment deenergized by a qualified person.
  - Ensure the equipment remains deenergized by using lockout/tagout procedures.
  - Use insulating protective equipment.
  - Maintain a safe distance from energized parts.

Sources

- Treatment plant operation and maintenance activities expose workers to a variety of intermittent or continuous high noise sources. These include: pumps, motors, blowers, compressors and hand tools. You should be aware of the work activities that you perform that may expose you to excessive noise levels.

- Remember that reducing your noise exposure is important not only to prevent permanent hearing loss but also to ensure that you can hear desired sounds such as speech and warning signals.

Exposure Limits

- The OSHA Occupational Noise Standard found in 29 CFR 1910.95 establishes an 8-hour time weighted average (TWA) noise exposure level of 90 decibels on the A-weighted scale (dBA), with an action level of 85 dBA, and a maximum noise level that should never be exceeded of 115 dBA. In general if you have to shout or cannot hear someone talking in a normal voice then the noise level can be assumed to be excessive.

Monitoring

- Plant noise surveys should be performed in high noise areas and for activities (e.g. using a jack hammer) to determine the noise level.

- Monitoring should be performed using a sound level meter set to the A-weighted scale by a person who has been trained to use the meter.

- Monitoring should be performed periodically and when new equipment is added to the plant.

Hearing Conservation Program

- At 85 dBA, exposed workers should be placed into a hearing conservation program that includes annual audiometric (hearing) testing, noise reduction efforts, noise monitoring, the provision and use of hearing protection, employee training and record keeping.

Noise Reduction and Hearing Protection

- Ideally, excessive noise sources should be eliminated or reduced by engineering or administrative controls such as:
  - Replacing equipment with less noisy equipment.
  - Enclosure of the noise source.
  - Preventive maintenance.
  - Sound proofing or dampening materials.

- When these efforts are not effective, employees must be provided with hearing protection in the form of earplugs or muffs with an adequate noise reduction rating (NRR) to reduce noise exposure to acceptable levels.

- To calculate the noise reduction provided by a particular hearing protection device, take the NRR of the device and subtract 7 dBA from it. Then, subtract that number from the measured noise exposure.

Calculation

A motor produces a sound level of 93 dBA and you have been provided with earplugs with an NRR of 25. What would the effective noise reduction from the earplugs be?

Walking/Working Surfaces

Walking and working surfaces in treatment plants are inherent sources of slip, trip and fall hazards.

- Ladders, walkways and stairs are continuously subjected to wet conditions and with the addition of slippery polymers used in the process, these areas can become even more hazardous. Even small polymer spills can create extremely slippery conditions on walking and working surfaces.
- Good housekeeping and the maintenance of clean dry floors and walkways are essential to reducing slip hazards.
- Make sure that you have good footwear with adequate tread.
- Floor and grate openings, especially during maintenance and repair activities, present trip and fall hazards. These opening should be protected by placing covers labeled "hole" or providing a guardrail around the opening.

Stairs, Ladders and Scaffolds

- Stairs must be kept dry, free of debris, equipment and materials that create a tripping hazard and must be properly illuminated.
- Ladders must be maintained in good condition. Ensure that fixed metal ladders that serve as access to manholes or chambers are free of corrosion and are dry.
- Portable extension and stepladders should be used appropriately and you should ascend and descend ladders using both feet and both hands. Raise and lower tools and equipment by a tag line.
- Portable ladders should be placed on solid footing at a pitch so that the horizontal distance from the top support to the foot of the ladder is one quarter of the working length of the ladder (4 to 1 rule). The ladder should extend at least 3 feet above the landing and/or be secured from falling. Portable ladders must not be used in a horizontal position as platforms, runways or scaffolds.
- Metal ladders should never be used around energized electrical equipment.

Working at Elevations

- Scaffolds must be erected by qualified personnel on solid, level, rigid footing capable of withstanding the maximum intended load.
- Guardrails, midrails and a toeboard must be provided when scaffolds are greater then 4 feet high or employees must be provided with other means of fall protection.
- Make sure that the required clearance, 10 feet minimum, is provided from energized electrical lines.
- Refer to the OSHA Safety Requirements for Scaffolding, 29 CFR 1910.28 for additional information on scaffold erection and use.

Working Above 4 Feet or Adjacent to Water or Hazardous Equipment

- Working surfaces that present a fall hazard of greater than 4 feet must be protected with a guardrail system or employees must be provided with a personal fall protection device.
- Working on top of tanks, walkways roofs, and other elevated surfaces more than 4 feet or when working above open tanks or hazardous machinery requires the provision of fall protection.
- Fall protection comes in various forms such as:
  - Guard rails, which typically includes a top rail at a height of about 42 inches and capable of withstanding 200 pounds of force.
  - A midrail at about the midway point between the top rail and working surface.
  - A toe board to prevent tools and/or equipment from falling.
  - Personal fall arrest systems, which include a full body harness, a shock absorbing lanyard and an anchorage capable of withstanding 5,000 pounds of force.
  - Aerial lifts, which are an excellent means to gain access to elevated work areas. Make sure that the aerial lift is in good working order, provided with a guardrail system and that you have been trained on how to use the lift. Also, when working on an aerial lift you must wear a full body harness attached by lanyard to the lift. Never step on top of the aerial lift railings or use a ladder to gain additional height. Make sure that the required clearance, 10 feet minimum, is provided from energized electrical lines.
  - Safety nets, which can also be used for fall protection and to catch debris and tools/equipment that might fall. Safety nets are typically not feasible for normal plant operations and maintenance.

For additional fall protection requirements and methods refer to the OSHA Standards on Guarding floor and Wall openings 929 CFR 1910. 23 and Fall Protection (29 CFR 1926 Subpart M).

- Many times you will be required to work above or adjacent to open tanks. Working in these locations exposes you to potential fall hazards that may lead to drowning.
    - A United States Coast Guard Approved life vest/jacket should be worn when fall protection, such as a guardrail system, is not provided.
    - Life saving devices such as life rings must be available for emergency rescue.
    - These areas should be provided with fall protection in the form of guardrails or personal fall protection.

- Prior to beginning any excavation, you must identify and locate potential underground utilities such as gas lines, water lines, electrical conduit and TV and cable lines. Typically, this can be handled by reviewing facility utility drawings and the Pennsylvania One Call System at 1-800-242-1776. Remember: Call Before You Dig. The free one call system is an essential resource for identifying underground utilities.

- Be familiar with the Uniform Temporary Markings for underground utilities as described below and are shown in the following figure.

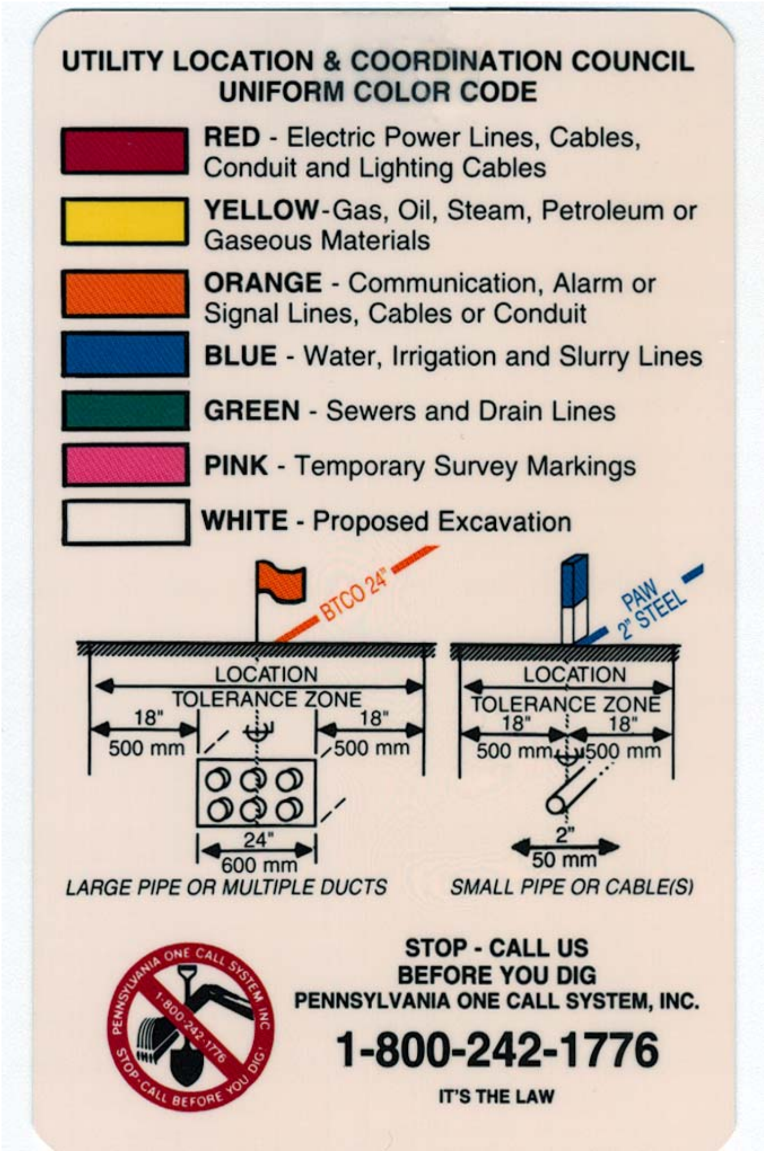

Figure 3.4 PA One Call System, Inc. Utility Markings[4]

Considerations

Additional considerations prior to excavation include:

- Surface encumbrances that are located in the area of your proposed excavation that may pose a hazard must be removed or supported to protect workers.
- Underground installations as described above must be identified and located. These must be supported, protected or removed if necessary to safeguard workers.
- General excavation requirements must also be considered. This includes the provision of access and egress for personnel as well as equipment. Ramps for access/egress must be designed by a competent person and be capable of handling the intended loads. A stairway, ladder or ramp must be provided within 25 lateral feet of employees in trench excavations greater than 4 feet.
- Workers must remain clear of loads handled by lifting or digging equipment to avoid being struck by falling objects or spillage.
- When mobile equipment is operated adjacent to an excavation or is required to approach the edge, a warning system must be used such as barricades, hand or mechanical signals, or stop logs.
- In excavations greater than 4 feet consideration should be made for the potential for hazardous atmospheres. If there is a potential for hazardous atmospheres either from oxygen deficiency, accumulation of combustion gases from excavation equipment or hazardous materials from contaminated soils or adjacent locations, then atmospheric monitoring must be performed prior to employees entering the excavation. Also, emergency rescue equipment such as an SCBA, safety harness and line or basket stretcher must be provided and readily available.
- Water accumulation should not be permitted in an excavation in which personnel are working.
- Adjacent structures such as buildings, walls and sidewalks must not be undermined unless they are shored, braced or underpinned to ensure stability and protection of excavation workers unless a registered professional engineer determines that there is no hazard posed.
- Loose rock or soil must be kept from falling onto workers inside the excavation. This can be accomplished by scaling the sidewalls to remove loose soils or rocks or installing protective barricades. Excavation spoils should be placed no closer than 2 feet from the edge of the excavation or shielded to prevent the material from falling back into the excavation.
- Fall protection should be provided for employees who must cross over excavations greater than 6 feet deep. This should consist of walkways with appropriate guardrails.

Inspections

- Inspections must be made by a competent person each day prior to the start of work and as needed throughout the shift.
- The inspections should focus on checking for evidence of possible cave in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. If hazards are identified the competent person must ensure that action has been taken to protect exposed workers.

Soil Classifications

Soil classification must be based on the results of at least one visual and one manual analysis in accordance with accepted methods. The soil classifications are defined as:

Stable Rock

- Stable rock is a natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Type A

- Type A soils are cohesive soils with an unconfined, compressive strength of 1.5 tons per square foot (tsf) or greater.
- Examples are clay soils and cemented soils like hardpan.
- Soil cannot be Type A if the soil:
  - Is fissured.
  - Is subject to heavy vibration.
  - Has been previously disturbed.
  - Is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical.

Type B

Type B soils consist of:

- Cohesive soils with an unconfined, compressive strength greater than 0.5 tsf but less than 1.5 tsf.
- Granular cohesionless soils.
- Previously disturbed soils other than Type C.
- Type A soil that is fissured or subject to vibration.
- Unstable, dry rock.
- Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical, but only if the material would otherwise be classified Type B.

Type C

Type C soils consist of:

- Cohesive soil with an unconfined, compressive strength of 0.5 tsf or less.
- Granular soils.
- Submerged soil or soil from which water is freely seeping.
- Submerged rock that is not stable.
- Material in a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical or steeper.

Protective Systems

- Protective systems such as sloping, shoring or shielding must be provided for excavations that are deeper than 5 feet in order to protect workers within the excavation from cave-in.

- The OSHA Standard for Requirements for Protective Systems, 29 CFR 1926.652 establishes this requirement and details the methods and types of protective systems.

- It is important to note that protective systems for excavations greater than 20 feet deep must be designed by a registered professional engineer.

The following is a brief summary of each of these systems in order to provide you with the basic fundamentals.

Sloping and Benching

- Sloping and benching consists of the removal of the trench wall at a specific slope based on the type of soil being excavated.

- A good rule of thumb is to slope the sidewalls at least one and one half foot back for every one foot in depth on both sides of the trench unless the soils have been classified as to the type and the options provided in the OSHA Standard have been selected by a competent person.

- Figure 3.5 shows the sloping and benching options by soil type that are provided in the OSHA Standard.

FIGURE B-1.2
EXCAVATIONS MADE IN TYPE B SOIL

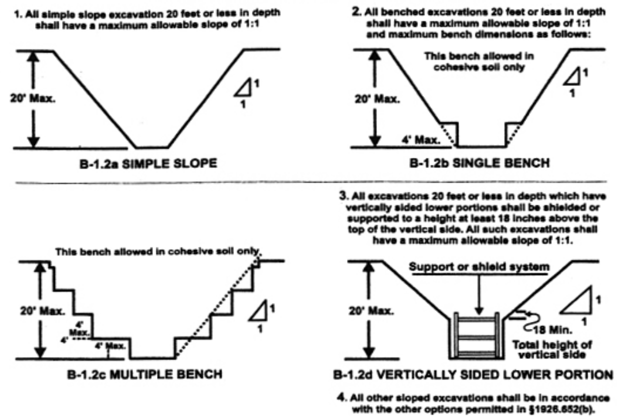

Table B-1 - Maximum Allowable Slopes

Soil or Rock Type	Maximum Allowable Slopes (H:V)[1] For Excavations Less Than 20 Feet Deep[3]
Stable Rock	Vertical (90 Deg.)
Type A[2]	3/4:1 (53 Deg.)
Type B	1:1 (45 Deg.)
Type C	1 1/2:1 (34 Deg.)

1. Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
2. A short-term maximum allowable slope of 1/2H:1V (63 degrees) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53 degrees).
3. Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

FIGURE B-1
SLOPE CONFIGURATIONS

(All slopes stated below are in the horizontal to vertical ratio)

B-1.1 EXCAVATIONS MADE IN TYPE A SOIL

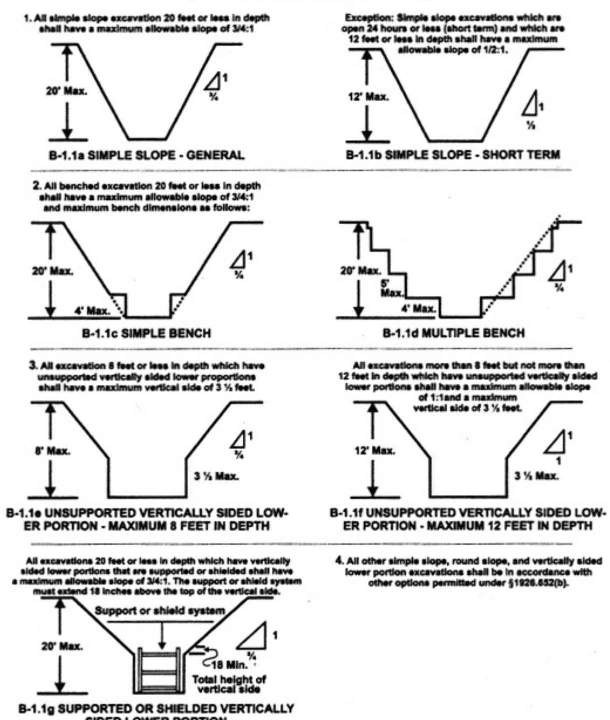

FIGURE B-1.3
EXCAVATIONS MADE IN TYPE C SOIL

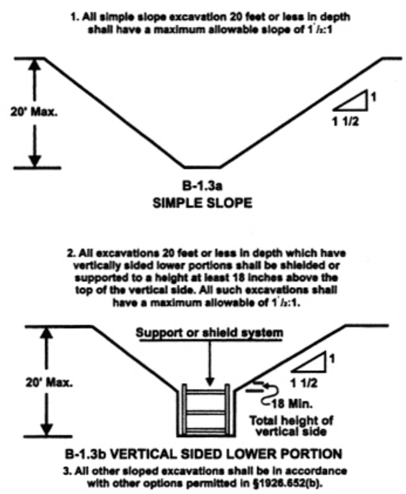

FIGURE B-1.4
EXCAVATIONS MADE IN LAYERED SOILS

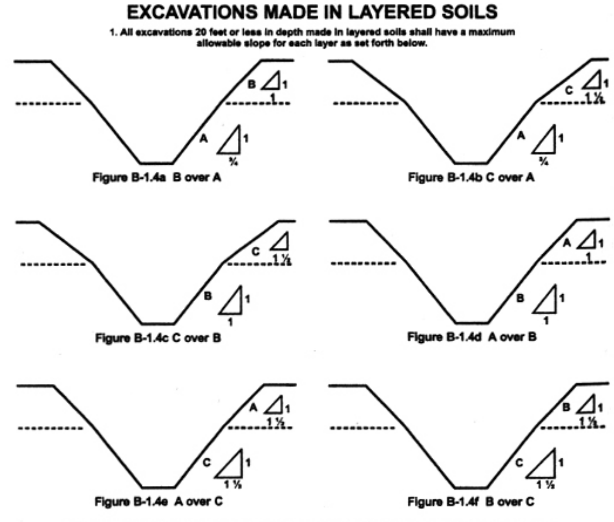

Figure 3.5 OSHA Slope Tables[5]

Shoring

- Shoring is a framework of timber and/or metal that is designed to support the walls of a trench.
- Sheeting, consisting of wooden sheets or metal plates, is placed against the side of the trench to hold back the walls. Uprights placed vertically along the face of the trench wall are used to support the sheeting. Stringers or wales are placed horizontally along the uprights in which trench braces are attached to prevent cave-in.

Shielding

- This uses a two-sided, braced box sometimes referred to as a drag shield or trench box, which is open at the top, bottom and ends.
- The trench box is literally pulled through the excavation as the trench is being dug.
- It is important to remember that you must always stay within the walls of the trench box and never leave the area of the shields protection while inside the trench.

It is important that you become familiar with the confined spaces and the hazards associated with your facility and that you have been thoroughly trained on the confined space entry procedures at your facility.

Never enter a confined space without following the appropriate procedures.

A confined space is defined as a space that meets the following three criteria:

- Is large enough and so configured that a person can bodily enter and perform their assigned work.
- Has a limited or restricted means for entry or exit.
- Is not designed for continuous worker occupancy.

Generally if you cannot walk upright into a space and you must duck, crawl, climb, or squeeze into a space, it is considered a confined space.

Characteristics of a Permit-Required Confined Space

A **permit-required confined space** is a confined space that has one or more of the following hazardous characteristics: it contains or has the potential to contain a hazardous atmosphere such as oxygen deficiency, toxicity or flammability; it contains a material that has the potential to engulf an entrant such as water; it has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross section such as a hopper or bin; it contains any other recognized serious safety or health hazard.

A **non-permit required confined space** does not contain or have the potential to contain, any hazard capable of causing death or serious physical harm.

Atmospheric Testing

Potentially hazardous atmospheres present a threat of causing death, injury, illness or incapacitation due to flammable/explosive, toxic or oxygen deficient atmospheres.

The primary atmospheric concerns associated with treatment plants are:

- Oxygen deficiency (less than 19.5% oxygen) from metal corrosion, oxygen scavenging or depletion by another gas.
- Flammability/explosive atmosphere from methane gas, hydrogen sulfide and fuels.
- A toxic atmosphere from hydrogen sulfide, chlorine and other process chemicals.

Monitoring

- It is important to keep in mind that the work you perform within a confined space may create a hazardous atmosphere. Welding, painting, solvent cleaning, pipe grouting or use of power tools with combustion engines can all produce hazardous contaminants that will create a hazardous atmosphere. Therefore, it is imperative that the atmosphere of a confined space that you will be entering is checked using reliable, calibrated direct-reading instruments prior to and during your entry into a confined space.

- The monitoring must be performed by an individual who is knowledgeable about the potential confined space hazards and air monitoring procedures.
  - Atmospheric monitoring should be performed outside of the confined space in the vicinity of the opening or at potential contaminant sources that may pose a problem and, at stratified levels (top, middle, and bottom) within the confined space.
  - Monitoring should be performed in the following order and acceptable results should be within the acceptable concentrations:

Contaminant	Acceptable Concentration
Oxygen	19.5% - 23.5%
Flammable gases/vapors	>10% of the lower flammable/explosive limit
Potential toxic contaminants:	
Hydrogen sulfide	<10 ppm
Carbon monoxide	<25 ppm
Chlorine	<0.5 ppm
Other contaminants	< the OSHA PEL or ACGIH TLV or other recognized exposure limit

Ventilation

Air monitoring results that are not within the acceptable concentrations will classify the space as a permit-required confined space and appropriate action must be taken to eliminate or control the hazard. This will involve the following:

- Allowing the space to naturally ventilate.

- Use of forced air ventilation.

- Purge the space with an inert gas or water.

The space should be continuously ventilated using explosion proof, forced air blowers.

- The blowers should be set up to either supply fresh air into the space or to exhaust contaminants out of the space (this is especially useful when activities within the space such as welding or painting create a potential hazardous atmosphere) or, a combination of supply and exhaust ventilation.

- It is important to know the density of the potential contaminants in order to properly position ventilation equipment. Heavier than air gases/vapors will sink to the bottom and lighter than air gases /vapors will tend to accumulate at the top of a space and, therefore, ventilation equipment should be positioned accordingly.

Controls

Prior to entry into a confined space all physical hazards must be considered.

- These may include:
  - Electrical.
  - Hazardous energy sources.
  - Power driven equipment.
  - Material or water flow.
  - Fall hazards.
  - Noise exposure.

- These physical hazards must all be controlled prior to entering a confined space.

- Water supply lines should be disconnected, shut off and locked out or blanked to prevent water flow into the space.

- Electrical and other hazardous energy sources must be deenergized and locked out.

- Appropriate personal protective equipment must be worn.

Confined Space Entry Program

Confined space entries should be performed under a facility specific Confined Space Entry Program that establishes:

- Written entry procedures to be followed.
- The responsibilities of each individual involved in confined space entry (entrants, attendants and supervisors).
- The confined space entry permit system to be used.

Permit-required confined spaces can only be entered under a permit system. A Confined Space Entry Permit is a written document that identifies:

- The space to be entered.
- The work to be done within that space.
- The potential hazards associated with the space.
- The hazard control measures taken.
- Documentation of atmospheric testing results.
- Identification of the workers working within the space (entrants).
- The worker serving as the attendant outside the space.
- The competent person who certifies the permit and authorizes the confined space entry and work.

Work within confined spaces can pose serious safety and health hazards if you are uninformed or untrained in confined space hazards and proper entry procedures. Make sure that your plant's confined spaces have been identified and the hazards associated with each space have been identified and assessed and that appropriate procedures have been established to enter and work within a confined space.

The OSHA Permit-Required Confined Space Standard, 29 CFR 1910.146, establishes the requirements for confined space entry programs, permit systems and entry procedures.

The major hazards of fire are the loss of life or the injury of plant employees or others as well the direct property damage to structures and equipment, which can be very costly.

There are also some less obvious consequences of fire. What do you think some of those consequences are?

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____

____

____

Every facility should develop and implement a fire prevention plan to minimize the risk of fires and to establish procedures on how to respond to a fire if one occurs.

Classes of Fire

Class A

- Includes ordinary combustibles such as wood, paper and textiles. Class A fire extinguishers are identified with a letter A in a triangle.

Class B

- Includes flammable or combustible liquids such as gasoline, oils, paints and greases. Class B fire extinguishers are identified with a letter B in a square.

Class C

- Are electric fires from wiring and electrical equipment or class A or B fires adjacent to electrical equipment. Class C fire extinguishers are identified with a letter C in a circle.

Class D

- Includes combustible metals such as aluminum, magnesium and titanium. Class D fire extinguishers are identified with a letter D in a five-point star.

Storage and Handling of Flammable Material

- Flammable/combustible liquids, solids and gases must be stored and handled appropriately. Storage should be in approved containers and storage areas that are equipped for the amount and type of material. Only the minimum needed amount of material should be stored and used at your facility. Incompatible materials should also be segregated. Flammable liquid containers should be bonded and grounded when transferring the material from one container to another in order to prevent vapor ignition from static spark.

- Flammable storage areas or rooms should be of adequate construction and size for the materials being stored and properly vented to prevent the build-up of vapors. Also, flammable storage areas should be provided with explosion proof electrical equipment such as lights and ventilation to prevent vapor ignition. Ignition source should be eliminated and appropriate fire fighting media (extinguishers, sprinklers, hoses, etc.) provided. Aisles and passageways must be kept clear and free of obstruction to allow for quick exit in case of an emergency and access by firefighters and equipment.

- Compressed gases, such as acetylene, should be stored separately from other flammable/combustible materials and separated from oxygen cylinders by at least 20 feet or a fire rated partition. Additional information on compressed gas handling and storage can be obtained from the Compressed Gas Association.

- Treatment processes produce explosive gases such as methane and hydrogen sulfide that pose serious fire and explosion hazards. Areas where these gases can accumulate should be provided with explosion proof electrical equipment and ventilation systems. Monitors should be provided to warn plant personnel of excessive concentrations of flammable gases. Smoking and other sources of ignition such as welding, grinding or cutting should not be performed unless hazardous areas have been check for flammable gas concentrations, properly ventilated and a hot work permit has been issued.

Fire Response Plan

Fire response plans should establish the appropriate personnel and responsibilities to respond to a fire. Plant employees should only attempt to extinguish incipient (beginning) stage fires only unless they have received comprehensive, hands-on training under the supervision of an approved fire fighting school. The plan should also include evacuation procedures and routes as well as provision for routine fire evacuation drills.

At minimum, plant workers must be trained on:

- How to recognize the types of fire.
- How to activate the fire alarm system.
- Location, selection and use of the appropriate fire extinguisher.
- How to fight incipient stage fires if required to do so.
- When and how to call for outside assistance.
- When to abandon the fire fight.
- When and how to evacuate the area.

The recommended procedure for fire response upon notification of a fire at your facility should be:

- Alert coworkers and other plant personnel of the fire and activate the alarm system.
- Evacuate the immediate area and/or the entire facility if necessary.
- Contain the fire if possible by turning off valves or shutting down fuel supply.
- Attempt to extinguish the fire with available equipment keeping in mind that only incipient stage fires should be handled by plant personnel if they have been trained to do so.

The OSHA General Industry Standards (29 CFR 1910) should be reviewed and will provide the necessary information to develop a fire prevention and response plan and safe storage and handling procedures.

Supplemental Reference Information

Additional sources of information include:

- The International Fire Information Network
- United States Fire Administration.
- National Fire Protection Association.
- OSHA general industry standards.

Manual Lifting Limits

- Keep in mind your manual lifting limits and ask for help when lifting or moving a heavy object. Reduce or eliminate manual lifting as much as possible.
- Items that are too heavy to be lifted or moved by hand should be performed by hoists, fork trucks, pallet jacks or other mechanical means.
- Manhole covers should never be removed using your hands and fingers. Serious hand, finger, and back injuries occur from removing manhole covers. Always use a manhole tool that is especially designed for that purpose.

Proper Lifting Procedure

Remember to use the following lifting procedure help reduce the risk of back injury:

- Size up the load.
- Bend at your knees, not your back to pick-up the load.
- Establish a firm grip on the load.
- Gradually lift with your legs not your back.
- Keep the load close to your body.
- Never twist while lifting.

NIOSH Lifting Equation

The National Institute for Occupational Safety and Health (NIOSH) has developed an equation that can help your facility's safety coordinator to identify and assess hazardous lifting activities.

For more detailed information on the NIOSH lifting equation refer to the NIOSH publication: *Applications Manual for the Revised NIOSH Lifting Equation* by Tom Waters, Vern Putz-Anderson and Arun Garg.

Pennsylvania Requirements

- Prior to starting work in a traffic area be sure to plan out the appropriate traffic control to protect you and your coworkers from vehicular hazards as well as the drivers. Ensure that you are providing adequate warning and protection for your work area by consulting the local police department and the Pennsylvania traffic codes for the required traffic control patterns required in your area. Avoid working during rush hour traffic.

- Make sure that appropriate warning signs, safety cones, barricades and flagmen are provided throughout the duration of your work. Flagmen should use a red warning flag or slow/stop paddle and appropriate hand signals to direct traffic.

- All personnel should wear a reflective safety vest. As added protection, if possible place your work vehicle or "crash truck" (with flashing or revolving amber warning lights on) between your work area and the oncoming traffic. This provides additional visual notification to the traffic of your work area.

[1] www.safetyinfo.com.

[2] www.safetyinfo.com.

[3] www.safetyinfo.com.

[4] Pennsylvania One Call System, Inc., reference card, revised January, 1997.

[5] Excavation Standard 29 CFR 1926 Subpart P, Occupational Safety and Health Administration.

[6] *Operation of Wastewater Treatment Plants, A Field Study Training Guide*, Vol II, (Sacramento California: California State University, Sacramento Foundation, 1999), p. 238.

Unit 4 – Preventing and Responding to Safety and Health Issues

Learning Objectives

- Explain the role of signage in preventing safety and health problems.
- Explain the essential elements of a safety and health program and describe the purpose of a safety policy statement.
- Explain how a safety committee should be organized and what its objectives and responsibilities are.
- Describe the important policies, programs and rules found in a safety and health manual.
- Explain two methods of safety promotion.
- Explain two options for staffing and implementation of a safety program.
- Explain four key components of managing a safety program and monitoring safety performance.
- Explain the value of safety and health training; describe the recommended and the required training, the training process and the recordkeeping requirements.
- List and explain three essential elements in regards to first aid and emergency response.

Signs and tags must conform to uniform style, color codes and wording. Signs and tags are necessary to protect or alert employees from immediate or potential hazards or to give general safety instructions.

Proper Identification of Hazard

Safety Color Coded for Marking Physical Hazards

- Red is used for the identification of fire protection equipment; to denote "Danger" such as for flammable liquids, barricades and Danger signs; to indicate "Stop" as with emergency stop bars, buttons or other emergency stop apparatus.

- Yellow is the basic color for designating caution and for marking physical hazards such as striking against, stumbling, tripping, falling and "caught in between."

Uniform Style

Specific Sign Classification and Design

- Danger signs indicate an immediate danger and signify that special precautions are necessary. They are to have the colors red, black and white.

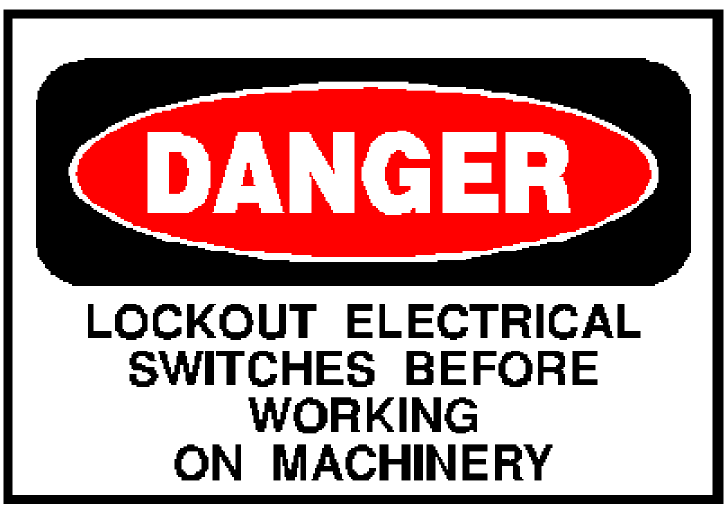

Figure 4.1 Example of a Danger Sign[1]

- Caution signs are used only to warn against potential hazards or to caution against unsafe practices. Employees should be instructed that caution signs indicate a possible hazard, which requires proper precaution. The colors include a standard yellow background and a panel that is black with yellow letters. Any letters used against the yellow background must be black.

- Safety instruction signs should be used where there is a need for general instructions and suggestions relative to safety. The background should be white, and the panel should be green with white letters. Any letters used against the white background must be black.

- Tags are used as a means to prevent accidental injury or illness to employees who are exposed to hazardous or potentially hazardous conditions, equipment or operations that are out of the ordinary, unexpected or not readily apparent. Tags should contain a signal word and a major message (e.g. Tagout tag). Signal words include “Danger,” “Caution” or “Biohazard” and should be readable from at least five feet. The major message should indicate the specific hazardous condition or the instruction to be communicated to the employee and presented in either pictographs, writing or both.

Essential Elements of Program

Management Commitment and Employee Involvement

- Successful programs have the complete support of top management that starts from a clearly communicated safety policy supported by management.
- Management commitment must be shown by making a commitment to assign responsibility, give authority and provided the needed resources to accomplish established, measurable safety goals.

Worksite Analysis of Hazards

- Identification and analysis of workplace hazards are the first two steps in preventing occupational accidents or illnesses. This should be accomplished by a comprehensive facility program to analyze hazards.

Hazard Prevention and Control

- Hazard controls should be implemented based on the hazard control hierarchy discussed earlier in this module.

Safety and Health Training

- One of the leading causes of unsafe acts is the lack of information or knowledge. All levels of employees, including workers, supervisors and top management should be trained relative to the hazards associated with their jobs and their roles and responsibilities.

Safety Policy Statement

- The purpose of the safety policy is to establish the foundation for the safety program by defining the intended purpose, scope, goals and objectives, responsibilities and functions, authority and accountability.
    - The policy should carry the signature of the Plant Manager or Board to show managements commitment and be reviewed and updated periodically to readdress goals and objectives.

Safety Committee

- The safety committee can be very useful in performing necessary monitoring, educational, investigative and evaluative activities.

- The safety committee should be a joint committee comprised of key plant personnel from all levels of the facility including management, supervisors and workers.

- Some responsibilities for plant safety and health committees might include:
  - Participate in safety and health instruction and training programs and evaluate the effectiveness of the programs.
  - Participate in regular facility safety and health inspections to check for unsafe conditions and practices.
  - Review and revise existing safety and health rules, procedures and programs.
  - Recommend appropriate hazard elimination or control measures.
  - Update existing work practices and hazard controls.
  - Review and assess the potential hazards posed by changes to the operations, processes, work procedure, and equipment.
  - Assess personal protective equipment.
  - Monitor the effectiveness of safety and health improvements.
  - Provide communications to employees regarding safety and health issues.
  - Participate in accident/incident investigations and review and analyze facility accident and injury information.

- The safety committee should report to top management and establish a stewardship process for reviewing, monitoring and evaluating safety initiatives.

Safety and Health Manual

- Each facility, as part of their safety and health program, should develop a safety and health manual that serves as a repository for the facility's safety and health policies, procedures, rules, written programs, forms and other relevant information.
- The safety manual serves as a resource tool and it establishes management's approach, or guideline, for addressing safety and health issues.
- Safety manuals establish the administrative approach of managing the safety program and must be accessible to all employees to ensure employee cooperation and commitment.
- An example of a model safety and health manual outline is shown on the following page.

Safety and Health Manual
Section Outline[2]

1.0 Introduction

This includes an introduction to the safety and health manual, the reason for its publication, an executive overview supporting the manual, and any special acknowledgements that may be appropriate.

2.0 Overview

An introductory overview of the manual contents, identification of the essential elements for the facility's safety and health system, and supportive information for reducing occupational injuries and illnesses.

3.0 Administrative Procedures

Provide the administrative procedures for how the safety system will be administered at your facility. This may include such elements as:

- Injury and illness reporting and recordkeeping procedures
- Safety committees and their charters
- Safety policy statement
- Accident/incident investigation procedures
- Regulatory agency inspection procedures (how your facility will handle them)

4.0 Safety Rules/Programs

This section should be devoted to facility specific safety and health policies, rules, procedures, programs, and practices that make up the comprehensive safety and health program. These may include the:

- Hazard communication program
- Confined space program
- Lockout/tagout program and procedures
- Fire prevention program
- Emergency response program

5.0 Resources

Include a list of resource or reference information that can be reviewed for additional information such as:

- Safety and health reference publications
- Government publications and standards
- Training materials
- Safety and health professional organizations

Safety Rules

- Specific safety rules, procedures and policies drive the safety program and therefore need to be established on a consistent basis with common characteristics that should include the following:
  - Purpose statement.
  - The scope.
  - Requirements.
  - Dates of issuance and revision.
  - Authorization signature.
- Safety rules must be contained in the safety manual and accessible to all facility personnel. They should also be periodically reviewed and updated to ensure that they are current relative to standards, codes, and current plant operations.

Safety Promotion

Safety can be promoted either directly or indirectly.

Direct Promotion

- The direct approach involves a specific intervention or hands on application to address a specific concern or issue.
- It may take the form of:
  - Changes to the safety training program or retraining.
  - Providing topic specific (e.g. eye injuries) safety talks at various times of a work shift.
  - Special safety meetings held by management personnel to explain concerns over declining safety performance.
  - Implementing a safety information program that might include the use of safety posters or warnings addressing specific facility safety concerns. Also, posting accident statistics and accident summaries to remind workers of the consequences of potential hazards.
  - Regularly evaluating safety performance. Supervisors should make regular, hands-on inspections and evaluations of job performance and provide instant feedback to the employee regarding the negative and positive aspects of their work performance regarding safety.

Indirect Promotion

- The indirect approach uses a secondary means to influence behavior and obtain a positive impact on a primary concern.

- For example, say your facility is having a string of back injuries lately and your manager wants to address this primary concern. In an effort to increase back safety awareness among his workers, the manager offers to take the entire crew out for dinner if they can have one month without a back injury. The offer of dinner as a reward would be the secondary means or indirect approach.

What are some other examples of indirect promotion?

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Implementation

- The implementation of a safety program must be the responsibility of all members of the organization's management team. Supervisors must be actively involved in the safety program for it to be implemented, take hold and remain successful, by incorporating safety and health into all daily functions and operations. Safety programs that are based on establishing all safety responsibility on the person in charge of facility safety have proven to be unsuccessful and ineffective.

Management of Program

- Managing a safety and health program involves the following responsibilities:
  - Reduce or eliminate accidents.
  - Prevent employee injuries and illnesses.
  - Reduce the direct and indirect costs associated with accidents.

- Successful safety programs will not only protect employees but they will also save your organization money in terms of direct and indirect costs.

Organizational Structure

- Management has the greatest degree of responsibility and accountability for a facility's safety and health program and is held responsible for the safe conduct of its employees. Therefore, the safety organization and the establishment of specific responsibilities should look similar to the following:

Plant Manager

- The Plant Manager is responsible for all plant operations and has overall administrative responsibility for the facility safety and health program by ensuring that the program is provided with adequate personnel and resources.

Supervisors

- Supervisors are responsible for all safety and health activities under their assigned area of control. They have daily contact with their employees and are responsible for implementing and enforcing the safety and health program for his/her employees.

- Safety duties may include but are not limited to providing training, performing safety inspections and observations, enforcing safety rules and procedures, conducting accident investigations, maintaining records and ensuring that appropriate PPE is provided and used.

Safety Coordinator

- The Safety Coordinator serves as an advisor to the Plant Manager and assists the Plant Manager in implementing, promoting, coordinating and evaluating the Safety and Health program.

- Specific responsibilities may include: assessing plant–wide safety performance; developing safety programs, procedures and rules; providing plant management with direction and advice on safety issues; selecting appropriate PPE; participating in accident/incident investigations; participating in design safety reviews; developing and coordinating training activities; maintaining statistics and safety records.

Employees

- Employees are responsible for following established safety and health procedures, wearing the appropriate PPE, participating in accident investigations and safety training and reporting potential safety and health concerns.

Recordkeeping

- Records must be maintained relative to your facility's safety and health program. Many of these may be required by regulatory agencies or may be maintained to serve as a tool for evaluating safety performance.

Monitoring Safety Performance

Inspection, Audits and Observations

- Safety performance can easily be evaluated by performing routine and periodic safety inspections, audits, and observations. These should be performed by supervisors, safety committee participants, safety personnel, management and outside consultants.

- Routine inspections should be established in specific safety programs or procedures and should be performed by workers and supervisory personnel. Safety inspections typically focus on the physical safety aspects of plant operations such as equipment and working conditions, but they can also be used to evaluate safe work practices. These can take the form of a standardized checklist or narrative reports.

- Safety observations should be performed periodically by supervisors, the safety director and/or management and safety committee representatives to observe work activities and conformance to established requirements and procedures. These are typically performed on the "floor" and feedback is given to the employees immediately in verbal form.

- Safety audits are formal tools used to assess the overall effectiveness of the safety program. Audits should be performed in teams that include safety personnel, management, employees, safety committee representatives and/or consultants. Safety audit results are usually presented in a comprehensive report that establishes positive and negative aspects of the safety and health program and provides recommendations to enhance the program.

Statistics

- Accident, injury and illness statistics are commonly used to measure safety performance. These can be used to compare performance against in-house established goals, historical performance, and/or industry standard statistics.

Safety and Health Training

Many OSHA standards require specific training of employees regarding the safety and health issues related to the performance of their jobs. Even if OSHA standards are not applicable, employee safety training is necessary as a normal part of plant operation.

Value

- The value of safety training is that employees are better informed about the particular hazards posed by their jobs.
- The greater the recognition of hazards and knowledge of how to control or avoid those hazards, the more effective employees will be in working safely, more efficiently and more productively.
- Additionally, regulatory violations can be eliminated or decreased; accident/illness rates lowered; qualified employees will not lose time from the job; and insurance costs, workers' compensation costs and other related costs will decrease.

Recordkeeping

- Records of training must be maintained either for the purposes of complying with regulatory agency requirements, insurance requirements or for in-house performance evaluation.
- Training records should include the training topic, a description of the materials and content covered, a copy of all hand out materials, a description of any hands-on activities, the date of the training, any exercises or tests that were given and the results and a sign-in log indicating the employees who attended.

Qualified Individuals and Medical Evaluation

- The plant should ensure that readily available qualified medical personnel be identified for advice and consultation on matters associated with plant health.
- In the absence of a medical clinic or hospital in close proximity to the facility, designated qualified personnel should be available who will respond to employee injuries and illnesses and administer the appropriate first aid while awaiting emergency response personnel.
    - These individuals should be trained in first aid procedures and cardio pulmonary resuscitation (CPR) by an appropriate agency such as the Red Cross.
- At least one trained and qualified first aid provider should be available for each shift of operation.
- Adequate first aid kits and supplies, approved by a qualified medical provider, must be readily available and maintained on site.

Emergency Response Plan

- All community water systems are required by DEP regulations (PA Title 25, Chapter 109.707) to develop an emergency response plan and to update it annually.
- All plant personnel should be trained in the plan and should be knowledgeable about what to do, where to go and how to evacuate in the case of an emergency.
- An emergency response plan should contain the following basic elements:
    - Emergency escape procedures and escape route assignment.
    - Procedures to be followed by personnel who must remain to operate critical plant operations before they evacuate.
    - Restart procedures following and emergency.
    - Procedures to account for all employees following an emergency evacuation.
    - Rescue and medical duties for personnel designated to perform them.
    - The procedure for reporting emergencies such as fire, chemical spill or other emergency.
    - The names or job titles of those individuals who can be contacted for additional information or explanation of duties under the plan.
- The facility must have an established employee alarm system and evacuation system.
- Evacuation routes must be conspicuously posted throughout the facility and planned emergency evacuation drills must be held.
- Emergency telephone numbers should be posted and all employees must be trained to recognize them and how to call.

[1] www.safetyinfo.com

[2] S.Z. Mansdorf, *Complete Manual of Industrial Safety,* (Prentice Hall, 1993), p.21.

Material Safety Data Sheet

May be used to comply with
OSHA's Hazard Communication Standard,
29 CFR 1910.1200. Standard must be
consulted for specific requirements.

U.S. Department of Labor

Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

IDENTITY *(As Used on Label and List)*	Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section I

Manufacturer's Name	Emergency Telephone Number
Address *(Number, Street, City, State, and ZIP Code)*	Telephone Number for Information
	Date Prepared
	Signature of Preparer *(optional)*

Section II - Hazard Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	%*(optional)*

Section III - Physical/Chemical Characteristics

Boiling Point		Specific Gravity (H_2O = 1)	
Vapor Pressure (mm Hg.)		Melting Point	

Vapor Density (AIR = 1)		Evaporation Rate (Butyl Acetate = 1)	
Solubility in Water			
Appearance and Odor			

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
Extinguishing Media			
Special Fire Fighting Procedures			
Unusual Fire and Explosion Hazards			

Section V - Reactivity Data

Stability	Unstable		Conditions to Avoid
	Stable		
Incompatibility *(Materials to Avoid)*			
Hazardous Decomposition or Byproducts			
Hazardous Polymerization	May Occur		Conditions to Avoid
	Will Not Occur		

Section VI - Health Hazard Data

Route(s) of Entry:	Inhalation?	Skin?	Ingestion?
Health Hazards *(Acute and Chronic)*			
Carcinogenicity:	NTP?	IARC Monographs?	OSHA Regulated?
Signs and Symptoms of Exposure			
Medical Conditions Generally Aggravated by Exposure			
Emergency and First Aid Procedures			

Section VII - Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled
Waste Disposal Method
Precautions to Be taken in Handling and Storing
Other Precautions

Section VIII - Control Measures

Respiratory Protection *(Specify Type)*		
Ventilation	Local Exhaust	Special
	Mechanical *(General)*	Other

Protective Gloves	Eye Protection
Other Protective Clothing or Equipment	
Work/Hygienic Practices	

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Chemicals Used in Treatment

Table 2.1 Chemicals Used in Treatment

Chemical	Use	Characteristics	**Hazards and Symptoms of Exposure**	**Exposure Limits**
Chlorine	Disinfection and odor control	Usually stored under pressure in cylinders in a liquefied gas form but can also be used in diluted liquid and granular forms. Heavier than air, yellow-green gas with a pungent, irritating odor. Nonflammable but a strong oxidizer.	Exposure to low concentration can cause burning in the eyes, nose, mouth, and throat. Chronic low-level exposure can cause teeth corrosion and susceptibility to tuberculosis and emphysema. Acute exposure to high concentrations can cause coughing, choking, nausea, nose and throat bleeding, respiratory distress, and dermatitis.	OSHA PEL = 1.0 ppm ACGIH TLV = 0.5 ppm NIOSH REL = 0.5 ppm IDLH = 10 ppm
Sodium Hypochlorite	Used in the disinfection process and is usually a safer substitute for chlorine.	Corrosive. Can be a potential fire and explosion hazard.	Causes irritation of the eyes, skin, mouth, and lungs. Prolonged exposure can burn the skin and cause permanent eye and lung damage.	OSHA PEL = Not established ACGIH TLV = Not established NIOSH REL = Not established IDLH = Not established
Chlorine Dioxide	Disinfection and taste and odor control.	A yellow to red gas or a red-brown liquid with an unpleasant odor similar to chlorine and nitric acid. Heavier than air as a gas and is considered flammable. The liquid form is considered a combustible.	Produces eye, nose and throat irritation, coughing, wheezing, bronchitis, and difficulty in breathing.	OSHA PEL = 0.1 ppm ACGIH TLV = 0.1 ppm NIOSH REL = 0.1 ppm IDLH = 5 ppm

Chemical	Use	Characteristics	**Hazards and Symptoms of Exposure**	**Exposure Limits**
Sulfur Dioxide	Dechlorination after disinfection.	A colorless, nonflammable gas with a characteristic, irritating odor. Also a strong oxidizer. Usually shipped as a liquefied compressed gas.	Irritates the eyes, nose, throat, and lungs. Produces rhinitis, choking, cough and bronchial constriction.	OSHA PEL = 5.0 ppm ACGIH TLV = 2.0 ppm NIOSH REL = 2.0 ppm IDLH = 100 ppm
Ferric Chloride	Used as a coagulant.	Acidic solution. Noncombustible.	Irritates (corrosive) the eyes, skin, and mucous membranes. Can produce abdominal pain, diarrhea, vomiting, and possible liver damage.	OSHA PEL = Not established ACGIH TLV = 1.0 mg/m^3 NIOSH REL = 1.0 mg/m^3 IDLH = Not Determined
Bases such as 1) sodium hydroxide (caustic soda), and 2) calcium oxides and 3) calcium hydroxides (limes)	Used for pH adjustment, water softening, sludge conditioning and dewatering, and phosphorous removal.	Colorless to white, odorless solid (flakes, beads, granules, or powder). Noncombustible but reacts violently with water and generates heat, which may produce burns.	The base typically causes eye, nose, throat, and mucous membrane irritation. Respiratory tract irritation, skin and nasal burns. Causes dermatitis.	OSHA PEL = 1) 2.0 mg/m^3, 2) 5 mg/m^3, 3) 15 mg/m^3 ACGIH TLV = 1) 2.0 mg/m^3, 2) 2.0 mg/m^3, 3) 5 mg/m^3 NIOSH REL = 1) 2.0 mg/m^3, 2) 2.0 mg/m^3, 3) 5 mg/m^3 IDLH = 1) 10 mg/m^3, 2) 25 mg/m^3, 3) Not determined

Chemical	Use	Characteristics	Hazards and Symptoms of Exposure	Exposure Limits
Aluminum Sulfate (Alum)	Used as a coagulant.	Used in both powder and liquid form. Creates slippery conditions when combined with water and can produce sulfuric acid.	Irritating to the skin, eyes, respiratory system, and mucous membranes. Can produce skin burns. Prevent skin contact.	OSHA PEL = Not Established ACGHI TLV = 2.0 mg/m^3 NIOSH REL = 5.0 mg/m^3 IDLH = Not determined
Polymers (Acrylamide containing)	Used for sludge conditioning.	Polymers are either in liquid or powder/granular form. They are very slippery, especially when in contact with water, and can cause a walking-surface hazard. Some polymers give off ammonia and formaldehyde vapors.	Acrylamide containing polymers irritate the eyes and skin. Also, can produce muscle weakness, hand sweats, fatigue, lethargy, and reproductive effects. Effects the Central Nervous System and may cause cancer. Absorbed through the skin.	As Acrylamide: OSHA PEL = 0.3 mg/m^3 ACGIH TLV = 0.03 mg/m^3 NIOSH REL = 0.03 mg/m^3 IDLH = 60 mg/m^3
Potassium Permanganate	Disinfection and taste and odor control.	Dark purple crystals with a blue metallic sheen. A flammable and explosion hazard by chemical reaction. A strong oxidizer.	Poison by intravenous or subcutaneous routes. Moderately toxic by ingestion. May cause gastrointestinal effects if ingested.	Not established

Chemical	Use	Characteristics	Hazards and Symptoms of Exposure	Exposure Limits
Resins (Styrene containing)	Water softening.	Styrene is a colorless to yellow, oily liquid with a sweet floral odor. Considered a flammable liquid.	Causes eye, nose, and respiratory system irritation. Headaches, fatigue, dizziness, unsteady gait, narcosis, dermatitis, liver damage, reproductive effects, and Central Nervous System effects.	OSHA PEL = 100 ppm ACGIH TLV = 20 ppm NIOSH REL = 50 ppm IDLH = 700 ppm
Ozone	Disinfection and taste and odor control.	Colorless to blue gas with a very pungent odor. Nonflammable gas but a powerful oxidizer.	Eye and mucous membrane irritant. Also, causes respiratory system effects.	OSHA PEL = 0.1 ppm ACGIH TLV = 0.08 ppm NIOSH REL = 0.1 ppm IDLH = 5.0 ppm