



# *INDUSTRIAL HYGIENE*

Qualification Standard  
*Reference Guide*

NOVEMBER 2006

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## **PURPOSE**

The purpose of this reference guide is to provide a document that contains the information required for a National Nuclear Security Administration (NNSA) technical employee to successfully complete the Industrial Hygiene Qualification Standard. In some cases, information essential to meeting the qualification requirements is provided. Some competency statements require extensive knowledge or skill development. Reproducing all the required information for those statements in this document is not practical. In those instances, references are included to guide the candidate to additional resources.

## **SCOPE**

This reference guide has been developed to address the competency statements in the July 2000 edition of DOE-STD-1138-2000, Industrial Hygiene Qualification Standard. Competency statements and supporting knowledge and/or skill statements from the qualification standard are shown in contrasting bold type, while the corresponding information associated with each statement is provided below it. The qualification standard for the Industrial Hygiene Reference Guide contains 25 competency statements. This reference guide will address all 25 statements.

Every effort has been made to provide the most current information and references available as of November 2006. However, the candidate is advised to verify the applicability of the information provided.

Please direct your questions or comments related to this document to the NNSA Service Center Learning and Career Development Department.

## TECHNICAL COMPETENCIES

1. **Industrial hygiene personnel shall demonstrate a working-level knowledge of health stressors that may be found in the workplace and the community.**
  - a) **Discuss the following types of health stressors and provide examples of hazards that may be anticipated.**
    - **Chemical**
    - **Biological**
    - **Physical**
    - **Ergonomic**

### *Chemical*

Using, handling, or conveying any type of hazardous chemical may present a health risk to employees in the workplace. The chemical may be present in the air as a gas or vapor (either visible or invisible), or in the form of dust, mist, fiber, or fumes. Contact with the body may occur through inhalation of contaminated air or through contact with the skin or eyes. Types of hazardous chemicals include gasoline, solvents, cleaning supplies, paints, pesticides, minerals, and wood dusts, as well as a wide range of chemicals used in industrial operations. The use of respirators is not a guarantee of adequate protection against hazardous chemicals.

### *Biological*

Biological stressors represent a distinct category of hazards. Unlike chemical or physical hazards, biological stressors (1) grow, reproduce, and die, (2) disperse both actively and passively, (3) interact with other biological populations in the ecosystem, and (4) evolve. Therefore, biological stressors as diverse as human pathogens (e.g., *Salmonella* and *Bacillus anthracis*), plant and animal pathogens (e.g., Asian soybean rust and avian influenza virus), and invasive species (e.g., Mediterranean fruit fly and kudzu) share many common features. The distinction between risk assessment for biological stressors and chemical risk assessment may be overstated, however, and a number of parallels can be drawn. For example, pathogen inactivation is analogous to chemical sequestration, and a population of invasive cells in the body is analogous to a population of invasive species in the environment. To date, however, the practice of risk assessment for biological stressors has not adopted conventions as simplifying assumptions to the extent that they are generally applied in the more mature field of chemical risk assessment. As with risk assessment in other fields, managing the tension between complexity and utility is likely to remain an ongoing challenge for the emerging field of risk assessment for biological stressors.

Title 29 CFR 1910.1030 defines bloodborne pathogens as pathogenic microorganisms that are present in human blood and can cause disease in humans. These pathogens include, but are not limited to, hepatitis B virus and human immunodeficiency virus.

Each employer having an employee(s) with occupational exposure shall establish a written Exposure Control Plan designed to eliminate or minimize employee exposure. Occupational exposure means reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that may result from the performance of an employee's duties. Each employer who has an employee(s) with occupational exposure

shall prepare an exposure determination. Engineering and work practice controls shall be used to eliminate or minimize employee exposure. Where occupational exposure remains after institution of these controls, personal protective equipment (PPE) shall also be used.

When there is occupational exposure, the employer shall provide, at no cost to the employee, appropriate PPE such as, but not limited to: gloves, gowns, and laboratory coats; face shields/masks and eye protection; and mouthpieces, resuscitation bags, pocket masks, or other ventilation devices. PPE will be considered appropriate only if it does not permit blood or other potentially infectious materials to pass through or to reach the employee's work clothes, street clothes, undergarments, skin, eyes, mouth, or other mucous membranes under normal conditions of use and for the duration of time the protective equipment will be used.

Title 29 CFR 1910.95 states that when employees are subjected to sound levels exceeding those listed in table 1, below, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels to permissible limits as specified in table 1, PPE shall be provided and used to reduce sound levels so that they fall within the levels of the table.

| Duration per day, hours | Sound level, dBA<br>Slow Response |
|-------------------------|-----------------------------------|
| 8                       | 90                                |
| 6                       | 92                                |
| 4                       | 95                                |
| 3                       | 97                                |
| 2                       | 100                               |
| 1½                      | 102                               |
| 1                       | 105                               |
| ½                       | 110                               |
| ¼ or less               | 115                               |

Table 1. Permissible noise exposures

The employer shall administer a continuing, effective hearing conservation program whenever employee noise exposures equal or exceed an eight-hour time-weighted average sound level of 85 decibels measured on the "A" scale (slow response) or, equivalently, a dose of fifty percent.

According to 29 CFR 1926.54, employees working in areas where there exists a potential exposure to direct or reflected laser light greater than 0.005 watts (5 milliwatts) shall be provided with anti-laser eye protection devices. Areas in which lasers are used shall be posted with standard laser warning placards. Employees whose occupation or assignment requires exposure to laser beams shall be furnished suitable laser safety goggles which will protect for the specific wavelength of the laser and be of optical density adequate for the energy involved.

Lasers are classified in categories 1 (safe) to 4 (dangerous). Most precautions apply to Class 3b and 4 lasers. The American Conference of Governmental Industrial Hygienists (ACGIH) provides threshold limit values (TLVs) for lasers, while ANSI Z136.1, American National

Standard for the Safe Use of Lasers, provides more detailed guidance on acceptable practices to provide safety. DOE O 420.2B, Safety of Accelerator Facilities, states that although eye injury from non-ionizing radiation is generally the primary hazard, laser systems can present electrical and chemical hazards as well. In addition to the non-ionizing radiation hazard, electrical hazards are associated with the high-voltage power supplies used in many laser systems. In particular, Class 4 lasers often use large power supplies that carry an appreciable risk of electrocution, especially in maintenance and adjustment procedures. Chemical hazards can be associated with halogen and dye lasers, as well as with radiation decomposition.

Electromagnetic radiation is restricted to that portion of the spectrum commonly defined as the radio frequency (RF) region, which includes the microwave frequency region. DOE G 420.2-1, Accelerator Facility Safety Implementation Guide for DOE O 420.2B, Safety of Accelerator Facilities, states that to avoid exposure of persons to unacceptable levels of RF fields, engineered control measures, such as shielding, prevention of wave guide leakage, enclosures, interlocks preventing accidental energizing of circuits, and dummy load terminations, should be given first consideration over any use of PPE. Where exposure in excess of the limits is possible, RF leakage tests should be conducted when the system is first operated and after modifications that might result in changes to the leakage. Area RF monitors are appropriate when RF energy can be expected in occupied areas. The ACGIH specifies guidelines for personnel protection in the form of TLVs. Use of the ACGIH guidelines in their most current form for RF and microwave fields is required by DOE O 440.1A as part of worker protection management for DOE contractor employees.

### *Physical*

The relationship between stress and physical health poses many questions for researchers. Most of their queries have focused on stressors such as divorce, bereavement, and job loss. However, more recent work has examined the health effects associated with extreme stressors, including war, sexual victimization, disasters, and serious accidents. Contributors examine the biology of stress and how trauma could lead to poor physical health through correlates such as depression, coping, and health behaviors. The effects of stress also present implications for clinical and health policy.

### *Ergonomic*

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among human and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance. Poor workplace designs can present ergonomic risk factors called stressors. These stressors include, but are not limited to, the following:

- Repetition is the number of motions or movements that are performed per cycle or per shift.
- Force is exerted by muscles in order to perform necessary activities such as lifting, grasping, pinching, and pushing.
- Extreme postures occur when muscles are required to work at a level near or at their maximum capacity.
- Static postures are awkward postures that occur when a body part is not moving, but is still doing work. Examples include sitting in a chair or holding an object.

- Contact pressure is the pressure that results from resting part of the body against a sharp edge or corner. Resting the wrists or forearms on an edge of a desk while typing is one example.
- Vibration occurs when a specific part of the body comes in contact with a vibrating object, such as a power hand tool. Exposure to whole-body vibration can occur while standing or sitting in vibrating environments or objects, such as when operating heavy-duty vehicles or large machinery.
- Cold temperatures reduce the natural elasticity of the body and reduce the sensation of touch (tactile feedback). In order to get the same amount of tactile feedback, an employee may exert more force than is necessary.

Employee exposure to these stressors can cause injury or musculoskeletal disorders.

**b) Describe how the following sources of information can be used to assist in the anticipation of health stressors.**

- **Standards**
- **Regulations**
- **Standard texts and references**
- **Site material safety data sheet (MSDS) inventories**

*Standards*

Standards are used to communicate DOE requirements to DOE employees. These requirements are updated frequently, and may be used to identify stressors that may exist and ways to mitigate or control these stressors.

*Regulations*

Regulations are the requirements for performance of tasks, required rules, or process operations. Regulations include areas that discuss safety measures to be taken, such as PPE, training, or required skills and knowledge to perform a task. Regulations also delineate the requirements for management of tasks.

*Standard Texts and References*

For some chemical processes, standard process descriptions can be found in chemical process references. Similarly, anticipated exposure patterns by operation, trade, or craft may be found in some references. Both may be of assistance in anticipating occupational exposure, although in most cases, the exposure data may reflect working conditions of 20 or more years ago, and operations described may not necessarily be performed in DOE.

*Site Material Safety Data Sheet (MSDS) Inventories*

The MSDS lists chemicals and the associated health stressors that they present. The MSDS can be used to identify stressors that exist in order to properly protect employees from such stressors. An MSDS is required for each type of chemical that is present in the work place.

- 2. Industrial hygiene personnel shall demonstrate the ability to anticipate health stressors during the planning and design phases of a work activity or from an operational description.**

**a) Discuss how a review of the following can be used to anticipate potential health stressors.**

- **Process raw materials**
- **A description of process chemical reactions**
- **Process products and by-products**
- **Process equipment**
- **Process operating procedures**

*Process Raw Materials*

A review of the raw materials involved in a process will identify any chemical hazards that are known to exist. Also, if the raw materials come in large quantities, industrial health personnel can ensure that stressors involving physical or ergonomic issues are addressed.

*A Description of Process Chemical Reactions*

Reactions among chemicals vary depending on the processes involved. The greatest short-term health stressors caused by chemical reactions are the production of large quantities of heat or poisonous gas and the possibility of an explosion. Latent stressors could be caused by the creation of carcinogens or other known chemicals that could have long-term, slow-acting effects on the worker. A review and understanding of the chemicals to be used can determine the required PPE that should be available and used. Also, knowing the effects of the chemicals enables management to create engineering controls to prevent or minimize potential health stressors.

*Process Products and By-Products*

Determining the products and by-products of a process allows for the development of safety procedures. Understanding the health hazards that exist from the byproducts of materials allows for proper disposal and minimization of health effects to people working with the materials. Also, determining the final byproduct of a process will allow for the required safety systems to be put into place for storage and movement of material.

*Process Equipment*

DOE G 420.1-1, Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria Guide for Use with DOE O 420.1, Facility Safety, states that building layouts should provide protection from the hazards associated with handling, processing, and storing of radioactive and/or hazardous materials.

The arrangement and location of hazardous process equipment and its maintenance provisions should provide appropriate protective and safety measures as applicable. The usual safety function of process equipment is to provide primary confinement and prevent or mitigate radioactive and/or hazardous material releases to the environment. Process equipment that would be required to provide primary confinement includes the following: piping, tanks, pressure vessels, pumps, valves, and gloveboxes. These examples represent process system components that could be used to contain radioactive or toxic materials directly. Process equipment for some applications can provide secondary confinement. Examples include double-walled piping systems, double-walled tanks, and gloveboxes.

Safety-class and safety-significant process equipment providing passive confinement (piping, tanks, holding vessels, etc.) must be designed to suitably conservative criteria. The redundancy criteria described in section 5.1.1.2 of DOE G 420.1-1 must be applied to the

design of safety-class structures, systems, and components (SSCs) that involve active confinement process equipment (pumps, valves, etc.). Redundancy criteria should also be considered in the design of safety-significant SSCs that involve active confinement process equipment.

#### *Process Operating Procedures*

Exposure to health stressors may be anticipated from plans wherever materials are added to or removed from an otherwise enclosed system. The need for the addition to, or sampling from, the process might be indicated on plans by the presence of enclosures or local exhaust at these locations. The presence in the plans of control booths for operators might indicate that the designer anticipates noise and heat to be generated from the process.

Process information should contain a list of chemical ingredients and products and information about where and how ingredients would be added. The chemical ingredient and product information should allow a prediction about what stressors are within the system. However, they cannot predict how much of a chemical could escape at the points where chemicals are added, products/wastes are removed, or process samples are taken, or through fugitive emissions.

#### **b) In planning a work activity, anticipate the ergonomic hazards that may result from the following:**

- **Workplace/equipment/tool design**
- **Repetitive motion tasks**
- **Work/rest cycle**
- **Temperature and other environmental extremes**

#### *Workplace/Equipment/Tool Design*

Tool selection is of critical importance for user safety, comfort, and health. However, even the best tools on the market will not transform a poorly designed workstation into a safe and comfortable one for the operator.

Many work-space components such as work surfaces, seats, flooring, tools, equipment, and environmental conditions determine whether or not a job can be performed safely. If the workplace design does not meet an individual's physical needs, it can create risk factors for discomfort, aches and pains, fatigue, and eventually, work-related musculoskeletal disorders (WMSDs). On the other hand, in a well-designed workplace where the worker has the opportunity to choose from a variety of well-balanced working positions and to change between them frequently, work can be carried out safely and injury-free.

Avoid bending over your work; instead, keep your back straight and, if possible, elevate the work area or task to a comfortable level. Keep your elbows close to the body, and reduce the need to stretch your arms overhead or out in front of you. Tool extensions can help where it is difficult to reach the object of work. Using a stepladder or step-stool can improve the working body position where the task requires elevating your arms above the shoulder. At the same time, frequent stretching breaks will relieve any built-up muscle tension. If standing, distribute your weight evenly between the feet. Even better, use a foot stool or rail to rest your legs, and shift from one leg to the other periodically.

Work Station Design for Precision Work. To accommodate workers that do precision work, incorporate the following:

- Provide the worker with a height-adjustable workstation.
- For a fixed-height workbench, provide work platforms to accommodate shorter workers, and raise the work surface for taller workers.
- Provide sufficient leg clearance to allow the worker to get close to the work object, thereby reducing the need to bend the torso.
- Provide a foot rest as foot support to improve body balance and minimize the static load on the workers back.
- Use anti-fatigue matting to reduce lower back and leg discomfort and minimize fatigue.
- Consider using chairs or stools to allow work to be performed in a sitting or standing position.
- Consider using arm slings. This reduces tension in the shoulder-neck area.
- Where feasible, provide the worker with a tilted workstation. This reduces static load on the back and upper body.
- Use jigs or vices to hold the work object steady and secure at the proper height and position for optimum comfort.
- Use vices to minimize pinching and gripping forces.

Work Station Design for Assembly Work. In assembly work, static load, awkward postures, and forceful movements are major risk factors for WMSDs. Prolonged standing and the resulting fatigue also contribute to WMSDs. Work station design should incorporate the following:

- Use jigs and vices to hold the work object steady at the right height and position for optimum comfort.
- Use tool balancers to reduce the effort of holding and operating the tool.
- If possible, use the lightest tool that can get the job done properly, preferably one weighing less than 1 kg (2 lbs).
- Use anti-fatigue matting to reduce lower back and leg discomfort and minimize fatigue.

Weight of the Tool. Ideally, a worker should be able to operate a tool with one hand. Therefore, the weight of the tool, especially one intended for repetitive use, should not exceed 1 kg (2.2 lbs.). It is also important that the center of gravity be aligned with the center of the gripping hand. In other words, a tool should feel easy to hold either in an upright position or in the position in which it will be used (i.e., pointing down). For example, a drill that is front-heavy will require effort (especially in the wrist and forearm) to hold it in a usable position, and should be avoided. The exception to this principle is a power hand tool, such as a grinder, that has to be heavy in order to reduce the force that the worker has to exert while using it. Tools heavier than 1 kg, or poorly balanced tools, should be supported by counter-balancers.

Power. Where possible, power tools should replace hand tools that normally require the exertion of frequent and repetitive force to do a job, because the greater the force exerted with a hand tool, and the more the hand has to twist to use it, then the greater the risk for WMSDs.

Handles. With the exception of tools for precision work (e.g., watch making, microsurgery, carving), the handles and grips of hand tools should be designed for a power grip. The belief that smaller tools should have smaller handles while larger tools should have larger ones is debatable.

Design considerations related to handles are addressed below:

- Handle shape — Tools with bent or angled handles or tools with pistol-grips are beneficial where the force is exerted in a straight line in the same direction as the straightened forearm and wrist, especially when the force must be applied horizontally. Tools with straight handles are for tasks where the force is exerted perpendicular to the straightened forearm and wrist, for instance, when the force must be applied vertically. Shaped tools such as bent-handle tools are effective where most of the tasks are done in the same plane and height as the arm and hand and when only one or two other tools are used. Knowing the tasks and the layout of the workplace where they will be used is vital for selecting the right tools for any given job. Select tools that do not require wrist flexion, extension, or deviation. In other words, select tools that allow you to keep the wrist straight or in a neutral position. The crucial ergonomic principle in tool use and design — which is, “bend the tool, not the wrists” — does not always prevent discomfort and injuries when bent-handle tools are used indiscriminately, regardless of the layout of the work situation.
- Diameter — Handles should be cylindrical or oval in cross section, with a diameter of between 30 mm and 45 mm. For precision work, the recommended diameter for handles is between 5 mm and 12 mm. For greater torque, large screwdrivers should have a handle diameter up to 50 mm to 60 mm.
- Length — A handle that is too short can cause unnecessary compression in the middle of the palm. It should extend across the entire breadth of the palm. Tool handles longer than 100 mm (preferably 115 mm to 120 mm) will reduce the negative effects of any compression exerted. Rounded handles will minimize palm compression on the palm still further. Keep in mind that the use of gloves requires longer tool handles.
- Separation between handles — Crushing, gripping, or cutting tools such as pliers or tongs are equipped with two handles. The recommended distance separating the handles is between 50 mm and 65 mm. Such a range will fit both male and female users. Tools with larger or smaller spans will reduce one’s maximum grip strength and may contribute to the onset of carpal tunnel syndrome.
- Power tool triggers — Frequent movement of the index finger while operating the trigger of power tools (such as a power drill) poses a considerable risk for both trigger finger and trigger thumb (tenosynovitis in the index finger and/or thumb). A longer trigger that allows the use of two or three fingers to activate it reduces discomfort and minimizes the risk for injury. The recommended minimum length of the trigger is 50 mm.
- Materials and texture of handles — To ensure a good grip on a handle, sufficient friction must exist between the hand and the handle. This is particularly important where a considerable force must be applied with a sweaty hand. Hand tools should be made of non-slip, non-conductive, and compressible materials. For example, textured rubber handles provide a good grip, reduce the effort needed to use the tool effectively, and prevent the tool from slipping out of the hand. Glossy coatings and highly polished handles should be avoided. The electrical and heat insulation properties of the handles are important for power hand tools. Handles made of plastics or compound rubber are recommended. Sharp edges and contours can be covered with cushioned tape to minimize lacerations.

Vibration. The only effective way to reduce vibration in power tools is through design. This fact makes tool selection most critical. The common practices of covering handles of vibrating tools with a layer of viscoelastic material or of using anti-vibration gloves made of similar material are of dubious value. These “anti-vibration” materials will dampen vibration above certain frequencies that are characteristic for the kind of material, but most of the vibration energy in the handle of a power tool is below those frequencies.

### *Repetitive Motion Tasks*

WMSDs are associated with the following factors:

- Work postures and movements
- Repetitiveness and pace of work
- Force of movements
- Vibration
- Temperature

Certain workplace conditions, for example, the layout of the workstation, the speed of work (especially in conveyor-driven jobs), and the weight of the objects being handled influence these factors.

Repetitive movements are especially hazardous when they involve the same joints and muscle groups over and over, and when we do the same motion too often, too quickly, and for too long. To analyze how repetitive a task is, we need to describe it in terms of steps or cycles. For example, the bottle packing operation requires workers to pack boxes with twenty-four bottles. One cycle can be described as follows:

- Reach for bottles
- Grasp bottles
- Move bottles to the box
- Place bottles in the box

If a worker grasps four bottles each time, the same cycle would have to be repeated six times to fill a box. Assuming that one cycle lasts two seconds, it would take twelve seconds to pack a box with twenty-four bottles.

There are no rules to judge movements as either high or low in repetition. Some researchers classify a job as high repetitive if the time to complete such a job was less than 30 seconds, or low repetitive if the time to complete the job was more than 30 seconds. Although no one really knows at what point WMSDs may develop, workers performing repetitive tasks are at risk for WMSDs. Work involving movement repeated over and over is very tiring because the worker cannot fully recover in the short periods of time between movements. Eventually, it takes more effort to perform the same repetitive movements. When the work activity continues in spite of the fatigue, injuries can occur.

Force is the amount of effort our bodies must exert to lift objects, to use tools, or to move. The amount of force we use to do a job depends on many factors such as the weight of the objects and their placement in relation to the body. It requires extra force to lift and carry a box with arms outstretched and held away from the body, or to lift the same objects in a pinch position rather than in a hook position. A force of more than four kilograms, or nine pounds, is considered significant. This is the force used to hammer a nail, for example.

Although no one really knows when WMSDs will develop, workers performing forceful movements are at risk. Work involving forceful movements is also very tiring because there is not time for a full recovery between movements. Eventually it takes effort to perform the same task. When the work activity continues in spite of the developing fatigue, injuries occur.

#### *Work/Rest Cycle*

The goal of rest breaks is to interrupt periods of static posture and repetitive motion and to introduce recovery time periods. But rest breaks are not the only way to achieve such a goal. This goal can also be achieved through alternative work and, in some cases, through careful scheduling of workflow. A combination of rest breaks and changes in work patterns/tasks can effectively reduce exposure to risk factors and maintain physiological integrity. This thought process raises several questions. The risk associated with a high-repetition, high-force task is greater than that associated with a low-repetition, low-force task. But what about the risks associated with a low-repetition, high-force task, or a high-repetition, low-force task? Furthermore, individual differences among people with respect to physical conditioning, skill level, and anthropometrics also play an important role.

#### *Temperature and Other Environmental Extremes*

Cold and hot working conditions can create added problems in assessing risk factors for WMSDs. Keeping hands warm may require gloves which, in turn, may cause workers to grip hand tools more forcefully, resulting in added stress to the hands and wrists. More forceful gripping may also occur under hot conditions because sweating may increase the slipperiness of hand tools. Workstation clearances should take into account workers wearing extra clothing for thermal protection in the cold. At the other extreme, hot working conditions may reduce a worker's capacity to do heavy physical work. In this situation, cardiac output needed to keep the body's temperature from rising too high limits the amount of blood that can deliver oxygen to the muscles. Fatigue buildup would be more readily experienced in these situations. The National Institute for Occupational Safety and Health (NIOSH) has published recommended exposure limits (RELs) for work under hot environmental conditions. These limits are provided for heat-acclimatized and non-acclimatized workers when performing tasks requiring different levels of energy expenditure.

#### **c) Read and interpret relevant portions of design drawings, plans, and specifications.**

Note: This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

### **3. Industrial hygiene personnel shall demonstrate a working-level knowledge of study and observation methods required to recognize and evaluate potential workplace health stressors.**

#### **a) Discuss how the presence and use of existing control measures affect the evaluation of health stressors.**

Existing control measures are already providing a level of safety. They are used either to minimize the formation of health stressors, or to identify patterns or trends that indicate additional or increased health stressors. The existing control measures are either preventive or for use in identifying health stressors.

DOE G 440.1-1, Worker Protection Management for DOE Federal and Contractor Employees Guide for Use with DOE Order 440.1, states that DOE O 440.1 requires assessment of worker exposure to chemical, physical, biological, and ergonomic hazards.

Monitoring results should be recorded with documentation that describes the tasks and locations where monitoring occurred, and which identifies workers monitored or represented by the monitoring, sampling methods and durations, control measures in place during monitoring (including the use of PPE), and any other factors that may have affected sampling results.

DOE G 440.1-3, Implementation Guide for Use with DOE Order 440.1, Occupational Exposure Assessment, states that qualitative exposure information and quantitative data may also be used to determine the adequacy of existing work controls. This may be done by comparing the exposure levels under existing controls with the operational exposure limits. Once levels under existing controls have been examined, it may be necessary to modify the controls or add new controls. PPE used for controls should provide adequate protection of the worker while avoiding any unnecessary stress that may be associated with wearing PPE.

**b) Describe how the following sensory indications may help with the identification of exposures.**

- **Odor**
- **Hearing**
- **Sight**
- **Touch**

*Odor*

Odor may help identify the material one is exposed to. However, odor is not a reliable indicator of the concentration of the substance in air. Gasoline, for example, has a detectable odor at very low concentrations; carbon monoxide, on the other hand, has no odor even at lethal concentrations.

*Hearing*

Hearing identifies noises and sounds present in an area. Different people have different noise tolerance levels. To identify if a level meets true noise level criteria, exposure sound testing needs to be performed in the area.

*Sight*

Sight is used to identify any unsafe configuration, layout, or operation that is being performed. The visual identification of materials or equipment that are in ill-repair, poorly located, or placed in an ill-advised location is done in many facilities as part of a hazard analysis/identification. Visual inspections are used in every facility to identify any potential health stressors.

*Touch*

Touch is a valuable tool for verifying the physical condition of components and equipment. To determine the condition of many components, touch can reveal many failures that may have occurred in mechanical systems or in structural components. The physical ability to touch, operate, and inspect the equipment allows personnel to determine the initial condition of the material.

**4. Industrial hygiene personnel shall demonstrate a working-level knowledge of occupational illnesses and their signs and symptoms and what their presence may indicate about past and current workplace exposure.**

**a) Discuss common signs and symptoms that may demonstrate an occupational illness or exposure.**

Signs and symptoms indicating occupational illness or exposure vary depending on the materials/chemicals to which a person is exposed. Some of the most prevalent symptoms and signs are nausea, headache, and cold-like symptoms. Symptoms for various other exposures are covered below.

*Occupational Asthma*

Signs and symptoms of occupational asthma may include

- wheezing
- coughing
- shortness of breath
- chest tightness
- difficulty exercising

Other possible accompanying signs and symptoms may include

- runny nose
- nasal congestion
- eye irritation

During the early stages of the disease, the worker usually develops symptoms shortly after exposure to the workplace substance that causes it. Sometimes, the worker may not notice any signs or symptoms until up to 12 hours later. The worker's asthma may worsen as the work week progresses, subside during weekends and vacations, and recur when he/she returns to work.

In later stages of the disease, signs and symptoms may also develop when the worker is away from work. Once the lungs have developed a pattern of overreacting to a certain substance, they may become sensitive to other substances, such as house dust, cigarette smoke, and cold air.

*Exposure to Mercury*

**Short-Term Exposure.** Inhaled mercury vapor may cause headaches, cough, chest pains, chest tightness, and difficulty breathing. It may also cause chemical pneumonitis. In addition, it may cause soreness of the mouth, loss of teeth, nausea, and diarrhea. Liquid mercury may irritate the skin.

**Long-Term Exposure.** Repeated or prolonged exposure to mercury liquid or vapor causes effects that develop gradually. The first effects to occur are often fine shaking of the hands, eyelids, lips, tongue, or jaw. Other effects are allergic skin rash, headache, sores in the mouth, sore and swollen gums, loose teeth, insomnia, excess salivation, personality change, irritability, indecision, loss of memory, and intellectual deterioration.

### *Overexposure to Lead*

**Short-Term (Acute) Overexposure.** Lead is a potent, systemic poison that serves no known useful function once absorbed by your body. Taken in large enough doses, lead can kill a person in a matter of days. A short-term dose of lead can lead to acute encephalopathy, a condition affecting the brain which develops quickly to cause seizures, coma, and death from cardiorespiratory arrest. Short-term occupational exposures of this magnitude are highly unusual, but not impossible. Similar forms of encephalopathy may, however, arise from extended, chronic exposure to lower doses of lead. There is no sharp dividing line between the rapidly developing acute effects of lead and chronic effects which take longer to develop. Lead adversely affects numerous body systems and causes forms of health impairment and disease which may arise after periods of exposure as short as days or as long as several years.

**Long-Term (Chronic) Overexposure.** Chronic overexposure to lead may result in severe damage to the blood-forming, nervous, urinary, and reproductive systems. Some common symptoms of chronic overexposure include loss of appetite, metallic taste in the mouth, anxiety, constipation, nausea, pallor, excessive tiredness, weakness, insomnia, headache, nervous irritability, muscle and joint pain or soreness, fine tremors, numbness, dizziness, hyperactivity, and colic. In lead colic, there may be severe abdominal pain.

Damage to the central nervous system in general, and the brain (encephalopathy) in particular, is one of the most severe forms of lead poisoning. The most severe, often fatal, form of encephalopathy may be preceded by vomiting, a feeling of dullness progressing to drowsiness and stupor, poor memory, restlessness, irritability, tremor, and convulsions. It may arise suddenly with the onset of seizures, followed by coma and death. There is a tendency for muscular weakness to develop at the same time. This weakness may progress to paralysis, often observed as a characteristic wrist drop or foot drop, and is a manifestation of a disease to the nervous system called peripheral neuropathy.

Chronic overexposure to lead also results in kidney disease with few, if any, symptoms appearing until extensive and most likely permanent kidney damage has occurred. Routine laboratory tests reveal the presence of this kidney disease only after about two-thirds of kidney function is lost. When overt symptoms of urinary dysfunction arise, it is often too late to correct or prevent worsening conditions, and progression to kidney dialysis or death is possible.

Chronic overexposure to lead impairs the reproductive systems of both men and women. Overexposure to lead may result in decreased sex drive, impotence, and sterility in men. Lead can alter the structure of sperm cells raising the risk of birth defects. There is evidence of miscarriage and stillbirth in women whose husbands were exposed to lead or who were exposed to lead themselves. Lead exposure also may result in decreased fertility and abnormal menstrual cycles in women. The course of pregnancy may be adversely affected by exposure to lead since lead crosses the placental barrier and poses risks to developing fetuses. Children born of parents either one of whom were exposed to excess lead levels are more likely to have birth defects, mental retardation, or behavioral disorders, or to die during the first year of childhood.

Overexposure to lead also disrupts the blood-forming system, resulting in decreased hemoglobin (the substance in the blood that carries oxygen to the cells) and ultimately

anemia. Anemia is characterized by weakness, pallor, and fatigability as a result of decreased oxygen carrying capacity in the blood.

Early signs of heavy metal poisoning are usually vague, often depending upon the level of toxicity. Toxins tend to accumulate within the brain, kidneys, immune system, and other body tissues where they can severely disrupt normal function. Mild cases of toxicity may be associated with headache, fatigue, and impaired ability to think or concentrate. As toxicity increases, so does the severity of signs and symptoms. A person with severe toxicity may also experience muscle pains, indigestion, tremors, constipation, anemia, pallor, dizziness, and poor coordination.

Numerous studies have demonstrated a strong relationship among intelligence, childhood learning disabilities, and body stores of lead, aluminum, cadmium, and mercury. Basically, the higher a child's level of heavy metals, the lower the child's IQ will be. The same sort of relationship exists with blood pressure, as high blood pressure is also associated with higher levels of lead and other heavy metals. Heavy metals have a very strong affinity for body tissues composed of fat, like the brain, nerves, and kidneys. As a result, heavy metals are almost always linked to disturbance in mood and brain function, as well as neurological problems (including multiple sclerosis) and high blood pressure (the kidneys regulate blood pressure).

There are other types of exposures in addition to those addressed above. Check the appropriate MSDSs for the chemicals personnel are exposed to for additional guidance. Understanding the risks associated with materials is paramount for employees working with hazardous materials.

**b) Describe the following occupational illnesses and explain their workplace cause:**

- **Asbestosis**
- **Mesothelioma**
- **Pneumoconiosis**
- **Dermatitis**
- **Cumulative trauma disorder**
- **Chronic beryllium disease**
- **Dermatosis**
- **Hypersensitivity pneumonitis**
- **Chronic obstructive lung disease**
- **Occupational Asthma**
- **Bronchogenic Carcinoma**
- **Glomerulonephritis**
- **Cirrhosis of Liver**
- **Jaundice**

*Asbestosis*

Title 29 CFR 1910.1001 defines asbestosis as a disabling fibrotic lung disease that is caused only by exposure to asbestos. Asbestosis is pulmonary fibrosis caused by the accumulation of asbestos fibers in the lungs. Symptoms include shortness of breath, coughing, fatigue, and vague feelings of sickness. When the fibrosis worsens, shortness of breath occurs even at rest. The diagnosis of asbestosis is based on a history of exposure to asbestos, the presence of characteristic radiologic changes, end-inspiratory crackles (rales), and other clinical features of fibrosing lung disease. Pleural plaques and thickening are observed on x-rays taken during the early stages of the disease. Asbestosis is often a progressive disease even in

the absence of continued exposure, although this appears to be a highly individualized characteristic. In severe cases, death may be caused by respiratory or cardiac failure.

Asbestos is composed of fibrous mineral silicates of different chemical compositions. When inhaled, asbestos fibers settle deep in the lungs, causing scars. Asbestos inhalation also can cause the two layers of membrane covering the lungs (the pleura) to thicken; these thickenings are called pleural plaques. These plaques do not become cancerous.

Inhaling asbestos fibers can occasionally cause fluid to accumulate in the space between the two pleural layers of the lungs (pleural space). This is called a noncancerous (benign) asbestos effusion.

Asbestos also causes cancer in the pleura, called mesothelioma, or in the membranes of the abdomen, called peritoneal mesothelioma. In the United States, asbestos is the only known cause of cancerous (malignant) mesothelioma. Smoking is not a cause of cancerous mesothelioma. Mesotheliomas most commonly appear after exposure to crocidolite, one of four types of asbestos. Amosite, another type, also causes mesotheliomas. Chrysotile probably causes fewer cases of mesotheliomas than other types, but chrysotile is often contaminated with tremolite, which does cause the cancer. Mesotheliomas usually develop 30 to 40 years after exposure and can occur after low exposure.

Asbestos can also cause lung cancer. Lung cancer from asbestos is related in part to the level of exposure to asbestos fibers; however, among people with asbestosis, lung cancer occurs most commonly in those who also smoke cigarettes, particularly those who smoke more than a pack a day.

Although the general public has become alarmed about the risks of asbestos, most non-occupationally exposed people are at extremely low risk of developing asbestos-related lung disease. The asbestos must be broken into tiny pieces to be inhaled into the lungs. Workers who demolish buildings that have insulation containing asbestos are at increased risk. People who regularly work with asbestos are at greatest risk of developing lung disease. The more a person is exposed to asbestos fibers, the greater the risk of developing an asbestos-related disease.

### *Mesothelioma*

The ingestion and inhalation of airborne asbestos fibers are the main causes of mesothelioma. Mesothelioma is a rare, but deadly, cancer that attacks the pleural lining of the chest cavity and the lungs or the peritoneal lining of the organs of the stomach. In more rare cases, the causes of mesothelioma can attack the pericardium of the heart or the lining of the reproductive organs.

The causes of mesothelioma are more likely to affect males than females, because males are more likely to be exposed to asbestos. Asbestos has been used commercially since the 1800s, and has been known to cause mesothelioma and other types of serious health problems. Asbestos exposure can be the cause of mesothelioma for workers in the mining, maritime, automotive, railroad, factory, and construction industries. Secondary exposure can contribute to cases of mesothelioma when workers inadvertently carry asbestos fibers home on their person, and family members are exposed.

Because inhalation and ingestion of asbestos are the primary causes of mesothelioma, the Occupational Safety and Health Administration (OSHA) has set permissible exposure limits (PELs) on the amount of asbestos that an employee can be exposed to in the workplace. Employee exposure to asbestos cannot exceed 0.1 fiber per cubic meter of space averaged over an eight-hour work day or 1 fiber per cubic meter in any thirty-minute period. Some work environments are required to conduct daily monitoring of asbestos levels to prevent the causes of mesothelioma. Protective gear, adequate ventilation, and respiratory equipment must also be supplied by employers to prevent the causes of mesothelioma from harming workers. Even with these precautions, as many as 1.3 million construction workers alone are exposed to the causes of mesothelioma every year.

Mesothelioma kills ten thousand people every year. At least two to three thousand people are diagnosed with mesothelioma annually. Mesothelioma can remain dormant in the body for up to forty years. Once diagnosed, the prognosis for mesothelioma victims is bleak. The average survival time following diagnosis is ten months to a little over a year.

When a victim does exhibit the symptoms of mesothelioma, the symptoms can progress rapidly. The symptoms of mesothelioma related to asbestos inhalation affect the plural lining in the chest cavity and can include: chest pain; chronic cough; difficulty breathing because of fluid accumulation; fever; and weight loss. The symptoms of mesothelioma related to asbestos ingestion bombard the organs of the stomach and can include stomach pain, nausea, vomiting, bowel problems, weight loss, swelling of the feet, anemia, fever, and fluid build up in the abdominal region.

#### *Pneumoconiosis*

Pneumoconiosis is the medical term for a type of disease caused by dust in the lungs. It can arise from a number of dusts found in workplaces. For example, silicosis is a kind of pneumoconiosis caused by the presence of silica dust in the lungs. Silica is a mineral found in many underground mines and in some surface quarries.

Dust in the lungs can scar the lung tissues, a condition called fibrosis. The lungs lose their elasticity and become less efficient. The heart must work harder to maintain the oxygen supply. The exposed person suffers shortness of breath. Decreasing physical strength and death can follow in extreme cases of the illness.

Dusts that do not scar the lungs may nevertheless cause non-fibrotic pneumoconiosis and interfere with the proper functioning of the lungs.

#### *Dermatitis*

Dermatitis can often be related to workplace factors. It is characterized by redness, itching, scaling, rashes, hives, or blistering of the skin.

The two common forms of dermatitis usually seen in the workplace are allergic dermatitis and irritant contact dermatitis. When the skin comes into contact with certain substances at work, occupational dermatitis can occur. Things that might cause occupational dermatitis include cleaning products, organic solvents, metalworking fluids, cement, adhesives, other chemicals, and even certain plants.

Substances causing occupational dermatitis are divided into two groups known as irritants and sensitizers. Irritants act directly on the skin through chemical reactions. With sensitizers, skin reactions may not be caused on initial contact, but after repeated exposure, some people will have an allergic reaction. The employer has an important role in controlling workplace exposures to agents that cause occupational dermatitis, and in providing appropriate health surveillance and encouraging employees to report symptoms at an early stage.

#### *Cumulative Trauma Disorder*

Cumulative trauma disorders (CTDs) are injuries of the musculoskeletal and nervous systems that may be caused by repetitive tasks, forceful exertions, vibrations, mechanical compression (pressing against hard surfaces), or sustained or awkward positions. Cumulative trauma disorders are also known as repetitive motion disorders (RMDs), overuse syndromes, regional musculoskeletal disorders, repetitive motion injuries, or repetitive strain injuries.

These painful and sometimes crippling disorders develop gradually over periods of weeks, months, or years. They include the following disorders, which may be seen in office workers:

- Carpal tunnel syndrome is a compression of the median nerve in the wrist that may be caused by swelling and irritation of tendons and tendon sheaths.
- Tendinitis is an inflammation (swelling) or irritation of a tendon. It develops when the tendon is repeatedly tensed from overuse or unaccustomed use of the hand, wrist, arm, or shoulder.
- Tenosynovitis is an inflammation (swelling) or irritation of a tendon sheath associated with extreme flexion and extension of the wrist.
- Low back disorders include pulled or strained muscles, ligaments, tendons, or ruptured disks. They may be caused by the cumulative effects of faulty body mechanics, poor posture, and/or improper lifting techniques.
- Synovitis is an inflammation (swelling) or irritation of a synovial lining (joint lining).
- DeQuervain's disease is a type of synovitis that involves the base of the thumb.
- Bursitis is an inflammation (swelling) or irritation of the connective tissue surrounding a joint, usually of the shoulder.
- Epicondylitis is elbow pain associated with extreme rotation of the forearm and bending of the wrist. The condition is also called tennis elbow or golfer's elbow.
- Thoracic outlet syndrome is a compression of nerves and blood vessels between the first rib, clavicle (collar bone), and accompanying muscles as they leave the thorax (chest) and enter the shoulder.
- Cervical radiculopathy is a compression of the nerve roots in the neck.
- Ulnar nerve entrapment is a compression of the ulnar nerve in the wrist.

Cumulative trauma disorders can also result from other than work activities that involve repetitive motions or sustained awkward positions such as sports or hobbies. Work and non-work activities may together contribute to cumulative trauma disorders. These disorders can also be aggravated by medical conditions such as diabetes, rheumatoid arthritis, gout, multiple myeloma, thyroid disorders, amyloid disease, and pregnancy.

The symptoms of cumulative trauma disorders include the following:

- Numbness
- Decreased joint motion
- Swelling

- Burning
- Pain
- Aching
- Redness
- Weakness
- Tingling
- Clumsiness
- Cracking or popping of joints

The listed symptoms may involve the back, shoulders, elbows, wrists, or fingers. If symptoms last for at least one week, or if they occur on many occasions, a doctor should be consulted.

#### *Chronic Beryllium Disease*

Beryllium is a metal that is found in nature, especially in beryl and bertrandite rock. It is extremely lightweight and hard, is a good conductor of electricity and heat, and is nonmagnetic. These properties make beryllium suitable for many industrial uses, including: metalworking (pure beryllium, copper and aluminum alloys, jet break pads, aerospace components); ceramic manufacturing (semiconductor chips, ignition modules, crucibles, jet engine blades, rocket covers); electronic applications (transistors, heat sinks, x-ray windows); atomic energy applications (heat shields, nuclear reactors, nuclear weapons); laboratory work (research and development, metallurgy, chemistry); extraction (ore and scrap metal); dental alloys (crowns, bridges, dental plates); and sporting goods (golf clubs, bicycle frames).

Exposure happens when a person breathes in beryllium mists, dusts, or fumes. Beryllium can then travel to the lungs where it can cause damage. Beryllium-related granulomas (non-cancerous tumors or growths) can also develop in other body tissues, but these do not usually result in a loss of function.

Machinists, welders, and operators may be exposed through direct handling of beryllium and beryllium compounds. Other workers may be exposed by performing laboratory analyses on beryllium compounds, by coming into contact with contaminated equipment, or by working near a beryllium operation.

#### *Dermatosis*

Dermatosis is just like dermatitis with the exception that there is no inflammation of the skin.

#### *Hypersensitivity Pneumonitis*

Hypersensitivity pneumonitis (also called allergic alveolitis) is a disease in which the air sacs (alveoli) of the lungs become inflamed when certain dusts are inhaled to which the person is sensitized or allergic.

These dusts contain organic substances, such as fungus spores from moldy hay or bird droppings.

When a person inhales such dusts the first time, no problem is noticed, but after repeated exposure to the dust, some people may develop symptoms. The tiny air sacs in the lungs known as alveoli become inflamed, their walls fill with white blood cells, and sometimes the sacs fill with fluid. If the disease recurs as a result of continued or repeated exposure to the offending dusts, parts of the lung may develop fibrous scar tissue and will no longer function normally in breathing.

The symptoms of an acute attack are similar to those of the flu and appear some 4-6 hours after the person breathes the offending dust. These symptoms include chills, fever, dry cough, shortness of breath, a tight feeling in the chest, and tiredness. The symptoms may persist for as little as 12 hours or as long as 10 days. Between attacks, the person may have no symptoms and may feel quite normal.

After repeated exposure to the dust, chronic cough may develop with excessive sputum production containing pus, and eventually there may be chronic shortness of breath. The person may also show loss of appetite and weight loss.

### *Chronic Obstructive Lung Disease*

Chronic obstructive pulmonary disease (COPD) refers to a group of diseases that cause airflow blockage and breathing-related problems. It includes emphysema, chronic bronchitis, and in some cases, asthma.

COPD is a leading cause of death, illness, and disability in the United States. In 2000, 119,000 deaths, 726,000 hospitalizations, and 1.5 million hospital emergency department visits were caused by COPD. An additional 8 million cases of hospital outpatient treatment or treatment by personal physicians were linked to COPD in 2000.

In the United States, tobacco use is a key factor in the development and progression of COPD, but asthma, exposure to air pollutants in the home and workplace, genetic factors, and respiratory infections also play a role. In the developing world, indoor air quality is thought to play a larger role in the development and progression of COPD than it does in the United States.

Emphysema can be aggravated by air pollution or exposure to certain chemicals. The first action to take to avoid emphysema is to not inhale smoke, especially cigarette smoke. Avoid workplace exposure to chemicals that have irritating vapors or dust. Certain occupations that involve irritating dust or fumes are at higher risk. The American Lung Association lists coal miners, grain handlers, metal molders, and other workers exposed to dust as being at a higher risk for chronic bronchitis.

Some occupational pollutants such as cadmium and silica increase the risk of COPD. Persons at risk for this type of occupational pollution include coal miners, construction workers, metal workers, cotton workers, etc.

Treatment of COPD requires a careful and thorough evaluation by a physician. The most important aspect of treatment is avoiding tobacco smoke and removing other air pollutants from the patient's home or workplace. Symptoms such as coughing or wheezing can be treated with medication. Respiratory infections should be treated with antibiotics, if appropriate. Patients who have low blood oxygen levels in their blood are often given supplemental oxygen.

### *Occupational Asthma*

Occupational asthma, one form of asthma, is a lung disease in which the airways overreact to dusts, vapors, gases, or fumes that exist in the workplace. When these irritants are inhaled, airway inflammation begins, muscles in the airways tighten, the airway tissue swells, and too much mucus is produced. These changes all make breathing difficult.

Occupational asthma is usually reversible, but permanent lung damage can occur if exposure to the substance that causes the disease continues. In highly sensitive persons, even very low levels of exposure may provoke an episode.

The symptoms of occupational asthma include wheezing, a tight feeling in the chest, coughing, and shortness of breath.

Sometimes the worker will only have a cough or any one of the other symptoms. Symptoms usually occur while the worker is exposed to a particular substance at work. In some cases, symptoms may develop several hours after the person leaves work, and then subside before the worker returns to the job the next day.

In the early stages of the disease, symptoms usually decrease or disappear during weekends or vacations, only to recur upon return to work. In later stages of the disease, symptoms may occur away from work after exposure to common lung irritants. Once the airways have a pattern of overreacting, many common substances such as cigarette smoke, house dust, or cold air may produce asthma-like symptoms.

Workers in hundreds of occupations are exposed to substances in the air that may cause occupational asthma in susceptible people. Many of these substances are very common and not ordinarily considered hazardous. Only a small proportion of exposed workers develop occupational asthma.

Workers most likely to develop the disease are those with a personal or family history of allergies or asthma and frequent exposure to highly sensitizing substances. But the disease also can develop in persons with no known allergies. Occupational asthma may be suspected whenever a worker begins to develop respiratory symptoms. It may take several years to develop. A thorough physical examination and medical history of a worker with asthma symptoms should include a detailed listing of his or her work history and workplace conditions.

New processes and substances that can cause occupational asthma are being identified continually. The following list includes some of the airborne substances and some related occupations known to be associated with the disease:

- Chemical dusts or vapors from plasticizers, polyurethane paints, insulation, foam mattresses and upholstery, and packaging materials used in manufacturing and processing operations. Among specific chemicals known to cause asthma are the isocyanates, trimellitic anhydride, and phthalic anhydride.
- Animal substances such as hair, dander, mites, small insects, and bacterial or protein dusts. Exposed workers at special risk include farmers, animal handlers, shepherds, grooms, jockeys, veterinarians, and kennel workers.
- Organic dusts such as flour, cereals, grains, coffee and tea dust, and papain dust from meat tenderizer. These substances can cause asthma in millers, bakers, and other food processors.
- Cotton, flax, and hemp dust inhaled by workers in cotton processing and textile industries.
- Metals such as platinum, chromium, and nickel sulfate, and soldering fumes. Workers are exposed in refining and manufacturing operations.

### *Bronchogenic Carcinoma*

Bronchogenic carcinoma is a highly malignant primary lung tumor that accounts for most cases of lung cancer and has a very poor prognosis. It is the second most common cancer in men (13%) and the third most common cancer in women (13%). It is the leading cause of cancer death among men (32%) and women (25%), and its incidence appears to be rising more rapidly among women. It is most common between the ages of 45 and 70.

Bronchogenic carcinoma is caused by cigarette smoking, with a relationship to second-hand smoke. A small proportion of lung cancers (15% in men and 5% in women) are related to occupational agents, often overlapping with smoking: asbestos, radiation, arsenic, chromates, nickel, chloromethyl ethers, mustard (poison war) gas, and coke oven emissions. The exact role of air pollution is uncertain.

Current research indicates that the factor with the greatest impact on risk of lung cancer is long-term exposure to inhaled carcinogens. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) identifies all radionuclides as carcinogens, although the nature of the emitted radiation (alpha, beta, or gamma, and its energy), its consequent capacity to cause ionization in tissues, and the magnitude of radiation exposure, determine the potential hazard. For example, Thorotrast, an incidentally radioactive suspension previously used as a contrast medium in x-ray diagnostics, is thought by some to be the most potent human carcinogen known because of its retention within various organs and persistent emission of alpha particles.

Bronchogenic carcinoma is prevented by not smoking. Because tumors don't develop for a long time, smokers can stop at any time and greatly reduce the risk of developing lung cancer. This is the single most important preventive measure.

The signs and symptoms of bronchogenic carcinoma are listed below:

- Persistent cough
- Blood tinged sputum or coughing up frank blood
- Fatigue and weakness
- Chest pain, shortness of breath
- Weight loss
- Shoulder, arm, or bone pain

Sometimes the cancer is diagnosed on routine examination, and the patient has no or minimal symptoms. Symptoms and signs are dependent upon the location and spread of the tumor.

Risk factors include smoking, exposure to the agents listed above, and being over the age of 60.

### *Glomerulonephritis*

Glomerulonephritis is a type of kidney disease caused by inflammation of the internal kidney structures (glomeruli).

Glomerulonephritis may be a temporary and reversible condition, or it may be progressive. Progressive glomerulonephritis may result in destruction of the kidney glomeruli, chronic renal failure, and end stage renal disease. The disease may be caused by specific problems with the body's immune system, but the precise cause of most cases is unknown. However,

potential causes are due to infectious (bacterial, viral, or parasitic pathogens), autoimmune, or paraneoplastic factors, or to exposure to hydrocarbon solvents.

Damage to the glomeruli with subsequent impaired filtering causes blood and protein to be lost in the urine. Because symptoms develop gradually, the disorder may be discovered when there is an abnormal urinalysis during a routine physical or examination for unrelated disorders. Glomerulonephritis can cause hypertension and may only be discovered as a cause of hypertension that is difficult to control.

It may develop after survival of the acute phase of rapidly progressive glomerulonephritis. In about one-fourth of the people with chronic glomerulonephritis, there is no prior history of kidney disease, and the disorder first appears as chronic renal failure.

Specific disorders that are associated with glomerulonephritis include the following:

- Focal segmental glomerulosclerosis (FSG)
- Good pasture's syndrome
- IgM mesangial proliferative glomerulonephritis
- Lupus nephritis
- Membranoproliferative GN I
- Membranoproliferative GN II
- Post-streptococcal GN
- Rapidly progressive (crescentic) glomerulonephritis
- Rapidly progressive glomerulonephritis (RPGN)

Symptoms of glomerulonephritis include the following:

- Blood in the urine (dark, rust-colored, or brown urine)
- Foamy urine
- Unintentional weight loss
- Nausea and vomiting
- General ill feeling (malaise)
- Fatigue
- Headache
- Frequent hiccups
- Generalized itching
- Decreased urine output
- Need to urinate at night
- Easy bruising or bleeding
- Decreased alertness
  - Drowsiness, somnolence, lethargy
  - Confusion, delirium
  - Coma
- Muscle twitching
- Muscle cramps
- Seizures
- Increased skin pigmentation (hyperpigmentation) — skin may appear yellow or brown
- Decreased sensation in the hands, feet, or other areas

Additional symptoms that may be associated with this disease include the following:

- Excessive urination
- Nosebleeds
- High blood pressure
- Blood in the vomit or in stools

### *Cirrhosis of Liver*

The liver is the largest internal organ of the body. Located behind your ribs, on the right side of your abdomen, it is also essential to life, performing such key tasks as removal of poisons, germs, and bacteria from the blood, production of bile (which helps our bodies absorb fats and fat-soluble vitamins), as well as production of important immune-building agents and blood-clot regulating agents.

Cirrhosis is a progressive disease of the liver with no known cure. In cirrhosis, scar tissue replaces normal, healthy liver tissue and blocks the flow of blood through the organ. As a result, the liver can't perform its critical functions. The disease may have no symptoms at first, but that doesn't mean damage isn't occurring. Left unchecked, cirrhosis can be fatal. According to the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), cirrhosis is the eighth leading cause of death by disease, killing about 25,000 people each year. According to the American Liver Foundation, cirrhosis is the fourth disease-related cause of death for people between the ages of 25 and 44.

Contrary to popular belief, alcoholism is not the only cause of cirrhosis. However, according to the National Digestive Diseases Information Clearinghouse (NDDIC), it is one of the most common ones in the United States, the other being Hepatitis C. No one knows for sure why alcohol affects some people's livers more than others. For example, NDDIC says that in women, as few as two to three drinks per day have been linked with cirrhosis, and in men, as few as three to four drinks per day can lead to cirrhosis. Alcohol may injure the liver by blocking the normal metabolism of protein, fats, and carbohydrates. Hepatitis C is the other major cause of chronic liver disease and cirrhosis in the United States. Infection with this virus causes inflammation of, and low grade damage to, the liver that over time can lead to cirrhosis.

Other causes of cirrhosis, according to NDDIC and the American Gastroenterological Association (AGA), include

- hepatitis B, which is the most common cause of cirrhosis in many parts of the world. Hepatitis B, like hepatitis C, causes liver inflammation. The hepatitis D virus is another virus that infects the liver, but only in people who already have hepatitis B.
- autoimmune hepatitis, which is caused by a problem with the immune system.
- alpha-1 antitrypsin deficiency, hemochromatosis, Wilson's disease, galactosemia, and glycogen storage diseases, which are inherited diseases that interfere with the way the liver produces, processes, and stores substances the body needs.
- nonalcoholic steatohepatitis, or NASH, in which fat builds up in the liver and eventually causes scar tissue. This type of hepatitis appears to be associated with diabetes, protein malnutrition, obesity, coronary artery disease, and corticosteroid treatment.

- blocked bile ducts, which cause bile to back up and damage the liver. NIDDK says that in babies, blocked bile ducts are most commonly caused by biliary atresia, a disease in which the bile ducts are absent or injured. In adults, the most common cause is primary biliary cirrhosis, a disease in which the ducts become inflamed, blocked, and scarred. Secondary biliary cirrhosis can happen after gallbladder surgery if the ducts are inadvertently tied off or injured.
- severe reactions to prescription drugs, prolonged exposure to environmental toxins, the parasitic infection schistosomiasis, and repeated bouts of heart failure with liver congestion.

In its early stages, AGA says cirrhosis often produces no symptoms. But over time, as liver function starts to fail, a person may experience fatigue, loss of appetite, nausea, weakness, and weight loss. Left unchecked, NIDDK says cirrhosis in its later stages can cause edema or swelling of the legs and abdomen, a tendency to bruise and bleed easily, jaundice or yellowing of the skin, intense itching, and gallstones. Since the liver can't remove toxins the way it's supposed to, someone with advanced cirrhosis may also start to build up toxins in their blood, they may develop intestinal infections or kidney problems, and they may be extra sensitive to medications. In addition, they may develop a specific type of high blood pressure, called portal hypertension, in the blood vessels that go from the intestine to the liver. Veins at the lower end of the esophagus (esophageal varices) may also enlarge, and the American Liver Foundation says obstruction of the venous circulation can cause severe vomiting of blood.

### *Jaundice*

Jaundice is a yellow color observed in the skin or in the eyes. The yellow pigment, a byproduct of old red blood cells, is called bilirubin. If you have ever had a bruise, you may have observed that the damaged red blood cells in the skin went through a series of color changes as the skin healed. When you saw yellow in the bruise, you were seeing bilirubin.

Most of the time, about one percent of our red blood cells retire every day, to be replaced by the same number of fresh, young red blood cells. The old ones are processed in the liver as they are disposed of. Much of the bilirubin leaves the body in the stool.

If there are too many red blood cells retiring for the liver to handle, yellow pigment builds up in the body. When there is enough pigment to be visible, jaundice results. The jaundice can be caused by too many red blood cells retiring, by the liver being unable to perform its job efficiently, or by a combination of the two. Dehydration or decreased stooling can accelerate the build-up of bilirubin concentrations and make jaundice get worse quickly.

Jaundice often becomes visible on the face when the bilirubin level is about 5 mg/dL. It can be seen from the head down to the belly when the bilirubin is about 15 mg/dL, and all the way to the soles of the feet at about 20 mg/dL. Physiologic jaundice in a term baby usually first appears when the baby is two or three days old. The jaundice peaks by day 4 and usually does not continue below the belly. The rate of bilirubin rises less than 5 mg/dL per day. The baby with physiologic jaundice should have no other symptoms.

Pathologic jaundice appears earlier or later, rises faster, reaches higher levels, lasts longer, or is accompanied by other symptoms (perhaps vomiting, dark urine, lethargy, too much weight

loss, abnormal body temperature, etc.). Jaundice that first appears on days 4–6 is often caused by sepsis or a urinary tract infection.

There are three different classes of causes for jaundice: pre-hepatic or hemolytic causes, where too many red blood cells are broken down; hepatic causes, where the processing of bilirubin in the liver does not function correctly; and post-hepatic or extrahepatic causes, where the removal of bile is disturbed.

- Pre-hepatic (or hemolytic) jaundice is caused by anything that causes an increased rate of hemolysis (breakdown of red blood cells). In tropical countries, malaria can cause jaundice in this manner. Certain genetic diseases, such as sickle cell anemia and glucose 6-phosphate dehydrogenase deficiency, can lead to increase red cell lysis and therefore hemolytic jaundice.
- Hepatic causes include acute hepatitis, hepatotoxicity, and alcoholic liver disease, whereby cell necrosis reduces the liver's ability to metabolise and excrete bilirubin leading to a build up in the blood.
- Post-hepatic (or obstructive) jaundice, also called cholestasis, is caused by an interruption to the drainage of bile in the biliary system. The most common causes are gallstones in the common bile duct and pancreatic cancer in the head of the pancreas.

**c) Discuss the following basic epidemiological terms and provide examples of how each is used:**

- **Retrospective**
- **Case control**
- **Cohort**

*Retrospective*

A retrospective is a study in which people are enrolled and have their history of risks, infections, or disease measured. It is used for sampling information and data gathering purposes.

*Case Control*

A case control is a study in which the risk factors of people with a disease are compared with those without a disease. It is used to determine how the risk factors affect the weight of each risk.

*Cohort*

A cohort is a subsection of a population with a common feature, usually age. For example, all those individuals in the UK who were born in 1964 form a birth cohort.

**d) Discuss how a health and safety complaint should be investigated.**

There are two ways that OSHA can respond to a complaint. OSHA can either perform an on-site inspection or an off-site investigation, also known as a phone/fax investigation.

Although every worker has a right to receive an onsite inspection if certain conditions are met, there are times when a phone/fax (or letter) investigation may be a better alternative. OSHA responds more quickly to lower priority hazards using a phone/fax approach. This enables the agency to concentrate resources on the most serious workplace hazards.

Employees who request a phone/fax investigation do not give up the right to request an on-site inspection of potential violations and hazards if they are not satisfied with the investigation. Workers should call their nearest OSHA area office to discuss their options.

If an off-site investigation is appropriate, the agency telephones the employer, describes the alleged hazards, and then follows up with a fax or letter. The employer must respond in writing within five days, identifying any problems found and noting corrective actions taken or planned. If the response is adequate, OSHA generally will not conduct an inspection. The employee or employee representative who filed the original complaint will receive a copy of the employer's response and, if still not satisfied, may then request an on-site inspection.

If the employee or employee representative files a written complaint that meets certain conditions described in OSHA Directive CPL 2.115, or a state plan's equivalent procedures, then OSHA may conduct an on-site inspection. Those conditions include claims of serious physical harm that have already resulted in disabling injuries or illnesses, or claims of imminent danger situations; written, signed complaints requesting inspections; and situations where the employer provided an inadequate response to a phone/fax investigation.

**5. Industrial hygiene personnel shall demonstrate a working-level knowledge of the recognition of potential ergonomic and office health hazards.**

**a) Ability to use accepted protocol to identify jobs with potential ergonomic problems.**

To identify jobs with potential ergonomic problems, review and analyze injury and illness records to determine whether there is a pattern of ergonomic-related injuries in certain jobs or work tasks. Analyze the jobs or work tasks themselves to identify potential ergonomic problems before employee injuries occur. Determine if jobs present ergonomic risks that may contribute to musculoskeletal disorders. Analysis tools may help in analyzing jobs. While there is no "one size fits all" approach, there are numerous non-OSHA, voluntary analysis tools that may be used to learn more about potential ergonomic risks associated with jobs. Seek employee input about the existence of ergonomic problems related to particular jobs or work tasks. This may be accomplished, among other ways, by

- speaking with employees
- conducting symptom surveys
- using employee questionnaires

Be aware of common contributing conditions within your industry or job classifications. If other companies in the same industry have ergonomic-related problems, then it is possible these potential problems are also your concern. Obtain information from others in your industry to

- see what problems others have experienced in their operations
- gain a better understanding of potential problems that may exist in your workplace

**b) Ability to recognize and evaluate the following potential ergonomic factors:**

- **Equipment/tool design and selection**
- **Work layout**
- **Visual displays**
- **Work/rest cycles**
- **Work area illumination and color**
- **Human capacity/job demands**
- **Requirements for manual handling**
- **Alternative work schedules and shift work**

### *Equipment/Tool Design and Selection*

Tool design (weight, shape, fit to the user and the task), workstation design (size, shape, and layout), and the way tasks are scheduled are all key factors in making hand-tool use safe and risk-free. Since, none of those three areas is more important than the other, an effective prevention strategy must address all of them simultaneously.

The condition of tools is an important factor. Blunt or dull tools, such as scissors, cutters, saws, and screwdriver tips, and any tools in a poor state of repair not only compromise safety, but also increase (sometimes by a factor of ten) the effort needed to use them. Tools in poor condition should be discarded (with the exception of those few that can be restored to optimum condition such as, for example, a wood chisel or wood saw) and replaced with new ones.

### *Work Layout*

Work layout should be evaluated for potential ergonomic factors to minimize equipment damages and personnel injury. Equipment should be configured with sufficient internal access and clearance space so that personnel injury due to cramped space is minimized and vulnerable components are not damaged during inspection, servicing, removal, and repair.

**Delicate Components.** Delicate components should be located where they will not be damaged while equipment is being worked on.

**Contaminants.** Components should be positioned so that oil, other fluids, and dirt are not likely to contaminate them.

**High-Temperature Parts.** High temperature parts should be labeled, guarded, or located such that personnel contact will not occur during operation or maintenance. Heat-producing equipment should be shielded so that technicians are not made uncomfortable.

**High-Current Switching Devices.** High-current switching devices should be labeled and enclosed to protect personnel.

**Discharging Devices.** Discharging devices such as shorting bars should be used to discharge high-voltage circuits and capacitors unless they discharge to 30 volts or less within 2 seconds after power removal.

**Grounding Equipment.** Equipment and electrically operated tools should be designed so that all external parts and surfaces (except antenna and transmission line terminals) will be at ground potential.

**Replaceable Multi-Lead Parts.** Replaceable multi-lead parts such as relays and selector switches should be mounted with mechanical connectors such as plugs to avoid the necessity for unsoldering and resoldering when replacement is required.

**Use of Insulation Materials.** Insulation materials such as rubber gloves, insulating blankets and matting, insulating sleeves, insulating line hoses, insulated work platforms, and insulated tools should be used to separate maintenance personnel from potential electric, heat, and cold hazards.

**Internal Controls.** Internal controls should be located away from dangerous voltages or places where they might be accidentally bumped while performing other maintenance activities.

Additional Electrical Safety Design Guidelines. Additional electrical safety design guidelines that should be followed include

- placing equipment in areas free of falling or standing water;
- placing electrical equipment and units on elevated pads in areas where standing water may accumulate;
- providing storage in or near electrical equipment for safety-related tools (e.g., shorting bars);
- locking, ventilating, and placing warning signs on doors to battery rooms, as well as prominently displaying instructions for personnel evacuation and first aid (e.g., eye wash stations);
- following clear-cut plant equipment identification practices (color coding may be considered to aid in identification) to minimize misidentification errors such as opening a breaker for one circuit and subsequently proceeding to work on a different protected circuit.

Accidental Activation. Components and units should be located so that their removal cannot cause accidental activation (or deactivation) of another unit or subsystem.

#### *Visual Displays*

Uses of Labels and Codes for Panels and Equipment. Labels and codes should be provided on and within the system panels or equipment as required to

- outline and identify functional groups of equipment;
- identify each item or part by name or common symbol;
- identify the value and tolerances of parts such as resistors, which should be direct rather than in color code where possible;
- identify each test or service point, and the sequence in which it is used;
- indicate the direction of current or flow to aid systematic elimination of possibilities without continuous cross-reference to schematics;
- provide maintenance highways to guide the technician through routine processes.

Content of Panel and Equipment Labels. Provisions should be made for the following information and instructions to appear on system panels and equipment when appropriate:

- The weight of units over 20.41 kg (45 lbs)
- Warning and caution labels, as necessary
- Instruction plates to outline procedures not made obvious by design and to supply whatever information is necessary for troubleshooting and maintenance
- The presentation and/or recording of historical data where practicable, particularly to
  - display periodic readings at test points to allow development of trends where these are fundamental to maintenance decisions
  - allow recording of replacement dates or other data necessary to replenishing or preventive maintenance

Characteristics of Labels and Codes. Labels and codes used in system panels and equipment should be

- consistently and unambiguously used throughout the system
- of such a nature as to be easily read and interpreted
- durable enough to withstand expected wear and environmental conditions

- coordinated and compatible with
  - codes and labels on related test and service equipment
  - other coding and labeling within the system
  - related job aids, instructions, handbooks, and manuals

### *Work/Rest Cycles*

Several literature sources provide a range of guidelines with respect to rest break cycles. Few of these guidelines refer exclusively to rest breaks. Rather, some of these recommendations call for stretching or exercise. Others refer to alternate work. Many refer to a combination of rest, exercise, and alternate work. Theoretical models of optimal rate-rest profiles have been developed. However, these models are very complex, and the profiles are not easily applied out in the real world. The frequency and duration of rest breaks in the industrial setting is commonly established by the engineer, taking into consideration people and production factors. This may not be the case in office settings. In both settings, labor practices and human resource issues may also influence decisions about breaks. In any case, it is not possible to recommend an optimal and/or generic rest break cycle, and there are no established standards for frequency and duration of breaks. Our attempts to prevent and to control cumulative trauma disorders and the associated losses include the application of principles of ergonomics. Ergonomic solutions include, but are not limited to, analysis of workplace design factors. Certainly, a thorough analysis of the job will address workplace design, work flow/organization, work practices, and other factors. Rest breaks are one facet of work organization or work flow design. But this is only one piece in a very large, complicated puzzle. In summary, rest breaks, alternative work, careful workflow design, and exercise can all be used effectively as part of a comprehensive ergonomics program designed to reduce or eliminate risk factors associated with cumulative trauma disorders and to reduce the incidence and associated loss costs of these disorders. The need for rest breaks will vary with aspects of the individual performing the job and with aspects of the job itself. Some of these factors are individual physiology, age, gender, intensity and duration of the task, workstation posture factors, and work station light factors. Therefore, flexibility in rest break frequency and duration is recommended.

### *Work Area Illumination and Color*

Whether in industrial or office settings, proper lighting makes all work tasks easier. People receive about 85 percent of their information through their sense of sight. Appropriate lighting, without glare or shadows, can reduce eye fatigue and headaches. It highlights moving machinery and other safety hazards. It also reduces the chance of accidents and injuries from momentary blindness while the eyes adjust to brighter or darker surroundings.

The ability to see at work depends not only on lighting, but also on the following:

- The time needed to focus on an object (Fast moving objects are hard to see.)
- The size of an object (Very small objects are hard to see.)
- Brightness (Too much or too little reflected light makes objects hard to see.)
- Contrast between an object and its immediate background (Too little contrast makes it hard to distinguish an object from the background.)

### *Different Sources of Light.*

Daylight — The amount of daylight that reaches inside a building depends on the amount and direction of sunlight, cloud cover, local terrain, and the season. The size, orientation,

and cleanliness of the windows are also important. The amount of daylight entering the workplace can be controlled with tinted glass, window blinds, curtains, and awnings. Daylight is desirable in the workplace providing it does not cause glare or make the work area too bright.

Not having enough light can also be a problem, so even in workplaces where daylight is available, it is essential to have a good electric lighting system.

Electric Lighting — The amount of light, the color of the light itself, and the color that objects appear to be vary with the type of electric lighting in use. The lighting must match the workplace and the task. Table 2, below, identifies common types of bulbs.

| <b>Light Bulbs</b>   |                           |                   |                        |
|----------------------|---------------------------|-------------------|------------------------|
| <b>Type</b>          | <b>Common Application</b> | <b>Efficiency</b> | <b>Color Rendering</b> |
| Incandescent         | Homes                     | Poor              | Good                   |
| Fluorescent          | Offices                   | Good              | Fair to good           |
| Mercury              | Factories, Offices        | Fair              | Fair to moderate       |
| Low Pressure Sodium  | Roadways                  | Good              | Poor                   |
| High Pressure Sodium | Factories, Commercial     | Good              | Fair to good           |
| Metal Halide         | Factories, Commercial     | Good              | Good                   |

Table 2. Light bulbs

There are three basic types of artificial lighting:

- General
- Localized-general
- Local (or task)

General lighting provides fairly uniform lighting. An example of general lighting would be ceiling fixtures that light up large areas.

Localized-general lighting uses overhead fixtures in addition to ceiling fixtures to increase lighting levels for particular tasks.

Local (or task) lighting increases light levels over the work and immediate surroundings. Local lighting often allows the user to adjust and control lighting and provides flexibility for each user.

#### *Human Capacity/Job Demands*

The amount of exertion a job requires will affect the ability of people to do the work. Each job/task that is performed requires a certain degree of physical effort on the part of the employee. The capacity of each person is different and is affected by existing environmental conditions. Working in high heat or low temperature areas affects the amount of work an employee can perform.

### *Requirements for Manual Handling*

In workplaces, employers are required to assess the risk to their employees from performing manual handling tasks. Risk assessments are carried out by trained assessors who decide whether or not there is a risk of injury and how much of a risk exists. This includes looking at the following factors:

- The task: How often is the task performed and for how long? Does it have to be performed quickly?
- The individual's capacity: Who is doing the task? Are they physically capable of carrying out the task safely?
- The load: How heavy is the object being handled? What shape is it? Does it have handles? Is it hot or cold or wet? Do gloves need to be worn?
- The environment: Where is the task being carried out (e.g., indoors or outdoors)? Is it cold and/or wet? Does the space restrict good posture? Is the ground clear and flat?

If an assessor thinks that there is a risk of injury, the employer must take certain steps to reduce the risk. The first step is to see if the task that involves the risk can be avoided.

If the task cannot be avoided, the next option is to minimize the risk of injury. Risk can be reduced in lots of ways:

- Inspect work areas to ensure they are clear of obstacles. Make sure that potential hazards are removed.
- Use mechanical equipment to perform a task that would be difficult or dangerous to perform manually.
- Consider breaking tasks into subtasks where appropriate.
- For strenuous or difficult tasks, extend the time taken to do the tasks by taking breaks.
- Get someone to help perform a task when needed.

### *Alternative Work Schedules and Shift Work*

Alternating work schedules and working different shifts can contribute to potential problems due to fatigue. If an employee is working longer days, or at different times during the day, they may have an increased fatigue level, which puts them at greater risk for causing a potential accident or incident at work.

#### **c) Ability to recognize and evaluate the following with respect to indoor air quality:**

- **Temperature and humidity control**
- **Proper heating, ventilation, and air conditioning (HVAC) design and maintenance**
- **HVAC filter selection**
- **Risk communication skills**
- **Introduction of sources of air contaminants into the office environment**
- **Water leaks**

### *Temperature and Humidity Control*

The ability to maintain a comfortable temperature and humidity level has a direct impact on employee effectiveness and performance. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) sets standards for indoor air quality for personnel comfort and safety. These values differ for different conditions and for different spaces, and should be used to ensure good air quality.

### *Proper Heating, Ventilation, and Air Conditioning (HVAC) Design and Maintenance*

The maintaining of HVAC systems is discussed in ASHRAE standards. These standards discuss the requirements for the heating, ventilating, and conditioning of a room, building, or other occupied space. These regulations are required to be implemented at all facilities.

### *HVAC Filter Selection*

The purpose of HVAC filters is to remove particulates from the air. For different applications, different filters are used. A facility may have many types of filters in use. The manufacturer will designate the appropriate filters for an HVAC system. The filters also need to be changed out on a certain periodicity that maximizes their efficiency. This is prescribed in manufacturer instructions.

### *Risk Communication Skills*

The ability of the facility to communicate risk associated with indoor air quality is important. The facility needs to be able to inform employees of any conditions or issues that arise in air quality. Alarms are in place in many facilities to alert workers to emergency conditions. Plans and procedures should be in place to allow for personnel to notify employees of any adverse air quality conditions.

### *Introduction of Sources of Air Contaminants into the Office Environment*

There are many sources of indoor air pollution that can affect the office environment. These include combustion sources such as oil and gas; building materials and furnishings as diverse as deteriorated asbestos-containing insulation, wet or damp carpet, and cabinetry or furniture made of certain pressed wood products; products for cleaning and maintenance; central heating and cooling systems and humidification devices; and outdoor sources such as radon, pesticides, and outdoor air pollution.

The relative importance of any single source depends on how much of a given pollutant it emits and how hazardous those emissions are. In some cases, factors such as how old the source is and whether it is properly maintained are significant. For example, an improperly adjusted gas stove can emit significantly more carbon monoxide than one that is properly adjusted.

Some sources, such as building materials, furnishings, and household products like air fresheners, release pollutants more or less continuously. Other sources, such as those related to activities carried out in an office environment, release pollutants intermittently. Examples include the use of solvents and janitorial supplies in cleaning, and the use of pesticides to keep buildings pest free. High pollutant concentrations can remain in the air for long periods after some of these activities.

### *Water Leaks*

Water leaks can lead to the creation of mold in places like building basements or other underground facilities. This mold presents a biological hazard for employees. Water leaks need to be identified and corrected immediately to prevent the creation of mold. Water leaks may not be easily detectable in facility basements, partly because of the industrial nature of most facility basements, and because a water leak may not be considered a very important issue in the space.

**6. Industrial hygiene personnel shall demonstrate a working-level knowledge of data collection plans for collecting data that accurately reflect exposure conditions.**

**a) Discuss the following factors as they relate to sampling strategy:**

- **Usefulness of bulk samples**
- **Degree to which operations being sampled are representative of normal conditions**
- **Duration of sample**
- **Level of detectability**
- **Exposure control methods in use during sampling**
- **Sample handling**
- **Data recording and management**
- **Sample chain of custody**
- **Statistical significance of sample**
- **Exposure criteria and limits**
- **Consent needs for biological samples**
- **Uses and limitations of personal and area sampling**

*Usefulness of Bulk Samples*

The addition of bulk samples can often make the difference between a successful or unsuccessful sampling effort. This is especially true where there is mixed-solvent exposure or unknown dust exposure, and when determining the silica content of dusts. The primary purpose of bulk samples is to provide the analytical laboratory with a large enough sample for qualitative and sometimes quantitative analysis. The two major types of bulk samples are bulk air and mass bulk (liquid or solid) samples.

**Bulk Air Samples.** Generally, a bulk air sample is defined as a large volume area sample collected for the purpose of qualitative analysis. A good example is multiple solvent exposure where the exact identity of the airborne solvents is unknown, e.g., painting operations. For most organic solvents, a bulk air sample consists of a charcoal tube (or whatever sorbent is called for) collected at 1 L/min for an hour or more. The sample is likely to exhibit breakthrough, but this does not matter since the primary interest is in determining what substances are present rather than in their exact concentrations (the latter aim is accomplished through the separate collection of proper samples). Any questions concerning how or whether or not a bulk air sample is needed should be addressed to the analytical laboratory prior to sampling. In the case of silica, either a bulk air or solid bulk sample (e.g., a rafter sample) or both are suggested so that enough material will be available to determine free silica content.

**Bulk Liquids and Solids.** The collection of bulk materials may be needed to establish the substances present in the workplace and, in some cases, to establish the relative levels of certain substances present in the raw material. A good example of the latter is the case of mixed solvent exposure when determining if a certain contaminant of interest is present, e.g., benzene. In some cases, a list of 30 solvents may be present (from MSDSs), but it is not certain which ones are present or in what proportions. This example is also true for dusts, which may exist in trace quantities.

In choosing bulk samples, the end goal must be considered. Is the interest in qualitative and/or quantitative analysis? In the case of a painting operation, it is preferred to have the

bulk samples separated by contaminants of interest, i.e., the solvent fraction separate from the pigment fraction. This allows the laboratory to analyze the different portions of the paints without having to go through a lengthy separation process. The cleaner the bulk sample, the easier it will be for the laboratory to conduct the analysis. In many cases, the industrial hygienist is interested in a dirty bulk. Any information that can be given to the laboratory on what may or may not be present will help speed up the analysis. Advance consultation with the laboratory is desirable.

In choosing bulk dust samples, the sample should be representative of the airborne dust to which the workers are being exposed. Usually this is a settled dust sample collected from rafters or near the workers' job site. In other cases, a process dust sample is chosen to determine the composition of the material before it is airborne. In cases where the choice is not clear, do not follow the adage that more is better. Bulk samples should be limited in number to optimize the laboratory's time. A good approach, when in doubt as to what bulk samples are needed, is to collect several but to allow the laboratory to analyze only those needed to answer questions as they arise.

When shipping bulk samples, care must be taken to preserve the integrity of the samples and to follow established Department of Transportation (DOT) shipping regulations. Only 5 to 10 mL of the liquid or solid is needed, so keep bulk sample sizes small. For storage, leak-proof glass containers are best since they will not react with most chemicals. However, polyethylene containers can be used in the majority of cases. A convenient container is a 20-mL scintillation vial with a polytetrafluoroethylene (PTFE)-lined cap. Specific chemicals for which polyethylene containers should not be used include aromatic compounds, chlorinated hydrocarbons, and strong acids. The lids of the containers should be sealed with shrink bands or tape for further assurance against leakage. These containers should be labeled as required by DOT under their regulations (49 CFR Parts 171-177). For most materials classified as flammable or poisonous, amounts up to one quart can be shipped by any carrier. Most bulk dusts are not covered by DOT regulations. Specific restrictions and labeling requirements should be checked prior to shipping any samples.

In the case of volatile bulk samples (and some air samples), consideration should be given to shipping the samples on dry ice or with bagged refrigerant (e.g., blue ice). Do not ship volatiles together with air samples. Again, check with the carrier you plan to use as there may be restrictions on the amount of dry ice they will accept in a package (usually five pounds or less is acceptable). Specific labels are usually required when dry ice is used.

*Degree to Which Operations Being Sampled are Representative of Normal Conditions*  
Sampling should be performed on operations that are representative of typical and of worst-case situations of the exposure group. Depending on the sampling results, the former may help to determine the need for employee medical surveillance, and the latter the need for the implementation of workplace controls.

#### *Duration of Sample*

In general, when plans and time allow, integrated personal sampling covering the entire duration of a representative operation is preferred, but this may not always be possible. When personal sampling is not possible, integrated area sampling may provide adequate information if carefully interpreted. If sampling over the full shift is not possible, the

performance of consecutive direct-reading or grab samples and their interpretation in accordance with standard methods may also yield useful information.

When sampling is performed for less than eight hours because the operation was completed in that time, this fact should be noted on the sampling sheet in order to justify the assumption that personal exposure for the remainder of the day was zero.

#### *Level of Detectability*

In order for the sample to be of much value, the level of detection must be lower than the criterion level of interest — either the acceptable limit or permissible exposure limit (PEL) — but preferably much lower. In order to ensure that the level of detection is as low as possible, the sample must contain a minimum volume of air.

#### *Exposure Control Methods in Use During Sampling*

Determinants of exposure have been studied using experimental and observational designs. In experimental designs, factors expected to influence exposure usually are selected using theoretical models or prior evidence from the hygiene literature, though production personnel and work site surveys may also provide vital clues. In many cases, the main study question is not the identification of exposure determinants, but quantification of the magnitude of effect or development of controls for known high-exposure conditions. Study conditions are altered in a controlled way under the direction of the investigator, and often in a laboratory setting.

Observational studies are conducted in actual employment settings without investigator control. Although there may be some effect due to the presence of a study team, the intent is to examine the workplace under usual operating conditions. Walkthrough surveys, process documentation, and discussions with plant personnel may provide the basis for selecting study factors, though theoretical models and existing literature also contribute.

In any case, the potential determinants identified must then be observed and documented throughout the study. Investigator control of the variety of determinants studied exists only through the selection of varied work sites, times, workers, etc.

Additional information regarding exposure control methods is available in the American Industrial Hygiene Association Journal, Exposure Control — Studying the Determinants of Exposure.

#### *Sample Handling*

Sampling should be performed according to established standard operating practices (SOPs) to ensure that the observations are recorded consistently and that sampling plans are coordinated with the laboratory to guarantee compatibility between sampling and analysis.

#### *Data Recording and Management*

Sampling sheet completion should be standardized and the completion reviewed by at least one level of supervision. Samples should be tracked in a log along with critical sampling information to maintain a hard-copy index of the sampling history of the facility. Critical sampling data should be entered into a database for easy retrieval and data sorting.

### *Sample Chain of Custody*

Chain of custody is critical with respect to the confidence of the integrity of the data. As a consequence, practices must be established to ensure the following:

- The sealing and labeling of samples
- The tracking of samples through the completion of analysis
- The forwarding of the analysis results to the sampling organization

### *Statistical Significance of Sample*

Statistical significance of sampling results may be obtained in two ways. The first relates to the analysis of individual samples through the determination of the upper and lower confidence limits of that sample. This is done in order to determine if the individual sample is above or below the occupational exposure level. The second aspect of statistical significance relates to the analysis of a group of past samples to determine the potential for overexposure in future samples. Statistical significance of this type is highly desirable and should be sought for operations that are performed regularly. For infrequently performed operations, the number of data points will probably be too small to achieve this type of statistical significance.

### *Exposure Criteria and Limits*

An effective worker protection program encompasses the concept of prudent avoidance of worker exposure to any occupational hazard. Prudent avoidance involves minimizing the number of individuals at risk of exposure, minimizing the individual worker's potential for exposure, and controlling all exposures to chemical and physical agents within established occupational exposure limits and keeping them as low as practical.

### *Consent Needs for Biological Samples*

Federal regulations set out four overriding principles which are meant to apply to all consents, unless there are specific exceptions made or allowed elsewhere in the regulations.

These principles are as follows:

- Human research can proceed only with informed consent unless waived under the federal regulations. No investigator may involve a human being as a participant in research covered by the federal regulations without legally effective informed consent of the participant or his/her legally authorized representative.
- The possibility of coercion in obtaining consent must be minimized. An investigator shall seek consent under conditions that provide the prospective participant or his/her representative sufficient opportunity to consider whether to participate, and that minimize the possibility of coercion or undue influence.
- Consent must involve understandable language. The information that is given to the prospective participant or his/her representative shall be in language the participant or the representative can understand.
- The waiver of rights is prohibited in the consent process. No informed consent, whether oral or written, may include any exculpatory language through which the prospective participant or his/her representative is made to waive or appear to waive any of the prospective participant's legal rights, or made to release or appear to release the investigator, the sponsor, the institution, or its agents from liability for negligence.

The federal regulations list eight required elements of informed consent. These are addressed below:

- Purpose and Procedures — You must tell a prospective participant that the study involves research, explain the purpose of the study and the length of time you expect the person to participate, describe the procedures to be followed, and identify any experimental procedures.
- Risks — You must describe any reasonably foreseeable risks or discomforts to the prospective participant.
- Benefits — You must describe any benefits to the prospective participant or to others which may reasonably be expected from the research.
- Alternatives — You must disclose any appropriate alternative procedures or courses of treatment that might benefit the prospective participant.
- Confidentiality — You must tell prospective participants whether their records will be kept confidential and, if so, explain the level of confidentiality.
- When There is Greater than Minimal Risk — You must tell prospective participants whether they will receive any compensation and/or medical treatments if injury occurs and, if so, what compensation or treatment will consist of, or where to obtain further information.
- Persons to Contact — You must tell prospective participants whom to contact if they have questions about the research and their rights as a study participant, and whom to contact if they have an injury that may be related to the research.
- Voluntary Participation, Refusal, and Withdrawal — You must state that participation is voluntary, that refusal to participate involves no penalty or loss of benefits to which the person is otherwise entitled, and that the person may discontinue participation at any time without penalty.

Additional information regarding consent needs is available in 45 CFR 46, Protection of Human Subjects.

#### *Uses and Limitations of Personal and Area Sampling*

In situations where immediate decisions are required, the use of direct-reading instruments may be the only sampling method available. Because the information that direct-reading instruments provide is limited, the proper interpretation of this data is dependent on the experience and imagination of the industrial hygienist. In general, when plans and time allow, integrated personal sampling covering the entire duration of a representative operation is preferred, but this may not always be possible. When personal sampling is not possible, integrated area sampling may provide adequate information if carefully interpreted. If sampling over the full shift is not possible, the performance of consecutive direct-reading or grab samples and their interpretation in accordance with standard methods may also yield useful information.

An area sample is an environmental sample collected at a fixed point in the workplace that reflects chemical contaminant concentrations or levels of physical or biological agents present at that point. Results from area sampling should be interpreted with caution because they do not represent employees' actual exposures to hazardous agents.

**7. Industrial hygiene personnel shall demonstrate a working-level knowledge of sampling techniques.**

**a) Describe the significance of instrument calibration and operation and data collection methods during sampling.**

Instruments must be calibrated before and after sampling. Most instruments also require additional periodic calibration in a laboratory. In the field, personal sampling pumps should be constantly monitored to ensure their continued operation. The performance of direct-reading sampling in association with integrated sampling may provide corroborative or supplemental information detailing changing levels throughout the operation. All calibration and instrument monitoring information, as well as descriptive information of the operation that could influence the sampling results, should be recorded on the sampling sheet.

**b) Describe how multiple exposures affect sampling techniques.**

Exposure to more than one hazardous agent may require the use of more than one sampling instrument by the same employee. More than one sampling instrument may also be required if substances of interest require the performance of incompatible laboratory analyses. The potential for chemical interferences may also require the use of more than one sampling method and may create complications in the interpretation of results.

**c) Describe the factors (e.g., concentration, duration, frequency) that determine the adequacy of samples.**

In order for the sample to be of much value, the level of detection must be lower than the criterion level of interest — either the acceptable level or PEL — but preferably much lower. To ensure that the level of detection is as low as possible, the sample must contain a minimum volume of air. This, in general, requires a minimum sample duration. Duration is also important when the sample is being related to specific criterion, e.g., short-term exposure limits (STELs), ceilings, etc. If possible, sampling should be performed for the entire duration of the operation being characterized. When sampling is performed for less than eight hours because the operation was completed in that time, this fact should be noted on the sampling sheet to justify the assumption that personal exposure for the remainder of the day was zero.

The frequency of sampling may be listed in a few expanded OSHA regulations; however, normally this is dictated by professional judgment. In general, initial measurements should be taken whenever it is believed that significant exposure is possible. A second set of measurements taken sometime after the first set is also advisable as a check against possible variation in operations. If both sets of results show insignificant exposure, sampling may probably stop. Continued surveillance of work places is necessary to verify that new operations have not been initiated and that previously characterized operations have not changed so as to increase the potential for exposure.

**d) Describe how environmental factors (e.g., wind, rain, temperature extremes) affect the need for further sampling.**

Environmental extremes may influence instrument operation. Extreme cold, for example, may affect pumps, direct-reading instruments, and detector tube operation. High moisture or humidity resulting in condensation may also affect operation of dosimeter microphones and the reliability of sampling media. Wind may also affect noise measurement. In general, potential environmental limitations and interferences will be clearly described in the instrument operator's manual and in standardized sampling and analytical methods, and the industrial hygienist should take note of them.

If results of monitoring are significant, periodic sampling may be required to verify the continuing adequacy of controls that are in place. Logically, the higher the previous results and the more dangerous the agent, the more frequent subsequent samples should be performed.

Follow-up to initial sampling may also be required if modifications in a process of controls indicate the possibility for increased exposure over earlier samples, and to verify that new engineering controls are performing as expected.

**8. Industrial hygiene personnel shall demonstrate a working-level knowledge of sample analysis, including the use of appropriate laboratory techniques.**

**a) Describe the following:**

- **Selection of proper analytical instruments and techniques**
- **Sensitivity and specificity of the analytical technique**
- **Precision versus accuracy**
- **Instrument bias**
- **Interferences in sampling**
- **Principles of instrument operation**

*Selection of Proper Analytical Instruments and Techniques*

In general, only the industrial hygienists who direct industrial hygiene laboratories require detailed knowledge of industrial hygiene laboratory analysis. However, it is important that all industrial hygienists sample, or ensure sampling, consistent with standardized local SOPs, the manufacturer's manuals, and NIOSH, OSHA, or other reference methods to ensure that samples provided to the laboratory are capable of being analyzed and quantified appropriately. One of the best means of guaranteeing the value of samples is regular communication with the laboratory performing the analysis.

In communication with the laboratory, there is the possibility that the use of technical terminology relating to analysis may be used. While the industrial hygienist in the field will rarely be called upon to make technical decisions relating to analytical subjects, passing familiarity with a few terms and their applicability may be desirable. The DOE industrial hygienist might also be required to assess contractor industrial hygiene laboratory qualifications and competence, so familiarity with analytical terminology may be doubly useful.

### *Sensitivity and Specificity of the Analytical Technique*

Specificity for a particular analyte is one requirement of an acceptable analytical method. There is relatively little value in analytic results when it can be realistically asserted that the sample measured contaminants other than those desired because of lack of specificity of method.

The degree of sensitivity required will be determined by the amount of contaminant anticipated and the reason for the sample. If low concentrations are anticipated, the more sensitive, the better. If only screening for a chemical is performed, low sensitivity may be desirable to ensure that the concentration in the atmosphere does not exceed the operating range of the instrument.

### *Precision versus Accuracy*

Precision is the degree to which the method is repeatable; accuracy is the degree to which results truly indicate the level of contaminant.

### *Instrument Bias*

Instrument bias refers to the instrument's systematic deviations from accuracy.

### *Interferences in Sampling*

Interferences are contaminants that influence the outcome of the analytical results, either high or low. For both instruments and recognized analytical methods, interferences are listed, and it is incumbent on the industrial hygienist to be familiar with them or account for them before sampling.

### *Principles of Instrument Operation*

The variety of types of direct-reading methods available is large and expanding, including detector tubes (both short- and long-term), aerosol monitors, integrating passive monitors for certain gases, and portable instrumentation for gas chromatography or infrared spectroscopy. Many direct-reading instruments now used for personal or area measurements have evolved from laboratory or process control instruments. Some of the considerations (i.e., specificity and sensitivity) for the use of direct-reading methods for quantitative determinations are similar to those for classical filter or sorbent methods. In many cases, direct-reading instruments, which are physically small and portable, qualify as personal sampling devices. These offer additional advantages over classical methods by reducing labor and analytical costs, and may be the methods of choice when instantaneous results are important, even at the expense of some degree of sensitivity or specificity. Manufacturers' instructions should be followed in the calibration and use of these devices. Because of the severe conditions to which direct-reading instruments may be subjected, performance checks and preventive maintenance on a periodic basis or before each use are very important. Many direct-reading instruments are powered by Ni-Cd batteries which can fail to provide a full charge over the full sampling period unless frequently or fully discharged and recharged several times just prior to use. The additional responsibility of field calibration of direct-reading instruments falls on the field sampling personnel.

**b) Discuss laboratory data recording requirements.**

DOE and contractor line management must ensure that written hazard assessment and control records are developed and maintained for all potentially hazardous work operations and activities. This includes assessments where no significant worker exposures are expected or determined. This latter case is important since new exposure effects may be identified, and retrospective health concerns can only be addressed by documented assessment records. Consequently, assessments for operations determined to have no significant exposure potential (i.e., “negative exposure”) should be appropriately documented for historical purposes following the standard protocol for all surveys. Because of the significance of the information contained in these records, it is crucial that the persons assigned this task be appropriately trained. Critical records should be reviewed and approved by the senior industrial hygienist or designate. All such record keeping must comply with the requirements of 29 CFR 1910.1020, any applicable DOE directives, and/or applicable OSHA hazard-specific or expanded health standards, as well as any applicable requirements imposed by the Americans with Disabilities Act, the Privacy Act of 1974, the Freedom of Information Act, or any other applicable law.

**c) Discuss the fundamentals of operating analytical equipment, including zeroing and the use of standards.**

Fundamental to the operation of a laboratory analytical instrument is the establishment of a calibration curve that defines the relationship between the instrument output and the contaminant level in its sample. At a minimum, this curve requires the plotting of the instrument determination of zero concentration and several laboratory standard concentrations to complete the curve. Most field instruments may also require calibration with a standard before use to demonstrate instrument status.

**d) Discuss the following laboratory concerns and their effect on sample analysis.**

- **Quality assurance**
- **Chain of custody (samples and results)**
- **Physical security of samples**
- **Personnel safety**
- **Equipment maintenance**
- **Laboratory management**

*Quality Assurance*

Quality assurance (QA) comprises the independent checks the laboratory makes on the accuracy of its own analyses. The program may be narrowly focused on analysis or more broadly directed at documentation and all laboratory processes. QA of analyses may involve the blind testing of samples provided from outside the laboratory, or internal comparisons between results provided by individual laboratory personnel.

*Chain of Custody*

At a minimum, sufficient chain of custody must be established to ensure security and traceability of samples after their arrival and through analysis.

### *Physical Security of Samples*

Physical security is required along with chain of custody of samples prior to analysis. It is essential to be able to assert that the sample analyzed reflected conditions sampled in the field.

### *Personnel Safety*

In accordance with the OSHA PPE standard, 29 CFR 1910.132, each department is required to take action in four major areas:

- Each department shall perform a hazard evaluation of those work areas or jobs where hazards are likely to be present.
- Where a hazard evaluation has determined that there is sufficient cause to require PPE, each department shall provide and require the use of such equipment at no cost to the employee.
- Each department shall ensure that all PPE, whether provided by the employer or owned by the employee, is capable of providing adequate protection and is in a clean and reliable condition at all times.
- Each department shall provide training to ensure that employees know when and why PPE is necessary, how to use it properly, how to care for it, the equipment's usable lifetime, and its limitations. If there is reason to believe that an employee does not have this level of knowledge, the department shall provide retraining for that employee.

Certain protective equipment that is of an individual or personal nature (i.e., prescription safety glasses, safety shoes) or that would be used by the employee off the job site may not be subject to this requirement.

### *Equipment Maintenance*

The laboratory shall maintain a preventive maintenance program for equipment used in measurement systems or quality control checks.

When equipment used for measurements or quality control is subject to change due to use or the passage of time, it shall be calibrated periodically. Calibration is performed by measurements with a certified source, a derived source traceable to the National Institute of Standards and Technology (NIST), or with a Transfer Reference Standard (TRS). For direct radiobioassay, recalibrations shall be performed with the appropriate calibration and source geometries, or with derived source calibration phantoms. However, calibration checks of instrument performance can be performed without using the DOE laboratory accreditation program's phantom geometries.

### *Laboratory Management*

On an annual basis, management should perform and document a self-assessment to ensure the effectiveness of the implementation of industrial hygiene practices and to ensure quality. Such self-assessments should include reviews of

- the adequacy and use of industrial hygiene resources;
- all exposure assessment records, including medical exposure data, audiometric testing records, illness and injury logs and supporting information, and any other records relevant to the maintenance of industrial hygiene functions;

- compliance with applicable industrial hygiene requirements and established performance measures;
- success in receiving and responding to employee occupational health concerns;
- industrial hygiene evaluation records to assess progress in abating health hazards;
- all required written programs that include industrial hygiene elements (e.g., the hazard communication program and respiratory protection program);
- training program effectiveness.

Management should correct any deficiencies identified by the program self-assessment in a timely manner.

To support health surveillance activities required by DOE O 440.1A, attachment 2, paragraph 19.d(3), management should maintain the following records and supporting documentation in a manner that permits ready retrieval of information:

- Drawings and/or written descriptions of operations, processes, and control systems
- Inventories of hazards
- Exposure assessment data
- Industrial hygiene evaluation reports, including all records of corrective actions

**e) Discuss the value and limitations of sampling during indoor air quality investigations for the following:**

- **Environmental conditions**
- **Chemical exposure**
- **Bioaerosols**

*Environmental Conditions*

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 55-2004. Earlier versions of this standard were based on the assumption of a well-mixed and uniformly conditioned environment. Under Floor Air Distribution (UFAD) systems, however, usually involve greater variability of thermal conditions over both space and time. The effect of providing occupant-control has not been fully taken into account, although it is well established that occupants will tolerate greater fluctuations in environmental conditions if they have control over them. The rather strict air velocity limitations that were specified in the previous version of standard 55 were incompatible with the increased local air velocities that are possible with UFAD and task/ambient conditioning (TAC) systems. ASHRAE standard 55-1992 was revised to allow higher air velocities than the previous version of the standard if the occupant has control over the local air speed.

Standard 55-1992 also specifies allowable air speeds as a function of air temperature and turbulence intensity with the objective of avoiding unwanted drafts when the occupant has no direct local control. The draft avoidance limits are solidly based on laboratory data for temperatures below 23°C (73.5°F). At warmer temperatures, however, occupants will desire additional cooling, and increased air movement (and turbulence) is an easy way of achieving such direct occupant cooling. Standard 55-92 allows these velocity limits based on turbulence intensity level to be exceeded if the occupant has control over the local air speed.

In the recently revised standard 55-2004, the benefits of providing personal control of operable windows to building occupants has been added through the inclusion of an adaptive

model of thermal comfort (based on field observations in naturally ventilated buildings). When thermal conditions in a building are regulated primarily by the occupants through opening and closing of the windows, the adaptive model allows a wider range of operative temperatures to be considered as acceptable thermal conditions. The adaptive model acknowledges that people who know they have control are more accepting of, and in fact prefer a wider range of, temperatures, making it easier to satisfy their comfort preferences.

ASHRAE Standard 62-2001. This standard provides guidelines for the determination of ventilation rates that will maintain acceptable indoor air quality. Currently under continuous maintenance, the revised version of standard 62 is expected to allow some adjustment in ventilation rates based on the ventilation effectiveness of the air distribution system. Mixing-type air distribution systems can at best achieve a perfectly mixed space, defined to have a ventilation effectiveness, or an air change effectiveness (ACE), of 1.0 as determined in accordance with ASHRAE standard 129. By definition, mixing-type systems cannot provide preferential ventilation ( $ACE > 1$ ) in which some credit could be obtained for improved ventilation effectiveness at the breathing level in the space. In the new version of standard 62, guidance will be given on how to determine an adjusted minimum outside air ventilation rate. This rate would be calculated by dividing the ACE for mixing systems (1.0) by the ACE for the particular system under consideration. If a UFAD system can be shown (through measurement or other prescribed method) to provide an ACE greater than 1.0, then a reduced ventilation rate could be implemented.

Standard 62 sets minimum ventilation rates for office space and conference rooms at 9.4 L/s (20 cfm) per person, and for reception areas at 7.1 L/s (15 cfm) per person. In the design and operation of a UFAD or TAC system containing a large number of occupant-controlled supply modules, some means must be provided to ensure that minimum ventilation rates are maintained, even when people choose to turn off their local air supply.

### *Chemical Exposure*

Exposure limits have been set for about 700 chemicals; they have not been set for many thousands of other chemicals. The lack of an exposure limit does not mean a chemical is harmless or non-toxic.

There are many gaps in science's knowledge of chemical toxicity and routes of exposure. Air sampling results are compared against exposure limits to evaluate how much improvement in controls is needed. Some of the exposure limits apply to the average exposure over a whole work day of 7 to 10 hours. Other exposure limits apply to short term exposures of 15 to 30 minutes. Some chemicals have a notation indicating that they may be absorbed through the skin as well as inhaled.

Many exposure limits are not completely safe because they are based on incomplete scientific information. The OSHA limits consider economic and technical feasibility as well as health effects.

### *Bioaerosols*

Air movement provides an important and common mechanism for biological dispersal (movement from one location to another). Each cubic meter of indoor or outdoor air may contain thousands or even millions of microorganisms and biological particles. The goal of

air monitoring is to provide a representative sample of microorganisms and particles present within the air that we breathe. Although this objective may appear straightforward, the process is actually riddled with potential problems. Sampling methods must account for a number of factors such as viable and nonviable organisms, differences in cell size and shape, temporal variances, spatial variances, occupant use, sampled air volumes, location of reference samples, and infiltration from outdoor air, just to name a few. Unfortunately, no single air sampling method addresses all of the above issues without some assumptions. To minimize these assumptions, an air monitoring strategy must be carefully designed. Such studies are extremely expensive, and often cost prohibitive. Even if an adequate design is achieved, the results represent only a snap-shot for that given sampling event.

Airborne particles are collectively referred to as bioaerosols. Examples of bioaerosols include viruses, bacteria, fungi, pollen, fragmented particles from microbial cells or insects, and by-products of living organisms (e.g., animal dander, insect excrement). The size of aerosolized particles varies from a fraction of a micrometer ( $\mu\text{m}$ ) to approximately  $30 \mu\text{m}$ . Particles larger than  $30 \mu\text{m}$  also become airborne, but for shorter periods of time.

Modern airborne sampling employs one of three protocols: (1) impactor sampling, (2) liquid impinger sampling, or (3) filtration sampling. Each of these methods pulls a measured volume of air with the aid of an electric or battery-powered pump. The air is then directed through a chamber (or a series of chambers), guiding the spores on a specific trajectory to a solid agar disc or adhesive medium (impactor samplers), a liquid buffer (impinger samplers), or a filter (filtration samplers). With the impactor method, cells or spores are usually cultured on a suitable nutrient medium. Each organism is then identified and reported as colony forming units  $\text{m}^{-3}$  (CFUs per cubic meter). One significant disadvantage of viable spore sampling is that it grossly underestimates the number of total cells/spores (viable and nonviable). Nonviable cells, although no longer infectious, still exhibit the same allergenic, irritant, toxigenic properties as viable cells/spores.

**9. Industrial hygiene personnel shall demonstrate a working-level knowledge of the analysis and interpretation of sample results.**

**a) Discuss how the following are used in the analysis of sampling results:**

- **Mathematical and statistical computations**
- **Units and conversions**

*Mathematical and Statistical Computations*

One of the most important objectives of any industrial hygiene program is to accurately assess employees' occupational exposure to airborne contaminants, where necessary, by exposure measurements. The use of statistics in this assessment process is necessary because all measurements of physical properties contain some unavoidable random measurement error. That is, because of the effect of random measurement errors, any exposure average for an employee calculated from exposure measurements is only an estimate of the true exposure average.

Statistical computations begin with a statistical population. A statistical population is an entire class of items about which conclusions are to be drawn. Usually it is impossible to take measurements on all items in the population. Thus, measurements are usually taken on several items comprising a statistical sample drawn from the population. The findings from

the sample are generalized to obtain conclusions about the whole population. After taking measurements on items on the statistical sample, the measurements can be ranked in groups either in a table or graphically. One then recognizes that the measurements have some distribution.

The next step in data reduction is finding where the measurements are centered. There are several statistical measures of central location, or central tendency. Two common ones are arithmetic mean and geometric mean. Lastly, how the measurements are distributed about the center value is determined. Several measures of dispersion give an idea of the scatter or variation of the measurements. Three common ones are the geometric standard deviation, the normal standard deviation, and the coefficient of variation.

In industrial hygiene, a sample usually consists of an airborne contaminant collected on a physical device. Industrial hygiene sampling is usually performed by drawing a measured volume of air through a filter, sorbent tube, impingement device, or other instrument to trap and collect the airborne contaminant.

Computations related to industrial hygiene analysis are available in NIOSH Publication 77-173, Occupational Exposure Sampling Strategy Manual.

#### *Units and Conversions*

Use of metric measurement standards in the United States has been authorized by law since 1866. In 1988, Congress enacted legislation to establish the metric system as the preferred system of weights and measures for all domestic trade and commerce. This legislation also required the use of metric measurement standards in all federal activities. On July 25, 1991, the president issued Executive Order 12770, which reiterated the order to implement the metric system “as the preferred system of weights and measures for United States trade and commerce.” This executive order directed all federal agencies to implement “metrification” to the extent economically feasible by September 30, 1992.

OSHA's safety compliance operations and industrial hygiene efforts have an advantage in metrification because the biological, chemical, and physical sciences have long used the metric system. Students of these subjects have been using metric weights and measures along with daily use of the English system of measures for decades. Time-weighted averages (TWAs), PELs, and sampling and reporting forms all make use of the metric system.

In occupational exposure limits, concentrations of gases and vapors in air are usually expressed in parts per million (ppm), a measure of concentration by volume, as well as in milligrams per cubic meter of air ( $\text{mg}/\text{m}^3$ ), a measure of concentration by mass. In converting from ppm to  $\text{mg}/\text{m}^3$ , a temperature of  $25^\circ\text{C}$  and an atmospheric pressure of 101.325 kPa (760 Torr, 1 atmosphere, 14.696 psi) are used. Concentrations of airborne particles (fume, dust, etc.) are usually expressed in  $\text{mg}/\text{m}^3$ . In the case of dust, the limits refer to the total inhalable fraction unless specifically indicated as referring to the respirable fraction. In the case of a man-made mineral fiber, the limit is expressed as fibers per milliliter of air (fibers/ml).

**b) Discuss how the following affect the significance of exposures.**

- **Selection of exposure criteria (e.g., action levels)**
- **Individual susceptibility to identified hazards**
- **Importance of non-occupational exposures**
- **Other occupational exposures**
- **Biological sampling results**
- **Worker population demographics**

*Selection of Exposure Criteria*

Exposure criteria or action level means a concentration designated in 29 CFR 1910 for a specific substance, calculated as an eight-hour TWA, which initiates certain required activities such as exposure monitoring and medical surveillance.

*Individual Susceptibility to Identified Hazards*

Most environmental toxicants are biotransformed into compounds that are either detoxification products or more toxic than the parent compound, and the ratio between different pathways may be found in determining the compounds' toxic effects. Individual genetic differences in the metabolism of xenobiotics are thus thought to have an important role in the development of diseases in which environmental toxicants play a major role. Variations in human metabolic capacity have been extensively studied in the last two decades, and in some cases the genetic basis for the phenotypic expression has been identified. A growing number of genes encoding enzymes involved in biotransformation of toxicants and in the normal cellular defense against toxicant-induced damage to the cells have been identified and cloned. Consequently, there is increasing knowledge of allelic variants of these genes — genetic defects that may result in a different susceptibility towards the environmental toxicants. Polymorphisms in metabolism genes tend to be much more common in the population than allelic variants of, for example, cancer genes. They are therefore, from a public health point of view, of great importance, although the increased risk of cancer associated with a genetic polymorphism is usually lower than the risk associated with the low frequency allelic variants of cancer suppressor genes.

The recent knowledge of the genetic basis for individual differences in metabolism has opened new possibilities for studies focusing on increased susceptibility to neurodegenerative diseases like Alzheimer's disease, and other degenerative diseases in addition to cancer.

Many of the polymorphic genes of the metabolism of xenobiotics show considerable ethnic differences in respect to allelic distribution (e.g., rare alleles, gene amplifications, and pseudogenes). Many of the first reports on genetic risk modification were from Japan, and only after several studies among various European populations was an estimate of allele frequencies (and thus of risk genotypes) elsewhere obtained. Remarkable variations in the metabolic phenotypes and genotypes have been reported for different ethnic and/or geographic populations.

For the oxidative metabolism of xenobiotics, the superfamily of cytochrome P450 enzymes catalyses oxidation of a large number of endogenous (e.g., hormones and fatty acids) and exogenous (e.g., polycyclic aromatic hydrocarbons, aromatic amines, and mycotoxins) chemicals. More than 20 individual groups of enzymes can be regarded as enzymes of detoxification. While the phase I enzymes are mainly involved in the activation of chemical toxicants, the phase I

enzymes (e.g., epoxide hydrolase, glutathione S-transferases, sulfotransferases, glucuronosyl transferases) are involved in the detoxification of the primary metabolites by conjugating them with glutathione, glucuronide, or sulfate to produce readily excretable hydrophilic products. Obviously, the balance between activation and detoxification enzymes determines the molecular dose of a biological active toxicant, thereby substantially influencing the potential disease risk.

#### *Importance of Non-Occupational Exposures*

Exposure limits cannot readily be extrapolated to evaluate or control non-occupational exposure, e.g., levels of contamination in the neighborhood close to an industrial plant.

#### *Other Occupational Exposures*

For other occupational exposures, control procedures shall be implemented that are consistent with the current ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Controls will depend on the physical and chemical properties of the material, how it will be handled (specifically if the material will be handled in such a way that it could be dispersed into the air or spread on surfaces), the quantity involved, and the duration and number of potential exposures.

#### *Biological Sampling Results*

DOE and contractor line management are required to ensure that worker exposure assessments for chemical, physical, and biological agents and ergonomic stressors are documented and that records are maintained. Further, the results of these exposure assessments must be promptly communicated to the workers and supervisors who perform the tasks evaluated, and to the organization(s) responsible for effecting any needed corrective actions, such as operations, engineering, or maintenance, as well as to affected disciplines such as occupational medicine, epidemiology, industrial safety, radiation protection, fire protection, and environmental protection, as appropriate.

#### *Worker Population Demographics*

See “Individual Susceptibility to Identified Hazards,” in this competency for information regarding worker population demographics.

### **c) Discuss the role standards, guidelines, and legal requirements have on analyzing and interpreting results.**

DOE and contractor line management are required to use appropriate industrial hygiene standards.

DOE O 440.1A contains a list of the DOE-prescribed worker protection standards that are associated with analyzing and interpreting results. The ACGIH, “Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices,” should be used when ACGIH TLVs are lower than OSHA PELs. When ACGIH TLVs are used as exposure limits, DOE operations shall comply with the other provisions of any applicable OSHA-expanded health standard.

### **d) Discuss the methods of sampling and their limitations for the following:**

- **Heat stress (ambient conditions and biological monitoring)**
- **Ergonomic hazards**
- **Bioaerosols**

### *Heat Stress*

**Body Temperature Measurements.** Although instruments are available to estimate deep body temperature by measuring the temperature in the ear canal or on the skin, these instruments are not sufficiently reliable to use in compliance evaluations.

**Environmental Measurements.** Environmental heat measurements should be made at, or as close as possible to, the specific work area where the worker is exposed. When a worker is not continuously exposed in a single hot area, but moves between two or more areas having different levels of environmental heat, or when the environmental heat varies substantially at a single hot area, environmental heat exposures should be measured for each area and for each level of environmental heat to which employees are exposed.

**Wet Bulb Globe Temperature Index.** Wet bulb globe temperature (WBGT) should be calculated using the appropriate formula. The WBGT for continuous all-day or several-hour exposures should be averaged over a 60-minute period. Intermittent exposures should be averaged over a 120-minute period.

**Measurement.** Portable heat stress meters or monitors are used to measure heat conditions. These instruments can calculate both the indoor and outdoor WBGT index according to established ACGIH TLV equations. With this information and information on the type of work being performed, heat stress meters can determine how long a person can safely work or remain in a particular hot environment.

**The Effective Temperature Index (ETI).** ETI combines the temperature, the humidity of the air, and air velocity. This index has been used extensively in the field of comfort ventilation and air conditioning. ETI remains a useful measurement technique in mines and other places where humidity is high and radiant heat is low.

**The Heat-Stress Index (HSI).** HSI was developed by Belding and Hatch in 1965. Although the HSI considers all environmental factors and work rate, it is not completely satisfactory for determining an individual worker's heat stress and is also difficult to use.

### *Ergonomic Hazards*

There are several sampling tools available for ergonomic hazards. Some of them are listed in table 3, along with the risk factors evaluated, the areas of the body that are addressed, and some examples of jobs to which the tools apply.

| <b>Tool</b>      | <b>Risk Factors Evaluated</b>            | <b>Areas of Body Addressed</b> | <b>Examples of Jobs that the Tool Applies To</b>   |
|------------------|--|--------------------------------|--|
| Job Strain Index | Repetition<br>Force<br>Awkward positions | Hands<br>Wrists                | Small parts assembly<br>Inspecting<br>Packaging<br>Keyboarding<br>Data Processing<br>Jobs involving highly repetitive hand motions |

| <b>Tool</b>                   | <b>Risk Factors Evaluated</b>            | <b>Areas of Body Addressed</b>                                   | <b>Examples of Jobs that the Tool Applies To</b>   |
|-------------------------------|--|--|--|
| NIOSH Lifting Equation        | Repetition<br>Force<br>Awkward positions | Lower back   | Package sorting, handling<br>Package delivery<br>Assembly work<br>Manual handling involving lifting weights > 10 lbs<br>Production jobs involving forceful exertions<br>Stationary lifting |
| Snook Push/Pull Hazard Tables | Repetition<br>Force<br>Awkward positions | Back<br>Trunk<br>Shoulders<br>Legs                               | Janitorial tasks<br>Package delivery<br>Jobs involving pushing/pulling carts<br>Jobs involving carrying objects  |
| Rapid Upper Limb Assessment   | Repetition<br>Force<br>Awkward positions | Wrists<br>Forearms<br>Elbows<br>Shoulders<br>Neck<br>Trunk       | Assembly work<br>Production work<br>Janitorial tasks<br>Maintenance  |
| Rapid Entire Body Assessment  | Repetition<br>Force<br>Awkward positions | Wrists<br>Forearms<br>Shoulders<br>Neck<br>Trunk<br>Back<br>Legs | Janitorial tasks<br>Emergency medical personnel  |

Table 3. Ergonomic sampling tools

### *Bioaerosols*

Bioaerosol monitoring is a rapidly emerging area of industrial hygiene. Bioaerosol monitoring includes the measurement of viable (culturable and nonculturable) and nonviable microorganisms in both indoor (e.g., industrial, office, or residential) and outdoor (e.g., agricultural and general air quality) environments. In general, indoor bioaerosol sampling need not be performed if visible growth is observed. Monitoring for bioaerosols in the occupational environment is one of the many tools the industrial hygienist uses in the assessment of indoor environmental quality, infectious disease outbreaks, agricultural health, and clean rooms. Contamination (microbial growth on floors, walls, or ceilings, or in the HVAC system) should be remedied. If personnel remain symptomatic after remediation, air sampling may be appropriate, but the industrial hygienist should keep in mind that false negative results are quite possible and should be interpreted with caution. Other exceptions for which bioaerosol sampling may be appropriate include epidemiological investigations, research studies, or situations so indicated by an occupational physician and/or immunologist.

Most aerosol sampling devices involve techniques that separate particles from the air stream and collect them in or on a preselected medium. Impaction, filtration, and impingement are three common sampling techniques used to separate and collect the bioaerosol.

Impaction is used to separate a particle from a gas stream based on the inertia of the particle. An impactor consists of a series of nozzles (circular- or slot-shaped) and a target. Perfect impactors have a “sharp cutoff” or step-function efficiency curve. Particles larger than a particular aerodynamic size will be impacted onto a collection surface while smaller particles proceed through the sampler. High velocity, inlet losses, interstage losses, and particle reentrainment affect the performance characteristics of an impactor.

Collection of particles from a nonbiological aerosol sample is most commonly achieved by filtration. Filter media are available in both fibrous (typically glass) and membranous forms. Deposition occurs when particles impact and are intercepted by the fibers or surface of filter membranes. Membrane filters are manufactured in a variety of pore sizes from polymers such as cellulose ester, polyvinyl chloride, and polycarbonate. Polymeric membrane filters lack rigidity and must be used with a support pad. The choice of a filter medium depends on the contaminant of interest and the requirements of the analytical technique.

Liquid impingers are a special type of impactor. Impingers are useful for the collection of culturable aerosols. Impingers use a liquid as the collection medium.

The particle size distribution of the bioaerosol is very important in the evaluation of the data obtained using the selected sampler. If the selected sampler does not provide particle size distribution data, then a cascade impactor should be used.

A membrane filter sampler is not appropriate for sampling culturable *E. coli* because the cells would desiccate and become either nonviable or viable but not culturable. In another example, an impactor with a  $d_{50}$  of  $4\ \mu\text{m}$  should not be used to collect *Aspergillus niger* spores because most spores would remain entrained in the air passing through the instrument.

**10. Industrial hygiene personnel shall demonstrate a working-level knowledge of the methods used to educate people about how to protect themselves from health stressors.**

**a) Discuss the importance of the following as they relate to employee training in industrial hygiene:**

- **Regulatory training and educational content requirements**
- **Qualifications and credibility of course instruction**
- **Audience receptivity of educational materials, format, and classroom conditions**
- **Audience educational level and language skills**
- **Bottom-line goals of the education being provided**

*Regulatory Training and Educational Content Requirements*

DOE and contractor line management are required to provide worker hazard training and to encourage employee involvement. Line workers are the individuals most in contact with the hazards and, therefore, have a vested interest in the Worker Protection Program. As such,

they can serve as valuable resources and problem solvers. Workers who are properly trained and allowed to contribute and implement ideas are more likely to support them since they now have a personal stake in ensuring that rules and procedures are followed. Therefore, line workers should be directly involved with, and should participate in, activities such as inspecting worksites, identifying hazards, selecting work practice controls, and serving on worker protection committees.

DOE and contractor line management shall ensure that workers are trained in

- methods and observations that may be used to detect the presence of an occupational health hazard in the work area (e.g., the use of continuous monitoring devices and how to recognize the visual appearance or odor of hazardous chemicals when being released);
- an understanding of the physical and health hazards of the chemicals, ergonomic stressors, and harmful physical and/or biological agents in the work area.;
- measures that workers can take to protect themselves from these hazards, including use of engineering controls, specific procedures, or other controls (such as appropriate work practices, emergency actions, and PPE);
- details of Chemical Hazard Communication (HAZCOM), the Laboratory Chemical Hygiene Plan (CHP), or the Hazardous Waste Operations and Emergency Response (HAZWOPER) program(s) developed by DOE or the contractor;
- details of any applicable operations or hazard-specific training programs.

Employee training shall include

- methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, the use of continuous monitoring devices, and the visual appearance or odor of hazardous chemicals when being released);
- the physical and health hazards of chemicals in the work area;
- the measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used;
- the applicable details of the employer's written Chemical Hygiene Plan.

#### *Qualifications and Credibility of Course Instruction*

Trainers should have satisfactorily completed a training course for teaching the subjects they are expected to teach, or they should have the training and/or academic credentials and instructional experience necessary to demonstrate competent instruction skills and a good command of the subject matter in the specific subject they are to teach.

#### *Audience Receptivity of Educational Materials, Format, and Classroom Conditions*

When starting on a new presentation, it's helpful to know the audience. The more you know about the audience, the greater the likelihood of creating a presentation that is tailor-made to meet their needs. The choice of stories and examples to include will depend on who they are, where they are, and what they already know. Consider these points when preparing a presentation:

- What is the gender of the audience? More male than female? More female than male? Or is it equally balanced?
- What is the age range?

- How many people will there be?
- What do they know? What information is the audience starting with? What is their level of knowledge about the subject? You do not want to intimidate them or talk above or down to them. Have they heard it before? Do not waste their time or yours. Give them something new or a different perspective.
- Why are they here? Is the audience attending voluntarily? Is it for personal gain, or did the boss send them?

Knowing the audience can help you target your message, and having a targeted message will improve audience receptivity.

#### *Audience Educational Level and Language Skills*

See the discussion on audience receptivity in this competency.

#### *Bottom Line Goals of the Education Being Provided*

Educating employees on workplace hazards and controls may be done for two reasons: (1) to achieve compliance with a regulatory requirement, and (2) to provide employees with the knowledge and skills needed to recognize and control the hazards of their jobs.

#### **b) List the fundamental assumptions of public and workplace risk communication and explain in general both how risk should be explained to a non-technical audience and what should be avoided in risk communication.**

There are many challenges in how we communicate risk, especially risks to health. Few areas continue to stir debate more than advances in medicine and biotechnology. Stem cell research, vaccine development, and genomic manipulation are but a few of the areas under recent attack. Even public health successes that have decreased morbidity and mortality — such as vaccination, air bags, and fluoridation — have been surrounded by controversy. Scientific and health literacy require understanding, but the incremental and imprecise nature of science and experimentation that contributes to defining risk thrives on doubts, criticism, and debate, which often translate into only theoretical causality and risk. Furthermore, scientifically valid information is not absolute and may change over time. Translating theoretical (imprecise and incomplete) and changing knowledge of causality and risk has developed into its own body of knowledge called risk communication. According to a 1996 National Research Council report, risk communication emphasizes the process of exchanging information and opinion with the public.

#### **c) Identify the potential non-occupational hazards associated with employee lifestyle that may contribute to occupational illness.**

As a means of reducing risk for employees, many companies over the last several decades have introduced worksite health promotion programs. Such programs have historically resulted in reduced absenteeism, increased employee retention, reduced health care costs, and employee satisfaction. Employers are charged with assisting employees in retirement planning, and now they are recognizing the need to educate employees regarding those lifestyle factors which are most likely to assure their reaching their retirement years in good health. There is increasing evidence that health promotion and wellness programs have proven successful for many companies and employees. Most chronic diseases are associated with lifestyle practices. Among these are heart disease, cancer, and other chronic debilitating

diseases such as arthritis and diabetes. Contemporary lifestyle may be an associated factor in the development and progression of these diseases. Education regarding prevention and management of these diseases may reduce loss of life, improve quality of life, and better utilize financial resources. Additionally, screening programs for early detection and assessment of risk factors for these diseases may prove a valuable component of the educational program. Early detection reduces absenteeism, often reduces cost of treatment, and improves the prognosis.

**11. Industrial hygiene personnel shall demonstrate a working-level knowledge of personal protective equipment (PPE) programs for controlling exposure, including their use and limitations.**

**a) Discuss how to recognize when personal protective equipment is an acceptable and appropriate alternative to other control mechanisms.**

When engineering and/or administrative controls have been considered and implemented and are not sufficient to fully protect the worker from a recognized hazard, PPE can be used to supplement these other controls as appropriate. PPE is acceptable as a control method

- to supplement engineering, work practice, and administrative controls when such controls are not feasible or do not adequately reduce the hazard;
- as an interim measure while engineering controls are being developed and implemented;
- during emergencies when engineering controls may not be feasible;
- during maintenance and other non-routine activities where other controls are not feasible.

**b) Discuss how to recognize when PPE is a necessary companion to other control measures.**

The use of PPE can itself create significant worker hazards, such as heat stress, physical and psychological stress, and impaired vision, mobility, and communication. An example would be a worker wearing several layers of clothing (for warmth and anticontamination), a respirator, gloves, and a helmet while welding or cutting. This arrangement of PPE could prevent the worker from being aware of the environment in the event of a fire or other emergency.

In these situations, engineering and/or administrative controls should be implemented to supplement PPE. Equipment and clothing should be selected that provide an adequate level of protection. The selection process should involve representatives of the affected safety disciplines working in concert.

Two basic objectives of any PPE practice should be to protect the wearer from safety and health hazards, and to prevent injury to the wearer from incorrect use and/or malfunction of the PPE. To accomplish these objectives, a comprehensive PPE practice should include: hazard identification; medical monitoring; environmental surveillance; selection, use, maintenance, and decontamination of PPE; and associated training.

**c) Discuss the selection, use, maintenance, limitations, and capabilities of respiratory equipment and other types of PPE (e.g., eye protection, protective clothing, personal hearing protection).**

*Respiratory Protection*

Respiratory protective equipment is used to reduce an individual's intake of airborne radioactive materials. Each respiratory protective device is assigned a protection factor that indicates the degree of protection afforded by the respirator. Respiratory protective devices should be chosen based on the protection factor and actual or potential airborne radioactivity levels, taking into account as low as reasonably achievable (ALARA) considerations, other industrial hazards, and worker safety. DOE requires its respiratory protection programs to be conducted in accordance with DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees, which endorses the most restrictive parts of ANSI Z88.2, American National Standard for Respiratory Protection (ANSI 1992), or 29 CFR 1910.134.

An important step in selecting the proper respiratory protective equipment is determining the actual or potential concentration of airborne radioactivity in the area the individual is to enter. Air sampling shall be performed as necessary to characterize the airborne radioactivity hazard where respiratory protection against airborne radionuclides has been prescribed. Typically, grab sampling is used to determine the airborne radioactivity concentration. Real-time air monitoring may be useful in areas where substantial work is being performed and airborne radioactivity concentrations fluctuate. If the individual is entering an area where the airborne radioactivity concentration is routinely sampled and is not likely to have changed since air monitoring was last performed, previously obtained samples may be used to characterize the airborne radioactivity hazard.

When the need for air monitoring is not clear, historical data from fixed-location air sampling and real-time air monitoring should be analyzed to determine whether respiratory protection is appropriate. NUREG-1400 provides a methodology for predicting the potential intakes, which can be useful in determining the need for respiratory protection.

*Eye Protection*

The employer should ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

The employer should ensure that each affected employee uses eye protection that provides side protection when there is a hazard from flying objects. Detachable side protectors (e.g., clip-on or slide-on side shields) must meet the pertinent requirements.

The employer should ensure that each affected employee who wears prescription lenses while engaged in operations that involve eye hazards wears eye protection that incorporates the prescription in its design, or wears eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses.

The employer should ensure that each affected employee uses equipment with filter lenses that have a shade number appropriate for the work being performed for protection from injurious light radiation.

Eye and face PPE should be distinctly marked to facilitate identification of the manufacturer.

#### *Protective Clothing*

Each operation should be analyzed to determine when personnel working with explosives and toxic materials must wear approved coveralls or laboratory coats to prevent contact with these materials and prevent contaminating personal apparel. Flame-retardant coveralls may be desired for explosives operations with the potential for flash fire. These coveralls shall not have cuffs and should not have metallic fasteners. Written procedures should include protective clothing and equipment requirements.

Cotton or other antistatic clothing and undergarments, including socks, should be worn where generation of static electricity would create a hazard.

#### *Hearing Protection*

Enrollment in a hearing conservation program is required where workers are exposed to continuous, intermittent, impact, or impulse noise at or above 85 dBA as an 8 hour TWA regardless of the use of any hearing protection. Continuous or intermittent sound levels higher than 85 dBA may not exceed the exposure time dependent limits, and no unprotected exposure to continuous, intermittent, or impact noise in excess of C-weighted peak 140 dB is permitted.

#### **d) Discuss how the properties of absorption, adsorption, and filtration mechanisms (respiratory protection) affect the selection of PPE.**

Appropriate PPE such as an air-purifying respirator with a filter/cartridge may be required when working with the properties of absorption, adsorption, and filtration mechanisms.

In general, only supplied-air respirators are effective in preventing inhalation of airborne tritium. Two types of air-supplied respirators are available: self-contained breathing apparatus (SCBA) and full-face supplied air masks.

A SCBA, consisting of a full-face mask fed by a bottle of compressed air carried on the worker's back, provides excellent protection against tritium oxide (HTO) inhalation. Because the mask provides no protection against absorption by most of the skin, the SCBA is normally reserved for emergency use only. The protection factor of 3 or more afforded by the SCBA may be adequate for some applications. A SCBA can be used as an added precaution during certain maintenance or operations that experience has shown should not result in the release of significant amounts of HTO. Nevertheless, the potential for exposure is real, and the SCBA gives the worker time to leave the area if necessary before a skin exposure occurs.

Full-face supplied-air masks are also available. Because the air is normally supplied by a fixed-breathing-air system, they are not practical for many emergency situations and, consequently, are not as popular as SCBAs.

NIOSH Pub. 2005-149, NIOSH Pocket Guide to Chemical Hazards, and NIOSH Pub 2005-100, Respirator Selection, provide a step-by-step selection process for respiratory PPE.

The selection of N-, R-, and P-series filters depends on the presence of oil particles as follows:

- If no oil particles are present in the work environment, use a filter of any series (i.e., N-, R-, or P-series).
- If oil particles (e.g., lubricants, cutting fluids, glycerine) are present, use an R- or P-series filter.
- If oil particles are present and the filter is to be used for more than one work shift, use only a P-series filter.

An easy prompt is:

**N** for **N**ot resistant to oil,

**R** for **R**esistant to oil,

**P** for oil **P**roof.

Selection of filter efficiency (i.e., 95%, 99%, or 99.7%) depends on how much filter leakage can be accepted. Higher filter efficiency means lower filter leakage.

An air-purifying chemical cartridge/canister respirator is recommended that has a sorbent suitable for the chemical properties of the anticipated gas/vapor contaminant(s) and for the anticipated exposure levels. Information on cartridges or canisters approved for use for classes of chemicals or for specific gases or vapors can be found in the NIOSH Certified Equipment List at <http://www.cdc.gov/NIOSH/npptl/topics/respirators/cel/>.

**e) Describe the major elements of the hearing conservation program.**

The standards for occupational noise exposure adopted by the DOE state that personnel without hearing protection must not be exposed to an intensity of noise exceeding 85 dBA based on an eight-hour TWA as measured on the A-weighted scale. This means that if personnel are working in an area where the intensity of noise exceeds an average of 85 dBA over eight hours, the amount of time that they may work in the area without hearing protection must be reduced in relation to the amount that the noise exceeds 85 dBA. For example, if the noise in an area is measured at an average of 90 dBA over an eight-hour period, personnel may only work in that area without wearing hearing protection for a maximum of four hours. According to this standard, personnel may work a full eight-hour shift without hearing protection in an area where the noise level does not exceed an eight-hour TWA of 85 dBA.

OSHA regulations require that employers implement a hearing conservation program for employees exposed to high levels of sound. This program includes sound measurements, training, record-keeping, and audiometric testing.

The employer shall administer a continuing, effective hearing conservation program, as described in 29 CFR 1910.95, whenever employee noise exposures equal or exceed an eight-hour TWA of 85 dBA (slow response) or, equivalently, a dose of fifty percent.

**f) Discuss limitations in the use of personal protective equipment.**

*Lab Coats and Coveralls*

Lab coats and coveralls (fabric barriers) are worn in most tritium facilities. Lab coats are routinely worn to protect personal clothing. Coveralls are sometimes worn for added protection instead of a lab coat when the work is unusually dusty, dirty, or greasy. The protection afforded by lab coats and coveralls is minimal (except for short exposures) when tritium is airborne, but they are more effective in preventing skin contact with contaminated surfaces.

Disposable water-proof and water-resistant lab coats and coveralls have been tested at various laboratories. They are not popular for everyday use because of the cost and excessive discomfort inflicted on the worker. Most facilities prefer using ordinary open-weave fabrics for lab coats and coveralls and using an approved laundry for contaminated clothing. Some facilities have chosen to use disposable paper lab coats and coveralls, exchanging the costs associated with a laundry for the costs associated with replacement and waste disposal.

*Shoe Covers*

Although shoe covers provide protection against the spread of contamination and exposure, the routine use of shoe covers in a tritium facility is usually weighed against actual need. Shoe covers can offer both a degree of personnel protection and control over the spread of contamination on floors. However, in modern facilities where tritium is largely controlled by the use of secondary containment, shoe covers may not be required. Such facilities can easily maintain a clean laboratory environment by the use of regular smear surveys and good housekeeping. Using liquid-proof shoe covers until spills are cleaned up should be considered following spills of tritium-contaminated liquids and solids to prevent the spread of local contamination.

*Gloves*

In most operations, the hands and forearms of workers are vulnerable to contact with tritium surface contamination. The proper use and selection of gloves are essential.

Many factors should be considered in selecting the proper type of glove. These include chemical compatibility, permeation resistance, abrasion resistance, solvent resistance, glove thickness, glove toughness, glove color, shelf life, and unit cost. Gloves are commercially available in butyl rubber, neoprene, polyvinyl chloride (PVC) plastics, latex, etc.

The most common type of glove found in tritium laboratories is the light-weight, disposable short glove (usually made of PVC or latex) used for handling lightly contaminated equipment. Depending on the level of contamination, such gloves may be changed frequently (every 10-20 minutes), a second pair may be worn, or heavier gloves may be used instead. When using gloves for this purpose, the work should be planned so that contaminated gloves do not spread contamination to surfaces that are being kept free of contamination.

When working in a glove box using the box gloves, disposable gloves are worn to prevent uptake of HTO contaminating the outside of the box gloves. Again, depending on the level of contamination, more than one additional pair may be required, one of which may be a longer, surgeon's length glove.

In spite of all the precautions normally taken, workers may occasionally be contaminated with tritium. The skin should be decontaminated as soon as possible after any potential skin exposure to minimize absorption into the body. Effective personal decontamination methods include rinsing the affected part of the body with cool water and soap. If the entire body is affected, the worker should shower with soap and water that is as cool as can be tolerated. Cool water keeps the pores of the skin closed and reduces the transfer of HTO across the skin. The importance of washing the affected skin as soon as possible after contamination cannot be over-emphasized. Even if gloves are worn when handling contaminated equipment or when working in contaminated glove box gloves, it is good practice to wash the hands after removing the gloves.

**g) Discuss how codes, regulations, standards, and certification procedures affect the use of PPE.**

Title 29 CFR 1910.132 provides general requirements for PPE. This section of the code includes the following.

Protective equipment, including PPE for the eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation, or physical contact.

Where employees provide their own protective equipment, the employer shall be responsible to assure its adequacy, including proper maintenance and sanitation of such equipment.

All PPE shall be of safe design and construction for the work to be performed.

The employer shall assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of PPE. If such hazards are present, or likely to be present, the employer shall

- select, and have each affected employee use, the types of PPE that will protect the affected employee from the hazards identified in the hazard assessment;
- communicate selection decisions to each affected employee;
- select PPE that properly fits each affected employee.

Note: Non-mandatory appendix B contains an example of procedures that would comply with the requirement for a hazard assessment.

The employer shall verify that the required workplace hazard assessment has been performed through a written certification that identifies the workplace evaluated, the person certifying that the evaluation has been performed, and the date(s) of the hazard assessment. The document must be clearly identified as a certification of hazard assessment.

Defective or damaged PPE shall not be used.

The employer shall provide training to each employee who is required by this section to use PPE. Each such employee shall be trained to know at least

- when PPE is necessary;
- what PPE is necessary;
- how to properly don, doff, adjust, and wear PPE;
- the limitations of the PPE;
- the proper care, maintenance, useful life, and disposal of the PPE.

Each affected employee shall demonstrate an understanding of the training specified in paragraph (f)(1) of this section and the ability to use PPE properly before being allowed to perform work requiring the use of PPE.

When the employer has reason to believe that any affected employee who has already been trained does not have the understanding and skill required by paragraph (f)(2) of this section, the employer shall retrain each such employee. Circumstances where retraining is required include, but are not limited to, situations where

- changes in the workplace render previous training obsolete
- changes in the types of PPE to be used render previous training obsolete
- inadequacies in an affected employee's knowledge or use of assigned PPE indicate that the employee has not retained the requisite understanding or skill

The employer shall verify that each affected employee has received and understood the required training through a written certification that contains the name of each employee trained, the date(s) of training, and the subject of the certification.

**h) Discuss the difficulties of optimizing PPE in a complex, multi-exposure environment.**

Agencies can positively impact their bottom line costs by conducting a Personal Apparel Assessment (PAA), which focuses on seven key disciplines and 35 best practices to determine potential areas for cost improvement. These disciplines include cost performance, injury reduction, productivity improvements, standardization, training, and controls. The objective is to create a more consistent, compliant, and cost-effective PPE program.

The success of this type of program will depend on the agency's ability to track the results on an ongoing basis. Financial models have been developed to quantify, measure, and document those results once the PAA has been completed and the recommendations implemented. This type of measurement will allow the agency to gauge the program's success and verify true costs savings.

To conduct a thorough assessment, the agency should align itself with a partner that has the ability to provide the necessary resources, quantifiable documentation, and follow up capabilities to ensure successful results. The measurement and improvement process should not end once the recommendations from the PAA are implemented. Follow up to analyze any changes that occur within the organization and to ensure that new products and ideas are properly introduced is just as important as conducting the initial assessment.

Conducting a PAA goes beyond examining applications and providing product recommendations. It involves developing a complete understanding of the various job requirements, identifying critical issues, analyzing application processes and any variables that may exist, and reviewing operating procedures and the effect they may have on employees. Providing true solutions that will positively impact the work place will be impossible without a thorough analysis of the entire process.

A successful assessment will require the support of key functions within the organization, including finance, operations, procurement, safety, and where applicable, union representatives. In most cases, each of these departments has its own initiatives. The assessment will help each department determine which disciplines and their associated best practices represent the greatest opportunities for cost savings.

Measuring the cost performance of a agency's PPE products is critical to controlling the company's expenses. The objective is to identify optimum product solutions and implement best practices that will maximize performance. Employees must be asked for their input so the assessor can gain insight into the total process and how PPE products are used.

It will also be important to benchmark the agency's present PPE product costs. This benchmark will allow the agency to use the financial models that will be put into place to measure the results of the recommendations that are implemented and to compare costs.

OSHA recently issued a report indicating that 70 percent of the workers that experienced hand injuries in manufacturing operations were not wearing gloves. Hand injuries among the remaining 30 percent occurred because hand protection was inadequate, damaged, or misapplied.

The objective of any PPE program is to provide solutions that significantly reduce recordable and non-recordable injuries and their associated costs. Wearing PPE is often a personal choice as far as employees are concerned. The OSHA study seems to indicate that many companies are not providing PPE products that are acceptable to employees and that provide the levels of protection needed for specific jobs. The direct (medical expenses) and indirect (lost time, decreased productivity) costs resulting from injuries can be enormous. Analyzing this discipline and implementing best practices provide agencies with an opportunity to reduce injuries and related costs.

**i) Discuss the use and limitations of PPE in a heat stress environment.**

Heat stress is caused by a number of interacting factors including environmental conditions, clothing, workload, and the individual characteristics of the worker. Because heat stress is probably one of the most common (and potentially serious) illnesses at hazardous waste sites, regular monitoring and other preventive precautions are vital.

Reduced work tolerance and the increased risk of excessive heat stress is influenced by the amount and type of PPE worn. PPE adds weight and bulk, severely reduces the body's access to normal heat exchange mechanisms (evaporation, convection, and radiation), and increases energy expenditure. Therefore, when selecting PPE, each item's benefit should be

carefully evaluated in relation to its potential for increasing the risk of heat stress. Once PPE is selected, the safe duration of work/rest periods should be determined based on the

- anticipated work rate
- ambient temperature and other environmental factors
- type of protective ensemble
- individual worker's characteristics and fitness

Because the incidence of heat stress depends on a variety of factors, all workers, even those not wearing protective equipment, should be observed carefully.

For workers wearing permeable clothing (e.g., standard cotton or synthetic work clothes), follow recommendations for monitoring requirements and suggested work/rest schedules in the current version of the ACGIH's TLVs for heat stress. If the actual clothing worn differs from the ACGIH standard ensemble in insulation value and/or wind and vapor permeability, change the work/rest schedules accordingly.

For workers wearing semi-permeable or impermeable encapsulating ensembles, the ACGIH standard cannot be used. For these situations, workers should be evaluated when the temperature in the work area is above 70°F (21°C).

## **12. Industrial hygiene personnel shall demonstrate a working-level knowledge of the design of engineering measures to control exposure.**

### **a) Discuss basic design principles for heating, ventilation, and air conditioning (HVAC) systems, including the following:**

- **Local exhaust ventilation**
- **Dilution ventilation**
- **Air recirculation**
- **Make-up air supply**

Regulations, technical guidance, and good practices emphasize the implementation of engineering controls to control exposure where feasible. Administrative controls are viewed less favorably, but are generally considered acceptable. Reliance on PPE, because of its reliance upon individual employee knowledge and other human variables, is regarded as the least desirable choice overall.

The most common form of engineering control is ventilation of the work place. The industrial hygienist must be familiar with the components of the facility's ventilation systems and the methods used to control both industrial sources of contaminants and indoor air contaminants. The industrial hygienist should also have a grasp of the state-of-the-art control technologies and methods used to evaluate control system performance.

Adequate ventilation is best achieved when the plant engineer, management, workers, and the industrial hygienist work together. Frequently, older facilities and their ventilation systems were designed for production purposes with little thought given to health considerations. Retrofit or redesign is sometimes required to meet today's standards.

Local exhaust is most often the control technology of choice in that its components remove contaminants at their source. Dilution is sometimes used, but is less effective in that contaminants remain (although they are less concentrated). Air recirculation may be used to conserve energy where air contaminants are of a low toxicity and concentration. Makeup air plays a key role in the HVAC process to introduce “fresh” air to the building and to replenish exhausted air. “Balanced” systems provide a good proportional flow of air to all areas, and also ensure that the HVAC system is at equilibrium between incoming and outgoing air. However, in some institutional or industrial situations, a “negative” or “positive” flow may be desirable to maintain parts of the building at positive or negative pressure.

In the figure below from DOE-HDBK-1169-2003, DOE Handbook: Nuclear Air Cleaning, the general approach to establish ventilation zones is in a three-tiered manner. Multizoned buildings are usually ventilated so that air flows from the less contaminated zone to the more contaminated zone. Areas from which air is not recirculated include areas that produce or emit dust particles, heat, odors, fumes, spray, gases, smoke, or other contaminants that cannot be sufficiently treated and could be potentially injurious to the health and safety of personnel or potentially damaging to equipment. These areas are 100 percent exhausted.

Recirculation within a zone (circulating the air through a high-efficiency air cleaning system before discharge back to the zone) is permitted, but recirculation from a zone of higher contamination back to a zone of lesser contamination is prohibited. The interiors of exhaust and recirculating ductwork are considered to be of the same hazard classification as the zone they serve. Airflow must be sufficient to provide the necessary degree of contaminant dilution and cooling and to maintain sufficient pressure differentials between zones where there can be no backflow of air spaces of lower contamination, even under upset conditions. The pressure differentials should be determined during the facility’s design and should be in accordance with the applicable standards. Substantially higher differentials are often specified between primary and secondary confinement zones than for other boundaries.

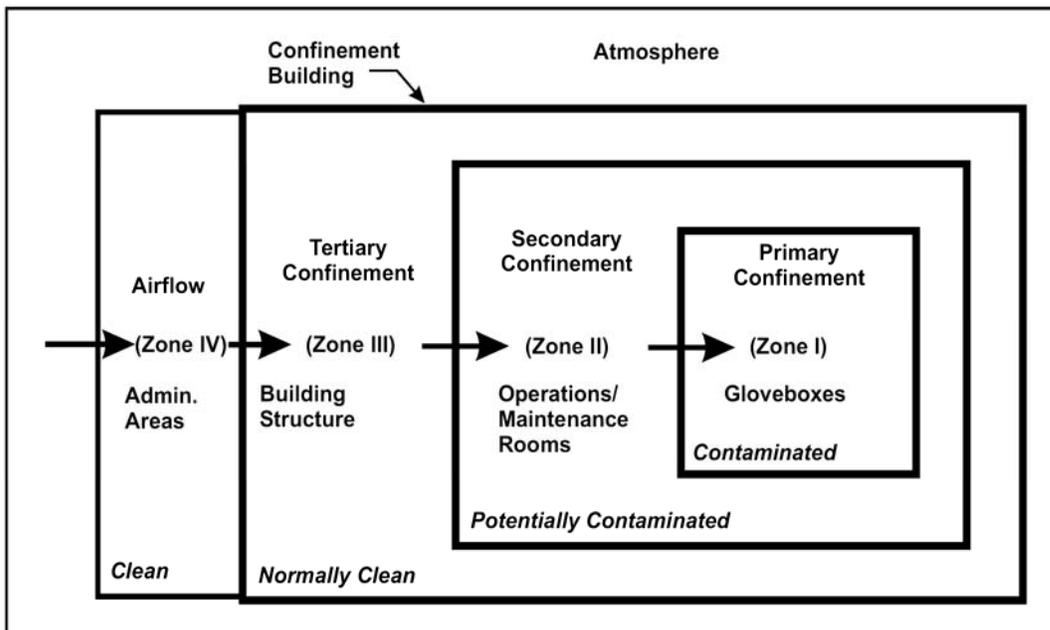


Figure 1. Typical Process Facility Confinement Zones

The primary confinement zone comprises those areas where high levels of airborne contamination are anticipated during normal operations. Facility personnel do not normally enter primary confinement zones. When entry is necessary, it is done under tightly controlled conditions. This zone includes the interior of a hot cell, glovebox, piping, vessels, tanks, exhaust ductwork, primary confinement high energy particulate air (HEPA) filter plenums, or other confinement for handling highly radiotoxic material. Confinement features must prevent the spread of radioactive material within the building under both normal operating and upset conditions up to and including the design basis accident for the facility. Complete isolation (physical separation) from neighboring facilities, laboratories, shop areas, and operating areas is necessary. Unavoidable breaches in the primary confinement barrier must be compensated for by an adequate inflow of air or safe collection of the spilled material. The exhaust system must be sized to ensure an adequate inflow of air in the event of a credible confinement breach. An air exhaust system that is independent of those serving surrounding areas is required. High-efficiency filters, preferably HEPA type, are typically required in air inlets, and two independently testable stages of HEPA filters are required in the exhaust. The exact number of testable stages is determined by safety analysis.

The secondary confinement zone comprises those areas where airborne contamination could be generated during normal operations or as a result of a breach of a primary confinement barrier. This zone consists of the walls, floors, ceilings and associated ventilation systems that confine any potential release of hazardous materials from primary confinement. Related areas include glovebox operating areas, hot cell service or maintenance areas, and the ventilation system servicing the operating areas. Pressure differentials must be available to produce inward airflow into the primary confinement should a breach occur. Penetrations of the secondary confinement barrier typically require positive seals to prevent migration of contamination out of the secondary confinement zone. Air locks or a personnel clothing-change facility are recommended at the entrance to the zone. Restricted access areas are generally included in the secondary confinement zone.

The tertiary confinement zone comprises those areas where airborne contamination is not expected during normal facility operations. This zone consists of the walls, floors, ceilings, and associated exhaust system of the process facility. It is the final barrier against release of hazardous material to the environment. This level of confinement should never become contaminated under normal operating conditions. The secondary and tertiary boundaries may exist in common, as in a single-structure envelope.

**b) Describe the design principles and performance of air cleaners and explain the roles they play in minimizing worker exposure to chemicals and biological hazards.**

Air cleaners are typically categorized as one of two types. The first type is used to remove industrial type pollutants — dusts, mists, fumes, vapors, and biologicals — from the immediate and surrounding areas. Devices such as precipitators, centrifuges, scrubbers, fabric, and HEPA filters are commonly used in these applications. The second type of air cleaner is used in recirculating HVAC systems as in-line devices to reduce low-level or toxic contaminants. These include fiber filters or electrostatic precipitators.

DOE-HDBK-1169-2003, DOE Handbook: Nuclear Air Cleaning, states that the complexity of the air cleaning system needed to provide satisfactory working conditions for personnel and to prevent the release of radioactive or toxic substances to the atmosphere depends on the following factors:

- The nature of the contaminants to be removed (e.g., radioactivity, toxicity, corrosivity, particle size and size distribution, particle shape, and viscosity)
- Heat (e.g., process heat, fire)
- Moisture (e.g., sensible humidity process vapors, water introduced from testing)
- Radiation (e.g., personnel exposure and material suitability considerations)
- Other environmental conditions to be controlled
- Upset or accident, or accident hazard considerations

In designing an air cleaning system, development of the environmental operating conditions must be the first step. Before appropriate individual system components can be environmentally qualified, the designer must consider all environmental parameters on an integrated basis.

The types of contaminants in the gas stream must be identified. All of the contaminants, both particulate and gaseous, including concentration levels and particle sizes, must be evaluated to properly design and size the system. The presence of other particulates, gases, and chemicals must be clearly determined. The presence of volatile organic chemicals (VOCs), entrained water, and acids will affect the performance of various system components and must be addressed, if they are present, in the design of the system and its components.

Pressure is one of a number of variables that needs to be evaluated in the course of designing the air cleaning system because it can significantly affect the fan power requirements and the airflow rate. The pressure of the airstream can be impacted significantly by the change from the normal operating pressure to the accident or upset air pressure.

Moisture is an important consideration in air cleaning system design. Moisture in the air may affect the performance of the air cleaning system by binding the particulate filters and/or blocking pores and fissures in the activated charcoal.

Although some air cleaning system components are prequalified to operate in a given temperature range, the air cleaning system designer must verify all components of the system will function at the maximum and minimum temperature conditions for the specified application. If the temperature range of the specific application exceeds the components' design qualification temperature, requalification is necessary to meet the operational and design life requirements of the system.

Many radiochemical operations generate acid or caustic fumes that can damage or destroy filters, system components, and construction materials. Some products of radiochemical operations can produce shocksensitive salts (e.g., perchloric acid salts and ammonium nitrate) that must be specifically considered in the design and operation. The air cleaning system designer must select components and materials of construction suitable for the corrosive environment to ensure high levels of system performance and reliability.

Vibration and pulsation can be produced in an air or gas cleaning installation by turbulence generated in poorly designed ducts, transitions, dampers, and fan inlets, and by improperly

installed or balanced fans and motors. Excessive vibration or pulsation can result in eventual mechanical damage to system components when accelerative forces (e.g., from an earthquake or tornado) coincide with the resonant frequencies of those components. Important factors in the prevention of excessive vibration and noise include planning at the initial building layout stage and space allocation to ensure that adequate space is provided for good aerodynamic design of ductwork and fan connections.

Emergency electrical power is required when specified by facility safety documentation. Emergency power has specific requirements and may not be required for all systems. Standby electrical power is used for many safety air cleaning systems not classified as safety class. Standby power is required for safety-significant air cleaning systems. The amount of emergency power required for fans, dampers, valves, controls, and electrical heaters to control the relative humidity of the effluent airstream (as dictated by the facility design requirements) must be accounted for during accident or upset conditions. Close coordination between the system designers of both the air cleaning and electrical systems is required to ensure this is done as there is a set amount of emergency power available.

Workroom ventilation rates are based primarily on cooling requirements, the potential combustion hazard, and the potential inhalation hazard of substances that are present in or could be released to the workroom.

Concentrations of radioactive gases and aerosols in the air of occupied and occasionally occupied areas should not exceed the derived air concentrations established for occupationally exposed persons under normal or abnormal operating conditions, and releases to the atmosphere must not exceed permissible limits for nonoccupationally exposed persons. Because radioactive gases and aerosols might be released accidentally in the event of an equipment failure, a spill, or a system upset, the ventilation and air cleaning facilities must be designed to maintain airborne radioactive material within prescribed limits during normal operations. In addition, the ventilation and air cleaning facilities must perform in accordance with expectations established during the evaluation of potential accident conditions.

**c) Discuss the interpretation and applicability of regulations and standards governing ventilation systems.**

Legal requirements for ventilation systems are addressed in 29 CFR 1910.94. However, these requirements are antiquated and limited to a few industrial situations, and are not generally useful.

Recognized consensus standards play a key role in ventilation practices. Standards published by ANSI, ASHRAE, the American Industrial Hygiene Association (AIHA), and ACGIH are at the forefront of these documents. Of significance in the control of indoor air quality is ANSI/ASHRAE 62-1989, Ventilation for Acceptable Air Quality.

DOE-HDBK-1169-2003, DOE Handbook: Nuclear Air Cleaning, chapter 2, System Considerations, identifies numerous regulations and standards applicable to ventilation systems. For example, the design of workroom ventilation systems should be consistent with the requirements of 10 CFR 835, Occupational Radiation Protection, Subpart K, Design and Control, which establishes DOE's design objectives for workplace radiological control.

Furthermore, effluent releases from ventilation systems must be in accordance with DOE directives and relevant regulatory requirements (e.g., DOE Order 5400.5, Radiation Protection of the Public and the Environment, and 40 CFR 61, subpart H, National Emission Standards for Air Pollution).

Also, for interpretations of 10 CFR 851 and technical safety issues, DOE established the DOE Response Line at 1-800-292-8061. The DOE OSH Standards Interpretations Response Line clarifies the requirements contained in the OSH standards to promote consistent application of those standards throughout DOE. The toll-free line, an extension of the DOE Interpretations Guide to OSH Standards, provides timely processing of DOE and DOE contractor requests for clarification of OSH standards. The 800-line is staffed by OSH experienced personnel who have access to a database that contains a wealth of information on OSH standards. The information database used by the 800-line staff is continually updated. In addition, new interpretations are included in the quarterly updates, which are sent to registered users of the DOE Interpretations Guide to OSH Standards.

**d) Describe the following environmental factors:**

- **Atmospheric dispersion modeling**
- **Control of hypo- and hyper-baric conditions**
- **Psychrometry**

*Atmospheric Dispersion Modeling*

Atmospheric dispersion modeling refers to the process of simulating an environmental release and estimating the resultant impact on a geographic area as affected by a number of variables, including the characteristics of the source, local weather, topography, and toxicity. Most frequently this is achieved by using computer programs and entering the available data.

*Control of Hypo- and Hyper-Baric Conditions*

Hypo- and hyper-baric environments are sometimes advantageous for biomedical, biophysical, and physical chemistry research and therapy. The use of pressurized or depressurized chambers presents unusual conditions and challenges for the industrial hygienist, including issues related to gas solubility, vapor pressures, and density properties, which may increase the dose to employees, affect engineering controls, and influence sampling results.

*Psychrometry*

Psychrometry refers to the measurement of the relative humidity of air using wet-bulb and dry-bulb thermometers.

**e) Discuss the principles of isolation and enclosure as they relate to the following:**

- **Noise**
- **Air contaminants**
- **Radiation**

Isolation and enclosure are two important controls available to the industrial hygienist. Isolation means restricting access to an operation so that only a few designated employees are potentially exposed. Enclosure means placing the operation in a physical enclosure (e.g., a glove box) to prevent release of contaminants. Isolation is intended to prevent unnecessary

exposure to the public or workers not performing the local operation; enclosure, on the other hand, is intended to contain the agent or contaminant and prevent exposure to all workers. Isolation can be used when few workers are involved or when operations are difficult to accomplish within enclosures, e.g., as is often the case with hazardous wastes. Sometimes isolation in conjunction with enclosure can be very effective. For example, this is the case for certain operations involving highly toxic beryllium powder that cannot be accomplished in a total enclosure. Noise can be reduced using both principles depending on the source and the conditions. The isolating barrier around a noisy machine and operations will prevent unnecessary noise to the rest of the workplace and public. Enclosures around an especially noisy piece of machinery would reduce exposure even for the workers in the immediate proximity of the machine.

**f) Discuss the economic feasibility parameters of the following:**

- **Engineering controls, including process change and substitution**
- **Administrative controls**
- **Personnel protective equipment**

Although not really an engineering control, material substitution, i.e., the replacement of a hazardous material with another material having less hazardous qualities, is considered comparable in effectiveness. Material substitution may be considered especially appropriate for the control of exposure to carcinogenic agents.

Engineering controls are preferred because they are considered more permanent and do not rely upon the performance of the individual worker. However, these controls usually require a high initial investment in planning and implementation. Payback is in the form of reduced exposure, increased productivity, and enhanced worker health. Administrative controls are usually less costly, but are less dependable. They have a high degree of risk because of human error or procedural noncompliance. PPE is an important part of the overall safety and health program; however, it should not be relied upon exclusively. PPE is less costly than engineering controls, but many variables can reduce the actual protection afforded, and using PPE creates some new risks. The use of PPE results in high administrative costs, and PPE may also be relatively costly as in the case of hazard-specific gloves or respirators and replacement of contaminated or worn out PPE.

**g) Discuss how engineering controls may be implemented for each of the following:**

- **Non-ionizing radiation**
- **Ionizing radiation**
- **Noise**
- **Vibration**
- **Repetitive motions**
- **Lifting heavy objects**
- **Biological hazards**
- **Heat and humidity**
- **Cold stress**

*Non-Ionizing Radiation*

Non-ionizing radiation requires engineering controls that are highly dependent on use and conditions. Locking mechanisms to control access and use, limitation of range of lateral movement of the source, distance, shielding, and enclosure can all be used for engineering controls.

### *Ionizing Radiation*

Engineering controls for ionizing radiation are primarily a function of shielding. Appropriate shielding thickness, material, density, and configuration specific to alpha, beta, gamma (and x-ray), and neutron radiation are dependent on the source material and its energy. Other engineering controls including distance and the use of locking devices may be appropriate to the application.

### *Noise and Vibration*

Noise and vibration control can be effectively achieved by several design techniques. These include source control (reducing speed, dampening, bracing, etc.), enclosure, isolation, insulation, shielding, distance, and baffling. Each of these or various combinations can be used depending on the particular situation and the economic support for the project.

### *Repetitive Motions*

Engineering controls such as work station redesign, adjustable fixtures, or tool redesign, and administrative controls such as job rotation, work pacing, or work breaks are methods to reduce repetitive motion injuries.

### *Lifting Heavy Objects*

The use of engineering controls to preplan delivery and design of storage areas and work areas can minimize manual lifting and carrying.

### *Biological Hazards*

Engineering controls are varied to include biological safety cabinets, HEPA filters, sinks with foot-actuated taps, easy-to-clean surfaces, HVAC systems that protect workers and the environment from contaminated airflow, appliances that minimize aerosol production, and security controls. Some of these engineering controls are discussed below.

**Facility Design.** Examples of facility design controls are HEPA filters, interlocks, and negative airflow units. Recommended facility design controls depend on the risk of transmission of specific biohazardous agents.

**Safety Equipment.** Safety equipment includes mechanical aids (e.g., tongs and tweezers), dead air boxes, sharps containers, laboratory-type fume hoods, biological safety cabinets (also referred to as “biosafety cabinets”), shielding, safety centrifuge cups, and special shipping containers for transporting biological materials and animals. Biological safety cabinets are discussed in detail below.

**Biological Safety Cabinets.** Ventilation control of infectious agents or other biologically derived molecules is usually achieved by performing the operation using a biological safety cabinet. There are currently three primary classes of biological safety cabinets (Classes I, II, and III). Each class is distinguished by its design and its containment and cleanliness capability. The selection of an appropriate biological safety cabinet for a given operation shall be approved by the area environment, safety, and health (ES&H) team industrial hygienist based on the specifics of the operation and an evaluation of the biosafety level (BSL) classification (i.e., BSL 1, 2, 3).

Class I cabinets are similar to a conventional laboratory hood with an open-face and negative-pressure design.

Class II cabinets, commonly referred to as laminar-flow biological safety cabinets, are effective in protecting operators from research materials as well as protecting research materials from external contamination. The class II cabinet design utilizes a HEPA filter in an overhead diffuser to reduce contamination in the cabinet. Air flows down toward the work surface and through two separate grills (front and rear). An air barrier for the protection of operators is created by the airflow into the cabinet from the room and the down flow air through the front grill. There are five basic types of class II cabinets: Types A, B1, B2, B3, and C. Each cabinet type has differences that include

- proportion of air recirculated into the work area
- airflow velocities into the work opening and down toward the work surface
- manner of exhaust air discharge
- air plenum pressure relative to the room

Class III cabinets are hermetically sealed enclosures for the handling of extremely hazardous materials at biosafety level 4.

### *Heat and Humidity*

Many industries have attempted to reduce the hazards of heat stress by introducing engineering controls, training workers in the recognition and prevention of heat stress, and implementing work-rest cycles. Heat stress depends, in part, on the amount of heat the worker's body produces while a job is being performed. The amount of heat produced during hard, steady work is much higher than that produced during intermittent or light work. Therefore, one way of reducing the potential for heat stress is to make the job easier or to lessen its duration by providing adequate rest time. Mechanization of work procedures can often make it possible to isolate workers from the heat sources (perhaps in an air-conditioned booth) and increase overall productivity by decreasing the time needed for rest. Another approach to reducing the level of heat stress is the use of engineering controls that include ventilation and heat shielding.

### *Cold Stress*

Radiant heaters may be used to warm workers. Shielding work areas from drafts or wind will reduce wind chill. Insulating material should be used on equipment handles, especially metal handles, when temperatures drop below 30° F.

## **h) Describe the control features (e.g., backflow prevention) of potable water supply distribution.**

The term backflow means any unwanted flow of used or non-potable water or substances from any domestic, industrial, or institutional piping system into the pure, potable water distribution system. The direction of flow under these conditions is in the reverse direction from that intended by the system, and is normally assumed by the owner of the system. Backflow may be caused by numerous specific conditions, but basically, the reverse pressure gradient may be due to either a loss of pressure in the supply main called backsiphonage, or by the flow from a customer's pressurized system through an unprotected cross-connection, which is called backpressure. Thus the term backflow covers both a backsiphonage condition and a backpressure condition. A reversal of flow in a distribution main — or in the customer's system — can be created by any change of system pressure wherein the pressure at the supply point becomes lower than the pressure at the point of use. When this happens in an unprotected situation, the water at the point of use will be siphoned back into the system, thus

potentially polluting or contaminating the remainder of the customer's system. It is also possible that the contaminated or polluted water could continue to backflow into the public distribution system. The point at which it is possible for a non-potable substance to come in contact with the potable drinking water system is called a cross-connection. To prevent backflow from occurring at the point of a cross-connection, a backflow prevention assembly must be installed. However, it is important that the backflow prevention assembly match the particular hydraulic conditions at that location and be suitable to protect against the degree of hazard present.

Some types of backflow preventers are described below.

#### *Air Gap*

An air gap is a physical separation of the supply pipe by at least two pipe diameters (never less than one inch) vertically above the overflow rim of the receiving vessel. In this case, line pressure is lost. Therefore, a booster pump is usually needed downstream, unless the flow of the water by gravity is sufficient for the water use. With an air gap, there is no direct connection between the supply main and the equipment. An air gap may be used to protect against a contaminant or a pollutant, and will protect against both backsiphonage and backpressure. An air gap is the only acceptable means of protecting against lethal hazards.

#### *Atmospheric Vacuum Breaker (AVB)*

The AVB is always placed downstream from all shut-off valves. Its air inlet valve closes when the water flows in the normal direction. But, as water ceases to flow, the air inlet valve opens, thus interrupting the possible backsiphonage effect. If piping or a hose is attached to this assembly and run to a point of higher elevation, the backpressure will keep the air inlet valve closed because of the pressure created by the elevation of water. Hence, it would not provide the intended protection. Therefore, this type of assembly must always be installed at least six inches above all downstream piping and outlets. Additionally, this assembly may not have shut-off valves or obstructions downstream. A shut-off valve would keep the assembly under pressure and allow the air inlet valve (or float check) to seal against the air inlet port, thus causing the assembly to act as an elbow and not a backflow preventer. The AVB may not be under continuous pressure for this same reason. An AVB must not be used for more than twelve out of any twenty-four hours. It may be used to protect against either a pollutant or a contaminant, but may only be used to protect against a backsiphonage condition.

#### *Pressure Vacuum Breaker (PVB)*

The PVB includes a check valve which is designed to close with the aid of a spring when flow stops. It also has an air inlet valve which is designed to open when the internal pressure is one psi above atmospheric pressure so that no non-potable liquid may be siphoned back into the potable water system. Being spring loaded, it does not rely upon gravity as does the atmospheric vacuum breaker. This assembly includes resilient seated shut-off valves and testcocks. The PVB must be installed at least twelve inches above all downstream piping and outlets. The PVB may be used to protect against a pollutant or contaminant, but may only be used to protect against backsiphonage. It is not acceptable protection against backpressure.

#### *Double Check Valve Assembly (DC)*

The DC consists of two internally loaded, independently operating check valves together with tightly closing resilient seated shut-off valves upstream and downstream of the check

valves. Additionally, there are resilient seated testcocks for testing of the assembly. The DC may be used to protect against a pollutant only. However, this assembly is suitable for protection against either backsiphonage or backpressure.

*Reduced-Pressure Principle Assembly (RP)*

This assembly consists of two internally loaded, independently operating check valves and a mechanically independent, hydraulically dependent relief valve located between the check valves. This relief valve is designed to maintain a zone of reduced pressure between the two check valves at all times. The RP also contains tightly closing, resilient seated shut-off valves upstream and downstream of the check valves along with resilient seated testcocks. This assembly is used for the protection of the potable water supply from either pollutants or contaminants, and may be used to protect against either backsiphonage or backpressure.

*Reduced-Pressure Principle Detector Assembly (RPDA)*

The RPDA is very similar to the double check detector assembly, except that the RPDA is designed for situations requiring the protection of a reduced-pressure principle assembly and detection of unauthorized use of water or leaks. As with the DC, the bypass meter must register accurately at low flows. This assembly is normally used on fire lines which may contain contaminants, such as anti-freeze additives or foamite.

**i) Discuss the importance of engineering controls as they relate to sanitation of food service facilities and equipment.**

Food preparation, serving, and storage should comply with the U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration, Food Code, 1997. Each food facility or multiple food facilities permitted within the same site and under the same management should have an owner or worker who has successfully passed an approved and accredited food safety certification examination. Hand-washing signs shall be posted at hand-washing stations and in restrooms. Where applicable, all food-service equipment should be certified by the National Sanitation Foundation. The Hazards Control Department conducts semiannual cafeteria inspections to ensure that the food-service management contractor is complying with this code. To prevent the growth of harmful bacteria, perishable food and beverages are stored below 5°C (41°F), and foods are heated above 60°C (140°F) during the serving period.

Receptacles constructed of smooth, corrosion-resistant, easily cleanable, or disposable materials with solid, tight-fitting covers shall be used for the disposal of food. They shall be emptied at least once each working day, unless unused, and shall be kept in a clean and sanitary condition.

All vending machines, where applicable, should be certified by the National Automatic Merchandising Association. Food should be stored in refrigerators and heated in microwave ovens designated for that purpose only. Refrigerators and microwave ovens must be maintained in a clean and sanitary condition. Food should not be eaten or stored in areas where toxic or biological materials are handled or stored. Suspected or alleged cases of food poisoning must be reported to the Hazards Control Department for immediate investigation.

**13. Industrial hygiene personnel shall demonstrate a working-level knowledge of the design of administrative measures to control exposure or protect employees.**

**a) Describe how the following administrative measures may contribute to exposure control:**

- **Procedural modifications (work practices)**
- **Operations and scheduling**
- **Standard operating procedures**
- **Reduction of exposure time**
- **Work/rest regimen for heat stress control**
- **Personal hygiene practices**
- **Promoting and implementing good housekeeping practices**

Administrative controls are management-dictated work practices and policies to reduce or prevent exposures to risk factors. Administrative control strategies include (1) changes in job rules and procedures such as scheduling more rest breaks, (2) rotating workers through jobs that are physically tiring, and (3) training workers to recognize risk factors and teaching them techniques for reducing stress and strain while performing their work tasks.

Although engineering controls are preferred, administrative controls can be helpful as temporary measures until engineering controls can be implemented, or when engineering controls are not technically feasible. Since administrative controls do not eliminate hazards, management must ensure that the practices and policies are followed. Common examples of administrative control strategies for reducing risk are as follows:

- Reducing shift length or curtailing amount of overtime
- Rotating workers through several jobs with different physical demands to reduce the stress on limbs and body regions
- Scheduling more breaks to allow for rest and recovery
- Broadening or varying job content to offset certain risk factors (e.g., repetitive motions, static and awkward postures)
- Adjusting the work pace to relieve repetitive motion risks and give the worker more control of the work process
- Providing training on the recognition of risk factors and instruction on work practices that can ease the task demands or burden

DOE/EH-0256T, DOE Radiological Control Manual, states that heat stress may result from working in areas of high heat, humidity, and radiant heat; working in protective clothing; and using respirators, particularly where other protective equipment is required. Heat stress has occurred at ambient temperatures less than 70°F when multiple sets of anticontamination clothing or plastic suits were in use or strenuous work was required. The planning stages for work in hot environments should address heat stress controls. Recommended work time limits and use of body cooling devices should be considered to reduce heat stress. Job supervisors should inform their personnel of heat stress precautions prior to work on job assignments in hot environments. If a person begins to feel symptoms of heat illness, the person should immediately notify the nearest co-worker, exit the area, remove personal protective equipment, notify the supervisor, and rest in a cool area. In such cases, medical assistance should be provided.

DOE-STD-6005-2001, Industrial Hygiene Practices, states that appropriate personal hygiene and work practices should be implemented, including the use of protective clothing, shower facilities, and change rooms; a prohibition on eating, drinking, and smoking in regulated areas; and the use of non-permeable work surfaces, as feasible.

The concepts of all chapters of DOE 5480.19, Conduct of Operations Requirements for DOE Facilities, apply to the conduct of exposure control. Cleanliness and good housekeeping are essential. A good program cannot exist in a sloppy, dirty workplace. Cleaning up after operations should be automatic for each person. It is not reasonable to expect exposure control to be separated from the work environment; they go together. The pre-job briefing should include provisions for housekeeping and final cleanup.

Additionally, paragraph 4.2.7 of DOE G 440.1-7A, Implementation Guide for Use with 10 CFR 850, Chronic Beryllium Disease Prevention Program, provides guidance on hygiene and housekeeping practices that limit exposure control. Specifically, employers should develop procedures that: establish specific acceptable areas for eating, drinking, smoking, and applying cosmetics; designate separate facilities free of beryllium where beryllium workers can change into and out of personal clothing and into clean protective clothing, and where they can store clothing and equipment; provide handwashing and shower facilities for beryllium workers who work in regulated areas; ensure workers are not exposed to beryllium at or above the action level while eating in lunchroom facilities; and provide change rooms or areas, shower and handwashing facilities, and lunchroom facilities that meet the sanitation requirements of 29 CFR 1910.141.

**b) Discuss how the following may be needed to implement effective exposure control:**

- **Medical surveillance of exposed employees**
- **Medical removal protection for sensitive workers**
- **Genetic screening**
- **Preplacement exams and periodic medical screening**

*Medical Surveillance of Exposed Employees*

If employees are subjected to specific types of hazards in their work environments, medical surveillance testing is provided to ensure the protection of their health. Employees that may require medical surveillance include workers exposed to asbestos, lead, noise, lasers, hazardous waste, or other chemical, physical, and biological hazards. The tests are conducted with state of the art equipment and highly trained medical staff. All test results are made available to each employee and maintained within their health record in the department.

*Medical Removal Protection for Sensitive Workers*

Medical removal protection is the required removal of an employee from work that deals with exposure, with full salary and benefits, until the physician authorizes return to the usual work.

*Genetic Screening*

The advent of a genetic screening test is viewed by some individuals associated with employee exposure as the proverbial light at the end of the tunnel, a way to eventually eradicate exposures from the workplace. Martin Powers, former vice president of Brush-Wellman, Inc., and now executive director of the Beryllium Industry Scientific Advisory

Committee, says “For years we’ve been searching for this, trying to find people who were susceptible so we could, in effect, protect them or take them out of the industry. If we could take that small percentage and screen them out, we could eliminate disease, eliminate the marketing problem that comes with having a toxic material, and we could begin doing away with some of those very expensive control measures.” Genetic screening, however, raises ethical concerns about workplace discrimination such as who will make these decisions and how such decisions will affect a worker’s ability to obtain health insurance.

#### *Preplacement Exams and Periodic Medical Screening*

Preplacement exams and periodic medical screening are in essence only two components of a comprehensive medical surveillance program. The fundamental purpose of preplacement exams and screening is early diagnosis and treatment of the individual, and thus has a clinical focus. The fundamental purpose of surveillance is to detect and eliminate underlying risk factors to employees, such as hazards or exposures, and thus has a prevention focus. Both can contribute significantly to the success of worksite health and safety programs.

#### **14. Industrial hygiene personnel shall demonstrate a working-level knowledge of the methods used to communicate control action recommendations.**

##### **a) Describe how to prepare a technical report.**

Traditionally, industrial hygienists communicate recommendations through a formal written report. By convention, the reports may contain an executive summary, a description of methods used, observations and findings, and recommendations. References and appendices containing sampling data should also be included. The report should describe the basis for exposure determinations and clearly describe items for corrective action. In some cases, recommended milestones or implementation plans might also be included, although in most cases these could be negotiated later.

These formal reports provide necessary documentation, but usually are not the most effective method of communicating outside of the industrial hygiene community. As a consequence, the recommendations will usually require extensive follow-up interaction between industrial hygiene, line engineering, maintenance workers, etc.

Formal reports should be written with the audience and mission in mind. The report should address the issues that created the need for survey or assessment, and be written in a manner that is easy to read and understand. To encourage the reader to begin reading the report, it should be visibly short. Individual narrative sections and paragraphs should also be brief, and if comprehension or follow-up action is required, the key ideas should be highlighted or bulleted. The information that by tradition is important to industrial hygienists should be retained and retrievable, but should not normally be included with the report.

##### **b) Discuss major record keeping requirements.**

DOE and contractor line management must ensure written hazard assessment and control records are developed and maintained for all potentially hazardous work operations and activities. This includes assessments where no significant worker exposures are expected or determined. This latter case is important since new exposure effects may be identified, and

retrospective health concerns can only be addressed by documented assessment records. Consequently, assessments for operations determined to have no significant exposure potential should be appropriately documented for historical purposes following the standard protocol for all surveys. Because of the significance of the information contained in these records, it is crucial that the persons assigned this task be appropriately trained. Critical records should be reviewed and approved by the senior industrial hygienist or designate. All such record keeping must comply with the requirements of 29 CFR 1910.1020, any applicable DOE directives, and/or applicable OSHA hazard-specific or expanded health standards, as well as any applicable requirements imposed by the Americans with Disabilities Act, the Privacy Act of 1974, the Freedom of Information Act, or any other applicable law.

**c) Discuss how to describe and recommend preferred control measures (including the desired hierarchy of controls), alternatives, and/or interim control measures.**

An efficient means of communicating requirements for workplace controls, and one that is increasingly used for projects and remediation, is the completion of standardized work permits. The advantage of permits is that they have little or no narrative, but instead contain spaces or blocks for each category of action that may be required, e.g., PPE, engineering controls, training, and medical certification. They are quickly and easily understood, and are available in the work place where they are needed. They also provide very fine control over the work place because they can be revised for each phase of a project, as opposed to relying upon a necessarily more general annual survey of an affected department or work center. The principal drawback to a permitting system is that all of its documentary support is elsewhere and must be accessed separately. This separation of information poses a challenge to auditors and the future defensibility of decisions unless permitting recommendations are regularly collated and audited with respect to program goals and compliance.

DOE and OSHA require that control measures be prioritized in accordance with the following hierarchy of controls.

*Engineering Controls*

Following are engineering controls that limit worker exposures:

- Change to a less hazardous process or substitute a less hazardous material or piece of equipment.
- Isolate or enclose the process or operation to prevent worker exposure to hazardous agents.
- Use mechanical ventilation or other engineered controls to prevent or reduce worker exposure to hazardous agents.

*Work Practice and Administrative Controls*

Although administrative controls can minimize worker exposures, they are often unreliable and difficult to implement. For this reason, engineering controls are preferable to administrative and work practice controls. However, following are work practice and administrative controls that limit worker exposures:

- Develop work practices and procedures (e.g., standard operating procedures, limited access, and showering and changing of clothes) to reduce/minimize hazardous exposures.
- Maintain administrative controls (e.g., schedule hazardous activities during periods when few employees are present).

### *Personal Protective Equipment*

Use of PPE is generally considered the last line of defense because it places the burden of hazard control directly on the worker. Its use should be limited to

- the period necessary to install, evaluate, or repair engineering controls;
- work situations such as maintenance and repair activities and hazardous waste and emergency response operations in which engineering controls are not feasible;
- work situations in which engineering controls and supplemental work practice controls are not sufficient to reduce exposures to, or below, occupational exposure limits;
- emergency or escape situations.

#### **d) Discuss development of a schedule for the implementation of control measures.**

Where applicable, a detailed schedule (that also addresses regular progress reports) for the implementation of any required health hazard prevention and control measures, including any long-term abatement and interim control measures, must be developed.

#### **e) Discuss how the safety aspects of a required task, and the imposition of controls and their related costs necessary for safety during the task, may affect management's prioritization of work or the completion of work that is affected by that task.**

There are a wide range of results that are undesirable to management and could be termed "high risk," i.e., they have the potential for death or serious injury. These risks could result in high compensation costs or in extremely adverse public relations or political consequences. The determination of what is high risk generally involves relating a plausibly adverse effect with the likelihood that the adverse effect will occur, the product of which is its risk. The more undesirable the effect and the more likely the outcome, the higher the activity risk.

Once high-risk activities are classified as such, the question becomes one of determining in what order to address them. In an organization with unlimited resources (money, personnel, time, confidence of the public and their senior managers), all could be tackled at once or as one chose. Realistically, however, resources are limited and it is upper management, with advice from technical experts, who must determine priorities. Their decisions take into account, in addition to risk, a wide range of considerations such as current and projected budget, future plans for the site and operations, current operational capabilities, politics, and liability. The more limited the resources and the higher the risk, the more difficult the decision making becomes.

In attempting to prioritize the control of risk, one of the considerations must be cost. An industrial complex may include many relatively high-risk activities which are of short or continuing duration, and which may expose many people or only a few. Available controls may be complete or partial, temporary or permanent, expensive in the short term and inexpensive in the long term, or vice versa. Achieving sufficient and cost-effective industrial hygiene controls across a site may require knowledge of all of these factors. The industrial hygienist helps to evaluate the costs and benefits of various options to control risks, and presents this information in a format that is useful to its decision makers.

**15. Industrial hygiene personnel shall demonstrate a working-level knowledge of industrial hygiene programs.**

**a) Describe the major components of sound industrial hygiene programs.**

A sound industrial hygiene program requires workplace surveillance. There is no minimum amount of surveillance required; rather, the frequency of surveillance should be according to some plan or schedule that is based upon the level of hazard present in the different work areas.

The surveillance should serve as the basis for personal monitoring of operations when it is believed that there is the potential for significant exposure (i.e., at about the action level where medical surveillance or protective action should be considered). Sampling should be performed with appropriate equipment and using defensible methods. Any laboratory analysis should be performed by an organization accredited to perform such analysis. Sampling and analysis should be performed in accordance with standard operating procedures to ensure the consistency and defensibility of the data generated.

When surveillance identifies hazards that must be controlled, recommendations should be provided in a useful format to the action line or staff organization. Assistance should be provided to these organizations in achieving the desired results, and the completion of required action should be monitored.

Retention of important documentation is critical. Any documentation relating to past technical decision making should be retained, and documentation that may be useful in present or future decision making should be easily retrievable.

DOE is convinced that management commitment and employee involvement are essential to a successful industrial hygiene program. Management commitment should be demonstrated by action. Employee involvement in the identification and control of the hazards of their jobs may result in dramatic improvement in worker protection.

**b) Discuss management of industrial hygiene resources.**

Refer to competency “14-e” for a discussion regarding the management of industrial hygiene resources.

**c) Discuss the impact of legal requirements.**

With the passage of the Occupational Safety and Health Act and the establishment of the Environmental Protection Agency (EPA) as foundations, industrial hygienists have become recognized as champions for workplace health and safety and, increasingly, champions for environmental health.

Today, we recognize that OSHA struggles to be a driving force for improving worker health. The importance of TLVs has come to the forefront due to the difficulty that regulatory agencies have in developing reasonable standards within realistic time frames. Changes in technology, business practices, market forces, and globalization have become the real drivers of worker health and safety.

**d) Discuss the implications of noncompliance.**

Noncompliance with industrial hygiene regulations can lead to massive fines and even jail time for environmental personnel. More importantly, noncompliance can injure people and the environment.

**e) Discuss how industrial hygiene programs relate to other environmental, safety, and health programs, and to the broad goals of protecting not only the worker, but also the public and the environment.**

Key DOE-wide initiatives, such as Integrated Safety Management, the Voluntary Protection Program, and Enhanced Work Planning, aggressively promote the principles of hazard identification, integration of functions, management commitment, and employee involvement.

**16. Industrial hygiene personnel shall demonstrate a working-level knowledge of professional and ethical issues.**

**a) Discuss the Code of Ethics developed by the American Industrial Hygiene Association (AIHA), the American Conference of Governmental Industrial Hygienists (ACGIH), the American Board of Industrial Hygiene (ABIH), and the American Academy of Industrial Hygiene (AAIH).**

Industrial hygienists are represented by several organizations that promote the profession and demonstrate their technical competence by achieving certification.

Among the professional associations and accrediting organizations, the AIHA and the ABIH have adopted a common code of ethics that requires their members to be factual in what they communicate, to provide service only in areas of competence, to keep confidential and personal business information gained on the job, and to avoid conflicts of interest.

Members are also reminded of the importance of practicing the trade in accordance with recognized scientific principles given its importance in ensuring the lives and health of the employees to be protected.

The ABIH is also the certifying organization. Certification is granted to those who demonstrate education and experience, and who successfully pass a written certification examination.

The ACGIH is a member-based organization and community of professionals that advances worker health and safety through education and the development and dissemination of scientific and technical knowledge.

**b) Discuss the adverse actions section of the ABIH bulletin, current edition.**

Adverse actions include denial of admission to examination, censure and revocation of certification, and provisions for mediation or arbitration.

### *Denial of Admission to Examination*

A person aggrieved by a decision of the ABIH to not admit him or her to an examination for certification, or who has failed to renew his or her certification, may file a written appeal with the Executive Director within three months of the date of notification of the Board's decision.

The individual must present facts to substantiate the appeal. Decisions related to the deadlines for submission of completed applications for examination are not appealable. Upon receipt of an appeal, the Executive Director shall examine all records in the Board's possession that bear upon the decision and appeal, and shall submit copies of the appeal and all pertinent records to each Director. Directors shall vote upon the appeal within 30 days of submission of the ballot by the Executive Director. A Director may vote to grant the appeal, deny the appeal, or to request further information. A two-thirds majority vote of the entire Board shall be necessary to grant the appeal. If a majority of Directors vote to deny the appeal or to request additional information, the results of such vote shall be sent to the applicant. If additional information is requested, the applicant shall have 30 days from date of receipt of notice to submit any additional material. The new material shall be submitted to the Board for a second mail ballot. The second ballot shall consider only the question of appeal. If the Board denies the appeal, the applicant may, at his/her option and expense, appear before the Board at its next regularly scheduled meeting to present evidence and documentation. Upon completion of the presentation, the applicant shall be excused, and the Board shall vote on the appeal. A vote equal to two-thirds of the entire Board shall be necessary to grant the appeal. The applicant shall be notified promptly of the decision of the Board. An oral notification of the decision shall be verified by a written notice.

### *Censure and Revocation of Certification*

The ABIH may recommend the imposition of a sanction in the nature of censure or revocation of certification of a Diplomate for misrepresentation with intent to deceive in the application; fraud in the examination or recertification process; unethical practice of industrial hygiene; activities which discredit the profession of industrial hygiene; or conviction of a felony. The Executive Director shall submit to the Board, along with a recommendation, sufficient evidence for the Directors to determine whether probable cause for censure or revocation of certification exists. A vote of the Directors shall be completed within 30 days of submission of the recommendation to determine whether a hearing on the adverse action shall be held. A positive vote by a majority of the Directors shall be necessary for commencement of such a hearing. If a majority of the Directors do not vote for such a hearing, the result of that vote, together with a statement that the Directors have found no probable cause for actions against the Diplomate, shall be made as a separate entry in the minutes of the ABIH. If a majority of the Directors have determined that probable cause for adverse action exists, within five days of the Board's action, the Diplomate shall be notified of the nature of the charges and of the adverse actions that may be forthcoming. The Diplomate shall further be notified of the following rights: to appear before the Board at a hearing; to be represented by counsel; to submit evidence to refute any or all charges; and to cross-examine all witnesses.

The hearing on the charges shall be held no less than 60 days and no more than 120 days from the date of notification of the Diplomate. The hearing may be held in the city of residence of the Diplomate, or it may be held at any meeting of the ABIH. The Diplomate shall notify the Board not later than 30 days before the date of the hearing whether he/she is to be represented by counsel.

A past chairman or director who is no longer a member of the Board may be selected to preside at the hearing. At least two-thirds of the Directors shall be present. The Board is authorized to retain counsel to prosecute the charges. The hearing shall be in the nature of an administrative hearing. A party is entitled to present its case or defense by oral or documentary evidence, to submit rebuttal evidence, and to conduct such cross-examination as may be required for a full and true disclosure of the facts. However, irrelevant, immaterial, or unduly repetitious evidence shall be excluded. A verbatim record shall be made of the hearing.

Only those members of the Board present at the hearing may vote. A vote equal to two-thirds of the entire Board shall be required for imposition of sanctions. Following the vote to impose sanctions, the Board members present at the hearing shall vote by closed ballot as to whether the Diplomate shall have his/her certification revoked. A two-thirds vote of all Directors present shall be required for revocation. If the required vote is not obtained, then the sanction shall be censure.

The Diplomate shall be notified of the action taken by the Board immediately upon the conclusion of the vote(s) of the Board. The notification shall be made a part of the record of the hearing. The decision(s) shall be published as a separate entry in the minutes of the ABIH.

In the case of a decision to sanction, the Diplomate shall have 30 days in which to file an appeal of the action. Such an appeal shall be in writing and shall state the specific grounds on which the reversal of the decisions is sought. The appeal shall be supported by new evidence or documentation and shall be sent to the Executive Director. The Executive Director shall send copies of the appeal and supporting documents to all Board members no later than 45 days after the date of the decision. A vote of the Board members shall be taken no later than 60 days after the date of the decision. Such vote may be taken by mail. The sanction shall be sustained upon the vote of a majority of the Board. No further appeals shall be taken. If no appeal is made to the Board within the 30-day period allowable for such request, then the original action shall be final.

The Board may publish notice of a final adverse action in the same manner as notices of examination and certification are published.

#### *Provisions for Mediation or Arbitration*

Any dispute between the ABIH and an applicant, examinee, candidate, Diplomate, or any other legal entity dealing with the Board, shall be submitted to mediation (or arbitration) if the grievance procedures have failed to resolve the dispute. If a disputant resorts to legal action prior to submission to mediation (or arbitration), that party shall be liable for all legal costs, including reasonable attorney's fees, arising from such legal action.

#### **c) Discuss legal issues affecting the practice of Industrial Hygiene, including confidentiality of medical data and restraint of trade (antitrust).**

##### *Medical Data*

An employee medical record shall be developed and maintained for each employee for whom medical services are provided. The confidentiality of all employee medical records shall be observed. Employee medical records shall be adequately protected and stored permanently.

### *Restraint of Trade*

The following is a description of the federal antitrust laws applicable to industrial hygiene activities and industrial hygiene organizations such as the AIHA.

There are two antitrust statutes which are of principal concern to individuals and firms who take part in non-profit organizational activities: the Sherman Act and the Federal Trade Commission Act. These laws prohibit contracts, combinations, and conspiracies in restraint of trade. The Supreme Court has said that not every contract or combination in restraint of trade constitutes a violation; only those which unreasonably restrain trade are unlawful. Thus the courts will look at all of the facts and circumstances surrounding the conduct in question to determine whether it unreasonably restrains trade and therefore violates the laws.

Certain kinds of conduct are exclusively presumed to be unreasonable and therefore unlawful. Such conduct, which is considered to be unlawful per se, consists of certain practices which clearly restrain competition and have no other redeeming benefits. Examples of such practices include

- agreements to establish price (price fixing)
- agreements to refuse to deal with third parties (boycotts)
- agreements to allocate markets or limit production
- tie-in sales which require the customer to buy an unwanted item in order to buy the product desired

Associations and other non-profit membership organizations by their very nature present potential antitrust problems. One reason is that in bringing competitors together into an organization, there exists the means by which collusive action can be taken in violation of the antitrust laws. Since both the Sherman and Federal Trade Commission Acts prohibit combinations in restraint of trade, and since a membership organization by its very nature is a combination of competitors, one element of a possible violation is already present. Only the action to restrain trade must occur for there to be a violation.

Another special antitrust problem of a membership organization is that many of its valuable programs deal with subjects sensitive from an antitrust viewpoint: price reporting, product standards, certification, statistics, and customer relations.

Members of AIHA should refrain from any discussion that could provide the basis for an inference that the members agreed to take any action that might restrain trade. An “agreement” among members in antitrust terms is a very broad concept: it may be oral or written, formal or informal, expressed or implied. A “gentleman’s agreement” to “hold the line” on prices is more than sufficient to evidence an unlawful conspiracy to fix prices.

The basic principle to be followed in avoiding antitrust violations in connection with organization activity is to see that no illegal agreements, expressed or implied, are reached or carried out through the organization. Members should also avoid engaging in conduct which may give the appearance of an unlawful agreement.

The following is an excerpt from the AIHA Code of Ethics related to confidentiality:

Keep confidential personal and business information obtained during the exercise of industrial hygiene activities, except when required by law or overriding health and safety considerations.

- Industrial hygienists should report and communicate information which is necessary to protect the health and safety of workers and the community.
- If their professional judgment is overruled under circumstances where the health and lives of people are endangered, industrial hygienists shall notify their employer or client or other such authority, as may be appropriate.
- Industrial hygienists should release confidential personal or business information only with the information owners' express authorization, except when there is a duty to disclose information as required by law or regulation.

**d) Discuss ethical behavior in scientific data gathering and reporting.**

Industrial hygienists shall practice their profession following recognized scientific principles with the realization that the lives, health, and well-being of people may depend upon their professional judgment, and that they are obligated to protect the health and well-being of people.

Industrial hygienists should base their professional opinions, judgments, interpretations of findings, and recommendations upon recognized scientific principles and practices which preserve and protect the health and well-being of people.

Industrial hygienists shall not distort, alter, or hide facts in rendering professional opinions or recommendations.

Industrial hygienists shall not knowingly make statements that misrepresent or omit facts.

**e) Discuss personal ethical behavior, including the following:**

- **Misrepresentation of qualifications and credentials**
- **Conflict of interest**

*Misrepresentation of Qualifications and Credentials*

Industrial hygienists must perform services only in the areas of their competence.

Industrial hygienists should undertake to perform services only when qualified by education, training, or experience in the specific technical fields involved, unless sufficient assistance is provided by qualified associates, consultants, or employees.

Industrial hygienists shall obtain appropriate certifications, registrations, and/or licenses as required by federal, state, and/or local regulatory agencies prior to providing industrial hygiene services, where such credentials are required.

Industrial hygienists shall affix or authorize the use of their seal, stamp, or signature on a document only when the document is prepared by the industrial hygienists or someone under their direction and control.

### *Conflict of Interest*

Industrial hygienists must avoid circumstances where a compromise of professional judgment or conflict of interest may arise.

Industrial hygienists should promptly disclose known or potential conflicts of interest to parties that may be affected.

Industrial hygienists shall not solicit or accept financial or other valuable consideration from any party, directly or indirectly, which is intended to influence professional judgment.

Industrial hygienists shall not offer any substantial gift, or other valuable consideration, in order to secure work.

Industrial hygienists should advise their clients or employer when they initially believe a project to improve industrial hygiene conditions will not be successful.

Industrial hygienists should not accept work that negatively impacts the ability to fulfill existing commitments.

In the event that the AIHA Code of Ethics appears to conflict with another professional code to which industrial hygienists are bound, they will resolve the conflict in the manner that protects the health of affected parties.

## **17. Industrial hygiene personnel shall demonstrate a familiarity-level knowledge of the principle external committees, agencies, and associations relating to the field of industrial hygiene.**

### **a) Describe the purpose and significance of the following:**

- **American Industrial Hygiene Association (AIHA)**
- **American Conference of Governmental Industrial Hygienists (ACGIH)**
- **American Board of Industrial Hygiene (ABIH)**
- **American National Standards Institute (ANSI)**
- **Mine Safety and Health Administration (MSHA)**
- **Occupational Safety and Health Administration (OSHA)**
- **Environmental Protection Agency (EPA)**
- **National Institute of Occupational Safety and Health (NIOSH)**

### *American Industrial Hygiene Association (AIHA)*

AIHA promotes healthy and safe environments by advancing the science, principles, practice, and value of industrial hygiene and occupational and environmental health and safety.

### *American Conference of Governmental Industrial Hygienists (ACGIH)*

The best known of ACGIH's activities is the Threshold Limit Values for Chemical Substances (TLV-CS) Committee, established in 1941. This group was charged with investigating, recommending, and annually reviewing exposure limits for chemical substances. It became a standing committee in 1944. Two years later, the organization adopted its first list of 148 exposure limits, then referred to as Maximum Allowable Concentrations. The term "Threshold Limit Values (TLVs)" was introduced in 1956. The first documentation of the TLVs was published in 1962 and is now in its seventh edition.

Today's list of TLVs includes 642 chemical substances and physical agents, as well as 38 biological exposure indices for selected chemicals.

Two other ACGIH committees have created publications that are recognized as the preeminent professional references in their respective fields: *Industrial Ventilation: A Manual of Recommended Practice*, first published in 1951, and *Air Sampling Instruments (ASI) for Evaluation of Atmospheric Contaminants*, which debuted in 1960. The ventilation manual is now in its 25th edition and the ASI manual is in its 9th edition.

The other ACGIH committees have also published valuable professional reference texts, including the following:

- *Bioaerosols: Assessment and Control* (1999)
- *A Guide for Control of Laser Hazards*, 4th Edition (1990)
- *Particle Size — Selective Sampling for Particulate Air Contaminants* (1999)
- *Biological Monitoring of Exposure to Industrial Chemicals* (1990)

ACGIH offers approximately 400 publication titles, including their well-known Signature Publications. Topics include: industrial hygiene; environment, safety and health; toxicology; medical issues; hazardous materials/waste; workplace controls; indoor air quality; physical agents; ergonomics; computer resources; downloadable TLV and Biological Exposure Indices (BEI) documentation; and professional development. All of ACGIH's publications can be ordered online at <http://acgih.org/store>.

In addition to producing publications, ACGIH has supported numerous educational activities that facilitate the exchange of ideas, information, and techniques. These courses, symposia, and workshops are all vehicles for achieving the ultimate goal of worker health and safety.

Over the years, the topics have included cotton dust exposures, workplace control of carcinogens, industrial hygiene for mining and tunneling, asbestos identification and measurement, and others. The ACGIH also holds seminars and conferences on bloodborne pathogens and sharps injuries, air sampling, industrial ventilation, bioaerosols, mining, occupational exposure databases, mold remediation, and other topics.

ACGIH also has a Professional Learning Center that offers courses, workshops, and symposia.

#### *American Board of Industrial Hygiene (ABIH)*

The ABIH, a not-for-profit corporation, was organized to improve the practice and educational standards of the profession of industrial hygiene.

The activities they are presently engaged in for carrying out this purpose are as follows:

- Offering certification examinations to industrial hygienists with the required educational background and professional industrial hygiene experience
- Acknowledging individuals who successfully complete the examination by issuing a certificate
- Requiring Diplomates to maintain their certification by submitting evidence of continued professional development
- Maintaining records and publishing a roster of certificate holders for the profession and the public

*American National Standards Institute (ANSI)*

ANSI is a private, non-profit organization that administers and coordinates the U.S. voluntary standardization and conformity assessment system.

The institute's mission is to enhance both the global competitiveness of U.S. business and the U.S. quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems and safeguarding their integrity.

*Mine Safety and Health Administration (MSHA)*

The mission of the MSHA is to administer the provisions of the Federal Mine Safety and Health Act of 1977 (Mine Act) and to enforce compliance with mandatory safety and health standards as a means to eliminate fatal accidents, reduce the frequency and severity of nonfatal accidents, minimize health hazards, and promote improved safety and health conditions in the nation's mines.

*Occupational Safety and Health Administration (OSHA)*

OSHA's mission is to assure the safety and health of America's workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health.

OSHA and its state partners have approximately 2,100 inspectors, plus complaint discrimination investigators, engineers, physicians, educators, standards writers, and other technical and support personnel spread over more than 200 offices throughout the country. This staff establishes protective standards, enforces those standards, and reaches out to employers and employees through technical assistance and consultation programs.

*Environmental Protection Agency (EPA)*

The mission of the EPA is to protect human health and the environment. Since 1970, EPA has been working for a cleaner, healthier environment for the American people.

EPA employs 18,000 people across the country. EPA's headquarters offices are in Washington, D.C., and it has 10 regional offices and more than a dozen labs. The staff are highly educated and technically trained; more than half are engineers, scientists, and policy analysts. In addition, a large number of employees are legal, public affairs, financial, information management, and computer specialists. EPA is led by the Administrator, who is appointed by the president of the United States.

*National Institute of Occupational Safety and Health (NIOSH)*

NIOSH is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH is part of the Centers for Disease Control and Prevention (CDC) in the Department of Health and Human Services, and is an agency established to help ensure safe and healthful working conditions for working men and women by providing research, information, education, and training in the field of occupational safety and health. NIOSH provides national and world leadership to prevent work-related illness, injury, disability, and death by gathering information, conducting scientific research, and translating the knowledge gained into products and services. NIOSH's mission is critical to the health and safety of every American worker.

**18. Industrial hygiene personnel shall demonstrate the ability to evaluate the adequacy of local compliance with the following document sections:**

- **29 CFR 1910, Occupational Safety and Health Standards such as the following:**
  - Subpart G, Occupational Health and Environmental Control
  - Subpart H, Hazardous Materials (including 1910.120, Hazardous Waste Operations and Emergency Response)
  - Subpart I, Personal Protective Equipment
  - Subpart J, General Environmental Controls (including 1910.146, Permit Required Confined Spaces)
  - Subpart K, Medical and First Aid
  - Subpart Q, Welding, Cutting, and Brazing
  - Subpart Z, Toxic and Hazardous Substances (including 1910.1020, Access to Employee Exposure and Medical Records)
  
- **29 CFR 1926, Safety and Health Regulations for Construction such as the following:**
  - Subpart D, Occupational Health and Environmental Controls
  - Subpart E, Personal Protective and Life Saving Equipment
  - Subpart H, Materials Handling, Storage, Use, and Disposal
  - Subpart J, Welding and Cutting
  - Subpart Y, Diving
  - Appendixes A&B to Subpart Y, Examples of Conditions which May Restrict or Limit Exposure to Hyperbaric Conditions and Guidelines for Scientific Diving
  - Subpart Z, Toxic and Hazardous Substances
  
- **Industrial hygiene-related technical standards such as the following:**
  - 10 CFR 850, Chronic Beryllium Disease Prevention Program; Proposed Rule
  - 40 CFR 763, Asbestos
  - ANSI Z88.2, American National Standard for Respiratory Protection
  - ANSI Z88.6, Respiratory Protection, Respirator Use, and Physical Qualifications for Personnel
  - ANSI Z136.1, Safe Use of Lasers
  - ANSI Z117.1, Safety Requirements for Confined Spaces
  - ANSI Z358.1, Emergency Eyewash and Shower Equipment
  - ANSI C95.1, Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
  - ACGIH TLV Booklet, American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices

**a) Describe the purpose, scope, and application of the requirements detailed in the listed document sections.**

*29 CFR 1910, Occupational Safety and Health Standards*

Subpart G, Occupational Health and Environmental Control

- Part 1910.94 contains antiquated ventilation requirements that, in general, will not be enforced unless the potential for overexposure is demonstrated.
- Part 1910.95 contains detailed requirements for noise control and hearing conservation.
- Part 1910.97 contains antiquated requirements for non-ionizing radiation and is superseded by other mandatory DOE guidance.

Subpart H, Hazardous Materials (Including 1910.120, Hazardous Waste Operations and Emergency Response)

- Part 1910.106 contains requirements for the safe storage of flammable and combustible materials.
- Part 1910.107 contains the requirements for ventilation during the spray finishing of flammable materials.
- Part 1910.120 contains detailed requirements for the development and implementation of a comprehensive safety and health program at hazardous waste cleanup sites, and also contains requirements for hazardous material cleanup responders.

Subpart I, Personal Protective Equipment

- Part 1910.132 contains general requirements for the use of personal protective equipment, its selection, and the training of personnel in its use.
- Part 1910.133 contains requirements for the selection and use of eye and face protection.
- Part 1910.134 contains quite general and very antiquated requirements for the selection and use of respiratory protection (more useful guidance is found in ANSI Z88.2 and Z88.6).
- Part 1910.138 contains requirements for the selection and use of hand protection.

Subpart J, General Environmental Controls (Including 1910.146, Permit Required Confined Spaces)

- Part 1910.146 requires the establishment of permit-required confined space entry programs, and includes the requirements for the listing of required spaces; the training of personnel with functions related to entry; the development, use, and maintenance of a permitting system; and the performance of monitoring prior to entry, and sometimes during occupancy.

Subpart K, Medical and First Aid

- Part 1910.151 lists general requirements relating to medical services and the requirement for eyewashes in certain work places.

Subpart Q, Welding, Cutting, and Brazing

- Part 1910.252–254 lists requirements relating to welding including the use of eye and face protection and screens, the separation of flammable and combustible materials from the welding operation, and antiquated ventilation requirements.

Subpart Z, Toxic and Hazardous Substances (Including 1910.1020, Access to Employee Exposure and Medical Records)

- Part 1910.1000–1050 contains OSHA PELs for chemical substances and comprehensive standards for specific chemical compounds.
- Part 1910.1200 contains detailed requirements for the communication of information related to the potential hazards of chemicals used in the work place.
- Part 1910.1450 contains requirements for safety and health programs for laboratories.

*29 CFR 1926, Safety and Health Regulations for Construction*

Subpart D, Occupational Health and Environmental Controls

- Part 1926.56 contains antiquated illumination requirements for construction work places (more current guidance for recommended lighting for any work environment is found in the Illuminating Engineering Society (IES) Lighting Handbook, current edition).

Subpart E, Personal Protective and Life Saving Equipment

- Part 1926.103 contains general and antiquated requirements for the use of respiratory protection in construction work places (more useful guidance is found in ANSI Z88.2 and Z88.6).

Subpart H, Materials Handling, Storage, Use, and Disposal

- Part 1926.250 contains requirements for storage.

Subpart J, Welding and Cutting

- Part 1926.354 contains requirements relating to welding including the requirement that toxic coatings be removed to within four inches of the point of hot work.

Subpart Y, Diving

- Subpart Y contains requirements relating to diving and, therefore, potential hyperbaric exposure.

Appendices A and B to Subpart Y, Examples of Conditions which may Restrict or Limit Exposure to Hyperbaric Conditions and Guidelines for Scientific Diving

- Appendix A includes examples of conditions which may restrict or limit exposure to hyperbaric conditions.

Appendix B includes guidelines for scientific diving.

Subpart Z, Toxic and Hazardous Substances

- Subpart Z contains OSHA expanded standards governing exposure to hazardous chemicals that are, in general, comparable to general industry requirements.

*Industrial Hygiene-Related Technical Standards*

Industrial hygiene-related technical standards include the following:

- Title 10 CFR 850 establishes a chronic beryllium disease prevention program that supplements and is integrated into existing worker protection programs that are established for DOE employees and DOE contractor employees.
- Title 40 CFR 763 relates to asbestos abatement in schools, but also contains training requirements that are now applicable to asbestos removal and maintenance personnel in the work place.
- ANSI Z88.2 contains guidance mandatory in DOE relating to the use of respirators in the work place.
- ANSI Z88.6 contains guidance for the physical qualification of respirator users and is referenced in the DOE RadCon Manual.
- ANSI Z136.1 contains guidance, mandatory in DOE, listing the detailed requirements for the establishment of a program governing the safe use of lasers.

- ANSI Z117.1 contains guidance governing safe work in confined spaces, but is not currently mandatory in DOE and has been largely superseded by OSHA, 29 CFR 1910.146.
- ANSI Z358.1 contains guidance for the operation and placement of emergency eyewashes and safety showers.
- ANSI C95.1 contains current and specific guidance regarding allowable exposure to radiofrequency radiation in light of the antiquated guidance of 29 CFR 1910.97.
- The ACGIH TLV Booklet contains a listing of allowable exposure limits to chemical and physical agents. Its use is mandatory in DOE. When a conflict exists between ACGIH and OSHA, the most protective criterion level is to be used.

**b) Discuss the process by which Department line management determines an appropriate level of coverage by industrial hygienists. Include in this discussion factors that may influence the level of coverage.**

In general, DOE line management must provide coverage sufficient to verify contractor compliance with applicable mandatory standards. At a minimum, this will require the verification that the contractor program defensibly meets all applicable requirements, with the emphasis on the requirements relating to the technical adequacy of exposure assessment and control, and the related documentation. A greater level of DOE oversight will include detailed and quantitative observation of procedures, sampling sheets, databases, training and health records, and field surveillance, with emphasis on technical adequacy as opposed to compliance with local procedures.

**c) Discuss what constitutes acceptable contractor work performance consistent with the requirements of the listed regulations and technical standards.**

In general, acceptable contractor work performance will, at a minimum, consist of nominal or defensible compliance with all mandatory requirements. This level of requirement should require some sort of documentation that all required program elements are in place; however, what constitutes the adequacy or detail of documentation will vary. Better contractor programs will be able to document compliance through quantitative internal assessments or statistical evaluation of sampling data upon which exposure assessments and control strategies are based.

DOE requires contractor adherence to a mixture of federal regulations and national consensus standards. Because these sometimes contain conflicting guidance, DOE requires that the most protective guidance be used, and this requires referencing guidance from different sources for the same program. Therefore, assessing a single component of program adequacy with respect to compliance will probably require knowledge and skill in the interpretation of guidance from more than one source, as well as the ability to technically evaluate related exposure issues.

**d) Using selected sections from 29 CFR 1910, 29 CFR 1926, and technical standards, prepare an action plan that adequately outlines interviews and observations to conduct, and details documents to review, during an evaluation of contractor compliance against the requirements of the selected sections.**

- e) Using an appropriate level of coverage, evaluate contractor compliance with the requirements of selected sections of 29 CFR 1910, 29 CFR 1926, and technical standards. During this evaluation, demonstrate the ability to conduct interviews, make observations, and review documents properly.
- f) Given data from an evaluation, analyze the results of the evaluation to determine contractor compliance or noncompliance with the requirements.
- g) Given the results from an analysis of contractor compliance or noncompliance, document and communicate the results to contractor and Department line management.

Elements “d” through “g” of this competency are performance-based competencies. The qualifying official will evaluate the completion of these competencies.

**19. Industrial hygiene personnel shall demonstrate the ability to determine the adequacy of local compliance with the industrial hygiene-related sections and/or requirements of Department of Energy (DOE) Orders such as the following:**

- DOE O 151.1, Planning and Preparedness for Operational Emergencies
- DOE O 232.1A, Occurrence Reporting and Processing of Operations Information
- DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees
- DOE N 440.1, Interim Chronic Beryllium Disease Prevention Program (Notice)
- DOE G 440.1–7, Interim Chronic Beryllium Disease Prevention Program (Implementation Guide)
- DOE Order 3790.1B, Federal Employee Occupational Safety and Health Program
- DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards
- DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities
- DOE Order 5480.20A, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities
- DOE Order 5480.22, Technical Safety Requirements
- DOE Order 5480.23, Nuclear Safety Analysis Reports
- DOE Order 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

- a) Describe the purpose, scope, and application of the requirements detailed in the listed Orders and guides with respect to industrial hygiene.

*DOE O 151.1, Planning and Preparedness for Operational Emergencies*

The current version of this Order is DOE O 151.1C, Comprehensive Emergency Management System. The AIHA has published emergency response planning guidelines to which the exposure level resulting from the release of non-radiological material is compared for determining whether protective actions should be implemented.

*DOE O 232.1A, Occurrence Reporting and Processing of Operations Information*

This Order was cancelled and replaced by DOE M 231.1-2, Occurrence Reporting and Processing of Operations Information. This Manual provides detailed information for reporting occurrences and managing associated activities at DOE facilities, including NNSA facilities.

*DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees*  
This Order lists the required elements of a comprehensive and effective industrial hygiene program to reduce the risk of work-related disease or illness.

*DOE N 440.1, Interim Chronic Beryllium Disease Prevention Program (Notice)*  
This Notice has been replaced by final rule 10 CFR 850, Chronic Beryllium Disease Prevention Program, published December 8, 1999.

*DOE G 440.1–7, Interim Chronic Beryllium Disease Prevention Program (Implementation Guide)*

This Guide has been replaced by DOE G 440.1-7A, Implementation Guide for Use with 10 CFR Part 850, Chronic Beryllium Disease Prevention Program. Specifically, this Guide discusses the regulatory requirements of 10 CFR 850, provides cross-references to DOE directives and industry consensus standards that contain detailed guidance for implementing specific requirements in 10 CFR 850, and provides explanations, with examples, of how to meet the basic requirements for developing and implementing a Chronic Beryllium Disease Prevention Program.

*DOE Order 3790.1B, Federal Employee Occupational Safety and Health Program*  
This Order has been cancelled and replaced by DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees

*DOE Order 5480.4, Chg 4, Environmental Protection, Safety, and Health Protection Standards*

The purpose of this Order is to specify and provide requirements for the application of the mandatory environmental protection, safety, and health standards applicable to all DOE and DOE contractor operations, to provide a listing of reference ES&H standards, and to identify the sources of the mandatory and reference ES&H standards.

*DOE Order 5480.19, Chg 2, Conduct of Operations Requirements for DOE Facilities*

The purpose of this Order is to provide requirements and guidelines for Departmental elements, including the NNSA, to use in developing directives, plans, and/or procedures relating to the conduct of operations at DOE facilities. The implementation of these requirements and guidelines should result in improved quality and uniformity of operations.

*DOE Order 5480.20A, Chg 1, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*

The purpose of this Order is to establish selection, qualification, and training requirements for management and operating (M&O) contractor personnel involved in the operation, maintenance, and technical support of DOE and NNSA category A and B reactors and non-reactor nuclear facilities.

*DOE Order 5480.22, Technical Safety Requirements*

This Order has been cancelled and replaced by 10 CFR 830, Nuclear Safety Management.

*DOE Order 5480.23, Nuclear Safety Analysis Reports*

This Order has been cancelled and replaced by 10 CFR 830, Nuclear Safety Management.

*DOE Order 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements*

This Order has been cancelled and replaced by DOE O 231.1A, Environment, Safety, and Health Reporting.

**b) Discuss what constitutes acceptable contractor compliance and work performance consistent with the requirements and recommendations of the listed Orders and Guides.**

In general, acceptable contractor work performance will, at a minimum, consist of nominal or defensible compliance with all mandatory requirements. This level of compliance should require some sort of documentation that all required program elements are in place; however, the definition of what constitutes adequacy or a sufficient level of detail in documentation will vary. Better contractor programs will be able to document compliance through quantitative internal assessments or statistical evaluation of sampling data upon which exposure assessments and control strategies are based.

DOE requires contractor adherence to a mixture of federal regulations and national consensus standards. Because these sometimes contain conflicting guidance, DOE requires that the most protective guidance be used, and this requires referencing guidance from different sources for the same program. Therefore, assessing a single component of program adequacy with respect to compliance will probably require knowledge and skill in the interpretation of guidance from more than one source, as well as the ability to technically evaluate related exposure issues.

- c) Using an appropriate level of coverage, evaluate contractor compliance with the requirements of the selected Orders. During this evaluation, demonstrate the ability to conduct interviews, make observations, and review documents properly.**
- d) Given data from an evaluation, analyze the results of the evaluation to determine contractor compliance or noncompliance with the requirements.**
- e) Given the results from an analysis of contractor compliance or noncompliance, document and communicate the results to contractor and Department line management.**

Elements “c” through “e” of this competency are performance-based competencies. The qualifying official will evaluate the completion of these competencies.

**20. Industrial hygiene personnel shall demonstrate a familiarity-level knowledge of industrial hygiene-related data management requirements.**

- a) Describe the Department’s organization and discuss the Department’s procedures for communicating between Headquarters and Field elements.**

In accordance with regulations, mandatory guidance, good practice, and common sense, it is vital that critical industrial hygiene-related data and information be maintained and be retrievable.

Critical data includes the following: (1) what is needed to make decisions at the moment, and (2) what is needed to document and defend decisions made in the past. This data would include exposure assessments, recommendations for as well as actual controls and medical surveillance, and past sampling data retrievable by employee, time, location, department, operation, and agent.

Copies of past operating procedures and manuals should probably also be retained for future reference.

**b) Describe the Department's procedures and policy for communicating with state and local organizations, the Occupational Safety and Health Administration (OSHA), and other regulatory agencies.**

The DOE complex operates on the basis of a "chain of command" among the different levels; headquarters, the operations or field office, the area office, and the contractor all have different responsibilities. Formal policy, requirements, assessments, responses, etc., should be passed up and down, with the different levels of the chain of command performing their assigned duties and being held accountable for their actions. In order for DOE to function effectively, all levels of the organization must be responsible for formally acting upon and initiating actions only from the appropriate level in the chain of command. Pressures to violate the chain of command should be resisted, and all formal actions must be transmitted through proper channels to ensure review and approval before decisions are made or actions are taken. Similarly, only authorized personnel may represent, make commitments for, or communicate in the name of DOE with other federal agencies.

**21. Industrial hygiene personnel shall demonstrate a working-level knowledge of assessment performance, including assessment planning and the use of field observations, employee interviews, and document reviews in the assessment of industrial hygiene performance.**

**a) Describe the role of an industrial hygienist with respect to oversight of contractor-operated Department of Energy facilities and operations.**

The industrial hygiene program should be designed to preserve employee health and well-being. This should be accomplished by identification, evaluation, and control of environmental factors and stresses found in the workplace. These include chemical (e.g., liquid, particulate, vapor, and gas); physical (e.g., electromagnetic radiation, noise, vibration, and magnetic fields); biological (e.g., agents of infectious diseases); and ergonomic (e.g., body position in relation to task, repetitive motion, and mental or physical fatigue) factors and stresses. The contractor industrial hygiene program must have the features addressed below.

*Identification of Health Hazards*

The industrial hygiene staff should identify and document existing and potential occupational health hazards through

- knowledge and assessment of the operations;
- periodic walk-through surveys;
- information provided by interorganizational communication;
- the review of proposed projects, facilities, engineering plans, and specifications;
- maintenance of a hazards inventory or tracking system.

### *Hazard Evaluation*

Once potential health hazards are identified, the industrial hygiene staff must determine the extent of the hazards through appropriate consultation with other professionals, sound judgment, the application of established standards or guides, and such evaluation techniques as air sampling and bioassay. A report should be sent to the first level supervisor with the industrial hygiene staff's evaluation of whether occupational exposures are within permissible limits, together with supporting evidence. The permissible exposure limits used in hazard evaluation should not exceed those in the mandatory industrial hygiene standards of DOE Order 5480.4, attachment 2, page 2, paragraph 2d(3). When a potential health hazard is identified that has no assigned permissible exposure limit, a guideline on evaluation and control should be developed based on the best available information (refer to paragraph 10a[1]).

### *Control Measures*

Control measures should be implemented whenever it is determined that a potential health hazard exists sufficient to produce illness or injury, or that applicable standards are not being followed. The industrial hygiene staff should formally recommend control measures to the first level supervisor who must respond promptly. Where feasible, engineering control measures, process change, or material substitution shall be used to prevent or minimize exposure to hazards. Administrative controls and PPE should supplement engineering controls as appropriate.

### *Periodic Review*

The satisfactory control of occupational health hazards should be given continuing attention despite the imposition of control measures. Periodic monitoring is essential to assure maintenance of satisfactory conditions. The industrial hygiene staff should determine the type and frequency of periodic monitoring. The industrial hygiene staff should report to line management regarding the continuing adequacy of controls, the need for additional controls, or recommendations for maintenance or reemphasis of administrative controls. Employees of DOE contractor organizations should be provided the results of the monitoring program for toxic materials or harmful physical agents, upon request.

### *Employee Education*

The industrial hygiene staff shall assist the first level supervisor in the development of an employee information and training program whenever a potential health hazard exists requiring engineering controls, administrative procedures, or PPE. The program should include written notification to employees of environmental monitoring results when the results indicate that the employees are exposed above permissible limits. Training should include information on operations that may lead to exposure, the potential health effects of the hazard, the content of applicable standards, and the purpose and results of environmental monitoring. Training should be updated and repeated periodically.

### *Medical Monitoring*

The industrial hygiene staff should inform the medical organization of potential and existing health hazards identified, the results of hazard evaluations, and other industrial hygiene information needed for operation of a medical monitoring program. The industrial hygiene staff should be available to accompany medical staff on periodic worksite visits.

**b) Describe the assessment requirements and limitations associated with the interface with contractor employees.**

As assessment requirements and limitations associated with the interface of industrial hygiene personnel and contractor employees vary from site to site, the local qualifying official will evaluate the completion of this competency.

**c) Describe the action to be initiated or taken if the contractor challenges the assessment findings, and explain how such challenges may be avoided.**

Disputes over the assessment findings, the corrective action plan, or its implementation (such as timeliness or adequacy) must be resolved at the lowest possible organizational level. The organization that disagrees with the disposition of a given issue may elevate the dispute for timely resolution. The organization that disagrees with the disposition of a given issue must elevate the dispute in a step-wise manner through the management hierarchy. The dispute must be raised via a deliberate and timely dispute resolution process that provides each party with equal opportunity for input and a subsequent opportunity to appeal decisions up to the Secretary of Energy, if necessary.

**d) Demonstrate knowledge of assessment performance through the completion of at least one assessment in accordance with the local DOE procedures, practices, and expectations. The scope of the assessment shall encompass site specific methods of hazard analysis and employee exposure assessment.**

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

**22. Industrial hygiene personnel shall demonstrate the ability to prepare assessment reports that document assessment results, support assessment conclusions, and clearly communicate conclusions and recommendations for corrective action.**

**a) Ability to distinguish between compliance-based and performance-based assessments.**

Compliance-based assessments focus on verification of adherence to established requirements. Performance-based assessments are conducted on activities and processes that relate directly to performance expectations and that emphasize safety and reliability.

**b) Completion of an assessment appraisal report. The appraisal report shall be completed in the local DOE format or in accordance with local procedures, practices, and expectations. The report shall demonstrate specific knowledge of the site's methods of hazard analysis and employee exposure assessment.**

**c) Ability to develop corrective actions and recommendations and communicate these to contractor management.**

Elements "b" and "c" of this competency are performance-based competencies. The qualifying official will evaluate the completion of these competencies.

**23. Industrial hygiene personnel shall demonstrate the ability to trend and analyze industrial hygiene-related information.**

**a) Identify and discuss the principal performance indicators that are normally used to review industrial hygiene performance and effectiveness.**

DOE requires that a program be established which identifies, gathers, verifies, analyzes, trends, disseminates, and makes use of ES&H performance indicators to improve the performance of DOE facilities, programs, and organizations.

Industrial hygienists should choose to track or trend indicators of both program productivity and quality. To a certain extent, they overlap, but indicators more related to productivity might include the number of personnel trained, or the number of surveys completed or samples performed relative to a listed plan or goal. Indicators more related to quality might include the number or percentage of workers or operations without the potential for overexposure and the percentage of workers trained or surveys completed relative to a goal.

Other quality indicators may be scores on standardized audits of ongoing operations. More traditional indicators of program quality include injury, illness, or mishap rates, or compensation costs, but a vast majority of these data points do not relate well to industrial hygiene issues, and those that do are lagging indicators, that is, current numbers reflect past mistakes or conditions. In all cases, the data must be both gathered and categorized in a standardized manner in order for comparisons to be defensibly made when tracking and trending.

**b) Trend and analyze relevant facility operations information and discuss the relationship of operations information to industrial hygiene performance.**

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

**24. Industrial hygiene personnel shall demonstrate a working-level knowledge of the interrelationship between quality assurance programs and industrial hygiene.**

**a) Describe how an industrial hygiene program may be evaluated for quality assurance activities, including the following:**

- **Industrial hygiene program procedures**
- **Sampling methods and chain of custody**
- **Laboratory accreditation**
- **Evaluation and maintenance of documentation**
- **Independent verification**
- **Technical staff qualifications**

Management should annually perform and document a self-assessment to ensure the effectiveness of the implementation of industrial hygiene practices and assure quality. Such self-assessments should include reviews of

- the adequacy and use of industrial hygiene resources;
- all exposure assessment records, including medical exposure data, audiometric testing records, illness and injury logs and supporting information, and any other records relevant to the maintenance of industrial hygiene functions;

- compliance with applicable industrial hygiene requirements and established performance measures;
- success in receiving and responding to employee occupational health concerns;
- industrial hygiene evaluation records to assess progress in abating health hazards;
- all required written programs that include industrial hygiene elements (e.g., the hazard communication program and the respiratory protection program);
- training program effectiveness.

**25. Industrial hygiene personnel shall demonstrate the ability to apply recognized technical practices and guidance properly to DOE non-industrial or non-repetitive work activities.**

- a) Ability to apply DOE Orders and standards logically and appropriately to environmental management and restoration sites.**
- b) Ability to apply industrial hygiene technical practices to the DOE Integrated Safety Management (ISM) initiative and its validations.**

Elements “a” and “b” of this competency are performance-based competencies. The qualifying official will evaluate the completion of these competencies.

## Acronyms

|          |  |
|----------|--|
| AAIH     | American Academy of Industrial Hygiene                                     |
| ABIH     | American Board of Industrial Hygiene                                       |
| ACE      | air change effectiveness   |
| ACGIH    | American Conference of Governmental Industrial Hygienists                  |
| AGA      | American Gastroenterological Association                                   |
| AIHA     | American Industrial Hygiene Association                                    |
| ALARA    | as low as reasonably achievable  |
| ANSI     | American National Standards Institute                                      |
| ASHRAE   | American Society of Heating, Refrigeration, and Air Conditioning Engineers |
| ASI      | air sampling instruments   |
| AVB      | atmospheric vacuum breaker   |
| BEI      | Biological Exposure Indices  |
| BSL      | biosafety level  |
| CDC      | Centers for Disease Control and Prevention                                 |
| CERCLA   | Comprehensive Environmental Response, Compensation, and Liability Act      |
| CFU      | colony forming units   |
| CHP      | chemical hygiene plan  |
| COPD     | chronic obstructive pulmonary disease                                      |
| CTD      | cumulative trauma disorder   |
| dB       | decibel  |
| dBA      | a-weighted decibel   |
| DC       | double check   |
| DOE      | Department of Energy   |
| DOT      | Department of Transportation   |
| EPA      | Environmental Protection Agency  |
| ES&H     | environment, safety, and health  |
| ETI      | effective temperature index  |
| FSG      | focal segmental glomerulosclerosis   |
| GST      | glutathione S-transferase  |
| HAZCOM   | chemical hazard communication  |
| HAZWOPER | hazardous waste operations and emergency response                          |
| HEPA     | high energy particulate air (filter)                                       |
| HSI      | heat stress index  |
| HTO      | tritium oxide  |
| HVAC     | heating, ventilation, and air conditioning                                 |
| IES      | Illuminating Engineering Society   |
| ISM      | integrated safety management   |
| M&O      | management and operating   |
| MSDS     | material safety data sheet   |
| MSHA     | Mine Safety and Health Administration                                      |
| NASH     | nonalcoholic steatohepatitis   |
| NDDIC    | National Digestive Diseases Information Clearinghouse                      |
| NIDDK    | National Institute of Diabetes and Digestive and Kidney Diseases           |

|        |   |
|--------|---|
| NIOSH  | National Institute for Occupational Safety and Health |
| NIST   | National Institute of Standards and Technology        |
| NNSA   | National Nuclear Security Administration              |
| OSH    | occupational safety and health                        |
| OSHA   | Occupational Safety and Health Administration         |
| PAA    | personal apparel assessment                           |
| PEL    | permissible exposure limit                            |
| PPE    | personal protective equipment                         |
| ppm    | parts per million                                     |
| PTFE   | polytetrafluoroethylene                               |
| PVB    | pressure vacuum breaker                               |
| PVC    | polyvinyl chloride                                    |
| QA     | quality assurance                                     |
| REL    | recommended exposure limit                            |
| RF     | radio frequency                                       |
| RMD    | repetitive motion disorder                            |
| RP     | reduced pressure                                      |
| RPDA   | reduced-pressure principle detector assembly          |
| RPGN   | rapidly progressive glomerulonephritis                |
| SCBA   | self-contained breathing apparatus                    |
| SOP    | standard operating practice                           |
| SSCs   | structures, systems, and components                   |
| STEL   | short-term exposure limit                             |
| TAC    | task/ambient conditioning                             |
| TLV-CS | threshold limit values for chemical substances        |
| TLVs   | threshold limit values                                |
| TRS    | Transfer Reference Standard                           |
| TWA    | time-weighted average                                 |
| UFAD   | under floor air distribution                          |
| VOC    | volatile organic chemical                             |
| WBGT   | wet bulb globe temperature                            |
| WMSD   | work-related musculoskeletal disorder                 |

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