CDC 4B051

Bioenvironmental Engineering Journeyman

Volume 2. Introduction to Occupational and Environmental Health Risk Management

Air Force Career Development Academy
Air University
Air Education and Training Command

4B051 02 2009, Edit Code 04
AFSC 4B051

Author: Mr. Mark H. Hanson
United States Air Force School of Aerospace Medicine (USAFSAM)
Bioenvironmental Education and Training Branch
2510 Fifth Street, Building 840
Wright-Patterson Air Force Base, Ohio 45433
DSN: 798-3010
E-mail address: mark.hanson.12@us.af.mil

Instructional Systems Specialist: Todd E. Knowles

Editor: Maxine Baldwin

Air Force Career Development Academy (AFCDA)
Air University (AETC)
Maxwell AFB-Gunter Annex, Alabama

Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For Weighted Airman Promotion System (WAPS) Specialty Knowledge Test (SKT) purposes, the examinee should check the *Enlisted Promotions References and Requirements Catalog* to determine the correct references to study.

THIS IS Volume 2 of Career Development Course (CDC) 4B051, *Bioenvironmental Engineering Journeyman*. Comprised of five individual units, this volume is designed to meet the proficiency code requirements of presenting a comprehensive "picture" of the occupational and environmental health risk assessment and its application(s) in both garrison and deployed environments.

Material in this unit has been progressively written to provide insight into the relationship of the occupational and environmental health (OEH) program to the Defense Occupational and Environmental Health Readiness System (DOEHRS), as well as determining and recommending risk hazards.

Unit 1 of this volume describes foundational preventive medicine principles of the occupational and environmental health program, including the documents and information management system that support the BEE's duties.

Unit 2 provides an overview of the occupational health program and strategies, models and assessment codes for applying occupational and environmental health (OEH) risk management control concepts.

Unit 3 describes biological hazards and methods for identifying, analyzing, and controlling them.

Unit 4 discusses strategies and methods for sampling chemical hazards in the same manner.

Unit 5 describes physical hazards including noise, ergonomics and thermal stress. It discusses the techniques for analyzing and controlling these hazards.

A glossary is included for your use.

Code numbers on figures are for preparing agency identification only.

The use of a name of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

To get a response to your questions concerning subject matter in this course, or to point out technical errors in the text, unit review exercises, or course examination, call or write the author using the contact information provided in this volume.

NOTE: Do not use Air Force Instruction (AFI) 38–402, *Airmen Powered by Innovation and Suggestion Program,* to submit corrections for printing or typographical errors. For Air National Guard (ANG) members, do not use Air National Guard Instruction (ANGI) 38–401, *Suggestion Program.*

If you have questions that your supervisor, training manager, or education/training office cannot answer regarding course enrollment, course material, or administrative issues, please contact Air University Educational Support Services at http://www.aueducationsupport.com. Be sure your request includes your name, the last four digits of your social security number, address, and course/volume number.

For Guard and Reserve personnel, this volume is valued at 8 hours and 3 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Page

Unit 1. Introduction to Occupational and Environmental Health Risk Assessment

THERE ARE a wide variety of hazards associated with military operations and deployments. These hazards may range from chemicals used in common industrial processes to chemical, biological, radiological, and nuclear (CBRN) warfare agents. Exposure to any hazard carries some risk to health and well-being as well as operational risks to the mission. There must be a process to allow commanders (CC) to determine which health risks are acceptable and which are not, facilitating informed decisions to accomplish the mission. CC rely on bioenvironmental engineering (BE) to provide them with health risk information.

201. The occupational and environmental health program

According to Air Force Instruction (AFI) 48–145, *Occupational and Environmental Health Program*, the process of determining the level of risk to health is called health risk assessment (HRA). BE implements HRAs through the Air Force's (AF) occupational and environmental health (OEH) program. The role of aerospace medicine relative to human OEH focuses on HRAs and associated health monitoring, sampling and surveillance of actual and potential physical, chemical, biological and radiological hazards, man-made and naturally occurring, in the workplace and community environments.

The AF OEH program is a multi-disciplinary program designed to mitigate OEH-related health risks through the optimum application of aerospace medicine capabilities. According to Air Force Policy Directive (AFPD) 48–1, *Aerospace & Operational Medicine Enterprise (AOME)*, a major aerospace medicine program is linked to the following four aerospace medicine mission areas:

1. Promote and sustain a medically ready force.
2. Prevent illness and injury.
3. Restore health.
4. Optimize and sustain human performance.

The AF OEH program seeks to identify health hazards and assess the associated health risks in the workplace and community environments, and finds ways to control or eliminate them. AFI 48–145 provides foundational instructions for overall AF OEH program implementation procedures that focus BE efforts toward capturing, analyzing, documenting, and communicating information regarding OEH hazards and risks in the work place. AFI 48–145 and Air Force Pamphlet (AFPAM) 90–803, *Risk Management (RM) Guidelines and Tools*, define *work place* as any occupational environment (e.g., industrial, administrative, or all-encompassing such as any setting while deployed) where a potential OEH exposure may occur. In identifying and addressing workplace hazards and risks, BE team members support the main purpose of the AF OEH program which is to protect health while enhancing combat and operational capabilities. The OEH hazard identification and risk assessment process is identical at both home station and deployed locations.

The AF OEH program facilitates the establishment of a longitudinal exposure record (LER) for each military member according to Presidential Review Directive 5, *Improving the Health of Our Military, Veterans, and Their Families*.

Bioenvironmental engineering's role in the AF OEH program

BE, in consultation with other health-related subject matter experts in aerospace medicine, is highly skilled in the HRA process. Its role in executing the AF OEH program includes the following:

- Identifying OEH hazards (to include CBRN and physical hazards).
- Assessing the significance of the health risk.
- Determining appropriate control measures.
- Effectively communicating health risk information along with control recommendations through the RM process to leadership.

BE has specific responsibilities within the AF OEH program as outlined in AFI 48–145. These responsibilities include the following:

- Assisting commanders and supervisors with integrating OEH input into RM-based decision processes.
- Accomplishing OEH risk assessments.
- Reviewing new processes or operations at the earliest feasible stage to prevent or control potential OEH hazards.
- Investigating proposed changes to existing processes or operations, including equipment and facilities for potential OEH hazards.
- Categorizing work places according to OEH risk levels, providing a complete list to the occupational and environmental health working group (OEHWG) for review, and ensuring personnel are assigned to appropriate similar exposure group (SEG).
- Evaluating risk(s) related to environmental health issues that could result in adverse health outcomes (e.g., poor indoor air quality in a dormitory).
- Evaluating and determining adequacy of OEH hazard controls and recommending alternatives.
- Providing HRA technical review and support for plans and activities related to cleanup of sites contaminated with toxic and hazardous substances, low-level radioactive materials (RAM) and other pollutants when a potential OEH threat to AF workers and community health exists.
- Effectively communicating the risks to the organizational leadership, the affected individual and members of a related SEG.
- Providing technical oversight or performing all OEH risk assessments at the geographically separated units (GSU) or munitions support squadron (MUNSS) sites in accordance with (IAW) support agreements discussed later in this unit.
- Executing an occupational and environmental health site assessment (OEHSA) for area of responsibility (AOR).
- Providing incident response according to AFI 10–2501, *Emergency Management Program.*
- Using the Defense Occupational and Environmental Health Readiness System (DOEHRS) web-based software application system to manage OEH and incident response exposure data.
- Completing deployment-specific OEH exposure documentation according to Air Component Commander Surgeon General policy.
- Assessing and documenting OEH exposure data in Air Force Safety Automated System (AFSAS) for potential OEH-related illnesses identified by public health (PH).
- Providing consultation and technical expertise to work areas/work places on potential OEH hazards, training and regulatory requirements.

- Providing consultation on OEH exposures and a workplace-specific occupational and environmental health exposure data (OEHED) document to the OEHWG.
- Serving as the AF OEH program liaison to appropriate regulatory authorities.
- Participating member of the installation hazardous material management program (HMMP) team according to Air Force Manual (AFMAN) 32-7002, *Environmental Compliance and Pollution Prevention.*

BE is a pivotal player of the aerospace medicine team and directly supports the AF OEH program to mitigate OEH-related health risks. This is accomplished through the execution of the program responsibilities previously mentioned. In order to perform these responsibilities, BE must have technical awareness of the overarching drivers for the AF OEH program. This is discussed in detail in the next lesson.

202. Federal, Department of Defense, and Air Force directives and technical orders

There are numerous federal, Department of Defense (DOD), and AF publications, instructions, and directives that drive AF OEH program policy. Some publications are regulatory in nature and outline specific requirements. Others provide technical guidance to BE for executing OEH risk assessments. In this lesson, we will focus on publications within each of these areas.

Federal Publications

Agencies within the federal government of the United States, like the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the Nuclear Regulatory Commission (NRC), the Department of Transportation (DOT), and others are considered regulatory agencies. These specific agencies are empowered to create and enforce rules and regulations that carry the full force of a law.

The Code of Federal Regulations (CFR) is the systematic arrangement of the general and permanent rules and regulations (sometimes called administrative law) published by the executive departments and agencies previously mentioned. The CFR is a multi-volume set divided into 50 titles that represent broad areas subject to federal regulation. The titles BE works with most frequently include the following:

- Title 10, *Energy*–Requirements binding on all persons and organizations who receive a license from the NRC to use nuclear materials or operate nuclear facilities.
- Title 29, *Labor*–Regulations dealing with protecting human health and welfare as related to the work place.
- Title 40, *Protection of Environment*–Mainly environmental regulations promulgated by the EPA dealing with protecting human health and the environment.
- Title 49, *Transportation*–Policy regarding the role of transportation and transporting cargo in the United States.

The DOD and AF comply with the intent of standards from regulatory agencies by directly referencing the applicable standards or incorporating the standards into DOD and AF publications.

Department of Defense Issuances

The Office of the Secretary of Defense uses DOD issuances to issue policy, guidance, and instructions to the DOD components to meet the requirements and direction of legislation, the president or the Secretary of Defense. Each branch of the Armed Services will then issue service-specific publications, if necessary, to further define and clarify DOD issuances.

The following table describes three of the most common DOD issuances:

Type of DOD issuance	Description
Department of Defense Directive (DODD)	DODDs are broad policy documents containing statute requirements by the President, or the Secretary of Defense. DOD Directives establish or describe policy, programs, and organizations; define missions; delegate authority; and assign responsibilities.
Department of Defense Instruction (DODI)	DODI implement, or prescribe the manner or a specific plan of action for implementing the Secretary of Defense policy.
Department of Defense Manual (DODM)	DODMs implement or supplement DOD Directives and Instructions by providing uniform procedures for management or operational systems and disseminating administrative information.

Air Force publications

Official AF publications are the only approved vehicles for issuing official AF policy and/or guidance. AF publications are either directive or non-directive in nature. They communicate policy, issue guidance and procedures, or simply serve to inform. AF publications are produced at the various levels of command, from departments within Headquarters Air Force (HAF) right down to the BE flight.

AF publications are organized into series relating to a corresponding Air Force specialty code (AFSC). The publication series more commonly referenced in the performance of BE duties include those shown in figure 1–1:

Figure 1–1. Common Air Force Specialty Codes.

Publications most relevant to OEH program activities fall primarily within the 48 series; however, it is important to keep in mind that BE is not limited to the 48-series guidance. BE roles and interactions with other AF agencies while conducting OEH activities require knowledge and use of other series publications. Often, other series publications will list BE responsibilities, explain procedures, identify regulatory compliance requirements, and provide guidance.

The following table defines different types of AF publications you will routinely access:

Publications	Definitions
Air Force Policy Directive (AFPD)	AFPDs are orders of the Secretary of the Air Force (SAF) that contain directive policy statements to initiate, govern, and/or regulate actions within specified areas of responsibility by AF activities.
Air Force Instructions (AFI)	AFIs are orders of the Secretary of the AF. They direct action, ensure compliance, and/or give detailed procedures to standard actions AF-wide.
Air Force Manual (AFMAN)	AFMANs are usually extensions of AFIs and provide additional guidance for performing standard tasks, or supporting education and training programs.
Air Force Pamphlet (AFPAM)	AFPAMs are informational, “how to” publications, which may include procedures for implementing AF guidance.
Supplement	Supplements are publications that extend or add material to publications issued by higher headquarters (HHQ) or agencies.
Installation Publication	Installation commanders have the authority to issue installation-specific publications that affect installation personnel.
Air Force Technical Order	A different type of AF publications, technical orders are critical elements in the maintenance and operation of AF assets. They provide instructions and procedures for operating, inspecting and maintaining systems and equipment, including the safety precautions required during maintenance and operations. Occasionally, you may need to review technical orders in the following series: 00, Methods and Procedures. 11, Armament Equipment. 14, Deceleration Devices, Personal and Survival Equipment. 33, Test Equipment.

The following table lists some of the federal, DOD, and AF publications and relationships within key areas of the OEH program; it is not meant to define program areas.

Federal	DOD	Air Force
Occupational and Environmental Health Program		
Title 29 CFR Part 1910, *Occupational Safety and Health Standards* Title 29 CFR 1910.1200, *Hazard Communication*	DODD 4715.1E, *Environment, Safety and Occupational Health (ESOH)* DODI 6055.01, *DoD Safety and Occupational Health (SOH) Program* DODI 6055.05, *Occupational and Environmental Health (OEH)* DODI 6050.05, *DOD Hazard Communication (HAZCOM) Program* DODI 6490.03, *Deployment Health* DODD 6200.04, *Force Health Protection (FHP)*	AFPD 90–8, *Environment, Safety & Occupational Health Management and Risk Management* AFPD 48–1, *Aerospace & Operational Medicine Enterprise (AOME)* AFI 48–145, *Occupational and Environmental Health Program* AFMAN 48–146, *Occupational & Environmental Health Program Management* AFI 90–821, *Hazard Communication (HAZCOM) Program*
Radiation Safety		
Title 10 CFR 20, *Standards for Protection Against Radiation* Title 29 CFR 1910.97, *Nonionizing Radiation* Title 29 CFR 1910.1096, *Ionizing Radiation*	DODI 6055.08, *Occupational Ionizing Radiation Protection Program* DODI 6055.11, *Protecting Personnel from Electromagnetic Fields* DODI 6055.15, *DOD Laser Protection Program*	AFMAN 40–201, *Radioactive Materials (RAM) Management* AFMAN 48–125, *Personnel Ionizing Radiation Dosimetry* AFMAN 48–148, *Ionizing Radiation Protection*

Federal	DOD	Air Force
Physical Exposures		
Title 29 CFR 1910.95, *Occupational Noise Exposure*	DODI 6055.12, *Hearing Conservation Program (HCP)*	
OEH Controls		
Title 29 CFR 1910.94, *Ventilation* Title 29 CFR 1910 Subpart I, *Personal Protective Equipment* Title 29 CFR 1910.134, *Respiratory Protection*		AFI 91–202, *The US Air Force Mishap Prevention Program*
Confined Spaces		
Title 29 CFR 1910.146, *Permit-required Confined Spaces*		
Potable Water		
Title 40 CFR Subchapter D, *Water Programs*	Water Safety on Military Bases	AFMAN 32–1067, *Water and Fuel Systems* AFI 48–144, *Drinking Water Surveillance Program*
Emergency Management		
	Department of Defense Manual (DODM) 3150.08, *Nuclear Weapon Accident Response Procedures (NARP)* DODI 6055.17, *DOD Emergency Management (EM) Program*	AFPD 10–25, *Emergency Management* AFI 10–2501, *Emergency Management Program*

Other agency publications

A number of organizations are dedicated to promoting health and safety in the work environment. Many of these organizations produce documents designed to assist OEH professionals with helpful guidance when performing OEH HRAs.

American Conference of Governmental Industrial Hygienists Guidelines

The American Conference of Governmental and Industrial Hygienists (ACGIH) is a private, non-governmental corporation whose members include industrial hygienists or other occupational health and safety professionals dedicated to promoting health and safety within the work place. The corporation publishes a list of threshold limit values (TLV) for chemical substances, along with biological exposure indices (BEI), used to make decisions regarding safe levels of exposure to various chemicals and physical agents found in the work place.

National Institute for Occupational Safety and Health Publications

The Occupational Safety and Health Act also established the National Institute for Occupational Safety and Health (NIOSH). NIOSH is part of the Department of Health and Human Services and is responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH and the OSHA work closely together toward the common goal of protecting worker safety and health. The AF uses NIOSH standards and references to evaluate working environments at base level industrial sites. For example, NIOSH produces several documents that support respirator selection and chemical hazard recognition and control.

American National Standards Institute Standards

American National Standards Institute (ANSI) is another non-governmental agency that publishes consensus standards of allowable concentrations for chemical and physical agents, as well as consensus standards on many items of protective equipment. These standards are useful in establishing engineering procedures to prevent objectionable levels of chemical and physical agents in the work environment, however, they are only enforceable through AF standards and Occupational Safety and Health Administration referenced standards.

United States Army Public Health Command

The United States Army Public Health Command (USAPHC) provides scientific expertise and services in areas of preventive medicine, environmental and occupational health, toxicology, and other related areas. The USAPHC chemical hazard risk assessments and Technical Guides provide military exposure guidelines (MEG) used to assess the significance of field exposures to OEH chemical hazards during deployments.

The OEH program contains policies driven by requirements outlined in federal, DOD and AF publications, instructions and directives. The majority of these requirements are regulatory and must be accomplished. To fully support the intent of the AF OEH program, BE must also be aware of local requirements outlined in support agreements and ensure required OEH program support is incorporated into the overall scope of BE operations.

203. Defense Occupational and Environmental Health Management Information System

The AF-approved occupational and environmental health management information system (OEHMIS) for active duty, Air National Guard (ANG) units and Air Force Reserve (AFR) components is the web-based software application system Defense Occupational and Environmental Health Readiness System (DOEHRS). DOEHRS is a joint-service application used by the Navy, Coast Guard, Army, Air Force, and their respective guard and reserve units.

DOEHRS facilitates the establishment of an LER for each military member in accordance with DODI 6490.03.

DOEHRS allows the DOD to manage OEH risk data and actively track biological, chemical, physical health hazards, and engineered nano-object processes to service members worldwide. Eight features of DOEHRS are listed below:

- Captures comprehensive, operational, and work-task potential exposures based on medical and environmental surveillance recommendations.
- Tracks DOD lifetime personnel exposure data.
- Captures workplace practices, uses, and recommendations of protection equipment and occupational and environmental data in support of military operations worldwide.
- Captures environmental surveillance data for deployed and garrison locations.
- Captures PH information related to food safety, general sanitation, entomology and waste management.
- Captures and maintains environmental exposure registries.
- Captures and tracks industrial ventilation system performance.
- Captures individual training/certifications and quantitative or qualitative respirator fit test results.

DOEHRS contains four modules (fig. 1–2).

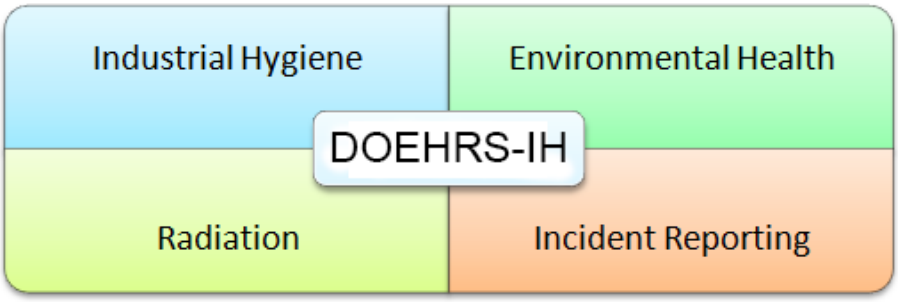


Figure 1–2. Four Modules of DOEHRS.

While each of the four modules is somewhat different, the intent is to support a common framework of threat/hazard identification, evaluation, and control. This common framework captures and documents exposures to service personnel whether the exposures are from industrial work places, local environmental conditions, or terrorist incidents. The following table defines the four DOEHRS modules:

DOEHRS Modules	
Modules	**Definitions**
Industrial Hygiene	The DOEHRS-Industrial Hygiene (IH) module implements the DOD IH Exposure Assessment Model. Unit 2 discusses the DOD IH exposure assessment model in detail. All hazards associated with processes in an industrial work place that put workers' health at risk are documented in the IH module. IH samples and surveys are documented in the IH module. The IH module is based on the concept of associating industrial process hazards with SEGs assigned to a shop.
Environmental Health	The Defense Occupational and Environmental Health Readiness System – Environmental Health (DOEHRS-EH) module is used to document complete and potentially complete exposure pathways environ-mental hazards in and out of work places and includes ambient environmental conditions. OEHSA survey in DOEHRS-EH is the primary tool utilized by BE for identifying and evaluating OEH threats that are not captured in the IH module. The OEHSA will be discussed in greater detail in Unit 2. It is important to recognize that hazards generated by industrial shop processes may be considered environmental and documented in the EH module in some cases. For example, nearby personnel may be exposed to emissions exhausted from a paint booth. The EH module is based on the concept of associating OEH threat exposure pathways to a population at risk (PAR).
Radiation	The DOEHRS-Radiation module is used to document radiation-specific health threats, samples and surveys.
Incident Reporting	The Defense Occupational and Environmental Health Readiness System – Incident Reporting (DOEHRS-IR) module is used to document any non-routine exposures that result from an isolated or rare event that is not otherwise captured in the IH, EH, or Radiation modules.

DOEHRS is intended to enhance timely, efficient sharing of data between OEH risk assessors (i.e., BE) and occupational health clinics. DOEHRS further supports elimination of redundant data collection through interfaces with clinical, environmental, safety, personnel, and financial automated information systems within DOD, as well as systems external to DOD that provide federal standards and compliance information.

DOEHRS integrates FHP information by providing automated support for the military health system, industrial hygiene, environmental health, and hearing conservation communities. Personnel in these

communities can use the deployment occupational and environmental surveillance data in DOEHRS-IH to meet the requirements of the theater medical information program (TMIP).

BE responsibilities

As previously mentioned, BE personnel must use DOEHRS-IH to document all information relating to OEH HRAs (e.g., assessment sample data, exposure information and recommendations, and control options). BE personnel may use DOEHRS-IH to create reports for risk communication to commanders and supervisors and provide occupational medicine with a workplace-specific OEHED document as an exposure summary for the medical records of each exposed worker.

Entering accurate data for every HRA into DOEHRS-IH is important as it serves as the basis for recommendations to protect workers from health threats and risks. Additionally, DOEHRS-IH maintains LERs for individual workers throughout the DOD. LERs contain a history of pre-deployment, deployment, and post-deployment exposures. These records provide a baseline to facilitate post-deployment follow-up.

The system provides personnel with the capability to perform quality assurance (QA) reviews of HRA data. A fully qualified bioenvironmental engineer (43E3A), civilian industrial hygienist (GS–9 or higher), or BE craftsman (4B071) should verify the accuracy and completeness of all exposure assessment data entered into DOEHRS-IH.

DOEHRS-IH is a tool BE can use to facilitate the application of accurate HRAs for mitigating and managing health risks to personnel and ensuring successful AF operations.

204. Health risk assessment

Nearly all AF missions involve risk. Commanders must weigh the risk and balance resource protection with mission accomplishment. The HRA is the process by which BE measures risk and informs decision makers. HRAs serve to:

- Estimate the level of damage or injury that may result from exposure to a hazard.
- Assist in making decisions as to whether the consequences are great enough to require management of the hazard.

The HRA is the process of identifying and defining dose-response relationships and hazard criteria, collecting all relevant and reliable exposure information to refine the hazard criteria, and characterizing the risks associated with realistic combinations of hazards and exposures.

Recall the BE mission and mission focus area statements:

- BE mission: Provide operational HRA expertise to enhance commander decision making and health service support capabilities.
- BE mission focus area: HRAs performed in the context of RM.

The HRA is part of the overall AF RM process. Take note of this important point: health risk management (HRM) and HRM are mutual processes.

In principle, an HRA can be described succinctly as a science-based evaluation of risk, while HRM is the process of identifying, evaluating, and implementing courses of action to reduce risk to human health. However, in practice, the terms *health risk assessment* and *health risk management* are often used interchangeably. This is because the OEH risk assessor (BE) does not simply stop after assessing risk, but follows through with implementation of risk control recommendations, and follows up with additional assessments to evaluate the effectiveness of controls.

Health risk assessment and health risk management

Figure 1–3 depicts the AF framework for RM. The RM process is a conceptual tool used throughout the AF to assess and manage risks associated with many activities. The RM process assists decision makers in reducing or eliminating unnecessary risk by systematically identifying, evaluating, and controlling risk (including health risk) associated with operational activities. RM enables commanders, functional managers, supervisors, and individuals to make decisions that will maximize operational capabilities while limiting risk.

Figure 1–3. AF Risk Assessment/Risk Management Framework.

The following listing provides examples of potential actions that may take place during each step of the RM process.

Steps	Actions
Anticipate and identify hazards	Intelligence estimate. Contingency/operational planning. OEH hazard surveillance. Risk communication planning.
Assess hazards to determine risk	Severity and probability of health risk. Stakeholder interest/concern assessment.
Develop controls and make risk decisions	Eliminate the hazard. Isolate/change the process. Accept the risk. Develop a risk communication strategy.
Implement controls	Implement engineering and administrative controls. Provide personal protective equipment (PPE). Train personnel. Implement risk communication strategy.
Supervise and evaluate	Inspections and audits. Illness/injury reporting. Medical evaluations for known exposures. Medical record keeping. Illness investigation/epidemiology studies. Evaluate risk communication efforts.

All operations require some level of risk assessment as well as RM. Each commander and supervisor, along with every individual, is responsible for identifying potential risks and adjusting or compensating appropriately. RM is an efficient process for evaluating possible strategies, identifying hazards and evaluating risk, and determining the best course of action (COA). Commanders manage risk by applying four basic RM principles that provide a framework for implementing the RM process (fig.1–4).

Figure 1–4. Risk Management Principles.

The acceptable risk level will vary and is dependent on the current circumstances of the situation. For example, the acceptable risk in a United States (US)-based AF industrial shop may be dictated by federal standards (i.e., the OSHA permissible exposure limit [PEL]). However, the acceptable health risk for a military-unique deployed operation is balanced with operational risk. It is the commander's discretion to determine whether or not health risk is the most important risk when determining how to complete or support the mission.

The appropriate level of leadership, authority, and accountability should make risk decisions. If the OEH risk assessor determines that available controls do not reduce risk to acceptable levels, decisions should be elevated to the next higher level.

When health risks are identified and managed within the framework of RM, it provides commanders the ability to balance operational risks with health risks. The integration of health risks with other risks provides commanders awareness of the full spectrum of risks they are facing. Commanders can then weigh the mission requirements against health risks and, ideally, prevent injury and illness, thus maximizing mission success.

The AF OEH program incorporates HRA and HRM into the general RM framework (fig. 1–5).

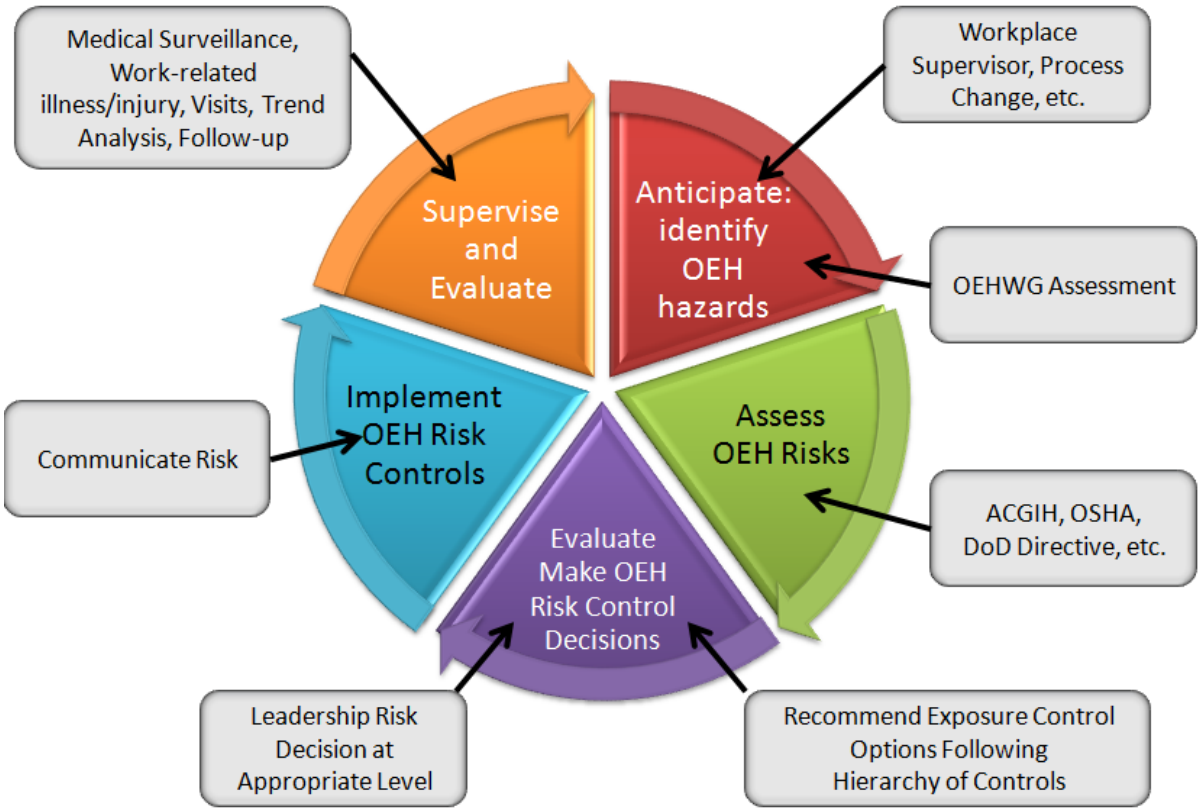


Figure 1–5. The OEH Program Implementation of the HRA/HRM Process.

Service members may encounter health threats in the work place, from the ambient and/or community environments, or during an incident and/or response to an incident. Different programmatic means exist for identification and assessment of exposures to OEH threats in different situations (e.g., industrial hygiene (IH) shop assessments, OEHSA, and incident response). BE Documents all exposures in the appropriate DOEHRS-IH module to support the LER.

A number of tools are available that support the BE mission of conducting HRAs. The OEH program provides guidance for conducting HRAs and HRM. The AF Exposure Assessment Model (discussed in Unit 2) dictates the process for performing HRAs in the context of HRM. BE uses the OEHSA as a tool to collect data for HRAs related to environmental exposures.

NOTE: The AF Exposure Assessment Model, OEHSA, and other tools will be discussed in detail in Unit 2.

In summary, your role in the HRA/HRM processes is to identify and analyze OEH risks at both garrison and deployed locations, determine appropriate control options, and communicate this information through your chain of command.

The ultimate goal of the HRA should be to provide leadership with a concise COA—one that clearly articulates potential health related impacts and advises on how to minimize health risks. HRM uses data from the HRA to determine how best to reduce the risk of exposure. BE analyzes and communicates all this data and information within the framework of RM.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

201. The occupational and environmental health program

1. What AF program is designed to restore health while optimizing and sustaining human performance?

2. Why is AFI 48–145 considered the foundational document for the overall AF OEH program?

3. What is BE's role in executing the AF OEH program?

4. What are BE's specific responsibilities within the AF OEH program as outlined in AFI 48–145?

202. Federal, Department of Defense, and Air Force directives and technical orders

1. Why are agencies within the federal government such as EPA, OSHA, NRC, DOT, and others, called regulatory agencies?

2. If you needed to research a topic dealing with protecting human health and welfare related to a work place, which CFR title would you need?

3. Within which AF publication series would you find most of the BE-related publications?

4. Which US agency publishes chemical hazard risk assessments and technical guides that provide MEGs used to assess field exposures to OEH chemical hazards?

203. Defense Occupational and Environmental Health Management Information System

1. What does the acronym DOEHRS-IH stand for?

2. List the eight features of the DOEHRS-IH system.

3 Which of the four DOEHRS-IH modules is used to record complete/potentially complete exposure pathways?

4. What is the primary tool BE uses for identifying and evaluating OEH threats not captured in Industrial Hygiene?

5. What is contained in and individual's LER?

204. Health risk assessment

1. What is the difference between an HRA and HRM?

2. Why are the terms HRA and HRM used interchangeably?

3. What five actions make up the AF HRA and HRM framework?

4. What are the four principles for implementing RM?

5. What is the ultimate goal of the HRA?

Answers to Self-Test Questions

201

1. AF OEH program.
2. The AFI provides foundational instructions for overall AF OEH program implementation procedures that focus BE efforts toward capturing, analyzing, documenting, and communicating information regarding OEH hazards and risks in the work place.
3. (1) Identifying OEH hazards.
   (2) Assessing the significance of the health risk.
   (3) Determining appropriate control measures.
   (4) Effectively communicating health risk information and control recommendations to leadership.
4. BE's responsibilities within the OEH program include:
   (1) Assisting commanders and supervisors with integrating OEH input into RM bases decision processes.
   (2) Accomplishing OEH risk assessments.
   (3) Executing an OEHSA for AOR.
   (4) Providing incident response.
   (5) Using DOEHRS-IH to manage data.
   (6) Completing deployment specific OEH exposure documentation.
   (7) Assessing and documenting OEH exposure data.
   (8) Providing consultation and technical expertise to work areas/workplaces.

(9) Providing consultation on OEH exposures.

(10) Serving as OEH program liaison to regulating authorities.

(11) Participating member of the HMMP team.

202

1. These agencies are empowered to create and enforce rules and regulations that carry the full force of the law.
2. Title 29 CFR, *Labor.*
3. 48 series.
4. USAPHC.

203

1. DOEHRS.
2. The DOEHRS-IH system automates the following:
   (1) Capture comprehensive, operational and work task potential exposures based medical and environmental surveillance recommendations.
   (2) Track DOD lifetime personnel exposure data.
   (3) Capture workplace practices, use, and recommendations of protection equipment, and occupational and environmental data in support of military operations worldwide.
   (4) Capture environmental surveillance data for deployed and garrison locations.
   (5) Capture PH information related to food safety, general sanitation, entomology, and waste management.
   (6) Capture and maintain environmental exposure registries.
   (7) Capture and track industrial ventilation system performance.
   (8) Capture individual training/certifications, quantitative or qualitative respirator fit test results.
3. Environmental Health.
4. The OEHSA survey.
5. A history of the following:
   (1) Pre-deployment.
   (2) Deployment.
   (3) Post-deployment exposure.

204

1. The HRA is the process of identifying and defining dose-response relationships and hazard criteria, collecting all relevant and reliable exposure information to refine the hazard criteria and to characterize the risks associated with realistic combinations of hazards and exposures. It can further be described succinctly as a science-based evaluation of risk, while HRM is the process of identifying, evaluating, and implementing courses of action to reduce risk to human health.
2. Individuals who assess OEH risks both evaluate the risk (HRA) and implement courses of action and conduct follow-up assessments.
3. The five components of the AF Risk Assessment/RM framework are:
   (1) Identify hazards.
   (2) Assess hazards.
   (3) Develop controls and make decisions.
   (4) Implement controls.
   (5) Supervise and evaluate.
4. The four principles of RM implementation are:
   (1) Accept no unnecessary risk.
   (2) Make risk decisions at the appropriate level.
   (3) Accept risk when benefits outweigh the costs.

(4) Anticipate and manage risk by planning.

5. The ultimate goal of the HRA is to provide leadership with concise COA that clearly articulates health related impacts and advises on how to minimize health risks.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (201) The process of determining the level of risk to health is called
   a. health risk assessment (HRA).
   b. risk management (RM) principles.
   c. Air Force risk management.
   d. combat and operational capability control.

2. (201) What are the four aerospace medicine enterprise (AME) mission areas?
   a. Prevent casualties, provide workplace safety and fitness programs, develop and deliver occupational preventive measures, and optimize human performance.
   b. Manage risk, administer occupational and environmental health (OEH) programs, prevent casualties, and promote and sustain a healthy and fit force.
   c. Promote and sustain a medically ready force, prevent illness and injury, restore health, and optimize and sustain human performance.
   d. Administer health risk assessments (HRA), restore health, optimize human performance, and manage risk.

3. (201) Which publication provides foundational instructions and implementation procedures for the overall Air Force Occupational and Environmental Health (OEH) Program?
   a. Air Force Manual (AFMAN) 48–154, *Occupational and Environmental Health Site Assessment.*
   b. Air Force Instruction (AFI) 48–145, *Occupational and Environmental Health Program.*
   c. AFMAN 91–203, *Air Force Occupational Safety, Fire, and Health Standards*.
   d. AFI 90–802, *Risk Management.*

4. (201) According to Air Force Instruction (AFI) 48–145, *Occupational and Environmental Health Program*, a *work place* is defined as
   a. a place where people work.
   b. any environment where mission-related activities are taking place.
   c. any environment where military personnel have been charged to perform tasks.
   d. any occupational environment where a potential occupational and environmental health (OEH) exposure may occur.

5. (201) What is the *main* objective of the Air Force Occupational and Environmental Health (OEH) Program?
   a. Evaluate risks related to environmental health issues and resulting adverse outcomes.
   b. Emphasize workplace safety, fitness, and preparedness to enhance Air Force (AF) resources.
   c. Identify hazards, assess the significance of each risk, and control every hazard.
   d. Protect health while enhancing combat and operational capabilities.

6. (202) Which title of the Code of Federal Regulations (CFR) deals with protecting human health and welfare as related to the work place?
   a. Title 10, *Energy*.
   b. Title 29, *Labor*.
   c. Title 49, *Transportation*.
   d. Title 40, *Protection of Environment*.

7. (203) How are the four modules of the Defense Occupational and Environmental Health Readiness System (DOEHRS) organized?
   a. Industrial Hygiene, Workplace Assessment, Workplace Monitoring, Personal Protective Equipment (PPE).
   b. Industrial Hygiene, Potential Health Hazards, Radioactive Materials, and Personal Profiles.
   c. Industrial Hygiene, Environmental Health, Radiation, and Incident Reporting.
   d. Industry Records, Environmental Health, Records, and Compliance.

8. (203) Bioenvironmental engineering (BE) personnel use the Defense Occupational and Environmental Health Readiness System (DOEHRS) for the primary purpose of
   a. updating personnel occupational duty records.
   b. recommending disciplinary action for workplace noncompliance.
   c. documenting all information relating to occupational and environmental health (OEH) health risk assessments.
   d. reviewing new processes or operations at the earliest feasible stage to prevent or control potential OEH hazards.

9. (203) Which term refers to the Defense Occupational and Environmental Health Readiness System (DOEHRS) data stored on an individual worker's history of pre-deployment, deployment, and post-deployment exposures?
   a. Routine exposure record.
   b. Vertical record of exposure.
   c. Longitudinal exposure record.
   d. Historical exposure data record.

10. (204) Health risk assessments (HRA) are performed to
    a. estimate the operational risk for equipment damage from exposure to hazards.
    b. determine whether in-garrison or deployed control standards should be implemented.
    c. estimate the level of damage or injury to human health that may result from exposure to a hazard.
    d. record data for annual reporting to Occupational Safety and Health Administration (OSHA) and federal authorities for review.

11. (204) Providing personal protective equipment (PPE) is a potential action that might take place during which step of the risk management (RM) process?
    a. Anticipate and identify hazards.
    b. Supervise and evaluate.
    c. Implement controls.
    d. Assess hazards.

12. (204) Which is *not* a role of bioenvironmental engineering (BE) in the health risk assessment and health risk management (HRA/HRM) process?
    a. Determine appropriate control options.
    b. Identify and analyze occupational and environmental health (OEH) risks.
    c. Communicate information through the appropriate chain of command.
    d. Evaluate personnel on compliance of personal protective equipment (PPE) and safety procedures.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Introduction to Occupational and Environmental Health Risk Management

SPECIFIC DOD INSTRUCTIONS, including DODIs 6055.01 and 6055.05, referred to in the previous unit, require that every employee be provided with a work environment that is free from recognized hazards that cause or are likely to cause death, injury or illness. To meet this objective, DOD personnel must be protected from hazards in the mission environment. The Air Force accomplishes this mandate by implementing consistent and meaningful OEH assessment programs according to AFI 48–145. OEH risk assessments are divided into two categories (fig. 2–1). Note the similarities and differences of each review process.

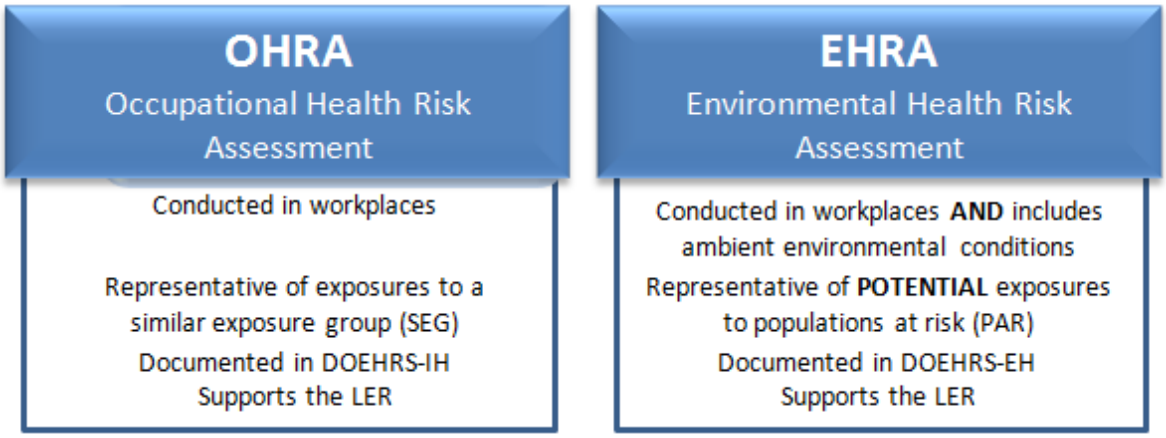


Figure 2–1. The OHRA and EHRA Risk Management Assessments.

Within the context of performing an occupational health risk assessment (OHRA) and/or environmental health risk assessment (EHRA), a work place (as previously defined) is any

environment where a potential OEH exposure may occur. Examples include an industrial shop, administrative building, and living quarters referred to in AFI 48–145. BE performs OHRAs (traditional industrial hygiene) and EHRAs to support the overall AF OEH program. Both OHRAs and EHRAs are documented in specific areas of DOEHRS. In combination, these two risk assessments support the LER documentation. There are inherent differences between these two categories of risk assessments. The information that follows highlights the similarities and differences between OEH programs. Whether performing an OHRA or an EHRA, BE should always follow the AF OEH Exposure Assessment Model to assess SEGs or PARs OEH exposure risks.

- SEGs establish a link between a group of workers and exposure to an occupational hazard. OHRAs and exposure data are linked directly to industrial shops. Service members are directly assigned to SEGs.
- PARs establish a link between OEH exposure(s) via a common location or sub-location. EHRAs and exposure data are linked to locations. Service members are not directly assigned and managed in PARs like SEGs.

2–1. Occupational Health Program

The occupational health program encompasses a large number of critical components that we must continually keep in place and constantly assess their effectiveness. This includes assessment strategies to ensure exposures are properly controlled, categorizing risk-levels within the work place and making recommendations, and performing reliable OEH assessments to ensure safe and healthful working conditions. When injuries or illnesses occur within someone's occupation, it is vital to investigate and see if safer steps may be implemented to reduce or eliminate future occurrences. Pregnancy evaluations are an important part of keeping both personnel and family members safe. Further, reviewing the Air Force Inspection System (AFIS) as it applies to our work environments is essential to proper implementation; soliciting expert input from external sources also provides invaluable feedback to improve our processes. Finally, when work order requests are submitted, it is important to ensure their implementation will not negatively impact a safe and healthful work environment.

205. Exposure assessment strategies

BE is responsible for conducting industrial hygiene assessments (e.g., OHRA) in industrial work places or IH shops and providing recommendations or solutions to control or reduce unacceptable exposures through HRM decisions.

The AF occupational health program implements the DOD-IH Exposure Assessment Model to assess and manage occupational health threats (fig. 2–2). The DOEHRS-IH system design is based on the DOD-IH Exposure Assessment Model. The DOD-IH Exposure Assessment Model consists of eight major elements that are implemented in the AF OEH Exposure Assessment Model. The AF implementation of the DOD exposure assessment model requires an organized, intentional and repetitive approach. It is organized into two basic courses of action: routine OEH assessment and special OEH assessment (fig. 2–2), referred to in AFI 48–145.

Routine OEH Assessment Overview

The routine OEH assessment is a short-duration assessment conducted to identify and scope out the processes used to execute a unit's mission. Both qualitative and/or quantitative data may be collected. Potential health hazards and associated risks should be studied in order to be categorized and additional health assessment requirements can be identified. The routine OEH assessment is designed to be short-duration, and identify/prioritize the need for a more in-depth (special) assessment.

The principal purpose of a routine OEH assessment encompasses the following:

- Identify OEH support requirements.

- Identify potential OEH hazards related to processes.
- Assign a qualitative risk to each hazard.
- Identify any health hazard that may require a design change or modification to an existing weapons system to eliminate/mitigate the hazard.
- Monitor Compliance with Air Force and OSHA regulatory requirements in-garrison.

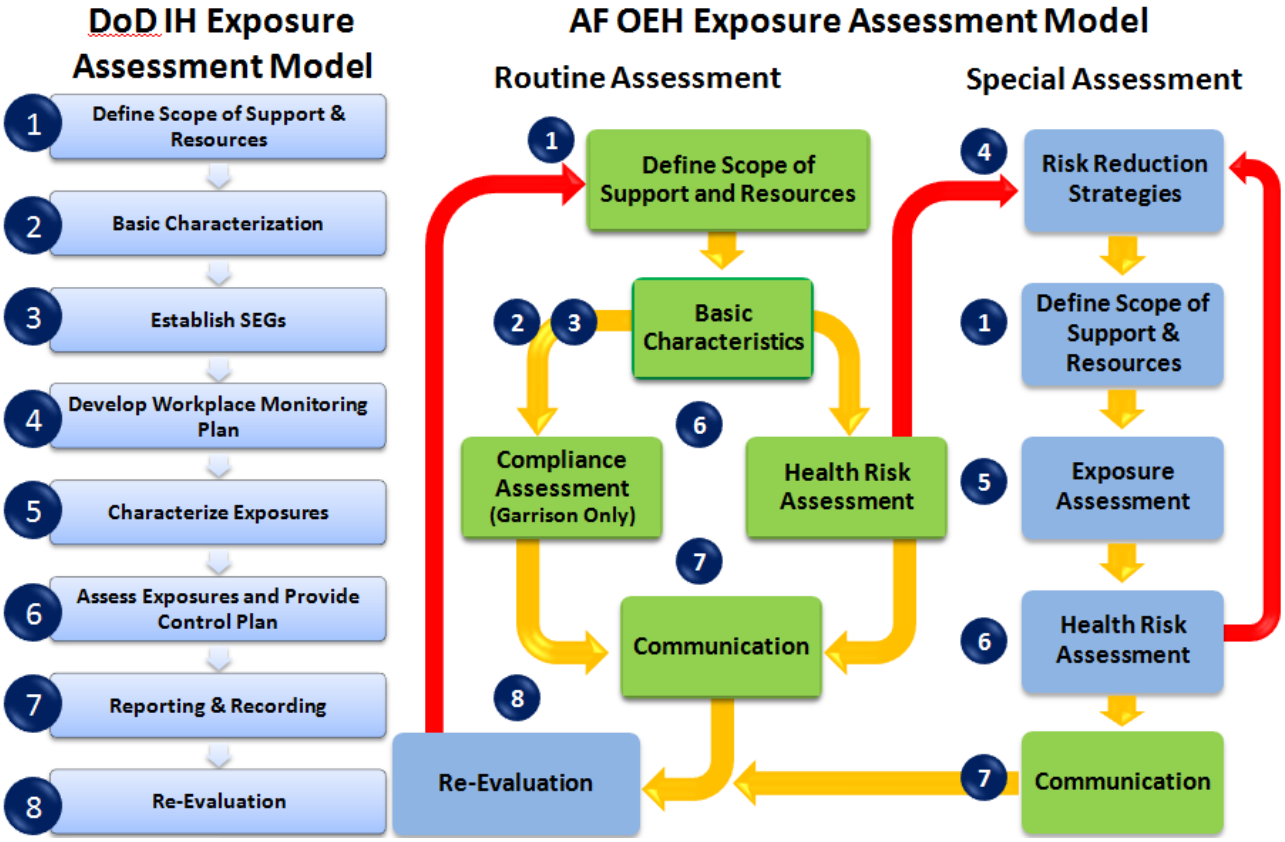


Figure 2–2. The DOD and Air Force Exposure Assessment Models. [1]

Information obtained from the routine OEH assessment is then conveyed to the appropriate organization for information/action (such as a change or modification to an existing weapons system to eliminate/mitigate a hazard). Furthermore, the routine OEH assessment focuses limited BE resources in a prioritized manner.

The process of performing a routine OEH assessment is discussed in-depth in later in this unit.

Special OEH assessment overview

The special OEH assessment is typically a quantitative assessment (e.g., air sampling) of OEH-related hazards that require additional evaluation or classification. During special OEH assessments, BE further characterizes health risk through specific additional monitoring. The results are interpreted by comparison with applicable health-based exposure standards. Information obtained from the HRA is then conveyed to the appropriate organization for information/action.

The principle purpose of a special OEH assessment encompasses the following:

- Quantify potential exposures identified during the routine assessment.
- Perform periodic control evaluations (e.g., ventilation surveys).
- Evaluate unscheduled requests (e.g., OEH illness/injury investigations, pregnancy evaluations).

- Provide follow-up action on recommendations/direction from the OEHWG.
- Sustain compliance with regulatory requirements (garrison only).
- Provide CC and affected individuals with a summary of the outcome of the special assessment and recommended actions to reduce hazard/risk to acceptable levels.

Specific requirements dictate when routine and special OEH assessments must be performed. The process for determining routine OEH assessment scheduling requirements is called workplace categorization**.**

206. Workplace categorization

Simply stated, the workplace categorization process is a method for achieving the following goals:

- Prioritizing resources and time for those work places or activities that pose the greatest health risks to AF personnel.
- Scheduling the frequency for routine OEH assessments in shops.

Workplace categories with assessment frequencies

Based on AFI 48–145 and local priorities, each work place is evaluated and categorized, and its minimum assessment frequency is then established. Most likely, your installation has a well-established surveillance plan and its existing work places have already been characterized. However, new work places are occasionally identified, such as during a change in mission. When establishing a program during bare-base build-up, all work places must be categorized. Information collected during the basic characterization step will be used to determine if the shop is a workplace category 1 (high hazard area), 2 (medium hazard area), or 3 (low hazard area), as illustrated in the following table. Note the distinguishing characteristics and minimum assessment frequency associated with each particular category.

Workplace Category	Characteristics	Minimum Assessment Frequency (Months)
1 - High Hazard Area	• Hazards poorly defined or poorly controlled; and unstable work environment and processes. • Inherent OEH risk present with medium to high hazard potential. • Regulatory assessment requirements, e.g., asbestos (Title 29 CFR 1910.1001, *Asbestos*). • Requirement for special purpose occupational exams, other than audiograms. • Potential for significant OEH regulatory non-compliance.	Assessed every 12 months.
2 - Medium Hazard Area	• Hazards well defined and controlled; work environment and processes stable. • Inherent OEH risk present with relatively low hazard potential. • Minimal potential for hazards to go out of control or create significant risk. • Requirement for annual audiograms. • Potential for OEH regulatory non-compliance.	Assessed every 30 months.

Workplace Category	Characteristics	Minimum Assessment Frequency (Months)
3 - Low Hazard Area	• No hazards; work environment and processes stable. • Non-existent or negligible sources of OEH risk present. • Full OEH regulatory compliance.	Assessment frequency locally determined.

The final categorization of each work place rests with your BE Flight/CC (or equivalent) in consultation with the OEHWG. Keep in mind that workplace processes and conditions can change, and therefore, affect the categorization. If changes occur, you must reassess the categorization. The categorization rationale for each work place should be documented in DOEHRS.

The required frequencies previously mentioned establish the minimum requirement for routine OEH assessments. However, a work place should be assessed as frequently as necessary to adequately identify, analyze, and control OEH hazards. Any decision to exceed the established minimum assessment frequency should be made by your BE Flight/CC, in consultation with the OEHWG.

207. Performing a routine occupational and environmental health assessment in a work place

Routine OEH assessments provide an opportunity to gather a snapshot of a work place's occupational health. While designed to be of short duration, routine assessments remain sufficient to accomplish the following:

- Update administrative data.
- Review previous assessment information.
- Identify processes and associated OEH hazards and controls.
- Assess health risks.
- Determine compliance with OEH program requirements.
- Identify the need to, prioritize, and schedule more in-depth (special) assessments.

The following paragraphs describe the steps that are involved in conducting routine OEH assessments.

Define scope of support and resources

- Identify work places (e.g., industrial shops) that require support.

NOTE: In DOEHRS, the term *shop* is synonymous with *work place*. Further, DOEHRS is designed around the concept of shops to identify industrial work places that contain occupational health hazards.

- Capture organization demographics.
- Receive unscheduled requests for surveys.
- Program and budget.
- Schedule and suspense.

Basic hazard characterization

Before visiting the work place, you should familiarize yourself with any existing OEH assessment data obtained and compiled during past assessments. This will allow you to determine a surveillance strategy for the pending routine OEH assessment. This data can be found in several places including DOEHRS, the Enterprise Environmental, Safety, and Occupational Health—Management Information System (EESOH-MIS), special survey reports, occupational illness reports, and so forth.

Review previously collected data, including a quality assessment of the data

After gathering the data, review the processes conducted in the work place, the potentially hazardous substances used, previously collected sampling data, and any available control measures. In addition, take notice of noted discrepancies and deficiencies and whether or not they have been corrected. This review should give a solid foundation to begin the next assessment.

Identify applicable processes

Per AFMAN 48–146, within DOEHRS a process is defined as the lowest level of work that may pose a risk. There may be one or more processes per shop. Each process may require evaluation and control to ensure human health is adequately protected.

Contact the workplace supervisor to explain the purpose of the routine OEH assessment and identify shop processes.

The minimum information for you to convey includes the following:

- Scope of and schedule for completing the routine OEH assessment.
- Status of previously identified findings.
- Adverse trends in clinical surveillance or OEH-related illnesses.

When you arrive at a work place you need to accomplish the following:

- Introduce yourself to the workplace supervisor and any other people present and *explain* the purpose of the assessment.
- Review the existing assessments and/or actions with the supervisor that have taken place since the last assessment or visit to the work place.
- Ask those in attendance if they have any questions about the routine OEH assessment process.

From the documentation previously reviewed and the opening conference, you should have a good idea of the types of OEH risks existing in the work place. During the routine OEH assessment, you should observe workers and processes, ask and answer questions, and take good notes to better understand the intricacies of the shop and processes accomplished therein. The more questions you ask, the more knowledgeable you will become of how shop personnel perform their duties as well as the potential OEH risks associated with their duties.

As you observe the various processes, ask questions that relate to the processes taking place. Some workers may not feel comfortable being observed and/or questioned. If you explain your purpose, present yourself in a professional manner, and ask sincere questions, you can put most workers at ease. Remind workers that you are there for them to ensure all OEH risks are identified, analyzed, and controlled. If you encounter a worker that will not cooperate with you, do not be aggressive. Proceed with the assessment and present your question(s) to another worker or the workplace supervisor.

You should always pay attention to the following:

- Processes: View the worker's equipment, observe procedures taking place, and control measures currently in place. Determine if shop personnel have the correct controls and if they are using and maintaining them properly.
- Chemical hazards: Identify chemicals used. How and why are workers employing these chemicals? How much of the chemicals are being used? Ask questions and look in the storage lockers.
- Physical/biological hazards: Look for sources of loud noise. Do personnel work in extreme temperature environments? Do they have the potential for exposure to any biological hazards?

- Exposure controls: Identify general and local exhaust ventilation systems. Are the workers using any PPE? Are the workers using controls properly? Inspect the PPE and note important information such as model number and condition (e.g., tears, serviceability).
- Pre-existing conditions: Are there any OEH hazards not previously identified and evaluated?
- Compliance: Compliance with the hazard communication program.

Associate OEH hazards with processes

Assign an appropriate name to each process and provide a clear description. The workplace supervisor or workers can aid in effectively naming and describing each process.

Walking around the work place and observing workers will provide a wealth of information about the workplace processes and hazards. While conducting the walkthrough, do not interfere with any work activities; however, get close enough to observe workers in action. In addition, you may have to request (through the workplace supervisor) that a worker perform a certain task/process; some potentially hazardous operations may not occur the day you are present. In most cases, the supervisor will not mind as long as you explain that your purpose is to evaluate all OEH risks in the work place.

If the flight has a workplace assessment checklist already developed, you should use it to assess all programs/processes; identify any discrepancies and assess hazards. Taking notes during a walkthrough will also help you to determine what special OEH assessments to schedule and prioritize. It will also help you develop the assessment letter. If the flight does not have a checklist, make notes during your documentation review which you can use when you do your routine OEH assessment.

Establish one or more SEGs based on the processes performed by each affected group.

The SEGs establish a link between groups of individuals in a work place who share a common exposure to an OEH hazard. Representative and/or individual exposure assessment data are applied to personnel assigned to a SEG. A SEG can be established by the following:

- Observing work practices.
- Accomplishing OEH hazard characterization/assessment and using data to define the SEG.
- Combining both activities.

Single SEG

A single SEG is adequate if all individuals assigned to a single work place encounter the same OEH hazards and have the same exposure potential.

Multiple SEGs

Multiple SEGs are necessary to accurately reflect representative exposures for workers assigned to the same work place, but who are exposed to different hazards or have different exposure potentials. Establishing SEGs is a critical step since the information you obtain may provide details to define the overall workplace prioritization category.

Personnel may be assigned to multiple SEGs and/or assigned to a SEG outside their assigned unit (e.g., an individual may be assigned to a hazardous material [HAZMAT] response team, which is composed of individuals from various work places). SEG data must be collected and documented in DOEHRS for both home station and deployed locations to ensure an accurate LER is maintained for all AF personnel. Upon arrival in-theater, the individual must be assigned to the appropriate deployed SEG.

Identify and evaluate controls designed to address each OEH hazard

BE assesses the adequacy of existing controls and provides OEH hazard control recommendations. OEH hazard controls are discussed in detail in section 2–3 of this unit, Health Risk Controls Overview.

Health risk assessment

An HRA for a routine OEH assessment is typically a qualitative estimation of hazard risk (i.e., high, medium, low) based on the magnitude of potential consequences (i.e., severity) resulting from exposure, and the probability that an exposure will occur. In order to estimate risk, BE personnel must perform a qualitative or quantitative assessment of exposure. The exposure assessment typically involves comparing a measured or estimated exposure to an applicable occupational exposure limit (OEL) (e.g., OSHA PEL, ACGIH TLV, and USAPHC MEG) in order to determine whether a measured or estimated exposure is unacceptable. When exposures are unacceptable, or when you are uncertain of the level of exposure, an additional special OEH assessment may be necessary.

Unacceptable exposure

A condition for which the probability of adverse health effects is significant, or there is evidence of adverse health effects associated with a specific OEH hazard.

Uncertain exposure

When the exposure level/profile of a hazard is not well characterized and the acceptability or unacceptability of a SEG's exposure assessment cannot be determined without further data collection.

If a standard is not available, base a qualitative exposure assessment on available information or communicated within the context that no standard is available. In other words, tell the stakeholders that no standard exists, and that the assessment is based on your best professional judgment. Many chemical hazards do not have established standards. In this case, research the chemical's toxicological properties and consider the primary route of exposure to conduct a qualitative assessment of the hazard.

Analyzing OEH threats includes much more than simply quantifying the hazard and comparing to a standard. Conditions will vary from situation to situation that potentially may affect which COA is selected to manage the threat. Analyze each health threat within the context of the operations occurring at the time. For example, the operational context at Wright-Patterson Air Force Base is very different from Bagram Airfield. Missions are different, threats are different, and priorities are different. These differences are considered operational context and may or may not take priority. Discuss the risk and the consequences of accepting or controlling the health risk with your chain of command, if necessary, through the RM process. All of this information will help the commander decide the appropriate COA. From that point, decision makers need ways to prioritize identified risks for the purposes of prioritizing HRAs and developing countermeasures against health threats.

Assess hazard exposure using the exposure assessment priority process

According to AFMAN 48–146, when a routine OEH assessment, or another trigger event (e.g., occupational health illness investigation), identifies a work place that needs additional data to properly analyze an OEH risk, you will conduct a special OEH assessment. Further, some special OEH assessments are required on a recurring basis (e.g., compliance air sampling for expanded standard chemicals), while others may be special requests from workplace supervisors, medical providers, and/or other base agencies. No matter what is driving the special OEH assessment, BE should prioritize by using the exposure assessment priority (EAP) process; establish a workplace monitoring plan, and schedule systematic steps/milestones through the master schedule in DOEHRS. In order to do this, the special OEH assessment must be associated with at least one hazard in DOEHRS.

Compliance assessment (garrison only)

The routine OEH assessment (or special OEH assessment) may satisfy all or part of an Environmental, Safety and Occupational Health Compliance Assessment Management Program (ESOHCAMP) assessment. The compliance assessment involves comparison of a sample that is representative of the SEG's exposure to a regulatory standard (e.g., OSHA PEL).

While conducting compliance assessment, be sure to accomplish the following:

- Identify applicable checklist items for the specific work place.
- Answer checklist questions for the applicable OEH program areas (e.g., respiratory protection program).

Exposure assessment

When you complete the EAP process described above, make a determination of the acceptability of the exposure. The following are the three options with their associated courses of action:

1. Acceptable: document and verify periodically through routine assessment.
2. Unacceptable: provide control recommendations as necessary using the hierarchy of controls.
3. Uncertain: gather additional information through qualitative and quantitative assessment.

Communication

The outcome (e.g., OEH risks and results) of the routine OEH assessment should be communicated to the workplace supervisor. No more than 60-days after initial contact with the workplace supervisor or according to OSHA standards (when applicable), BE will communicate significant findings at the conclusion of the assessment. BE should perform OEH risk communication through a closing conference and with a written routine OEH assessment report.

Closing conference

BE should perform a closing conference with the workplace supervisor to discuss findings, conclusions, and recommendations that will be included the routine OEH assessment report. You should be prepared to discuss the following topics at the closing conference:

- Review findings: Discuss with the workplace supervisor the specific findings of your assessment such as any new health risks not previously identified, repeat findings not corrected, control measures, and any issues of non-compliance.
- Make recommendations and discuss follow-up actions: After reviewing the findings, discuss any specific recommendations that the workplace supervisor should implement to ensure workplace compliance and/or reduce workers' risks. The key is to explain why the recommendations are necessary and the likely consequences of not correcting the non-compliance issue (e.g., hearing loss, overexposures, etc.). Review necessary follow-up actions. For example, if you are going to return to conduct any special OEH assessments, such as a ventilation survey or air sampling, let the supervisor know what the assessment is, why it is necessary, and how long it will take. If possible, schedule a time for the special OEH assessment while you are still at the work place.
- Discuss expectations: Discuss any expectations that you have of the workplace supervisor. For example, request the supervisor contact you to schedule a time when you can go out to the work place to perform any special OEH assessments such as air sampling, noise dosimetry, and so forth.

Workplace supervisor

BE will provide the workplace supervisor with a detailed workplace routine OEH assessment report containing significant assessment findings, conclusions, and recommendations discussed during the closing conference. The assessment report flows to the workplace supervisor via the workplace CC (e.g., squadron CC).

According to AFMAN 48–146, the following is mandated content and attachments for the routine OEH assessment report:

- Cover letter.
- Summary of health risks and list of current processes which exceed action levels.

- Summary of all risk assessment codes (RAC) assigned to the work place.
- Recommendations and required follow-up actions, including suspense dates and request to notify BE of completion in writing.
- Attachment: Identified health risk controls linked to specific process(es) and SEG(s).
- Attachment: Certified PPE list (mandatory).

BE should direct the workplace supervisor to make the report and attachments available to all employees according to AFI 91–202.

Documentation

Routine OEH assessments are complete when all the following are accomplished:

- All assessment documentation/data is entered into DOEHRS.
- The OEHED summary is updated.
- The assessment report is sent to the workplace supervisor through the workplace CC.

The OEHED is exposure data used to determine the operational risk associated with actual and/or potential OEH exposures and to develop preventive medicine recommendations associated with the SEG. The OEHED is updated by BE as part of the routine OEH assessment by inputting the appropriate assessment data into DOEHRS. The DOEHRS-generated OEHED is provided to the OEHWG to determine Medical Surveillance Exam requirements.

Furthermore, BE should chronologically document each contact with a work place by filling in the Observations and Notes section in DOEHRS. This includes recording the date, individual contacted, type of contact, reason for the contact, and a summary of any relevant information discussed.

Re-evaluation

The workplace process hazards and controls should be re-evaluated within a timeframe that does not exceed the workplace category minimum assessment frequency [1]. Work places can and should be re-evaluated more frequently when existing controls do not adequately protect the worker and when process changes occur.

208. Occupational and environmental health injury and illness investigation

According to AFI 48–145 an occupational injury or illness is defined as a suspected or confirmed adverse health event caused or aggravated by employment as described in Occupational Injury and Illness Reporting Guidelines for Federal Agencies. An occupational illness and injury investigation is a type of special OEH assessment.

The purpose of conducting an occupational illness or injury investigation is to:

- Determine if a worker’s injury or illness is or was related to his/her job.
- Identify the reason(s) why a person experienced the illness/injury so future occurrences can be prevented.

Differences between an occupational illness and injury

There is a difference between what is considered an occupational illness versus an occupational injury. According to AFMAN 48–146, an occupational injury is a medical condition that evolves over the period of no more than a single workday or work shift (e.g., laceration). An occupational illness, on the other hand, is a medical condition that evolves over more than one work shift (e.g., carpal tunnel syndrome). Illnesses include acute and chronic illnesses or diseases that may be caused by inhalation, absorption, ingestion, or direct contact. There are different categories of occupational illnesses; these include, but are not limited to, those discussed in the occupational illness category listing, provided in the following table:

Occupational Illness Categories	
Category	**Examples**
Skin diseases and disorders	Contact dermatitis, eczema, or rash caused by primary irritants and sensitizers or poisonous plants, oil acne, chrome ulcers, chemical burns, or inflammations.
Dust diseases of the lungs (pneumoconiosis)	Silicosis, asbestosis, and other asbestos-related diseases, coal workers pneumoconiosis, byssinosis, siderosis, and other pneumoconiosis.
Respiratory conditions due to toxic agents	Pneumonitis, pharyngitis, rhinitis or acute congestion due to chemicals, dusts, gases, or fumes; farmer's lung.
Poisoning (systemic effect of toxic materials)	Poisoning by lead, mercury, cadmium, arsenic, or other metals; poisoning by carbon monoxide, hydrogen sulfide, or other gases; poisoning by benzol, carbon tetrachloride, or other organic solvents, poisoning by insecticide sprays such as parathion, lead arsenate; poisoning by other chemicals such as formaldehyde, plastics, and resins.
Disorders due to physical agents (other than toxic materials)	Heatstroke, sunstroke, heat exhaustion, and other effects of the environment; caisson disease; effects of ionizing radiation; and effects of nonionizing radiation.
Disorders associated with repeated trauma	Noise induced hearing loss; synovitis, tenosynovitis, and bursitis; Raynaud's phenomena; and other conditions due to repeated motion, vibration, or pressure.
All other occupational illnesses	Brucellosis, infectious hepatitis, malignant and benign tumors, food poisoning, histoplasmosis, and coccidioidomycosis.

Procedures for investigating a report of occupational illness or injury

An occupational illness investigation begins when a health care provider (HCP) sees a patient and suspects the person experienced an illness/injury related to his/her workplace environment. The HCP enters the patient information into the Armed Forces Health Longitudinal Technology Application (AHLTA) system. AHLTA notifies and prompts PH that there is a pending occupational illness. PH will interview the person, gather facts about the illness, and enter the applicable information into the AFSAS. PH notifies your office if there is an occupational illness that requires an investigation by your flight. You, or someone from your flight, will review the information in AFSAS and conduct the workplace occupation illness investigation using the steps in the following paragraphs:

Exposure assessment

This step involves identifying and assessing the conditions or circumstances that caused or contributed to the occupational illness. You can do this through worker interviews, workplace visits, observations, and special OEH assessments. A special OEH assessment may be needed if, during the investigation, you find that existing controls are inadequate or the hazard is poorly characterized.

Evaluate effectiveness of controls

This is where you determine the availability and serviceability of workplace controls, and if they properly used. The following are some items you need to assess:

1. If the individual was wearing appropriate PPE (gloves, safety glasses, coveralls, etc.).
2. Use of required engineering controls (such as a ventilation system).
3. Adequate employee training.
4. Evidence of appropriate workplace personal hygiene practices.

Identify non-compliance factors

Based on all the assessment information you obtained, determine if the occupational illness was a result of non-compliance. Some non-compliance factors include but are not limited to: incorrect PPE,

improper/missing hazard communication training, unauthorized use of HAZMATs, and improper workplace hygiene (e.g., food/drink in an ingestion hazard area).

Document the occupational illness

After the occupational illness investigation is complete, you will enter the facts and findings of your investigation in AFSAS. PH will print out an AFSAS-produced AF Form 190, Occupational Illness/Injury Report, and file a copy in the individual's medical record.

Your role in the occupational illness/injury report process is to gather and document all of the pertinent facts. The OEHWG, in conjunction with the occupational health physician, makes the determination of whether the individual's illness was a result of a workplace exposure. In addition, if you notice there were any non-compliance issues in the work place that contributed to the occupational illness, brief this information along with any control measure recommendations to the workplace supervisor.

209. Pregnancy profile evaluations

Pregnant workers in certain AFSCs have the potential to be exposed to a variety of agents known or suspected of posing a risk to the human reproduction system and/or the fetus. AFI 44–102, *Medical Care Management*, provides guidance concerning the basic restrictions for pregnant workers.

Pregnant worker evaluations protect the reproductive health of AF members from occupational exposures to chemical, biological, radiological, or physical substances. This includes any known or suspected substances capable of posing a risk to human reproduction and to identify potential reproductive and developmental hazards. The depth of your investigation depends on the risks and existing information concerning the agents the individual encounters in the work place.

Procedures for conducting pregnant worker evaluations

The process begins when PH refers a pregnant worker to your office to conduct a detailed pregnancy worker evaluation. Once notified, you should conduct the evaluation as thoroughly and as quickly as possible, providing the information back to PH within the timeframe established by local policy. The following seven steps are involved in conducting a pregnant worker evaluation:

1. Verify job description with the worker and worker's supervisor. Due to Health Insurance Portability and Accountability Act (HIPPA) regulations, do not reveal to the supervisor that the worker is pregnant.
2. Review the workplace assessment/exposure data (if available).
3. Determine if there are any previously measured or unmeasured exposures that could apply to the pregnant worker.
4. Note all known or suspected reproductive hazards by comparing the worker's exposures to various references and identify all teratogens, mutagens, and carcinogens.
5. Identify chemical, physical, radiological, and biological data, to include heat stress, noise, and vibration data. Specify whether the hazards are based on human or animal studies.
6. List all of the PPE that is available and used to execute assigned duties.
7. Document the facts you observe during your evaluation.

Keep in mind that when conducting your evaluation, it is not your responsibility to recommend removal of an individual from performing any duties**.** Your role is to do the research, identify and document the hazards, and provide the facts. It is the HCP's responsibility to review the facts and make a determination whether or not to remove the individual from any current workplace duties.

210. Internal/external inspections of the Air Force Inspection System

The AFIS focuses on assessing and reporting on a unit's readiness, economy, efficiency, effectiveness and state of discipline to execute assigned missions. The AFIS provides commanders at all levels an independent assessment of the following:

- A unit's compliance with established directives and ability to execute its assigned mission, leadership effectiveness, management performance, and aspects of unit culture and command climate.
- A unit's ability to find, analyze, report, and correct deficiencies.
- A unit's ability to prevent fraud and minimize waste and abuse.

AFIS gives major commands (MAJCOM) an assessment of the functional effectiveness and compliance in the field, and of the adequacy of organization, policy, guidance, training, and resources. Furthermore, it provides a mechanism to direct a targeted, more detailed and thorough inspection of specific programs, organizations, or issues. Inspections are part of a cyclical feedback loop to measure performance and adherence to standards.

Inspections and BE responsibilities

BE has numerous responsibilities and requirements associated with the AF OEH programs. These requirements form the basis upon which a BE flight's performance is assessed in determining how effective the BE flight supports the overall AF OEH program. BE responsibilities and requirements come from many government regulations such as OSHA, EPA; DOD, and AFIs; industry guidelines (e.g., ANSI consensus standards and NIOSH guidelines); and MAJCOM, Wing, and Squadron policies. Taken together, these requirements form the basis for standards of performance.

Inspections are performed by authorities within (i.e., internal inspections) and outside the unit (i.e., external inspections).

External inspections

The BE flight may participate in numerous external inspections and evaluations. These may include but are not limited to the unit effectiveness inspection (UEI), RAM permit inspection, and nuclear surety inspection (NSI).

Unit effectiveness inspection

UEI is a continual evaluation of Wing performance throughout the inspection period—a photo album versus a snapshot. The inspection period begins immediately after the close-out of the previous UEI report. The UEI inspects the following four major grading areas (MGA):

1. Managing Resources.
2. Leading People.
3. Improving the Unit.
4. Executing the Mission.

UEIs validate and verify a wing CC's inspection program (CCIP) for accuracy, adequacy and relevance, and provide an independent assessment of the wing's resource management, leadership, process improvement efforts and ability to execute the mission. A UEI is a years-long, continual inspection of the unit's effectiveness, and is intended to help the wing CC understand the areas of greatest risk from undetected non-compliance. The UEI is not primarily focused on detecting non-compliance. On the contrary, the UEI should validate and verify the commander's own compliance detection program, identify areas for the wing/CC where he/she has significant risk of undetected non-compliance. The frequency for UEIs is a 24- to 30-month cycle. BE requirements associated with supporting the AF OEH programs are inspected under the UEI, according to AFI 90–201, *The Air Force Inspection System*.

Radioactive material permit inspection

The AFIS performs this no-notice inspection that occurs periodically (the frequency depends on your installation's RAM permit). The purpose of the inspection is to evaluate the BE flight's performance in managing permitted RAM.

Nuclear surety inspection

An NSI assesses a unit's ability to accomplish its assigned nuclear weapons mission and produce reliable nuclear weapons in a safe and secure environment in compliance with applicable directives. Additionally, an NSI inspects a unit's capability to safely and reliably receive, store, secure, assemble, transport, maintain, load, mate, lock/unlock, test, render safe, and employ nuclear weapons. The NSI inspects and evaluates the following DOD MGAs:

- Management and administration.
- Technical operations.
- Tools, test, tie down and handling equipment.
- Storage and maintenance facilities.
- Security.
- Safety.
- Supply Support.
- Nuclear weapon personnel reliability program (PRP).

The medical group will be involved in both the safety and nuclear weapon PRP pieces of the inspection. MAJCOMs must perform NSIs at least once every 18 months. However, this directive can potentially be waived (by the MAJCOM/CC) to allow a frequency of 24 months.

Internal inspections

Inspections are an inherent function of command that allows commanders to hold leaders at all levels accountable for readiness, compliance and discipline. Internal inspections allow the commander to determine appropriate training and resourcing requirements; assess status of discipline; evaluate wing readiness; and formulate command welfare strategies.

According to AFI 90–201, CCIP addresses internal inspections. A validated and trusted CCIP is the cornerstone of AFIS. The CCIP should give the wing/CC, subordinate commanders and wing Airmen the right information at the right time to assess risk, identify areas of improvement, determine root causes, and precisely focus limited resources—all aligned with the commander's priorities and on the commander's timeline.

Commander's inspection program

The purpose of the CCIP is to improve effectiveness, compliance, readiness, discipline and surety in Air Force wings while allowing commanders the ability to assess their own unique mission issues. A CCIP annual inspection plan executed by the wing inspector general (IG) will help to reduce the risk of undetected non-compliance. The CCIP will inspect wing-wide and subordinate unit effectiveness,

as well as assessing cross-unit programs as directed by the wing/CC (fig. 2–3). Commanders will determine the appropriate scope, scale, timing, and methodology to most effectively accomplish the objectives of CCIP. In addition, CCIP's two outputs are the wing commander's inspection report (CCIR) and Management Internal Control Toolset (MICT) data which provides critical data to HAF and MAJCOM staffs about the adequacy of policy, training, manpower, funds, equipment, and facilities. The CCIP consists of the following two components:

1. The wing inspection program, which is executed by the wing IG, will inspect the efficiency of wing-wide performance and programs.
2. A self-assessment program, using MICT, reports compliance with the self-assessment checklist (SAC).

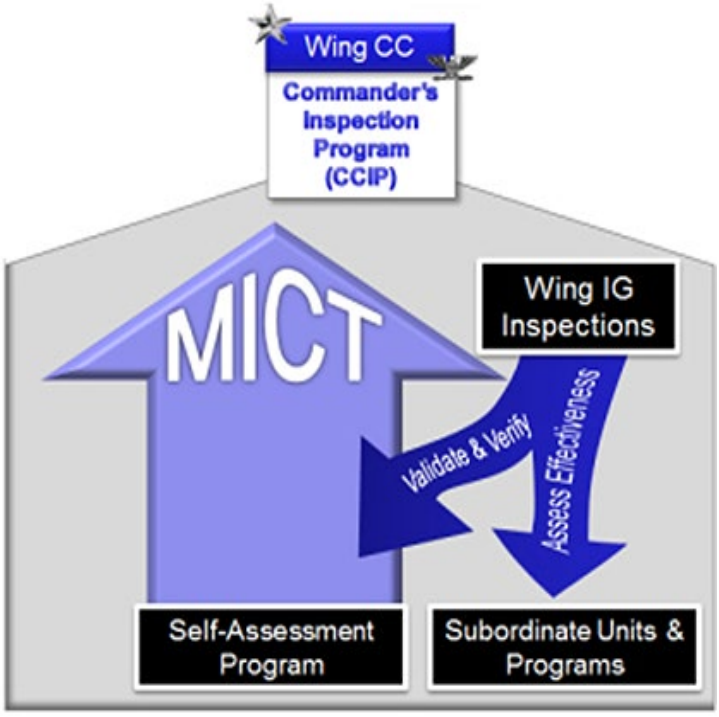


Figure 2–3. Commander's inspection program.

Wing inspection program

The wing inspection program is the first part of the CCIP. The wing IG develops an annual inspection plan according to the wing commander's guidance to enable a reliable assessment of the wing's readiness, compliance and state of discipline. The wing commander will determine the inspection interval for wing programs and processes. Real-time data on programs and inspections are reported to the wing commander, including non-compliance on MICT and deficiencies in the CCIR. The BE flight will have both direct and indirect involvement in these exercises. Further, there is the responsibly to provide input into the MICT and answer any deficiencies during an exercise. Therefore, it is imperative to know what types of exercises are going to be scheduled, some of which are included in the following table.

Exercise Description	Frequency	Remarks
Emergency Management	Annual	See DODI 6055.17 for details regarding forum and integration with other exercises
Antiterrorism	Annual	See DODI O-2000.16, Volume 1, *DOD Antiterrorism (AT) Program Implementation: DOD AT Standards*, for details
Force Protection Condition Measures	Annual	See DODI O-2000.16, Volume 2, *DOD Antiterrorism (AT) Program Implementation: DoD Force Protection Condition (FPCON) System*, for details
Public Health Emergency	Every two years	See DODI 6200.03, *Public Health Emergency Management within the Department of Defense*, for details
Fire & Emergency Services (F&ES) Disaster Preparedness Plans	Annual (each fiscal year by tabletop or physical exercise)	Exercise methodology used at discretion of Wing/CC. See DODI 6055.06, *DOD Fire and Emergency Services (F&ES) Program*, for details.
Information Assurance	Varies between annual and semiannual	Frequency depends upon installation mission assurance category and confidentiality level. See DODI 8500.02, *Use of Commercial Wireless Devices, Services, and Technologies in the Department of Defense (DOD) Global Information Grid (GIG)*, for details
Nuclear Weapons Accident Response	Annual	Must participate in an exercise annually. See DODD 3150.08 for details
Continuity of Operations	Annual	See DODD 3020.26, *DOD Continuity Policy*, for details
Chemical, Biological, Radiological, Nuclear and High-Yield Explosives	Annual	See DODI 3020.52, *DOD Installation Chemical, Biological, Radiological, Nuclear, and High-Yield Explosive (CBRNE) Preparedness Standards*, for details.

Self-assessment programs

Self-assessment is the second part of the CCIP and provides commanders with a means for internal assessment of a wing's overall health and complements external assessments. The primary purpose of the self-assessment program is to accurately identify and report issues through the chain of command. Commanders at the wing, group, and squadron level appoint self-assessment program managers. There are two tools the self- assessment program uses: the SAC and the MICT. The SAC is used to populate the MICT with information. Each program manager will use the MICT to record self-assessments and identify individual assessors for each SAC based on how HAF assigns each SAC. You may be assigned as an assessor and complete a SAC on various OEH programs within the flight, and then populate the MICT with the results.

SAC

A SAC is a two-way communication tool designed to improve compliance with published guidance. HHQ functional managers create SACs within the MICT to help Airmen understand what is most important, and to provide an efficient means of communicating compliance or non-compliance up the chain of command and appropriate staffs. Then, as part of the CCIP, Airmen report compliance and non-compliance with SACs through MICT. Compliance with SAC does not relieve individual Airmen from knowing the requirements of their programs and complying with guidance in AFIs and other policy documents. You may be assigned to use SAC to evaluate an OEH program and provide results in MICT for the commander's review.

MICT

MICT is an AF program of record used by Airmen to accomplish self-assessment of program management and compliance with HHQ directives. MICT provides the tiered visibility and monitoring into user-selected compliance reports and program status. Commanders and functional throughout the chain of command can monitor programs for near real-time compliance and trends using MICT. Additionally, MICT can assist IGs with formulating specific inspection methodology and IG team composition for the CCIP and on-site UEI. MICT can also help facilitate the special interest item program by gathering time-sensitive data in an expeditious manner.

As stated previously, you have responsibilities and requirements associated with the AF OEH programs; therefore, understanding the AFIS is essential. You will have a direct or indirect role in both external and internal inspections, assessments, and reporting using the SAC and the MICT. Comprehensively collect and organize your findings. Based on your results and information, commanders determine appropriate training/resource requirements, assess status of discipline, evaluate wing readiness, and formulate command welfare strategies.

211. Reviewing local work order requests

Air Force operations are continually modified as time, technology, operations, and capabilities progress, creating construction-related changes to AF facilities. BE must actively engage in this process to ensure the protection of AF personnel. While other organizations such as civil engineering (CE) have the primary responsibility for managing facility construction, the BE insight into health risk compliance requirements is a key part of the process. The desired outcome is to limit cost, eliminate adverse health effects for AF personnel, and enhance compliance with regulatory requirements.

Self-help projects, work order requests, and construction design plans are reviewed for the following two reasons:

1. To assess the long-term impact on workplace operations (e.g., adequate ventilation).
2. The hazards the construction itself may generate (e.g., disturbing asbestos containing material).

Knowledge and experience gained from workplace surveillance enables you to provide the professional judgment to anticipate potential hazards when reviewing project plans. In some cases, projects are initiated to reduce hazards previously identified by BE, perhaps to mitigate hazards assigned by a RAC.

Identifying potential hazards

As identified earlier, you are a health risk assessor no matter where the potential risk may be. You perform an HRA to identify potential hazards and recommend control to protect the workers. There is no difference when performing a work order request review. You are expected to thoroughly and critically review the planned project, and facts about the process; afterwards, identify potential threats, examine potential control solutions, and communicate recommendations. When reviewing the work order, you will look for potential hazards at the site of the project and potential hazards the project itself might create. The following table provides examples of chemical, biological, and physical hazards for consideration when performing work order review:

Chemical Hazards	Biological Hazards	Physical Hazards
Asbestos (damaged floor tiles or insulation)	Mold	Noise
Lead-based paint	Potable water contamination	Vibration
Solvents and Adhesives		Thermal Stress
Paint overspray		Ergonomic factors
Welding fumes		

Chemical Hazards	Biological Hazards	Physical Hazards
Diesel exhaust		

After identifying potential hazards, provide recommendations on how to reduce or eliminate the hazards to the workers or surrounding population. Normally, it is important to use the hierarchy of controls: engineering, administrative, and PPE; however, during the work order review process you need to determine best COA, depending on the situation. For example, PPE is normally considered the last resort; however, if a worker scheduled to perform work for a work order where he/she may be exposed to a hazardous noise source for a short duration (few months), it may be more cost efficient to recommend hearing protection than an engineering control. Communicate all information on potential hazards and recommended controls to all players within the work order review process.

Partners in construction projects and review

A work order review board or work request review board (WRRB) includes representatives from most of the offices listed in the following paragraphs. According to AFI 32–1001, *Civil Engineer Operations*, the Automated Civil Engineer System Operations (ACES OP) will be used to collect and manage the work order requests. Members discuss the project and any concerns. A BE representative should attend the WRRB not only to review project requests, but also to establish working relationships with the other partners in the process.

Facility managers

Often assigned as an additional duty, the facility managers are the designated liaisons with CE to raise and help resolve issues. The facility manager is generally responsible for oversight on building security, maintenance, and other issues (including asbestos and lead-based paint). BE often works closely with facility managers to communicate and track resolution of facility-related health risks in the work place. The facility manager is responsible for electronically initiating work requests or corrective action in the facility through the use of ACES OP. This facilitates the request to be directed to the appropriate customer service location within CE.

Civil engineering operations

Generally, the CE operations flight is responsible for day-to-day maintenance, repair, and modification of installation facilities. They respond to requests from the facility manager, conduct repairs through in-house capability, and assist with project planning. They generally handle smaller-scale and lower-cost construction activities. The mission of the facility maintenance work center, an element of CE operations flight, is to accomplish recurring work, minor maintenance and repair, and selected work orders. Large work order requirements normally meet a WRRB, which determines the priority of execution and method of accomplishment (e.g., in-house or contract).

Civil engineering customer service

This is a section of CE operations that interfaces with the facility manager to receive the work order request and ensure proper completion.

Civil engineering flight

The overall mission of the engineering flight is to plan, program, develop, and manage contracts to construct, improve, and maintain base facilities and resources in support of the AF mission. Under the cradle-to-grave concept, the contracts element manages construction contracts. Under this procedure, projects are initiated, designed, and constructed by the assigned team until completed and accepted by the government. The engineers oversee development of construction plans, and coordinate input from the users and other organizations regarding the project.

Construction inspector/quality assurance evaluator

The main responsibility of the team's construction inspector, sometimes referred to as the quality assurance evaluator (QAE), is to ensure the government receives quality and completed work, as

outlined in government-produced contract documents (i.e., specifications and project drawings). This person, usually from the CE engineering flight, provides day-to-day oversight of contract activities. It is important to ensure the QAE is familiar with health-related issues and compliance requirements, including design requirements specified in the project contract. The QAE is the most direct person to contact if problems are identified.

Project forms

The review and approval process varies, depending on the cost and size of the project. The following are the four means of completing construction:

1. Self-help.
2. CE work/job order.
3. Operations and maintenance projects.
4. Military construction projects.

Often persons from the organization that requires the work (self-help project) or CE operations personnel (CE work-order request) accomplish smaller-scale and lower-cost construction activities. Self-help projects and CE work-order requests can pose hazards to the individuals carrying out the renovations, or to occupants of the building. As stated previously, ACES OP will be used to collect and manage the work order requests; additionally, it will automatically coordinate the request to the appropriate agencies. Typically, operations, maintenance, and military construction processes complete new construction.

Work order request

All work requests, regardless of scope, are initiated within ACESOP. Work requests for projects, including self-help work, are submitted to their work order monitor. A complete description of proposed work and supporting documentation, including sketches, site plans, and so forth if applicable, should be provided. Once the project is accepted, the BE needs to be part of the review to identify hazards and control to reduce or eliminate potential hazards.

Department of Defense Form 1391

Department of Defense (DD) Form 1391, FY ____ Military Construction Project Data, is used to request and justify a construction need. It is normally used for military construction projects based on an organization's work request to CE. However, practically speaking, sometimes these work order requests might not meet the formal work order review process at some installations.

Reviewing work order and project requests takes time to correctly modify and approve; however, it is an important part of performing an HRA to identify and recommend controls to reduce health hazards. The individual who reviews each work order or project request performs the same process as reviewing actual work. For example, a they conduct a thorough review of the planned project and facts about the process, identify potential health hazards and necessary controls, and then communicate the recommendations. One further step in reviewing contract specifications is to ensure they include monitoring or testing acceptance at the completion of the project. This is accomplished through the contract; otherwise, BE will usually be required to do acceptance testing.

With experience and senior leadership, this process becomes less of a burden. Part of assessing health aspects of a project design often includes review of project drawings. Reviewers receive project drawings or blueprints in conjunction with specifications for review.

Construction plan review

The best time to review construction plans and introduce engineering controls is when the facility is in the design phase. At that time, control measures can be integrated more readily into the design rather than after the facility has been built or the processes are on-line. Ultimately, someone in your

flight—typically senior leadership—will approve and sign the construction plans, so it is imperative to comprehend and participate in the construction plan development through the review process.

The following paragraphs describe some typical plan sheets BE looks at for detailed information.

Summary sheet

The summary sheet typically provides a general overview of the project and may include notes pertaining to other sections of interest. This sheet also may include a table to contents to help navigate the blueprints.

Heating, ventilation, and air conditioning

Determining if adequate ventilation is provided often requires review of dilution ventilation details. In the case of engineering controls, the details regarding the entire system design requires a thorough review. At a minimum, the required flow rate and/or capture velocity (c) must be specified. Pay attention to make-up air as well. Unfortunately, many ventilation systems' construction do not meet requirements or do not adequately control hazards. This is often a combination of insufficient design and construction deficiencies.

Plumbing

Thoroughly review water system details for the same concerns as in the specification. As applicable, reviews should include water main layout, valves, fixtures, and backflow prevention devices just to name a few.

Project specific drawings

These are drawings developed to show specific requirement details. Some examples are noise attenuation, radiation shielding requirements (try to get Health Physics consultative review also), wastewater systems, and possibly even ergonomic details.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

205. Exposure assessment strategies

1. What does the principle purpose of a routine OEH assessment encompass?

2. Is a special OEH assessment typically a qualitative or quantitative assessment?

206. Workplace categorization

1. What two goals does the workplace categorization process achieve?

2. How often are routine OEH assessments performed in Workplace Category 1 shops and Workplace Category 2 shops?

207. Performing a routine occupational and environmental health assessment in a work place

1. What is the first step you should take before visiting the work place?

2. How is a shop process defined within DOEHRS?

3. What are three acceptable methods for establishing a SEG?

4. When is a special OEH assessment required?

5. What is the purpose of using the EAP?

6. How do you communicate to the work place the results of its OEH assessment?

208. Occupational and environmental health injury and illness investigation

1. What is the purpose of conducting an occupational illness or injury investigation?

2. What is the difference between an occupational injury and an occupational illness?

3. What are the steps to conduct the workplace occupation illness investigation?

209. Pregnancy profile evaluations

1. What are pregnant worker evaluations designed to accomplish?

2. Who is responsible for reviewing the facts and making a determination whether or not to remove the pregnant individual from current workplace duties?

210. Internal/external inspections of the Air Force Inspection System

1. What does the AFIS provide commanders?

2. What type of external inspections and evaluations might BE be involved with?

3. What four MGAs does a UEI follow?

4. Which external inspection is no-notice?

5. Who will determine the appropriate training and resourcing requirements; assess status of discipline; evaluate wing readiness; and formulate command welfare strategies?

6. What program addresses internal inspections?

7. Who executes the wing inspection program?

8. What two tools are used in the self-assessment program?

9. What AF program of record do Airmen use to accomplish self-assessment of program management and compliance with HHQ directives and provides the tiered visibility and monitoring into user-selected compliance reports and program status?

211. Reviewing local work order requests

1. List two reasons why we review self-help projects, work order requests, and construction design plans.

2. What types of hazards should you consider when reviewing work orders?

3. Who is responsible for initiating work requests or corrective action in the facility?

4. When it is the best time to review construction plans and introduce engineering controls?

2–2. Environmental Health Program

While a great deal of BE efforts focuses on HRA/HRM in industrial shops, you should anticipate OEH threats from multiple sources including both occupational and environmental sources. Non-industrial (i.e., administrative) workers may be exposed to hazards generated by industrial shops. Industrial shop workers may be exposed to an OEH threat generated by a different shop. These are considered environmental exposures because the hazard is not directly related to the work being performed. EHRAs are conducted both in and outside the work place and may include ambient

environmental conditions. Recall that a work place is defined as any environment where a potential OEH exposure may occur. The primary tool for gathering data to support EHRAs is the OEHSA.

212. Occupational and environmental health site assessment

The OEHSA definition according to AFI 48–145 is in figure 2–4:

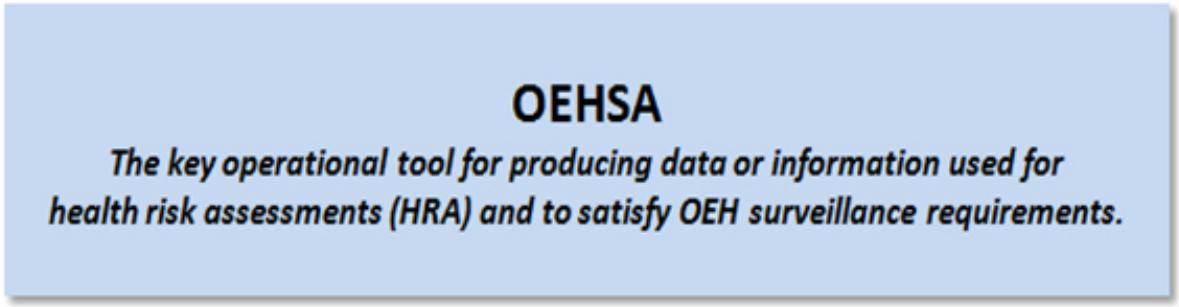


Figure 2–4. Definition of OEHSA.

In order to assess health risk, you must first identify the health hazards on your installation by performing a site assessment, the OEHSA (fig. 2–5).

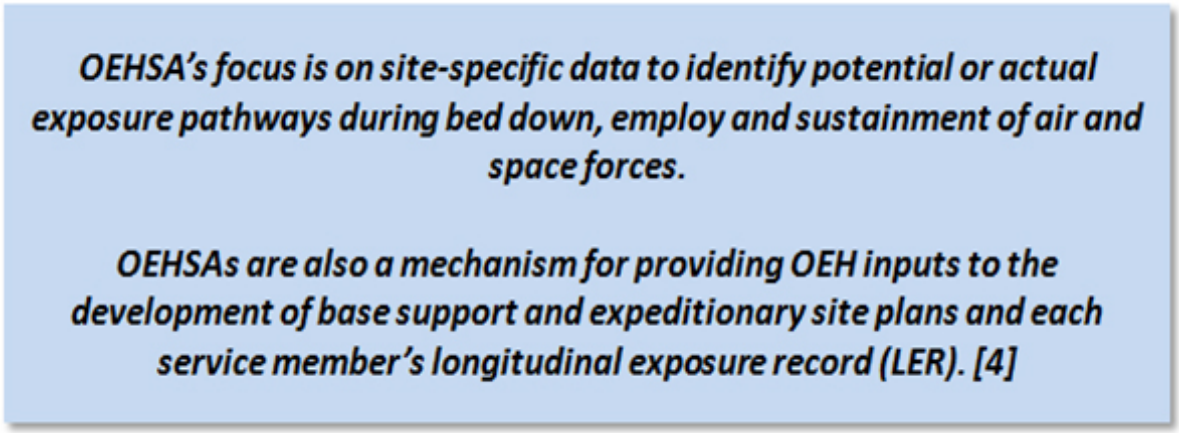


Figure 2–5. Focus and Function of OEHSA.

According to Air Force Tactics, Techniques, and Procedures (AFTTP) 3–2.82_Interservice Publication (IP), *Occupational and Environmental Health Site Assessment,* the OEHSA accomplishes the following:

- Supports OEH RM activities on military installations.
- Documents environmental conditions.
- Identifies OEH threats.
- Guides OEH data collection activities for HRAs.
- Exists as a key element of the HRA process and assists health risk assessors to make RM decisions concerning OEH threats.

As you conduct an OEHSA, your focus should be on collecting site-specific data in order to identify OEH threat exposure pathways from a threat source to a PAR. Later, you will conduct an exposure assessment for each complete exposure pathway identified in the OEHSA. An exposure pathway is the course that a chemical of concern or environmental health threat takes from the source of release to a human receptor.

The following are five elements to an exposure pathway that must be considered:

1. Source of an OEH threat release.
2. Environmental media.
3. Health threat.
4. Route of exposure.
5. PAR.

Each of these five elements of the exposure pathway is defined in greater detail in the following paragraphs.

Source of an OEH threat

The source of an OEH threat release is a point or non-point origin of a health threat. In documenting source details, you should strive to be as specific as possible.

Some examples of health threat sources include fields of buried drums, burn pits, bulk chemical storage, incinerator, radio frequency emitters, fugitive emission from off-site industries, on-site sanding/painting operations, transportation routes, and so forth.

Environmental media

Environmental media is the material an OEH threat can travel through and the means by which human exposure occurs. The OEHSA survey in DOEHRS offers the following choices for environmental media: air, water, soil, other.

Health threat

A health threat is any chemical, biological, radiological, or physical agent with the potential to harm human health (e.g., trichloroethylene, *E.* coli bacteria, cesium–137, noise, jet propulsion fuel (JP)-8, and particulate matter (PM) 10 micrometers or less in diameter (PM_{10}).

Again, you should be as specific as possible. If the definitive health threat is not known, the class or category should be identified (e.g., paint, volatile organic compounds, combustion by-products, and heavy metals). The OEH threat is synonymous with health risk.

Route of exposure

Route of exposure is the mode by which the health threat enters or interacts with a human being. The OEHSA survey in DOEHRS offers the following choices for route of exposure: inhalation, ingestion, skin contact, physical, skin absorption, and other.

PAR

The PAR is a group of human beings whose health is potentially impacted by a health threat. It is also referred to as population affected within the DOEHRS. The PAR is a scaled term and ranges from the entire base population to a SEG.

PARs may be defined by locations. Examples include liquid fuel system maintainers, flight line personnel, adjacent shop workers, north cantonment area, base housing, daycare centers, Hangar 9, and the entire installation.

Conceptual site model

After gathering the data within these five elements, you create a depiction or model of the situation by using texts, graphs, charts, maps, site diagrams, tables, images, or a combination of these. Collectively, this depiction of exposure pathways is referred to as the conceptual site model (CSM).

The CSM is the defining element of an OEHSA. It is a written description and visual representation of all OEH threats with a complete or potentially complete exposure pathway to human receptors.

The CSM accomplishes the following:

- Identifies complete or potentially complete exposure pathways from OEH threat sources to PARs with additional information.
- Serves as communication tool in the decision making process.
- Develops initial step of pre-deployment/baseline activities.
- Evolves as more information is ascertained.

A preliminary CSM for a potentially complete exposure pathway may look like the following:

- Source—Burn pit emissions.
- Environmental media—Air.
- Health threats—Air contaminants.
- Route of exposure—Inhalation.
- Population affected—Tent city.

BE personnel gather data throughout each step of the OEHSA process to create the CSM. Thus, OEHSA can be summarized as follows (see fig. 2–6):

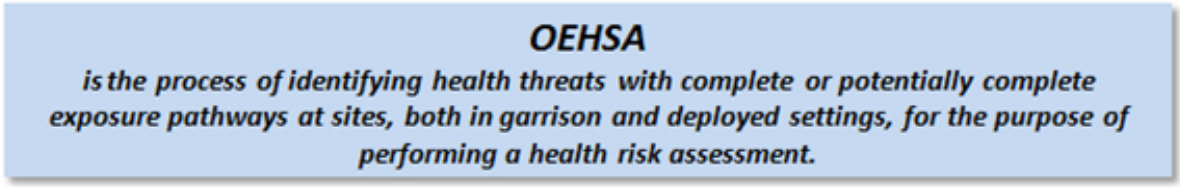


Figure 2–6. OEHSA Process.

An understanding of the key terms complete, potentially complete, and incomplete exposure pathways is important when determining whether or not a special assessment for HRA needs to be conducted. These terms are defined as follows:

Complete exposure pathway

All five elements of an exposure pathway are present as determined by professional judgment, initial field screening, modeling, and so forth.

Potentially complete exposure pathway

One or more elements of an exposure pathway cannot be eliminated due to an information gap. Further investigation is required to make a determination on the exposure pathway's completeness.

Incomplete exposure pathway

One or more of the elements of an exposure pathway are not present. An element may be eliminated based on objective sampling data or professional judgment. Sound documentation of the OEHSA should include an inventory of incomplete exposure pathways and the basis for why each was incomplete. All complete and potentially complete exposure pathways identified at the installation must be documented in DOEHRS and will be listed in the CSM.

OEH hazards and potential exposure pathways to PARs can be identified at any point during the execution of an OEHSA. Remember that as you conduct the OEHSA, you will be working toward building a CSM.

OEHSA execution

OEHSAs must be conducted in both garrison and deployed settings. Performing HRAs at both locations supports the BE strategic objective: Garrison = Deployed. The major difference in OEHSA

execution between in-garrison and deployed is typically the amount of information readily available on the site.

The process for conducting an OEHSA in garrison has been outlined in AFMAN 48–146 and by USAFSAM in the Occupational and Environmental Health Site Assessment Documentation and Data Management Technical Guide. The primary guidance document for performing an OEHSA in a deployed location is AFTTP 3–2.82_IP.

The OEHSA process consists of six steps, as depicted in figure 2–7.

Figure 2–7. Steps of the OEHSA process.

Pre-deployment/baseline activities

OEHSA should begin before arriving at the deployed location or immediately upon arriving at your garrison location. The pre-deployment/baseline activities step is the time to gather information from existing documents about the site and installation programs to identify OEH threats. The goal of these activities is to accomplish the following:

- Identify potential on-site and off-site OEH threats prior to arrival (pre-deployment) and/or immediately upon arrival (baseline).
- Generate a list of potential OEH threats to validate (e.g., adjacent off-site industrial operations, ambient environmental conditions, AF weapon systems).
- Develop a preliminary CSM.

A wealth of research information exists to aid in identifying OEH threats for garrison installations. Home station documentation is a good place to start. Established bases should have substantial documentation regarding OEH threats, hazards, and exposures. These may even include any toxic industrial chemicals (TIC) or toxic industrial materials (TIM) from industries external to the bases. Additional insight may be gained by reviewing documents of major occupational and environmental programs, outlining historical programs as well as the status of the current programs.

When conducting pre-deployment surveillance for expeditionary settings little site-specific information may be available. Intelligence agencies (e.g., the National Center for Medical Intelligence [NCMI]) are an excellent source of information because they can assist with identifying unique threats to the deployed area (such as industries in the surrounding area or common disease vectors).

Documents can provide preliminary clues suggesting health threats that may exist at the site. Documents and information sources should be reviewed for the following types of site-specific information:

- Base operations (e.g., industrial, commercial, and institutional facilities).
- Maps and geological information relevant to the area (soil conditions, topography, vegetation, rainfall, etc.).
- Typical climate and prevailing wind direction.
- HAZMAT transport and storage.
- Historical and current property use of the site.
- Hazardous waste disposal sites.
- Vulnerability assessments (VA), such as TIC/TIM potentially within water systems.
- Known contamination and pollution in air, water, and soil (e.g., environmental restoration program [ERP] sites).

Site identification and sectoring

The objective of site sectoring is to designate sectors containing significant known OEH threats (e.g., IH shops, flight line, or HAZMAT storage) and major PARs (e.g., housing, child development centers, admin offices, tent city, and cantonment areas). Site sectoring establishes logical boundaries to delineate and separate known OEH threats and PARs.

Site sectoring involves formulating a big picture of what operations are being conducted at the site and where. During site identification and sectoring, you should also ascertain the anticipated use of the site/sector because this could have an effect on the assessments conducted at the site. More detailed assessments may be desired for areas where the potential for contact with the threat is greater or sectors with a PAR that is considered more sensitive (e.g., children).

Site selection

As a BE team member (primarily as a member of the preventive aerospace medicine team), you may be involved in the site selection process. Site selection allows you the opportunity to recommend facility configurations that will best meet health, hygiene, and sanitation requirements of deployed forces and minimize environmental impact. Site selection begins during the OEHSA pre-deployment step and may continue throughout the OEHSA process.

Site selection tasks include the following:

- Use operational plans, unit/operational engineer and intelligence assists or other pre-deployment planning documents to identify OEH threats at the site.
- Interview other team members, construction crews, and host nation liaison to determine potential cantonment (quarters) and work areas.
- Recon to verify OEH threat sources identified during pre-deployment activities in order to discover new potential OEH threat sources.
- Identify OEH threat sources as well as optimal locations for PARs (e.g., tent city, dining hall, medical facilities) on planning documents.
- Communicate the results of the OEHSA to the commander.

Interviews and site reconnaissance

Data gathering via interviews and site reconnaissance is invaluable in assessing site conditions to verify the existence of health threats posed by operations or environmental contamination on or near the site.

The goals for interviews and site reconnaissance include the following:

- Identify and validate all OEH threat information collected during pre-deployment and baseline activities.
- Build upon what is known from pre-deployment/baseline activities.

- Fill data/information gaps and identify additional threats not foreseen.

Interviews and site reconnaissance continue data gathering and identification of OEH threat(s) that began with pre-deployment/baseline activities.

Interviews are necessary to obtain information that may not have been previously available as well as to validate previously collected information about OEH threats. For instance, interviewing the solid waste program manager about active or inactive landfills in the area could reveal information about leaching pollutants. Interviews are typically conducted before reconnaissance and continued during and after site reconnaissance.

Some typical organizations and personnel that you should consider interviewing include, but are not limited to, the following:

- CE operations.
- Environmental program managers.
- Hazardous/solid waste program managers.
- Security forces.
- Office of Special Investigations.
- Host nation liaison.
- Industrial shop supervisors.
- Logistics readiness squadron.
- Radiation safety officer.
- PH.

For garrison settings, initial interviews are likely to be with CE program managers for environmental programs and supervisors of category 1 shops for process hazards that are spilling from one shop into adjacent areas. In an expeditionary setting, this could be discussions with key base leaders and local officials or agencies and reviewing historical documents such as after-action reports, if they exist.

Site reconnaissance must be extensive enough to consider all sources of threats that might impact personnel. Site recon performed in-garrison generally takes a targeted approach in order to focus resources on areas with known risks first (e.g., category 1 shops, ERP sites). For expeditionary settings, less information is typically available and a comprehensive recon of the entire base (and off-site threat sources) should be performed.

For example, some potential sources of health threats are likely to include, but not limited to, the following:

- ERP sites and landfills.
- Processes conducted within occupational work places.
- Off-site industrial and agricultural activities up-wind and up-gradient from the site.
- Hazardous and solid waste disposal facilities (e.g., burn pits, incinerators).
- Ambient desert environment (e.g., PM, heat).

The optimal method of validating anticipated threats is observing activities occurring at the site and around the perimeter staying aware of visual clues to help identify potential threats within the work places and in the surrounding area. The surrounding area includes a radius of 10 kilometers around the installation for off-site OEH threat sources. This is because threats can travel from the source (recall transport and fate principles) to the site.

Threat analysis begins with the collection of qualitative data during site reconnaissance. Think of qualitative data as preliminary information upon which one can begin to form judgment—in this case, forming initial judgments about health threats. Qualitative data is collected through observations,

discussions with personnel (e.g., unit commanders, host nation personnel, intelligence officers, etc.), questionnaires, and surveys (e.g., previous illness accounts, environmental contamination reports).

Once you have identified potential threats and/or validated existing ones, the preliminary CSM should be updated to depict any new complete or potentially complete OEH threat exposure pathways. Determining whether or not exposure pathways are complete should be accomplished to the extent practical using professional judgment and pathway screening with field portable direct reading instruments (DRI).

Initial assessment (pathway screening)

Initial assessment (i.e., exposure pathway screening) provides basic data to detect or identify threats that you suspect exist based on the data collected to this point. It is typically a quick qualitative exposure assessment to determine whether or not an exposure pathway is complete.

The goals for these activities include the following:

- Detect or identify ambient health threats that pose potential health risks.
- Answer the question: "Is the exposure pathway complete?"
- Determine the need for specialized assessment.

Pathway screening sampling should be performed for any potentially complete exposure pathways identified in the CSM. There is no requirement to conduct screening sampling during the initial assessment step if you have already determined that the exposure pathway is complete. For example, if there is visual evidence such as a plume of smoke from a burn pit drifting over tent city, the exposure pathway is complete; if you can smell JP–8 fuel in an administration building adjacent to the Fuel Systems Repair shop, the exposure pathway is complete.

A potentially complete exposure pathway can be determined to be complete based on:

- DRI.
- Professional judgment.
- Physical evidence.
- Literature search.
- Similar installation review.
- Sampling.

Pathway screening sampling with DRI is beneficial because it can narrow the parameters for analysis by ruling out the presence of high-potential threats. Analyses must be quick and accurate; therefore, DRI used to perform initial assessments must be portable and reliable. The DRI typically used for initial assessment includes, but is not limited to the following equipment.

- Photoionization detector.
- Enzyme immunoassay.
- X-ray fluorescence (XRF) analyzer.
- Flame ionization detector.
- Radiation detectors.
- HAPSITE®.

Pathway screening should be performed under worst case conditions. This screening technique increases the probability of detection. If contaminants of concern are identified (i.e., the exposure pathway is complete) additional sampling through special assessment is performed to better quantify the threat and assess the health risk. If initial screening results are high enough to warrant immediate concern, based on your professional judgment, do not wait to complete the OEHSA; control the exposure.

Build the consolidated CSM

As mentioned previously, the CSM is the defining element in performing an OEHSA. It is the end product of data gathering and OEH threat validation from pre-deployment/baseline activities to site reconnaissance to initial assessment and evolves through each OEHSA step as more information is ascertained. It could be said that if you can develop a CSM, arguably you have completed an OEHSA.

The OEHSA drives exposure assessment for each identified CSM exposure pathway. Only complete or potentially complete exposure pathways are listed on the CSM for further assessment because a completed exposure pathway must exist for a threat or hazard to be a risk to personnel. Exposure pathways may be ruled out as incomplete and removed from the CSM if any of the following five elements are missing from an exposure pathway (fig. 2–8).

Figure 2–8. Five elements of an Exposure Pathway.

The example to follow is offered to help illustrate the material discussed up to this point. Figure 2–9 presents a fictitious base Camp Falcon. Looking at this example, you should see that Camp Falcon has several potential OEH threat sources.

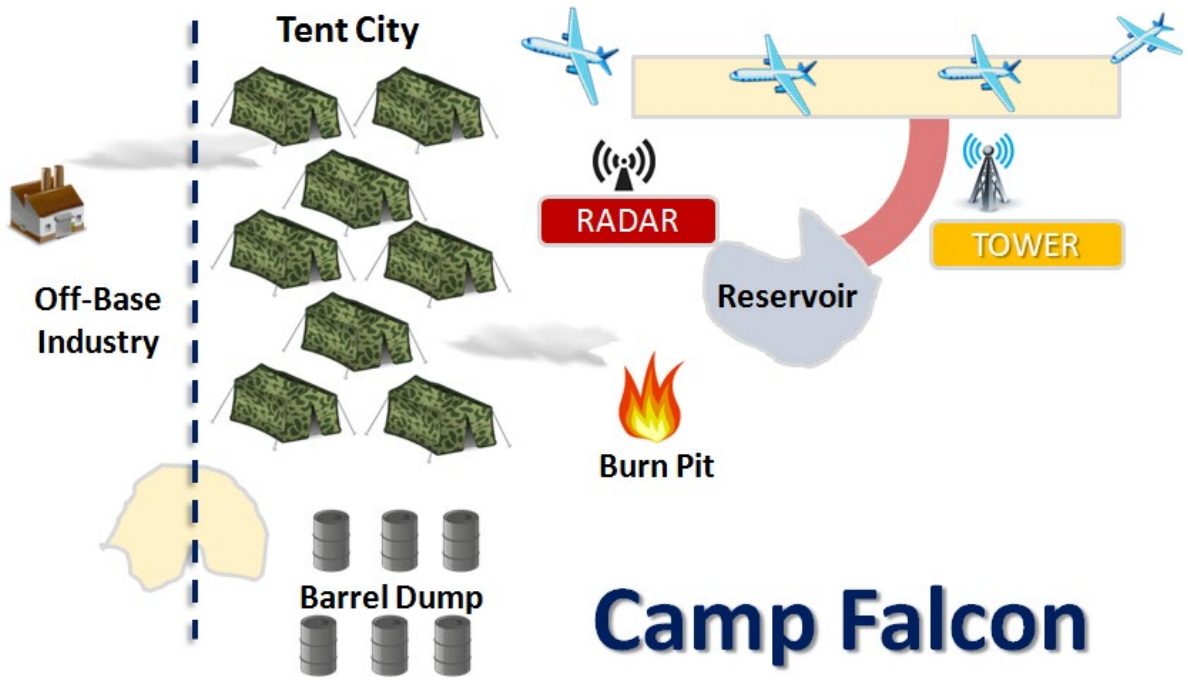


Figure 2–9. Example Illustration of Potential Threats and PARs. [7]

This example illustrates that Camp Falcon operates a burn pit. The burn pit is the source of an OEH threat. The environmental media transporting the health threat is air. The health threat might be PM and other combustion byproducts such as polycyclic aromatic hydrocarbon (PAH). A likely route of exposure for PM in air is inhalation. The PAR is tent city. Consider how many other potential OEH threats and exposure pathways may be identified. Several exposure pathways for Camp Falcon are depicted in the following CSM table.

CSM								
Source	**Environ Media**	**Health Threat**	**Route of Exposure**	**Population Affected**	**Existing Controls**	**Frequency/ Duration**	**Severity**	**Probability**
Burn Pit Emissions	Air	PM, PAHs	Inhalation	Tent City	None	16 hours/day, 7 days/week	Marginal	Likely
Burn Pit Runoff	Water	Water contaminant	Ingestion, Contact	Tent City	Water treatment plant	24 hours/day, 7 days/week	Negligible	Unlikely
Flight line	Air	Noise	Physical	Tent City	Distance, Shielding	10 hours/day, 6 days/week	Marginal	Frequent
Off-Site Industry	Air	TIC/TIM	Inhalation	Tent City	None	12 hours/day, 7 days/week	Negligible	Seldom
Barrel Dump	Soil	Soil contaminant	Contact	Tent City	None	24 hours/day, 7 days/week	Negligible	Unlikely
Desert Environment	Air	PM	Inhalation, Ingestion	Camp	None	24 hours/day, 7 days/week	Marginal	Occasional

Notice the four additional columns at the end of this CSM. The existing controls (if any) and the frequency and duration are obtained through data-gathering steps (i.e., interviews and site reconnaissance). If an existing control prevents exposure from a hazard to the PAR, and there is no chance of control failure, the exposure pathway is considered incomplete The RM probability and severity information will assist with exposure pathway prioritization for a special OEH assessment.

OEHSA exposure pathway prioritization

Once the OEH hazards having been identified and all complete or potentially complete exposure pathways have been documented in the CSM, you are now ready to prioritize the CSM exposure pathways for special assessment. Remember, OEH hazards with incomplete exposure pathways are still documented in the OEHSA survey in DOEHRS; however, they are not placed on the CSM and do not require further evaluation.

Exposure pathway prioritization for environmental health hazards is accomplished using RM principles. The probability and severity of each exposure pathway in the CSM must be estimated based on available information using the standard RM probability/severity definitions available in DOEHRS or in the OEHSA Tech Guide.

A qualitative risk of very high, high, moderate, or low threat is determined by estimating the probability and severity of the health threat in accordance with RM principles.

- The probability of the potential health threat should be estimated in terms of how often the event is expected to occur such as frequently, likely, occasional, seldom, or unlikely.
- The severity of the potential health threat should be estimated in terms of its potential impact (catastrophic, critical, moderate, or negligible) on personnel and the mission. The severity assertion of the estimate includes factoring in whether completion of the exposure pathway causes a health outcome.

HAZARD SEVERITY	HAZARD PROBABILITY				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic I	Extremely High	Extremely High	High	High	Moderate
Critical II	Extremely High	High	High	Moderate	Low
Marginal III	High	Moderate	Moderate	Low	Low
Negligible IV	Moderate	Low	Low	Low	Low

Figure 2–10. Risk assessment matrix.

Continuing with the Camp Falcon example, use the risk assessment matrix (fig. 2–10) to determine the estimated risk. The consolidated CSM might look like the example in the following table, where the probability and severity columns are replaced with the estimated risk.

CSM							
Source	**Environ Media**	**Health Threat**	**Route of Exposure**	**Population Affected**	**Existing Controls**	**Frequency/ Duration**	**Risk**
Burn Pit Emissions	Air	PM, PAHs	Inhalation	Tent City	None	16 hours/day, 7 days/week	Moderate
Burn Pit Runoff	Water	Water contaminants	Ingestion, Contact	Tent City	Water treatment plant	24 hours/day, 7 days/week	Low

CSM							
Source	**Environ Media**	**Health Threat**	**Route of Exposure**	**Population Affected**	**Existing Controls**	**Frequency/ Duration**	**Risk**
Flight line	Air	Noise	Physical	Tent City	Distance, Shielding	10 hours/day, 6 days/week	High
Off-Site Industry	Air	TIC/TIM	Inhalation	Tent City	None	12 hours/day, 7 days/week	Low
Barrel Dump	Soil	Soil contaminants	Contact	Tent City	None	24 hours/day, 7 days/week	Low
Desert Environment	Air	PM	Inhalation, Ingestion	Camp	None	24 hours/day, 7 days/week	Moderate

The RM risk prioritization helps commanders understand which health risks may have the greatest impact to personnel and mission and which risk(s) require attention before others, thereby helping them strike the balance between protecting resources and accomplishing the mission.

Recall that environmental special assessment priorities must be balanced against occupational special assessment priorities. This requires you to integrate a quantitative risk estimate (i.e., the EAP) along with a qualitative risk estimate (i.e., the RM rank) as presented in the following table.

	Occupational EAP Ranking	**Environmental RM Ranking**
Priority	61–125	Very High
	30–60	High
	16–29	Medium
	1–15	Low

The methodology used to incorporate environmental and occupational special assessment priority lies with each individual flight; however, the key is to develop a method and remain consistent using that method. The final decision on special assessment prioritization lies with the BE flight commander.

Special assessment and reassessment

Recall that a special assessment is a quantitative exposure assessment of OEH threats that need additional evaluation. In this case, the determination for a special assessment requirements is based on findings from the OEHSA. Special assessments should be conducted for exposure pathways documented on the OEHSA survey CSM. All special assessments related to the OEHSA survey must be associated with a location and an exposure pathway that is documented in DOEHRS.

Once you have a consolidated CSM, the OEHSA survey in DOEHRS is complete. The outcome and findings from the OEHSA survey must be communicated to the OEWHG. However, remember that the OEHSA is a continuous process, meaning that you should always have OEHSA in mind. Continue to update the OEHSA as new threats are identified and as old threats are mitigated. As the CSM is updated, additional special assessments may need performing. Health threats/risks must be reassessed to validate that previous data and assumptions remain current or have changed. If changed, then the data may need to be recollected and assessed. Reassessment should be accomplished every three years and whenever there is a change in leadership.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

212. Occupational and environmental health site assessment

1. What does an OEHSA accomplish?

2. What are the five elements of an exposure pathway that must be considered?

3. What OEHSA tool, often described as the defining element of an OEHSA, provides a visual representation of all OEH threats that have a complete or potentially complete exposure pathway to human receptors?

4. What is a Complete Exposure Pathway?

5. What is the major difference in the pre-deployment/baseline activities step of an OEHSA performed in-garrison versus deployed?

6. What is the objective of site sectoring?

7. What is the recommended radius distance for evaluating off-site OEH threats to the base population?

8. What is the term for a quick qualitative exposure assessment that is used to determine whether or not an exposure pathway is complete?

9. What two RM concepts are used to prioritize a special OEH assessment of CSM exposure pathways?

10. Once you have a consolidated CSM and the OEHSA survey in DOEHRS is complete, to whom are you required to communicate the outcome and findings of the OEHSA survey?

2–3. Health Risk Control Overview

Controlling a threat is not always a cut and dried task. Some threats by their very nature present difficult problems. There may be cases when it is tempting to overlook a threat because of the time and complexity required to solve it. As a BE team member, it is recommended that you place yourself in the worker's shoes. Would you be willing to work in the same environment? Within this section, we will discuss the OEH exposure controls; protective clothing concepts; BE's roles and interactions in PPE guidance, and the proper use, selection and limitations of PPE.

213. Occupational and environmental health exposure controls

When you answer the question about being willing to work in the same environment, you will agree that it is important that all potential threats be controlled. This is one of the most important guiding principles of our profession regarding health risk control. Controlling exposures to OEH hazards is the fundamental method of protecting workers; the controls eliminate or minimize an OEH hazard and provide a healthier work environment. A control can be defined as the following:

- An adjustment or regulation of an activity to meet a standard or guideline.
- A reduction or prevention of contaminant release.
- The ability to contain a hazard.

OEH controls are any one or a combination of engineering, administrative, or PPE control(s) implemented to eliminate or minimize an OEH threat. Controls should always be considered in the following priority:

1. Engineering controls.
2. Administrative controls.
3. PPE controls.

If engineering controls are not feasible or are not completely effective in controlling the OEH exposure, administrative controls and/or PPE must be used.

The following table provides an overview of control options along with corresponding examples, which are discussed in further detail in subsequent paragraphs.

Type of Control	Approaches and Examples
Engineering	Substitution—Substituting a less hazardous material, equipment item, or process for a more hazardous one (e.g., use of soap and water in place of solvents, use of automated instead of manually operated equipment). Isolation—Separating employees from hazardous operations, processes, equipment, or environments (e.g., use of control rooms, placing barriers between employees and hazardous operations). Process change—Changing a process to make it less hazardous (e.g., paint dipping in place of paint spraying). Ventilation—Fundamental approaches include dilution (general exhaust), local exhaust (capture of air contaminants), and makeup air (industrial)/supply (heating, ventilation, and air conditioning [HVAC]).
Administrative	Management involvement, training of employees, rotation of employees, scheduling of processes, preventive maintenance (PM) or other actions taken, personal hygiene, housekeeping, etc.
PPE	Equipment worn to minimize exposure to a variety of hazards (gloves, aprons, face shields, respirators, etc.)

Engineering controls

Engineering controls are important. They control the hazard at the source, which reduces the amount of the OEH hazard (i.e., chemical, radiation, noise, etc.) being released into the work environment. If

you are not in a position to implement engineering controls at the design phase of a job, you will be left with modifying an existing job by applying methods of substitution, isolation, enclosure, shielding or ventilation. The following briefly addresses each one of these modification alternatives.

Elimination

Elimination involves the complete removal of a process, substance, or equipment thus, eliminating hazardous exposure. An example of eliminating hazardous exposure would be removing a chemical from use or removing a generator that creates hazardous noise. Another example is consolidation of a process amongst several shops into one work center thus eliminating some personnel from having to conduct the process. While this may be the preferred control, it may not always be feasible. Certain chemicals or equipment may be used for specific reasons, making their elimination impractical.

Substitution

Substituting or replacing a toxic material with a harmless one is a very practical method of mitigating an industrial health hazard, and therefore should always be consider when modifying a job. It can be the least expensive and most positive method of controlling many OEH hazards, often resulting in substantial savings; however, it could also be impractical, depending on the process.

Substitution can include any of the following:

- Substituting a HAZMAT with something less hazardous.
- Substituting the equipment generating the hazard.
- Substituting a process being performed (e.g., brush painting instead of spray painting).

Isolation, enclosure and shielding

Another engineering method available to control hazardous exposures is to use isolation, enclosures or shielding. For example, the source can be isolated from the work area by placing either the source or the worker in another location, reducing or eliminating the worker contact with the hazard. Additionally, physical barriers can enclose or shield the source or the worker. This separates the worker from the exposure when neither the source nor the worker can be relocated to separate work areas.

Ventilation

Airborne particulates are a major OEH threat because they enter the lungs during breathing and are quickly absorbed into the bloodstream. One of the most effective ways to prevent this type of OEH exposure is to keep them out of the breathing zone; ventilation, a widely used and time-tested engineering control limits this exposure. Ventilation is the process of supplying fresh air or removing contaminated air to provide a healthy and safe working environment or improve worker comfort. Ventilation can be accomplished by natural means (e.g., opening a window) or mechanical means (e.g., fans or blowers). Ventilation resides in one of the two following categories:

General ventilation

- Dilution (general exhaust) ventilation—Air contaminants are diluted with surrounding air in order to reach safe concentrations.
- Makeup air/supply ventilation—Provides fresh clean air, usually from air outside the building; makeup air refers to industrial operations and supply refers to general facility HVAC systems.

Local exhaust ventilation

This type of ventilation captures air contaminants at the source before they escape into the work environment and contaminate the air being breathed.

Administrative controls

In some instances, such as when engineering controls alone do not eliminate OEH hazards or reduce them to an acceptable level, administrative controls will need to be in place to prevent or limit OEH exposures. Administrative controls are any procedures or particular set of actions undertaken in order to significantly limit OEH threat exposure.

Administrative controls include, but are not limited to the following:

- Management policies.
- Worker training.
- Worker rotations.
- Proper scheduling of hazardous processes.
- Equipment PM.
- Personal hygiene.
- Housekeeping.

Many industry regulations or management policies require administrative controls to be implemented, even when engineering controls are in place, to adequately control the OEH hazard. For example, training plays a critical role in limiting worker exposures; without it, workers may not be aware of how to identify a potential hazard before an incident occurs. Having shop personnel follow the manufacturers' PM guidelines helps ensure equipment operates as it was designed, and reduces the risk of creating potential OEH hazards. Rotating work schedules or exposure times, and scheduling hazardous operations during specific times of the day or night can also help maintain exposures below established exposure limits; however, it is important to note this may result in more workers being exposed to the OEH hazards.

Administrative controls depend on constant employee implementation and intervention. This tends to make them less desirable; however, they are often a very critical form of control. If you plan on administrative controls, be aware that rotating workers to maintain compliance when there is exposure to cadmium, is prohibited. Because of this, it is important to review all applicable standards before implementing these controls.

Personal protective equipment

Consider PPE as a last resort in protecting workers from hazards in the work place because it places only a barrier between the worker and the hazard. The hazard still exists; therefore, you are relying on the integrity and fit of the PPE to protect the worker. It should only be considered when exposures to an OEH hazard cannot be engineered completely out of normal operations and when administrative controls cannot provide sufficient additional protection. PPE can become ineffective without the workers' knowledge, thereby not protecting the workers from the OEH hazards. Where appropriate, use PPE in conjunction with other engineering and/or administrative controls.

The following are key factors to identify in PPE selection:

- The OEH hazard/threat.
- Potential routes of exposure.
- Effectiveness of specific PPE material.

In order to provide effective protection, you must consider all of these key factors. Some types of rubber gloves, for example, protect well against alcohols; however, they protect poorly, or not at all, against organic solvents. Additionally, goggles protect eyes from damage when working with acids, but will not provide protection for the face; therefore, a face shield may be more appropriate.

Control determination

Generally, the source, path, and receiver are three locations where an OEH threat can be controlled. , you must have a thorough understanding of the conditions surrounding an exposure in order to choose effective control methods. Figure 2–11 illustrates how these important principles relate to determining control methods for a chemical hazard, and can generally be applied to other hazards as well (i.e., noise, radiation, etc.). You may find that the preferred method of control does not provide adequate protection; therefore, a combination of controls may be necessary to reduce exposure.

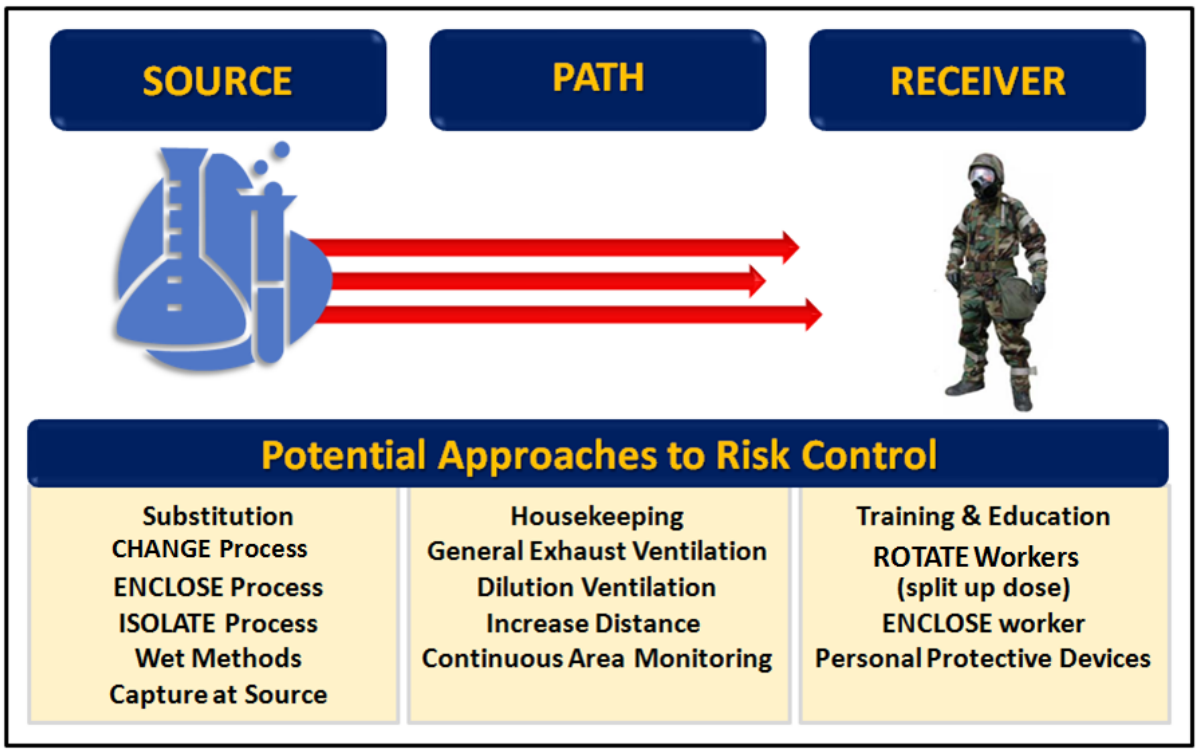


Figure 2–11. Generalized control methods.

Regardless of the situation or the type of OEH threat, the principles applied for determining possible OEH control options are the same. However, remember that operational context must be considered. In other words, consider how a process interacts with the shop, the equipment and the worker. This will help you develop a generalized method for determining either singular or multiple (in combination) options for controlling a threat.

The two scenarios provide in figure 2–12 present two diverse situations that illustrate the process for determining controls based on two distinct situations.

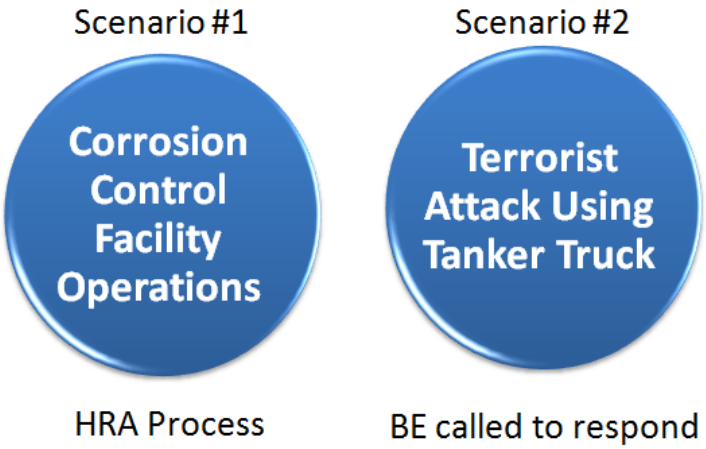


Figure 2–12. Scenarios #1 and #2.

Scenario #1: Corrosion Control Facility Operations

Corrosion control activities present multiple health threats associated with de-painting (sanding, abrasive blasting, etc.) and painting processes. After BE identifies and evaluates OEH threats in the SEG, using the HRA process exposure control, recommendations are made.

OEH Exposure Assessment: Based on air sampling, exposure levels are above the OEL for hexavalent chromium during a sanding operation.

Engineering Control: Implement local exhaust ventilation in combination with orbital sanding units to reduce exposures.

- If this is effective at maintaining exposures below the OEL and the action level, then BE must continue to perform routine monitoring to ensure the control remains effective.
- If this is not effective or if exposures remain above the action level, then consider implementing administrative controls in addition to the recommended engineering controls.

Administrative Control: Implement new work practices (e.g., utilize a high-efficiency particulate absorption vacuum to clean the work place) in order to reduce exposure to acceptable levels.

- If this is effective, then BE must continue to perform routine monitoring to ensure the control method remains effective and investigate the use of engineering controls in the future.
- If this is not effective, then consider using PPE in addition to the previous controls.

PPE: Implement respirator usage in addition to coveralls, gloves, etc. to reduce exposures to acceptable levels.

- If this is effective, then BE must continue to perform routine monitoring to ensure control remains effective as well as investigate the possibility of implementing engineering and administrative controls in the future.
- If this is not effective, then decide on an RM regarding whether or not to continue operations.

RM considerations:

- What is the mission impact due to ceasing this operation?
- Can the ventilation system be modified to meet necessary specifications?
- Can the workload be sent to another base/contract facility that can properly control the exposure?
- Is risk to unprotected personnel acceptable in order to meet mission requirements?

Scenario #2: Terrorist Attack Using Tanker Truck

A small group of radical extremists commandeer a truck carrying a pesticide. The truck is driven up to the main gate of an Air Force base and an explosive charge releases the pesticide. A plume ensues and begins migrating across the base. After the initial first responders arrive on scene, BE is asked to respond. Air sampling indicates that the truck was carrying an organophosphate pesticide. All base personnel are carrying a full complement of individual protective equipment (IPE).

OEH Exposure Assessment: Personnel are experiencing shortness of breath, headaches and nausea.

Engineering Control: Engineering control options are not applicable for immediate alleviation of the health threat in this situation.

Administrative Control: Consider evacuating all personnel in the hazard area upwind or crosswind from the chemical plume.

- If this is effective, then personnel should be monitored for latent effects from the exposure.
- If this is not effective, then consider a shelter-in-place option.

PPE: Direct personnel to wear IPE. Does this step effectively mitigate the threat in order for mission essential work to continue in contaminated areas?

- If yes, the BE must continue to perform monitoring to ensure the control method remains effective until the threat is eliminated or dissipates from the area of concern.
- If no, then a RM decision needs to be made regarding whether or not to continue operations in contaminated areas.

RM considerations:

- What is the mission impact due to ceasing this operation?
- Can operations be relocated until the threat dissipates in order to meet mission requirements?
- Is the risk to personnel acceptable in order to meet mission requirements?
- How quickly/effectively can a shelter-in-place or evacuation plan be executed as the plume migrates?

The control determination process is dynamic; that is, once a control has been selected, its effectiveness must be routinely evaluated. A control's effectiveness can be assessed by applying the following three parameters:

1. The control must be able to mitigate the OEH threat exposure to an acceptable level.
2. The responsible organization must be able to reasonably implement the control option.
3. The control must be practical when considering cost and time associated with implementation.

Keep in mind that the processes and the respective OEH threats associated with the processes may change. Therefore, the frequency of evaluating a control should be based on several factors to include the following:

- Risk to personnel if performance or control degrades or fails.
- Reliability and historical performance of control and operators.
- Toxicity of the material being controlled.

Additionally, new control options may become available that provide better protection (e.g., improved ventilation system, noise source isolation, etc.).

214. Protective clothing concepts

Remember that as a rule, PPE should be used only as a last resort and as a temporary measure until more permanent controls can be installed. Although PPE should never be used as a substitute for engineering and/or administrative controls, often there are times when it is not feasible to render the work environment free of hazards, making PPE necessary to protect the workers. When PPE is needed, make sure each piece of protective equipment and clothing selected will do the job for which it was intended. For example, when working with acids, goggles will protect the eyes from damage, but the goggles will not provide protection for the rest of the face. A face shield may need to be added to more appropriately protect workers from this potential exposure hazard.

PPE standards

Essential regulatory requirements mandated by OSHA are contained in several standards. Some of the more common standards you will encounter are provided in the following list:

- Title 29 CFR 1910.95 – *Occupational Noise Exposure.*
- Title 29 CFR 1910.132 –*General Requirements* (for personal protective equipment).
- Title 29 CFR 1910.133 – *Eye and Face Protection.*
- Title 29 CFR 1910.134 – *Respiratory Protection.*
- Title 29 CFR 1910.135 – *Head Protection.*
- Title 29 CFR 1910.138 – *Hand Protection.*

A number of AFIs and standards specify the specific type of PPE required in the work place. The following, although not a complete list, highlights the more common standards used for PPE selection:

- AFMAN 48–148, *Ionizing Radiation Protection.*
- AFI 48–139, *Laser and Optical Radiation Protection Program*.
- AFMAN 91–203, *Air Force Occupational Safety, Fire, and Health Standards*.
- AFOSH Standard 48–9, *Electro-Magnetic Frequency (EMF) Radiation Occupational Health Program*.
- AFI 48–127, *Occupational Noise and Hearing Conservation Program*.
- AFOSH Standard 48–137, *Respiratory Protection Program*.
- AFI 48–151, *Thermal Injury Protection Program*.

The Air Force complies with applicable OSHA, ANSI and Air Force standards to protect personnel in the work place; however, it is important to check all applicable standards to make sure all requirements are being met.

Factors to consider when selecting chemical protective clothing

Protective clothing includes items such as gloves, aprons, coveralls, face shields, and goggles. The purpose of PPE is to shield or isolate individuals from chemical, physical, and biological hazards that may be encountered. It is important for workers to understand that no single protective clothing item can protect against all hazards. It may be necessary to recommend a combination of PPE items to adequately protect personnel. For example, an individual may need insulated gloves to protect them from the cold as well as rubber gloves to protect them from a chemical used.

The majority of occupational health hazards arise from inhaling chemical agents or by skin contact with the chemicals. They present a variety of hazards such as toxicity, corrosiveness, flammability, reactivity, and oxygen deficiency. Any combination of hazards may exist depending on the chemical(s) present; therefore, selecting the proper composition of chemical protective clothing (or equipment) will depend on the particular substance and requirements posed by the AF, OSHA,

technical orders, manufacturer's recommendations and safety data sheets (SDS). Some chemicals require PPE to be made of designated materials designed to protect against them.

We know that protective clothing should not be considered as a replacement for other control methods; however, when there are no other alternatives, the concepts of permeation, breakthrough time, penetration, and degradation must be understood, particularly when dealing with chemicals. These indicate the level of chemical resistance qualities the materials have and affect the protection provided by the PPE. Therefore, they are considered when testing and developing standards for chemical protective clothing.

Permeation is the process by which a chemical dissolves in or moves through a material on a molecular basis. In most cases, there will be no visible evidence of chemicals permeating a material. Permeation is based on intact material, as depicted in figure 2–13. The higher the permeation rate, the faster the chemical can move through protective material.

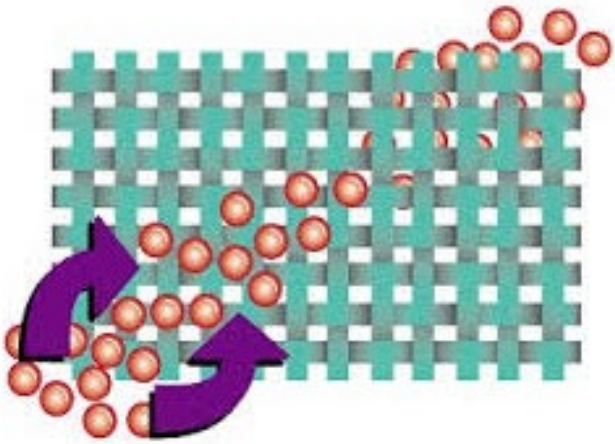


Figure 2–13. Illustration of Permeation.

Breakthrough Time is the time it takes a chemical to permeate completely through a material. Permeation can be determined by applying the chemical on the outside of a material and measuring the time it takes to detect the chemical on the inside surface of the material. The breakthrough time gives some indication of how long a particular protective item, such as the glove, can be used. Note that while gloves may be made of the same material and with nominal thickness, if they are from different manufacturers, they may have significantly different breakthrough times. This difference may result from differences in formulation of glove materials or manufacturing procedures used.

Penetration is different from permeation in that penetration refers to the movement of chemicals through zippers, seams, or imperfections in a protective clothing material, as shown in figure 2–14. Even the best protective barriers can become ineffective if punctured or torn.

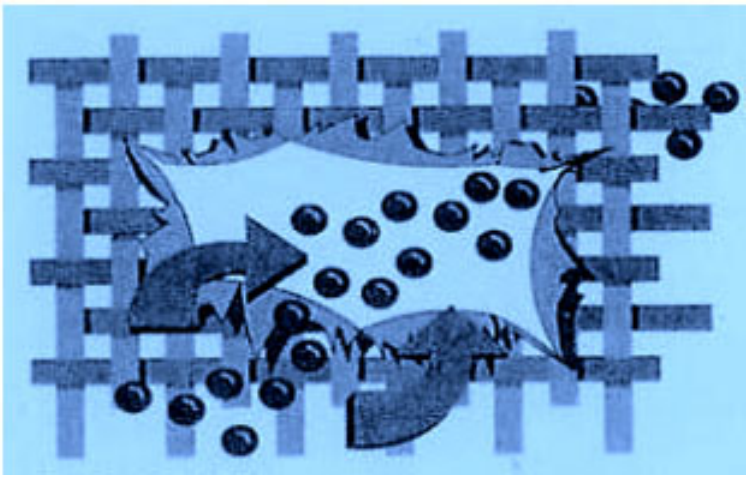


Figure 2–14. Illustration of Penetration.

Degradation is the physical changes or deterioration of the material as a result of a chemical exposure, use, or ambient conditions (e.g., sunlight), as shown in figure 2–15. These changes include things such as the material becoming discolored; swelling; and getting harder, stiffer, more brittle, softer, or weaker. An extreme case of degradation is when the material may actually dissolve in the chemical.

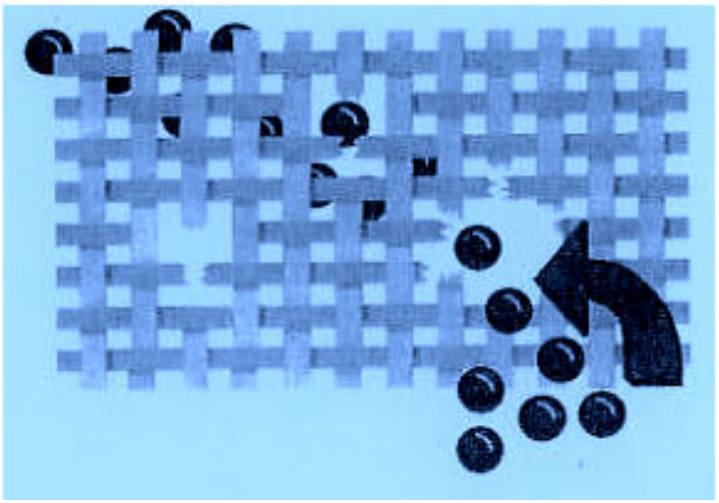


Figure 2–15. Illustration of Degradation.

Keep in mind that chemicals allowed to remain on protective clothing or equipment can diffuse through the material, even if it is in storage. Chemical protective clothing, if re-used, must be cleaned before storage. In some cases it may be more cost effective to select chemical protective clothing with a relatively short breakthrough time and discard it after use.

Limitations and physiological effects of wearing protective clothing

Using protective clothing can itself create significant problems for the wearer. For example, wearing protective clothing can affect the workers' heart rate, increase water loss, and impair vision, mobility, and communication. Wearing PPE can cause workers to slow their work rate or take short cuts in work methods. The number of errors and the frequency of unsafe behaviors can increase. Attitudes may change as workers become irritable, causing morale to decrease. Ultimately, these negative effects may deter workers from wearing and using appropriate PPE. For example, let us say you performed an HRA on a structural maintenance wash rack process and determined that personnel must wear rubber aprons, gloves, and face shields. Wash rack operations are typically performed

outdoors or under overhangs, exposing personnel to thermal stresses. PPE can provide an effective barrier to prevent cleaning compounds from contacting the wearer's skin; however, it can also trap heat inside. The heat burden or other stressors such as loss of manual dexterity may cause people to not properly wear the protective equipment. Generally speaking, the greater the level of chemical protective clothing, the greater the associated physiological risks.

215. BE roles and interactions in personal protective equipment guidance

As previously stated, PPE is implemented as a last resort and/or as a temporary measure. This being the case, until permanent controls can be installed, quite often there is no alternative except to implement and use PPE. It may be appropriate during short exposures to hazardous contaminants, such as non-routine equipment maintenance or emergency responses to spills. In these scenarios, you will work together with the workplace supervisors and others to make sure the proper PPE is selected. The text that follows outlines which personnel are involved in PPE use and which guidance BE may work with/support.

Responsible players in PPE guidance

One of the primary directive documents in OEH hazard control is AFMAN 91–203. This instruction assigns responsibilities to individuals and functions, and includes the full spectrum of leadership, ranging from commanders to low-level workers. It also includes civilian management employees in order to ensure compliance with OSHA and AF guidance throughout all programs. The following is a list of some of the responsibilities outlined in the AFI.

Headquarters Air Force Safety Center

- Formulates and executes policy in PPE guidance.
- Clarifies roles, responsibilities, and guidance applicable to all areas of safety.
- Acts as the approval authority for safety variances.

MAJCOMs, direct reporting unit and field operating agencies

- Provide program oversight and supplement safety and health guidance.

Commanders and functional managers

- Ensure availability to all personnel and promote applicable occupational safety and health (OSH) guidance for work places.
- Ensure and promote compliance with occupational safety, fire prevention and health program requirements in their areas of responsibility.
- Provide a safe and healthful work place by conducting monthly spot-inspections for hazards or deficiencies.
- Provide employees training in job safety, fire prevention and health, as required by OSHA directives, Air Force Occupational Safety and Health (AFOSH) directives, AFPDs, AFIs, AFMANs, and any other associated directives.
- Provide necessary PPE and ensure compliance with program requirements.

Supervisors

- Ensure safe working conditions.
- Identify hazards that may require PPE.
- Provide necessary protective equipment.
- Ensure required guards and protective equipment are provided, used and properly maintained.
- Ensure workers exposed or potentially exposed to hazardous chemicals or materials are properly trained on how to use them.
- Additionally, are responsible for same items as commanders and functional managers.

- Air Force employees (military and civilian) promptly report unsafe working conditions/activities to the supervisor.
- Promptly report injuries and illnesses to the supervisor.
- Comply with PPE requirements, including its use, inspection and care.
- Give due consideration to personal safety and the safety of fellow workers.

BE responsibilities

The role you play in PPE selection and use is an important one. It is your responsibility to recommend, evaluate, and determine the adequacy of OEH hazard controls such as approving and certifying PPE for use in a work center. However, before certifying PPE controls, the first thing you should do is make sure all necessary actions have taken place in terms of engineering controls, work practices, administrative controls, and hygiene to control the hazard. Remember, PPE does not prevent an accident from happening, does not eliminate the hazard, and does not influence any pre-contact activities.

OSHA Standard Title 29 CFR 1910 Subpart I, *Personal Protective Equipment,* requires that (with the exception of uniquely military situations) all PPE needs are assessed and that consultation regarding PPE training requirements be provided. This is a requirement BE takes very seriously, especially since all military personnel (including those involved in uniquely military operations) must comply with PPE requirements of applicable AF policies and standards. In order to meet these requirements, BE takes the following four steps:

Conduct a walk-through

Identify walk-throughs in the areas in question to identify sources of hazards. This is generally conducted during BE routine and specialized OEH assessments.

1. Key OEH hazards to consider include chemicals used, heat sources present, harmful dust exposures, light (optical) radiation hazards and hazardous noise sources.
2. In addition to the OEH hazards, pay attention to safety concerns such as impact, penetration, and compression hazards.

Organize and analyze findings

Organizing and analyzing findings of a risk assessment based on the type of hazard, level of risk, and seriousness of injury help determine how to control the hazards. Consider engineering, workplace, and/or administrative controls to eliminate or reduce the hazards before resorting to PPE.

Select PPE

Once you become familiar with the potential hazards, it is time to become familiar with the type of protective equipment available and compare hazards with the capabilities of the available protective equipment. The key is to select the PPE that ensures a level of protection greater than the minimum required. Any PPE selected by BE becomes part of the work place's certified PPE listing, and workplace personnel are not authorized to substitute the PPE unless it is first assessed and approved by BE personnel.

Fit and train

Fit the user and make sure a PPE training program that addresses proper PPE use and care is in place.

PPE training

OSHA Standard Title 29 CFR 1910, Subpart I and AFI 48–145 both specify training requirements whenever PPE is used as a control. Training provided by BE must include, at a minimum, the following:

- 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 (fig. 2–16).

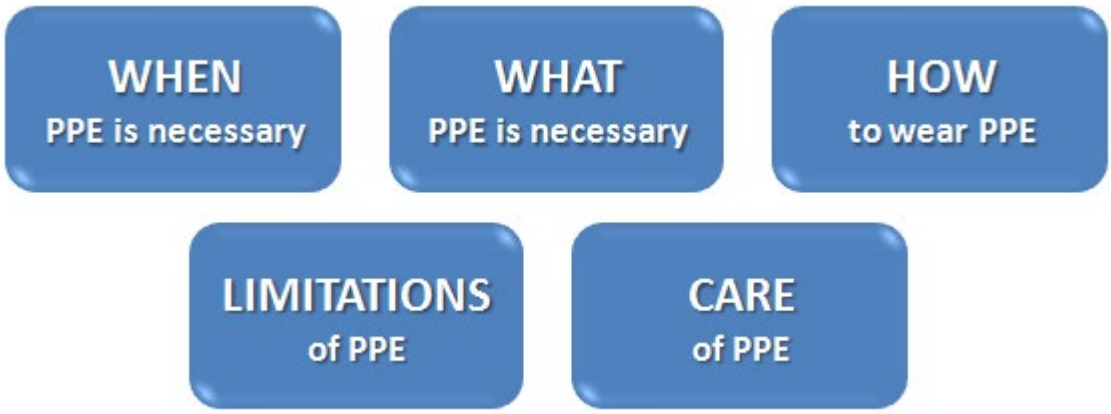


Figure 2–16. PPE Training Standard.

To meet these requirements, many OEH programs (i.e., hazard communication, OSHA expanded standards, respiratory protection) incorporate PPE training requirements into the respective regulation.

As with any other OEH data, all PPE information must be documented with the respective workplace information. Requirements must be communicated to all personnel in the work center.

216. Correct use, selection, and limitations of personal protective equipment

Once the decision has been made to approve PPE for use, it is important to select the right one for the hazard. BE's role is to observe the operations being performed, the type of contaminants being generated, and the overall risks those contaminants present. In making these observations, BE can assess the continued need for PPE or the need for it as a control if not yet considered. AFMAN 91–203 outlines the responsibilities for the use of PPE in effectively controlling workplace hazards to include the requirements for use, care, and maintenance of protective equipment.

Types, capabilities, and limitations of personal protective equipment

PPE includes a variety of devices and garments to protect workers from illness and injuries. PPE is not just for protection from chemical hazards; it also protects workers from biological, radiological, and physical hazards. PPE is commonly described according to the area of the body it protects, as provided in the following paragraphs.

Eye and face protection

This includes items such as goggles, face shields, protective glasses, welding shields, and laser safety goggles. Protection of the eyes and face from injury by physical and chemical agents or by radiation is vital in any occupational safety program. Eye-protective devices must be considered optical instruments and should be carefully selected, fitted, and used. Eye-protection equipment's design enhances one or more of the eye's natural defenses. Face shield and/or goggles as well as face mask/respirators are worn for procedures that may involve splashing or spraying; however, since face shields by themselves do not always provide adequate protection against liquid splashes, they should be used in conjunction with goggles.

Hand and arm protection

A large number of health hazards arise from skin contact with chemicals, thermal exposures, and puncture hazards. Currently, there is no known glove available capable of protecting against all potential hand hazards; commonly available glove materials provide only limited protection against many chemicals. An example of how this affects decisions on which gloves to select is shown in the following table. If a work center has an operation where the workers' hands may come in contact with kerosene, BE would need to ensure they are using the correct gloves and describe the limitations of those gloves.

There are literally hundreds of gloves manufactured; however, not all are suitable for chemicals. Therefore, of the ones that are, which provide the best protection? According to the NIOSH, there are several types of gloves that provide protection from exposure to kerosene.

The following table is an excerpt from *Recommendations for Chemical Protective Clothing: A Companion to the NIOSH Pocket Guide to Chemical Hazards,* Table K.

Chemical	CAS No.	Recommendation for skin protection	Recommended protective clothing barriers
Kerosene	800–82–06	Prevent skin contact	8 hours: Nitrile, PE, Viton 4 hours: Neoprene, PVA, PVC, Barricade, Responder
**Where:* *Nitrile = Nitrile Rubber (Gloves, Suits, Boots).* *PE = Polyethylene (Gloves, Suits, Boots).* *Viton = Viton™ (Gloves, Suits).* *Neoprene = Neoprene Rubber (Gloves, Suits, Boots).* *PVA = Polyvinyl Alcohol (Gloves).* *PVC = Polyvinyl Chloride (Gloves, Suits, Boots).*			

Additionally, the *Quick Selection Guide to Chemical Protective Clothing* indicates that butyl rubber, natural rubber and Tychem SL (Saranex) are not recommended for protection against kerosene. Further, PVC gloves are only recommended for 1–4 hours.

In this example, we can see that there are several types of gloves that the workers can use and several that are not recommended. When you visit the shop, you may find that they are using neoprene rubber gloves. After inspecting the PPE, you would verify they are using the correct PPE by determining the specific activity, the hazard involved in that activity (in this case, kerosene contact), the manufacturer of the PPE, the description (neoprene gloves), and any limitations and worker preferences. The table above lists four hours for neoprene gloves, which means that the gloves are only certified to be used for up to four hours of the operation. If you decide to certify the neoprene gloves and the activity lasts more than four hours, the limitation is that the worker must get a new pair of gloves at least every four hours.

Head protection

Although head protection (i.e., helmets, hard hats) deals more with the safety of workers, they often protect workers 'health as well. For example, helmets are often used in welding and media blasting operations. Additionally, the acoustic properties of helmets can often attenuate noise at the ear. The maximum amount that a hearing protector can reduce the sound reaching the ear is from about 35 decibels (dB) at 250 Hz to about 50 dB at the higher frequencies. Assessments have shown that by wearing hearing protectors and then adding a helmet that encloses the head, an additional 10-dB reduction of sound transmitted to the ears can be achieved.

Foot and leg protection

Encapsulating and non-encapsulated chemical-protective ensembles include boots made of varying materials to protect against specific hazards. It is important to verify that the footwear worn by workers is suitable for the materials and equipment used, and is in good condition. Additionally, the chemical resistance concerns presented previously for hand and arm protection apply equally to footwear.

Body and torso protection

This includes, but is not limited to aprons, jackets, coveralls, encapsulating suits, and cooling vests. Just as with the PPE devices discussed earlier, body and torso protection depends on chemical resistance and physical properties to ensure the PPE properly protects workers from the materials.

Hearing protection

Hearing-protective devices such as earplugs and earmuffs have one serious drawback—they do nothing to reduce or eliminate the hazard. Personal hearing-protective devices are acoustic barriers that reduce the amount of sound energy transmitted through the ear canal to receptors in the inner ear. Inserts or muffs are hearing-protective devices that are in common use today. The insert-type protector attenuates noise by plugging the external ear canal, whereas the muff-type protector encloses the auricle of the ear to provide an acoustic seal. The effectiveness of hearing-protective devices depends on several factors related to the manner in which the sound energy travels through or around the device.

Respiratory protection

Respirators should not be used as the primary or only means of protection against hazardous chemical vapors because too many factors limit their use; however, they can be used as emergency or backup protection. Respiratory protective equipment, especially the air-purifying type, is limited by leakage around the mask edges, surface contamination, impaired efficiency with use, and the need for adequate oxygen. Additionally, improper care may present a greater danger to an employee than no protection at all, as it gives a false sense of security. Workers become careless and may inadvertently expose themselves to hazardous levels of toxins. Because of this, respirators should be controlled through a program that provides for proper selection, fitting, testing, education, and maintenance under the surveillance of competent personnel.

Selecting personal protective equipment

Selecting the right PPE for the activity being performed is critical to protect the health of personnel. The following paragraphs provide some general guidelines for selecting the correct PPE.

Clothing design

Categorizing clothing by design is mainly a means for describing what areas of the body the clothing item protects. For example, the type of protective clothing for emergency response, hazardous waste site cleanup and other dangerous chemical operations, primarily involves using encapsulating suits and non-encapsulating or splash suits with additional accessory clothing items.

Manufacturers sell clothing in a variety of styles and configurations; therefore, some design aspects to consider when selecting PPE include the following:

- Clothing configuration.
- Components and options.
- Sizes.
- Ease of donning and doffing.
- Clothing construction.
- Accommodation of other selected ensemble equipment.

- Comfort.
- Restriction of mobility.

Material chemical resistance

Ideally, the chosen PPE resists permeation, degradation, and penetration by the chemicals being used. However, it is important to note that no material protects against all chemicals and combinations of chemicals, and that no currently available material is an effective barrier to any prolonged chemical exposure. With that in mind, the PPE, at a minimum, must be resistant enough to protect workers while they are performing a hazardous operation. The following three paragraphs provide information on available sources of information:

Guidelines for the Selection of Chemical Protective Clothing

This reference provides a matrix of clothing material recommendations for approximately 500 chemicals based on an evaluation of chemical resistance test data, vendor literature, and raw material suppliers. The major limitation is that this reference presents recommendations by generic material class; however, numerous test results have shown that similar materials from different manufacturers may give widely different performance. That is to say manufacturer A's butyl rubber glove may protect against chemical X while the butyl glove made by manufacturer B may not.

Quick Selection Guide to Chemical Protective Clothing

This pocket-sized, color-coded guide provides chemical resistance data and recommendations for 11 generic materials against over 400 chemicals. As with the first reference previously mentioned, the major limitation of this reference is that it is also based on generic material class data.

Vendor data or recommendations

The best source of current information on material compatibility with chemical hazards should be available from the manufacturer of the selected clothing. The supply charts from many vendors show actual test data or vendor recommendations for specific chemicals. However, unless vendor data or the recommendations are well documented, end users must approach this information with caution. Material recommendations must be based on data obtained from tests performed to standard American Society for Testing and Materials (ASTM) methods.

Physical properties

As with chemical resistance, manufacturer materials offer wide ranges of physical qualities in terms of strength, resistance to physical hazards, and operation in extreme environmental conditions. Assess material physical properties by posing the following questions.

- Does the material have sufficient strength to withstand the physical demands of the tasks at hand?
- Will the material resist tears, punctures, cuts, and abrasions?
- Will the material withstand repeated use after contamination and decontamination?
- Is the material flexible or pliable enough to allow end users to perform needed tasks?
- Will the material maintain its protective integrity and flexibility under hot and cold extremes?
- Is the material flame-resistant or self-extinguishing (if these hazards are present)?
- Does the construction of garment seams provide the same physical integrity as the garment material?

Ease of decontamination

The degree of difficulty in decontaminating protective clothing may dictate whether disposable or reusable clothing is used, or a combination of both.

Cost

Protective clothing users and managers must buy PPE with the available resources while still meeting the specific safety and health needs of the application.

Chemical protective clothing standards

Protective clothing often must meet the requirements of specific standards so it is important to consider all applicable requirements before making a selection.

Verify use and training on PPE including limitations

When conducting a workplace assessment, BE reviews and verifies the selection, use, and training of PPE. AFMAN 91–203 Chapter 14 includes a PPE checklist that can be used to assist with completing the review.

When in the work place, it is also important to wear the appropriate PPE. This not only safeguards you, but also serves as an example to the workers. If you assess an area that requires PPE and you do not wear the appropriate PPE, you demonstrate by your own behavior that it is not necessary to wear PPE.

Risk associated with incorrect selection and use of PPE

When making a PPE selection, consider the fit and comfort of the equipment. The fact that PPE can be bulky, heavy, impair mobility, cause thermal stress problems or some other physiological strain may discourage workers from using the PPE. In other words, the physical properties of specific PPE are essential for the needs of each person.

Remember, consider the permeation, degradation, and penetration; they can each affect the protection provided by PPE. Many workers either do not understand or consider these factors when putting on their PPE. You will often find work centers using either latex or nitrile rubber gloves when performing operations that actually require them to use butyl rubber gloves. The chemicals permeate through the latex or nitrile gloves too easily, but the butyl gloves may feel uncomfortable or the workers do not know any better. This type of scenario may result in inadvertent exposure to the worker and possible injury or illness.

It is also important to remember that even wearing the correct glove may not be enough. Gloves can only be used safely for limited periods based on permeation rates and breakthrough times. Always review the data from the specific PPE manufacturer whenever possible to assist you in making your selection.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

213. Occupational and environmental health exposure controls

1. List the three types of OEH controls in order of priority.

2. When recommending engineering controls, what are three approaches that can be used to control OEH hazards?

3. What three parameters can be applied to assess the effectiveness of a control?

214. Protective clothing concepts

1. What four concepts describe the quality of PPE chemical resistance?

2. Describe permeation as it relates to PPE.

3. Describe breakthrough time as it relates to PPE.

4. What are some of the physiological effects of wearing PPE?

215. BE roles and interactions in personal protective equipment guidance

1. List the steps generally taken by BE personnel to assess PPE needs as required by OSHA and Air Force PPE standards.

2. What are the five minimum PPE training requirements that BE is responsible to provide to workers?

216. Correct use, selection, and limitations of personal protective equipment

1. The general guidelines for selecting PPE include what six factors?

2. When selecting PPE, why must resistance be a consideration?

3. What is the best source of information on material compatibility with chemical hazards?

2–4. Risk Assessment Codes

Workers must be protected from potential as well as existing occupational risks. This is achieved through a risk assessment process, which involves risk analysis, risk assessment and risk control practices. As occupational health threats and risks are assessed and ideally abated, commanders like to have the ability and means to correct threats/risks as soon as possible. However, commanders also have a responsibility to operate within resource constraints (money, manpower, etc.). For this reason, it is necessary for commanders to prioritize how resources will be applied in order to abate existing health threats/risks. The base safety office helps commanders with this by managing the installation master hazard abatement program master file.

217. Occupational health risk assessment codes

Occupational RM is an iterative, cyclic, and systematic process. The process includes the examination of all characteristics of the work system where the worker operates, namely the work place. These characteristics include equipment/machines, materials, work methods/practices, and work environment. The aim of RM is to identify what could go wrong and to decide on proper safety control measures to prevent occupational accidents, injuries, and diseases, and then implement those control procedures. The main goal of risk assessment is to eliminate, or at least reduce, the risks according to the as low as reasonably achievable (ALARA) principle.

Procedures for assigning risk assessment codes

As stated in previous lessons, carrying out RM implies performing several steps, including the following:

- Identification of exposed workers.
- Characterization of tasks, equipment, materials and procedures.
- Identification and characterization of safety measures in use.
- Identification of accidents and diseases related to the work lace in analysis.
- Identification of standards and/or regulations related to the work place in analysis.

Several means can support these activities, including the following:

- Direct observation during job performance.
- Interviews with workers and supervisors.
- Review accident reports and disease records.
- Check equipment/machine technical data.
- Examine SDS regarding chemical substances in the work place.
- Consider legislation, standards and regulations that are applicable.

A RAC is an expression of the degree of risk associated with an occupational hazard or deficiency that combines hazard severity and mishap probability into a single numeric identifier known as a RAC category. RAC categories range from a RAC 1 through a RAC 5. RACs 1, 2, or 3 are classified as occupational hazards. These are conditions, procedures, and practices directly related to the work environment that create a potential for producing occupational injuries or illnesses to exposed personnel within the work place. RACs 4 or 5 are classified as occupational deficiencies. These are conditions, procedures, and practices that often can be fixed on the spot or be included in the letter to the shop which do not pose an immediate threat. Therefore, they can be addressed at a later date. RACs divide into five RAC categories, as shown on the following table.

RAC Category	Category Description	Comments
RAC 1	Imminent—Conditions or practices in a work place expected to cause death or severe physical harm before the danger is eliminated through normal abatement.	Included in formal installation hazard abatement plan (using AF Form 3, Hazard Abatement Plan) if not corrected within 30 days.
RAC 2	Serious—Condition or practices in a work place that can cause danger by serious bodily harm or serious sickness, but are not life threatening.	Included in formal installation hazard abatement plan (using AF Form 3) if not corrected within 30 days.
RAC 3	Moderate—Conditions or practices in a work place that can cause moderate danger but are not life threatening and will not cause serious illness.	Included in formal installation hazard abatement plan (using AF Form 3) if not corrected within 30 days.

RAC Category	Category Description	Comments
RAC 4	Minor—Usually administrative deficiencies such as workers not trained on hazards. Usually deficiencies of this nature can be remedied on the spot or addressed at a later date.	Tracked by base Safety until closed, but is *not* required to be included in the installation hazard abatement plan.
RAC 5	Negligible—Same as for RAC 4.	Tracked by base safety until closed, but is *not* required to be included in the installation hazard abatement plan.

Only qualified safety, fire protection and health personnel can evaluate hazards or deficiencies and assign a RAC. According to AFI 91–202, personnel who possess a safety, fire protection, BE, aerospace medicine, or medicine Air Force specialty code are considered qualified; however, enlisted military personnel must possess a 7-skill level (or be a 5-skill level and be certified to perform the task). AFMAN 48–146, *Occupational & Environmental Health Program Management,* specifically tasks BE personnel with assigning RACs when a health hazard requires action by a non-BE entity (e.g., workplace supervisor, commander). Since the base safety office manages the installation master hazard abatement program master file, BE is required to notify the safety office if BE assigns a RAC.

Some situations that could warrant a BE-assigned RAC and drive non-BE follow-up actions include, but are not limited to the following:

- Sampling results above established OEL.
- A leaking blasting booth/glove box/dust collection system.
- Shop personnel performing welding operations without proper shielding/curtains.
- Personnel working in an administrative work center and exposed to hazardous noise**.**
- Shop personnel not using approved PPE (gloves, respirators).
- Local exhaust ventilation system not meeting baseline airflow requirements.
- Required respiratory protection mask inspections not being performed.
- Shop does not have a required respiratory protection plan.
- Any other health hazard that requires an organization to take action to reduce the hazard.

A RAC shall not be assigned to equipment issued during routine maintenance or servicing. For example, technical order-directed tagging of the starter switch during engine maintenance does not require a RAC. The senior operating official exercising managerial control of the activity or operation with the RAC, also known as the functional manager, owns responsibility for the assigned RAC. This person can usually acquire and commit resources for the abatement of the hazard.

The primary AF guidance for assigning RACs is AFI 91–202, *The US Air Force Mishap Prevention Program*, which is the reference used for this lesson, unless otherwise noted. There are two methods for calculating RACs. Which method is used depends on what type of hazard is present. Safety, fire and ergonomic hazards use one calculation method and health-related hazards use another.

Ergonomic risk factors

Ergonomic or musculoskeletal disorders (MSD) affect the muscles, nerves, tendons, ligaments, joints, cartilage and spinal disks can present serious risks as well as injuries in the work place. These risks and injuries can seriously impact the mission. By looking at the workplace operations, you can identify risk factors (via RAC assignment) and eliminate or control them as early as possible.

The risk of MSD injury depends on work positions and postures, how often the task is performed, the level of required effort, and how long the task lasts. Risk factors may lead to the development of MSDs; therefore, they must be assessed for potential occurrence and severity and RAC assignment. These risk factors include the following:

- Exerting excessive force.
- Performing the same or similar tasks repetitively.
- Working in awkward postures or being in the same position for long periods of time.
- Localized pressure into the body part.
- Cold temperatures.
- Vibration.
- Combined exposure to several risk factors.

In addition, if you observe the following work habits, the workers may have ergonomic issues:

- Modifying tools, equipment, or work area.
- Personnel shaking their arms and hands, or rolling their shoulders.
- Use of back support belts or wrist braces in the work place.

In addition, workers can identify and provide important information about hazards in their work places. Once these issues/problems have been identified, steps can be taken to define and assess the risk, assign a RAC, and comprehensively address the issue(s).

Steps in determining a safety or ergonomic RAC

A safety, fire, or ergonomic RAC is determined by combining into a single numeric identifier the potential mishap severity and mishap probability using the following table from AFI 91–202 as outlined in these three steps:

- *Step 1*: Determine the potential mishap severity (I, II, III or IV) using the severity code descriptions.
- *Step 2*: Determine the probability that a mishap will occur (A, B, C or D) using the probability code descriptions.
- *Step 3*: Find the severity and probability ratings intersecting point to determine the RAC.

Severity	Mishap Probability [13]			
	A	B	C	D
I	1	1	2	4
II	1	2	3	4
III	2	3	4	5
IV	4	4	5	5

Severity Code Description

I Death, permanent total disability or loss of a facility or asset of $2,000,000 or more.

II Permanent partial disability, temporary disability in excess of 3 months or major damage of $500,000 up to $2,000,000.

III Lost workday injury or compensable injury or minor property damage $50,000 up to $500,000.

IV Minimal threat to personnel or property, first-aid, minor supportive medical treatment, violation of a standard or damage less than $50,000.

Probability Code Description

A Likely to occur immediately

B Probably will occur in time

C Possible to occur in time

D Unlikely to occur

RAC Description

1 Imminent 2 Serious

3 Moderate 4 Minor

5 Negligible

Steps in determining a health-related RAC

Health-related RACs are determined by plotting health hazard severity category (HHSC) and the illness probability category (IPC). The specific steps involved are as follows and shown in figure 2–17:

- Step 1: Determine the HHSC (sum of *exposure points* and *medical effects points*).
- Step 2: Determine the IPC (sum of *duration of exposure points* and *number of exposed points*).
- Step 3: Use health-related RAC matrix to determine RAC.

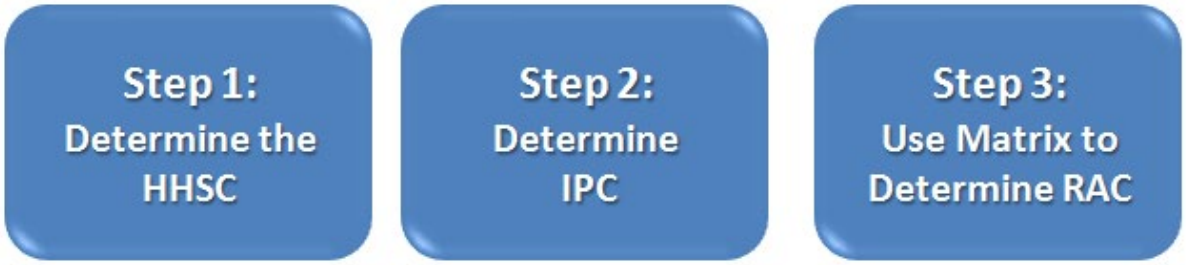


Figure 2–17. Safety Probability Matrix. [13]

The process begins by determining the HHSC. As indicated above, the HHSC is derived from combining the points for the exposure conditions and the medical effects.

Exposure points

When assigning exposure points, you must determine whether there are alternate routes of exposure as well as what the exposure conditions are. The NIOSH Pocket Guide can aid in identifying whether a chemical has an alternate exposure route. Consider whether sampling results are above an action level or OEL when assigning points for exposure conditions.

	Exposure Conditions			
Alternate Route Exposure?	**< Action Level (AL)**	**Occasionally > AL; Always < OEL**	**> AL < OEL**	**> OEL**
No	0	3	5	7
Yes	2	4	6	9

Example: A review of ten air sampling results for lead exposure in a sanding process indicates a maximum exposure of 35 micrograms per cubic meter (µg/m^3). According to OSHA Standard Title 29 CFR 1910.1025, *Lead*, the PEL for lead is 50 µg/m^3 averaged over an 8-hour period, and the AL is 30 µg/m^3 averaged over an 8-hour period. The *NIOSH Pocket Guide to Chemical Hazards* states the potential exposure routes include inhalation, ingestion, skin and/or eye contact. Your assessment of the process validates all of these routes of exposure. Based on this data, you would probably assign *six exposure points* if assigning a RAC to the sanding process.

Medical effects points

Points for medical effects are simply based on what health effects may be caused by the hazard of concern and comparing those effects to the following information:

	Medical Conditions				
Probability	Permanent, severe, disabling, irreversible illness or death, such as lung cancer	Permanent, non-severe illness or loss of capacity, such as permanent hearing loss	Temporary reversible illness with a variable but limited period of disability, such as metal fume fever	Temporary reversible illness requiring supportive treatment, such as eye irritation & sore throat	No medical effect, such as nuisance noise or nuisance order
High	8	6	4	2	0
Low	7	5	3	1	0

Step 1. Once the number of points to assign for the medical conditions has been determined, *add the two values* (*exposure points* and *medical effects*) to determine the HHSC using the information in the following table.

Sum of Exposure and Medical Effects Points	HHSC
13 to 17	1
9 to 12	2
5 to 8	3
0 to 4	4

Step 2. Once the HHSC has been determined, the next step is to determine the IPC. The IPC is a function of the duration of exposure and the number of exposed personnel. Determine the MPC for health hazards by following the appropriate guides (to assess points). The probability of mishap reflects the duration of exposure and the number of exposed personnel.

Duration of exposure points

Consider the type of exposure (whether irregular or regular) and the total time (in hours) of exposure per week. Apply that information to the following table to determine points for duration of exposure.

	Exposure Duration		
Type of Exposure	**1–8 hours/week**	**> 8 hours/week, not continuous**	**Continuous**
Irregular, intermittent with **low** probability	1	4	—
Irregular, intermittent with **high** probability	2	6	—
Regular, periodic with **low** probability	2	5	8

Number of exposed personnel points

Assessing points for number of personnel exposed is straight forward using the following table:

Number of workers in the SEG who perform the process(es) that produce the hazard	Exposed Personnel Points

Number of workers in the SEG who perform the process(es) that produce the hazard	Exposed Personnel Points
1–2	1
3–4	2
5–6	3
7–9	4
10–29	5
30–49	6
49–100	7
> 100	8

Add the two point values (*duration of exposure* and *number of exposed personnel*) to determine the IPC using the information in the following table.

Total Points	IPC
14 to 16	1
10 to 13	2
5 to 9	3
< 5	4

Step 3. Once the HHSC and IPC have been determined, the health-related RAC matrix can be used (see the following table) to assign the applicable RAC.

HHSC	IPC			
	1	1	2	3
1	1	1	2	3
2	1	2	3	4
3	2	3	4	5
4	3	4	5	5

Posting of hazards

If a RAC 1, 2, or 3 has been assigned, AFI 91–202 specifies forms that must be filled out to track the status of the RAC and post notices to alert workers of the hazards. The following forms are used:

Form	Purpose
AF Form 979, Danger Tag	A temporary means of identifying hazardous conditions; can be used for equipment.
AF Form 1118, Notice of Hazard	Used to post notices of hazard for facilities.
AF Form 3, Hazard Abatement Plan	Used to enter a RAC 1, 2, or 3 into installation's formal hazard abatement plan when more than 30 calendar days are needed to abate the hazard.

AF Form 979

The AF Form 979, Danger Tag, shown in figure 2–18, is a temporary means of identifying hazardous conditions. Since the Danger Tag provides a means for supervisors to immediately alert workers to existing and/or potential hazards, it can be used by the supervisor as an interim device until an AF Form 1118 is posted. Afterwards, the AF Form 979 may be removed. This tag shall only be used where an immediate hazard (RAC 1 through 3) exists and specific precautions are required to protect

personnel or property — or as required by technical orders, AF instructions or other requirements. Only the worker, or supervisor, responsible for installing the Danger Tag may remove the tag, and only if the hazard has been abated, with coordination from the installation safety office. BE personnel should not use this form when assigning health-related RACs, but should instead use AF Form 1118.

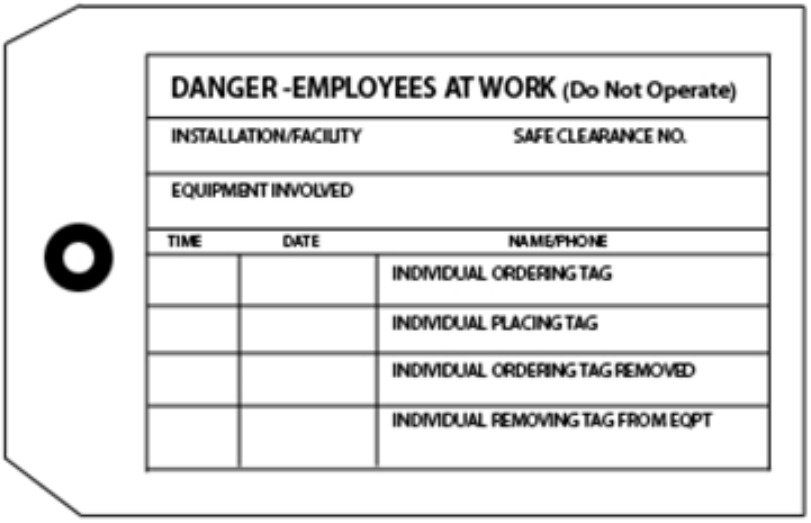


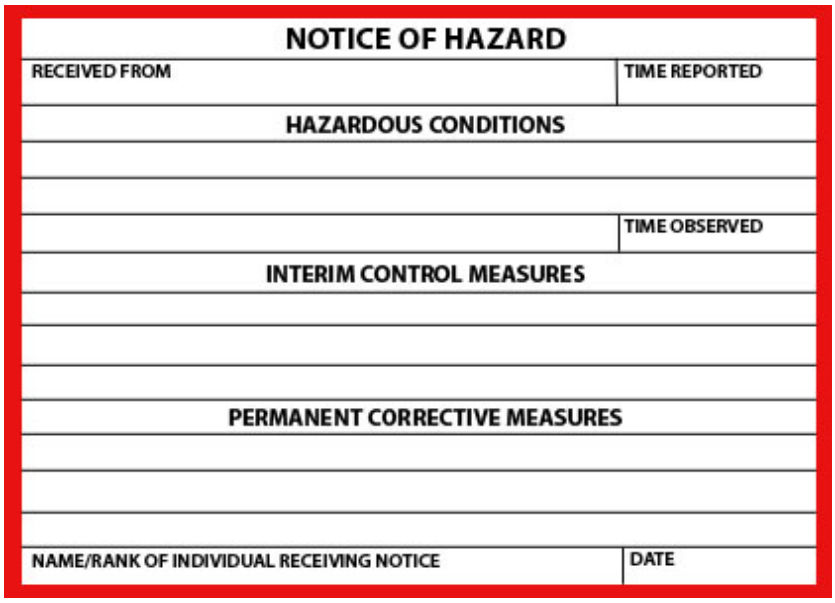
Figure 2–18. AF Form 979, Danger Tag.

AF Form 1118

The fire, safety or health officials complete the AF Form 1118, Notice of Hazard, shown in Figure 2–19, when identifying a RAC 1, 2, and 3 hazard. AFI 91–202 has instructions for completing the form. Once the form is complete, forward it to the supervisor for posting.

Posting requirements are as follows:

- The supervisor must post the form as near as possible to the hazard.
- The form must be posted no later than the end of the next duty day after identification of the hazard.
- Where the nature of the hazard or work place is such that this is not practical, post notices in a prominent place where all employees can see them.
- The form must remain posted for three days or until the hazard is corrected, whichever is greater.
- The workplace supervisor must ensure the posted AF Form 1118 is maintained in good condition and employees are kept informed of any changes.
- If adverse conditions are present, enclose the notice in a suitable protective cover such as a document protector.
- If the hazard is not abated within 30 days, a copy of the AF Form 1118 will be sent to the wing safety office by the office assigning the RAC (BE for health-related RACs) so safety can add the RAC to the master hazard abatement program for tracking.
- The supervisor, with coordination from the installation safety office, fire department or BE, as appropriate, is responsible for removing the tag after the hazardous condition has been corrected.



NOTICE OF HAZARD

RECEIVED FROM	TIME REPORTED

HAZARDOUS CONDITIONS

	TIME OBSERVED

INTERIM CONTROL MEASURES

PERMANENT CORRECTIVE MEASURES

NAME/RANK OF INDIVIDUAL RECEIVING NOTICE	DATE

Figure 2–19. AF Form 1118, Notice of Hazard.

AF Form 3

If a RAC 1, 2, 3 cannot be corrected after 30 calendar days, the base safety office adds the RAC to the installation's formal hazard abatement plan via AF Form 3, Hazard Abatement Plan, which is prepared by the workplace functional manager, using hazard information provided on AF Form 1118 and with support from the safety office. Once an abatement project has been completed, the project must be certified by the appropriate agency (i.e., safety, fire, or BE) to ensure the hazard was properly abated before it can be closed. Certification in this particular instance means the appropriate official has performed a site visit to verify that the hazard has been fully abated.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

217. Occupational health risk assessment codes

1. What is a RAC?

2. According to AFI 91–202, who is qualified to evaluate hazards or deficiencies and assign a RAC?

3. For a health-related RAC, how is the health hazard severity category (HHSC) determined?

4. If the sum of exposure conditions and medical effects points equals 10, what is the HHSC?

Answers to Self-Test Questions

205

1. (1) Identify OEH support requirements.
   (2) Identify potential OEH hazards related to processes.
   (3) Assign a qualitative risk to each hazard.
   (4) Identify any health hazard that may require a design change or modification to an existing weapons system to eliminate/mitigate the hazard.
   (5) Monitor compliance with Air Force and OSHA regulatory requirements in-garrison.
2. Quantitative.

206

1. (1) Prioritizing resources and time for those work places or activities that pose the greatest health risks to Air Force personnel.
   (2) Scheduling the frequency for routine OEH assessments in shops.
2. Every 12 months for Workplace Category 1 shops; every 30 months for Workplace Category 2 shops.

207

1. Familiarize yourself with any existing OEH assessment data obtained and compiled during past assessments to determine a surveillance strategy for the pending routine OEH assessment.
2. As the lowest level of work performed in a shop that may pose a risk.
3. (1) Observing work practices.
   (2) Accomplishing OEH hazard characterization/assessment and using data to define the SEG.
   (3) A combination of both activities.
4. When a routine OEH assessment, or another trigger event (e.g., occupational health illness investigation), identifies a work place that needs additional data to properly analyze an OEH risk. Further, some special OEH assessments are required on a recurring basis (e.g., compliance air sampling for expanded standard chemicals), while others may be special requests from workplace supervisors, medical providers, and/or other base agencies.
5. To prioritize special OEH assessments.
6. BE should hold a closing conference with the workplace supervisor and provide a written routine OEH assessment report. During the conference, it is important to review findings, make recommendations and discuss follow-up actions, and discuss expectations.

208

1. (1) Determine if a worker's injury or illness is or was related to his/her job.
   (2) Identify the reason(s) why a person experienced the illness/injury so future occurrences can be prevented.
2. An occupational injury is a medical condition that evolves over the period of no more than a single workday or work shift (e.g., laceration). An occupational illness, on the other hand, is a medical condition that evolves over more than one work shift (e.g., carpal tunnel syndrome).
3. (1) Exposure assessment: identify and assess the conditions or circumstances that caused or contributed to the occupational illness.
   (2) Evaluate effectiveness of control: determine if the affected individual should have been using any workplace controls, if the controls were available, if they were being used, if they were being used properly, and the serviceability of the controls.
   (3) Identify non-compliance factors: determine if the occupational illness was a result of non-compliance such as incorrect PPE, improper/missing hazard communication training, unauthorized use of HAZMATs, and improper workplace hygiene (i.e., food/drink in an ingestion hazard area).
   (4) Documentation of the occupational illness: After you have completed your occupational illness investigation, you will enter the facts and findings of your investigation in AFSAS.

209

1. Protect the reproductive health of AF members from occupational exposures to chemical, biological, radiological, or physical substances.
2. The HCP.

210

1. An independent assessment of the following:
   (1) A unit's compliance with established directives and ability to execute its assigned mission, leadership effectiveness, management performance, and aspects of unit culture and command climate.
   (2) A unit's ability to find, analyze, report and fix deficiencies.
   (3) A unit's ability to prevent fraud and minimize waste and abuse.
2. UEI, RAM permit inspection, and NSI.
3. (1) Managing resources.
   (2) Leading people.
   (3) Improving the unit.
   (4) Executing the mission.
4. RAM Inspection.
5. Commander.
6. CCIP.
7. Wing IG.
8. The SAC and MICT.
9. MICT.

211

1. (1) To assess the long-term impact on workplace operations (e.g., adequate ventilation).
   (2) The hazards the construction itself may generate (e.g., disturbing asbestos containing material).
2. Chemicals, biological, and physical hazards.
3. Facility manager.
4. When the facility is in the design phase.

212

1. (1) Supports OEH RM activities on military installations.
   (2) Documents environmental conditions.
   (3) Identifies OEH threats.
   (4) Guides OEH data collection activities for HRA.
   (5) Is a key element of the HRA process and assists health risk assessors to make RM decisions concerning OEH threats.
2. (1) Source of an OEH threat release.
   (2) Environmental media.
   (3) Health threat.
   (4) Route of exposure.
   (5) PAR.
3. CSM.
4. All five elements of an exposure pathway are present as determined by professional judgment, initial field screening, modeling, and so forth.
5. Typically, the amount of information readily available on the site.
6. To designate sectors containing significant known OEH threats (e.g., IH shops, flight line, HAZMAT storage) and major PARs (e.g., housing, child development centers, admin offices, tent city, and

cantonment areas) by establishing logical boundaries to delineate and separate known OEH threats and PARs.

7. A radius of 10 kilometers around the installation.
8. Initial assessment.
9. Probability and severity of each exposure pathway in the CSM.
10. The OEWHG.

213

1. (1) Engineering controls.
   (2) Administrative controls.
   (3) PPE controls.
2. Substitution, isolation, and ventilation.
3. (1) The control must be able to mitigate the OEH threat exposure to an acceptable level.
   (2) The responsible organization must be able to reasonably implement the control option.
   (3) The control must be practical when considering cost and time associated with implementation.

214

1. Permeation, breakthrough time, penetration and degradation qualities.
2. The process by which a chemical dissolves in or moves through a material on a molecular basis.
3. The time it takes a chemical to permeate completely through a material.
4. Changes in heart rate, increase water loss, impair vision, mobility and communication.

215

1. (1) Conduct a walk-through to identify sources of hazards.
   (2) Organize and analyze findings to determine how to control the hazards.
   (3) Select PPE that ensures a level of protection greater than the minimum required.
   (4) Fit the user and ensure a PPE training program is in place that addresses proper PPE care and use.
2. PPE training, as a minimum, should include the following:
   (1) When PPE is necessary.
   (2) What PPE is necessary.
   (3) How to properly don, doff, adjust, and wear PPE.
   (4) The limitations of the PPE.
   (5) The proper care, maintenance, useful life and disposal of the PPE.

216

1. (1) Clothing design, (2) material chemical resistance, (3) physical properties, (4) ease of determination, (5) cost, and (6) chemical protective clothing standards.
2. At a minimum, PPE must be resistant enough to protect the worker while performing the hazardous operation.
3. The manufacturer of the selected clothing.

217

1. An expression of the degree of risk associated with an occupational hazard or deficiency that combines hazard severity and mishap probability into a single numeric identifier.
2. Personnel who possess a safety, fire protection, BE, aerospace medicine, or medicine Air Force Specialty Code are considered qualified; however, enlisted military personnel must possess a 7-skill level (or be a 5-skill level and be certified to perform the task).
3. From combining the points for exposure conditions and the medical effects.

4. 2.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

13. (205) What type of occupational and environmental health (OEH) process assessment are you conducting when it is a qualitative workplace assessment to identify and scope the processes employed to execute the unit's mission?
    a. Routine.
    b. Special.
    c. Periodic.
    d. Termination.

14. (206) The workplace categorization process is a method for
    a. scheduling routine occupational and environmental health (OEH) assessments.
    b. identifying similar exposure groups.
    c. assigning a conceptual site model.
    d. classifying workplace types.

15. (206) Which is a characteristic of a Category 1 High Hazard Area?
    a. Full occupational and environmental health (OEH) regulatory compliance.
    b. Inherent OEH risk present with low hazard potential.
    c. Hazards poorly defined or poorly controlled.
    d. Requirement for annual audiograms.

16. (206) What is the *minimum* assessment frequency for a Category 3 Low Hazard Area?
    a. Every 12 days.
    b. Every 12 months.
    c. Every 30 months.
    d. Frequency locally determined.

17. (207) When performing basic hazard characterization, what should be done *before* visiting the workplace?
    a. Review existing occupational and environmental health (OEH) assessment data.
    b. Determine whether a routine or special survey will be needed.
    c. Establish parameters of compliance.
    d. Identify workplace demographics.

18. (208) In what step of an occupational illness investigation does bioenvironmental engineering (BE) identify the conditions or circumstances that caused or contributed to the occupational illness?
    a. Exposure assessment.
    b. Identify non-compliance factors.
    c. Evaluate effectiveness of controls.
    d. Documentation of occupational illness.

19. (209) When performing a pregnant worker evaluation, the depth of the investigation depends on the
    a. age of the individual.
    b. symptoms exhibited by the individual.
    c. timeframe in the pregnancy the exposure occurred.
    d. risks and existing information concerning the agents the individual encountered.

20. (209) What is bioenvironmental engineering's (BE) role in conducting pregnant worker evaluations?
    a. Notify public health (PH) of local policies.
    b. Research, identify, and document hazards.
    c. Examine documentation and make determinations.
    d. Recommend the individual to be removed from duty if appropriate.

21. (210) What is the *primary* focus of the Air Force Inspection System (AFIS)?
    a. Provide an automated reporting mechanism for occupational and environmental health (OEH) program(s).
    b. Ensure that occupational and OEH inspections are conducted on schedule.
    c. Provide cyclical feedback to measure workplace exposure.
    d. Assess unit readiness to execute assigned missions.

22. (210) Which inspection is a "no notice" inspection performed by Air Force Inspection System (AFIS)?
    a. Radioactive material (RAM) permit inspection.
    b. Nuclear weapon personnel reliability inspection.
    c. Unit effectiveness inspection (UEI).
    d. Nuclear surety inspection (NSI).

23. (210) Which command function allows a commander (CC) to determine appropriate training requirements, evaluate wing readiness, and formulate command welfare strategies?
    a. External inspection.
    b. Internal inspection.
    c. Unit effectiveness inspection.
    d. The Air Force (AF) system inspection.

24. (210) What is the purpose of a self-assessment checklist (SAC)?
    a. Improve compliance with published guidance.
    b. Ensure all assessments have been accomplished.
    c. Serve as the first part of the commander's inspection program (CCIP).
    d. Assist the inspector general (IG) with formulating inspection methodology.

25. (211) What is the purpose of reviewing local work order requests?
    a. To assess long-term impact and hazards that may be generated.
    b. To identify immediate chemical, biological and physical hazards.
    c. Assess the short-term impact on workers and the financial burden on the organization.
    d. Assess the hazards the construction itself may generate and resources required to complete the project.

26. (211) What type of building projects normally require the use of the Department of Defense (DD) Form 1391?
    a. Civil engineering (CE) construction.
    b. Self-help renovations.
    c. Military construction.
    d. Minor renovation.

27. (211) When is the *best* time to review construction plans and introduce engineering controls for a facility?
    a. In the design phase.
    b. During each construction phase.
    c. When ventilation is being installed.
    d. Mid-way through construction completion.

28. (212) Which is *not* a direct function of the occupational and environmental health site assessment (OEHSA)?
    a. Identifies personal protective equipment (PPE) required for a particular task.
    b. Identifies Occupational and Environmental Health (OEH) threats.
    c. Guides OEH data collection activities for health risk assessments (HRA).
    d. Documents environmental conditions.

29. (212) The mode by which a health threat interacts with a human being is called
    a. population at risk (PAR).
    b. source of threat/release.
    c. environmental media.
    d. route of exposure.

30. (212) The *defining element* of an occupational and environmental health site assessment (OEHSA) is the
    a. Air Force Manual (AFMAN) 48–146, *Occupational and Environmental Health Program Management.*
    b. source of an occupational and environmental health (OEH) threat release.
    c. OEH data collection activities.
    d. conceptual site model (CSM).

31. (212) What is the primary guidance document for performing an occupational and environmental health site assessment (OEHSA) in a deployed location?
    a. Air Force Manual (AFMAN) 10–2502, *Air Force Incident Management System (AFIMS) Standards and Procedures.*
    b. Air Force Tactics, Techniques, and Procedures (AFTTP) 3–2.82_Interservice Publication (IP), *Occupational and Environmental Health Site Assessment.*
    c. Air Force Instruction (AFI) 48–145, *Occupational and Environmental Health Program.*
    d. Technical Guide 230, *Chemical Exposure Guidelines for Deployed Military Personnel.*

32. (212) Why is it beneficial to conduct pathway screening sampling with direct reading instruments (DRI)?
    a. It can rule out the presence of trace contaminants.
    b. It can rule out the presence of high-potential threats.
    c. Commanders can receive directives from bioenvironmental engineering (BE) from the results.
    d. Results can immediately be entered into Defense Occupational and Environmental Health Readiness System (DOEHRS).

33. (213) Controls are the fundamental method used for protecting workers because they
    a. can easily be documented in Defense Occupational and Environmental Health Readiness System (DOEHRS).
    b. increase awareness of the occupational and environmental health (OEH) risk(s).
    c. eliminate or minimize the OEH hazard and provide a healthier work environment.
    d. prioritize the OEH exposure pathway.

34. (213) Which is *not* a form of substitution?
    a. Process.
    b. Materials.
    c. Personnel.
    d. Equipment.

35. (213) Which type of occupational exposure control changes a process to make it less hazardous?
    a. Engineering.
    b. Administrative.
    c. Preventive maintenance (PM).
    d. Personal protective equipment (PPE).

36. (213) Which occupational exposure control should be used in conjunction with other controls?
    a. Engineering.
    b. Administrative.
    c. Preventive maintenance (PM).
    d. Personal protective equipment (PPE).

37. (214) It is important to know the composition of the personal protective equipment (PPE) as well as the chemical used during operations, making sure the PPE
    a. becomes aqueous after repeated use.
    b. will not be hardened by the chemical.
    c. continues to provide suitable protection.
    d. does not contain polyvinylchloride (PVC).

38. (214) When a pair of gloves becomes discolored and the fabric becomes softer, this is a result of
    a. degradation.
    b. permeation.
    c. toxic stress.
    d. penetration.

39. (215) Who is responsible for formulating and executing policy in personal protective equipment (PPE) guidance?
    a. Headquarters Air Force Safety Center.
    b. Major command (MAJCOM).
    c. Supervisors.
    d. Managers.

40. (215) Which is a responsibility of bioenvironmental engineering (BE) regarding personal protective equipment (PPE) controls?
    a. Certifying PPE for use in a work center.
    b. Eliminating the hazard from the workplace.
    c. Formulating and executing policy for managers and supervisors.
    d. Provide necessary PPE and ensure compliance with program requirements.

41. (215) Which *must* be included when bioenvironmental engineering (BE) provides personal protective equipment (PPE) training?
    a. Training schedule.
    b. The limitations of the PPE.
    c. Consequences of PPE misuse.
    d. Why the particular PPE was selected.

42. (216) Bioenvironmental engineering's (BE) role of selecting the correct personal protective equipment (PPE) is essential to
    a. consider the cost and proper maintenance of the PPE.
    b. determine length of training time required.
    c. effectively control workplace hazards.
    d. determine usability.

43. (216) Why should face shields be used in conjunction with eye goggles?
    a. Face shields enhance the eyes' natural defenses.
    b. Goggles enhance protection against puncture hazards.
    c. Face shields do not provide adequate protection against liquid splashes.
    d. Goggles do not provide adequate protection against exposure to radiation.

44. (216) When selecting personal protective equipment (PPE), *one* of the physical properties to consider is whether
    a. a lesser quality article be used.
    b. it is recommended by the vendor.
    c. the article is comfortable and properly fits the worker.
    d. the article is flame retardant and resistant to most hazards.

45. (217) The three steps in determining a health-related risk assessment code (RAC) are to first determine the health hazard severity category (HHSC), then determine the illness probability category (IPC), and then
    a. determine medical effect points.
    b. assess points for number of personnel exposed.
    c. use the health-related RAC matrix to determine the RAC.
    d. find severity and probability ratings intersecting point.

46. (217) Which form should be used when assigning health-related risk assessment codes (RAC)?
    a. AF Form 3, Hazard Abatement Plan.
    b. AF Form 55, Employee Safety and Health Record.
    c. AF Form 979, Danger Tag.
    d. AF Form 1118, Notice of Hazard.

Please read the unit menu for unit 3 and continue ➔

Unit 3. Biological Health Hazards

BIOLOGICAL HAZARDS or biohazards are living organisms that pose a risk to the health and wellbeing of humans. Biological hazards (hereafter referred to as biological threats) include naturally occurring pathogens, engineered agents, amplified agents, or toxins that can threaten personnel. They can be part of the total environment, associated with a particular occupation, or can be used in warfare and terrorist activities in both garrison and at deployed locations.

The US Army Medical Research Institute of Infectious Diseases (USAMRIID) Book of Medical Management of Biological Casualties Handbook, hereafter called the Blue Book, summarizes the US military agenda for biological weapon threats. For example, the US military has maintained an on-going research agenda against biological weapon threats since World War II. However, the terrorist attacks on the US mainland in September 2001 and the anthrax mail attacks in October 2001 provided a wake-up call for lawmakers, the public at large, and medical providers of all backgrounds that the threat of biological attacks is real and requires planning, training, and resources for response. Consequently, there has been an explosion of interest among health-care practitioners to better understand how to manage the medical consequences of exposure to biological weapons that can lead to mass casualties. As a result, this unit will consider potential biological health threats, how to identify and analyze these biological health threats, and some controls to put in place for such threats.

218. Categories and characteristics of potential biological health threats

This lesson examines the categories and characteristics of potential biological health threats, beginning with a discussion of microorganisms. For example, microorganisms comprise diverse types of microscopic life forms, including bacteria, fungi, algae, and protozoa. In addition to their ability to produce infectious diseases, microorganisms such as fungi produce spores capable of causing allergic and inflammatory reactions in humans.

Microorganisms are separated into three domains: bacteria, Archaea (both are prokaryotes), and *eukaryotes*. Prokaryotes are organisms in which DNA is not physically separated from the cytoplasm. At the present time, Archaea is not associated with any human diseases. Eukaryotes are organisms containing a membrane-bound nucleus. All three are organisms because they contain all of the enzymes required for their own replication as well as the biological equipment necessary to produce metabolic energy. This distinguishes them from viruses.

Viruses are microorganisms that have no independent metabolic activity and are totally dependent on their hosts for replication. Viruses invade living organisms, causing disease while existing in the host's bodily fluids and using the host's cells to reproduce. Prions are sub-cellular structures that behave similarly to a virus. Prions are malformed protein structures that are infectious and convert other normal proteins to the abnormal prion form.

Biohazardous agents

One of the most significant organizations involved with microbiological safety is the Centers for Disease Control and Prevention (CDC). The CDC has grouped bioterrorism agents/diseases into three categories, based on the risk to national security.

Category A agents/diseases

These include anthrax, botulism, plague, smallpox, tularemia, and viral hemorrhagic fevers. Category A agents/diseases are the highest priority and include organisms that have the following characteristics:

- Easily disseminated or transmitted from person to person.
- Result in high mortality rates and have the potential for major PH impact.
- Cause public panic and social disruption.
- Require special action for PH preparedness.

Category B agents/diseases

These include brucellosis, epsilon toxin of Clostridium perfringens, food safety threats, glanders, melioidosis, Q fever, ricin toxin, staphylococcal enterotoxin B, typhus fever, viral encephalitis, and water safety threats. Category B agents are the second highest priority and have the following characteristics:

- Moderately easy to disseminate.
- Result in moderate morbidity rates and low mortality rates.
- Require specific enhancements of CDC's diagnostic capacity and enhanced disease surveillance.

Category C agents

Category C agents include emerging infectious agents such as Nipah virus and Hantavirus, which could be engineered for mass dissemination in the future. Category C agents are the third highest priority agents and have these characteristics:

- Availability.
- Ease of production and dissemination.
- Potential for high morbidity and mortality rates and major health impact.

An important aspect of identifying biological hazards is knowing the type of organism that transmits the disease. The following table summarizes several biological hazards:

Biohazardous Agent	Description	Genus (Common Name)	Typically Found
Bacteria	Causes disease by invading a host tissue or by producing toxins. Oldest and most abundant life forms on earth. Found almost everywhere.	*E. coli.* *Mycobacterium tuberculosis.* (Tuberculosis or TB). *Bacillus anthracis* (Anthrax) *Legionella* (Legionnaire's disease). *Rickettsia* (Rocky Mountain spotted fever).	Fecal matter. Human carrier. Naturally occurring/found in soil. Cooling towers, swimming pools, freshwater ponds. Lives in cells of ticks and mites.
Fungi	Found in soil, on plants, trees, other vegetation, on human skin, and in intestinal tracts. Includes mushrooms, molds, and yeasts.	*Aspergillus*, fungal meningitis, hospital-associated infections, community-acquired infections (coccidioidomycosis / Valley fever).	Degrading organic matter. Native and common fungi to environment.
Parasites	Live in or on a host, deriving nourishment without providing any benefit.	Protozoa (e.g., *Giardia*), ticks, mites, mosquitoes, tapeworms.	Contaminated food or water. Person to person contact. Vector bite.
Arboviruses	Viruses transmitted from arthropods to vertebrates.	West Nile fever and Ebola virus.	Transmitted by or borne by insects.

Biohazardous Agent	Description	Genus (Common Name)	Typically Found
Viruses other than arboviruses	Ultramicroscopic pathogenic infectious agents, multiplies with other living cells.	Common colds, warts, influenza, hepatitis A, B, C, D, and E, herpes, and rabies.	Found in all living things in certain bodily fluids.

Chain of infection

Infection and disease do not necessarily occur simply because a person is exposed to a disease-causing agent in the work place or as the result of a biological warfare incident or terrorist attack. In order for infection and disease to occur, the pathogen (the microorganism able to cause disease) must get from the source to the susceptible host; each link in the chain must be present (fig. 3–1). The biological agent, the host, and the environment must all be considered. Infection results from an orderly progression of events, referred to as the chain of infection.

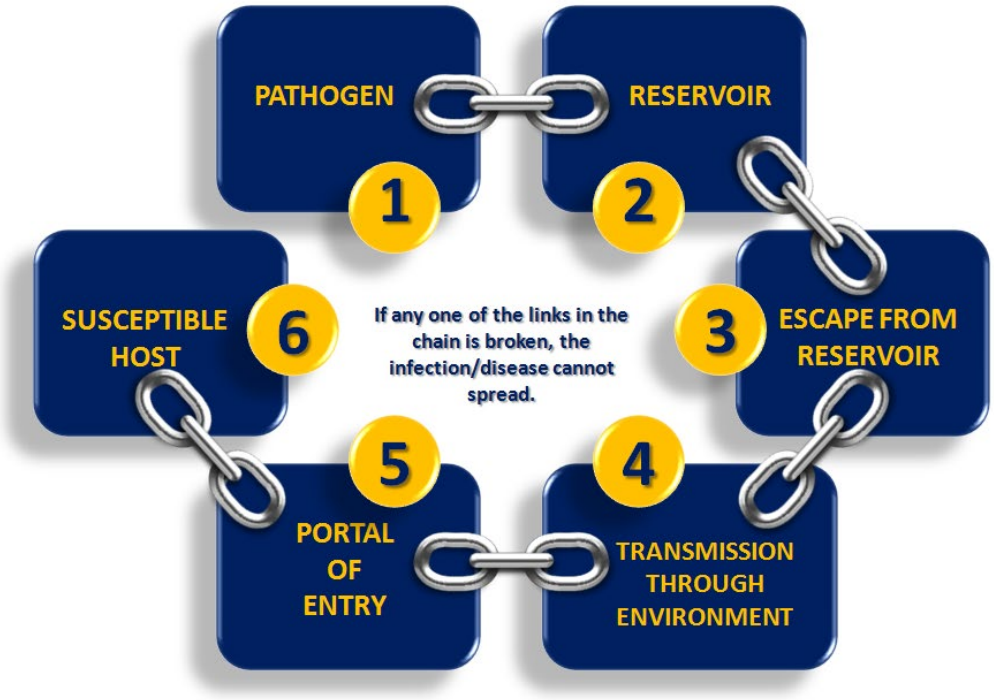


Figure 3–1. Chain of infection.

As presented in figure 3–1, the following are the six conditions (chain of events or links) for infection and illness to occur:

1. The agent must be pathogenic.
2. There must be a reservoir (adequate environment e.g., temperature, humidity) for the organism to live and reproduce.
3. The agent must be able to escape from the reservoir.
4. The agent must be transferable (able to move/be moved through the environment).
5. There must be a portal of entry (i.e., route of exposure or route of entry) into the new host (individual).
6. The new host must be susceptible to the biological agent.

One of the required links in the chain of infection (fig. 3–1) is a portal of entry into the host. You will recall from an earlier unit that the route of exposure or entry is one of the *primary factors* influencing the degree of toxic action produced by a substance. The route of entry influences which organs are affected (can be referred to as target organs) and also plays a vital role in how fast and how much of a substance reaches the target organs. For example, the organism causing anthrax may be inhaled, ingested, or absorbed. The route of exposure influences the severity of the affects to the body and potential recovery.

Modes of transmission

Direct transmission is exposure through direct physical contact between an infected person and an uninfected person (e.g., handshake, hug, kiss, etc.). Indirect transmission is where there is no direct human-to-human contact. Exposure come by contact with contaminated surfaces (e.g., doorknob, etc.), airborne infectious aerosol (i.e., sneeze, cough), or other vector (e.g., mosquito, tick, etc.).

Routes of exposure

There are four major routes of exposure by which a pathogen, whether found in a work place or used in a terrorist attack, enters the body. These include (1) inhalation, (2) absorption via dermal (skin) contact, (3) ingestion, and (4) injection.

Inhalation

Biological agents entering the body via inhalation may not only affect the lungs and associated structures but may spread to other organs via the blood stream causing further adverse effects. However, the particles must be the right size to enter and settle deep in the lungs where infection is likely to occur. Particles as large as 20 microns can infect the upper respiratory tract; however, natural processes generally filter these relatively large particles out and only the much smaller particles (ranging from 0.5 micron to 5 microns) reach the alveoli efficiently. Particles less than 0.5 micron generally are expelled with exhaled air; they are too small to get deep into the lungs.

Absorption

Absorption into a person's body via dermal contact is the most commonly encountered cause of occupational disease. The skin provides a natural barrier against OEH threats, but it is not completely effective. OEH threats can still enter through hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the outer layers of the skin. Therefore, the condition of a person's skin plays an important role in determining if a harmful substance will be absorbed. An example of a biological agent entering a person's body is when laboratory workers accidentally splashes blood samples onto their skin or mucous membranes (such as in the eye).

Ingestion

Ingestion refers to a substance entering a person's body through eating or drinking. Under normal circumstances, people would not purposely eat or drink a known hazardous biological agent. However, unlike some chemical substances, workers may not know if a biological agent is present. Microorganisms are usually not visible and may have no smell or taste to warn the worker. Many times ingestion of a harmful substance is accidental. For example, if workers do not wash their hands before they eat, drink or smoke, they may contaminate their food, drink or cigarettes and then ingest the contaminant. Personnel may also ingest food or water deliberately contaminated as an act of bioterrorism.

Injection

Although not a common route of exposure, biological hazards have the potential to be accidently injected into a person's body. This frequently occurs in places where there are contaminated needles and/or sharp instruments used in hospitals or medical laboratories. For example, a person accidentally stuck by a needle could be exposed to a contaminant that was on or in the needle. Another way to

receive a virus or disease by injection is through insect bites (ticks, flees, mites). Lastly, air under sufficiently strong pressure can push or inject a substance into the skin.

Routes of exposure are the same for biological agents, whether in an occupational setting or a biological warfare attack. In most instances, the disease produced by a biological warfare attack mimics the naturally occurring infectious disease caused by the same pathogen. The delivery of an agent to a portal of entry different from the natural portal of entry can result in different clinical presentations. For example, staphylococcal enterotoxin B when ingested in food can cause acute gastrointestinal illness; however, when delivered via aerosol to the respiratory tract, it can produce respiratory disease.

General characteristics of biological threats

Biological agents exhibit several characteristics that help determine whether or not a disease will spread throughout a population, how rapidly it will spread, and the length of time before exposed personnel exhibit symptoms. These characteristics are provided in the following paragraphs.

Contagiousness

Some diseases, such as TB and smallpox, are contagious and may spread rapidly from one person to another. Some diseases such as botulism or anthrax are non-contagious, meaning they are only transmitted from the source to a susceptible person.

Incubation period

The incubation period is the amount of time from initial exposure to a biological agent to onset of signs/symptoms of the disease. Incubation periods vary based on the type of agent and may be as short as a few hours, or as long as a few weeks.

Communicability period

The communicability period is the time during which a contagious agent can be transmitted from person to person. This period can last for days, weeks, or months depending on the type of agent. For example, a person exposed to the chickenpox virus can spread the virus to others for a period up to five days before the onset of any rash until five days after the first appearance of vesicles.

Resistance

Some biological agents are sensitive to treatment and can be eliminated with antibiotic or antiviral treatments. Other infectious diseases and weapons-grade biological agents are impossible to prevent and/or treat with current medical interventions/treatments.

219. Identifying and analyzing biological health threats

With Air Force personnel stationed all over the world, the probability of entering an area containing one or more biological threats is high. Potential threats to air bases can occur through various exposure routes. The secretive and concealed nature of biological agents makes them an effective weapon for enemy use both in the United States and globally.

Natural disease events (i.e., pandemics) and natural disasters also present increased risk for exposure to biological threats. Make sure to review current intelligence, presence of naturally occurring illnesses and potential routes of entry in order to assess potential and present risks to biological agents. Natural diseases and disaster also present biological threats. Make sure to review current intelligence, presence of naturally occurring illnesses and potential routes of entry in order to assess potential and present risks to biological agents.

Identifying biological health threats

Many potential biological health threats associated with the mission and the work place can be identified by employing the OEHSA process. The first step is to gather critical information about potential/existing biological health threats, such as data from the following sources:

- DOEHRS.
- NCMI.
- Intelligence reports (enemy capabilities).
- After-action reports for the area.
- Epidemiological data.
- US Army Public Health Command.
- Disenfranchised employees.
- Extremist groups.
- Natural disasters.

Recall that when identifying a potential or actual health threat, you should not consider any countermeasures or controls necessary to reduce the threat. This is because even if a control is in place to reduce the threat, the biological agent(s) present must still be identified.

On an installation, certain occupations have a greater chance of coming into contact with biological threats. These include nurses, technicians, doctors, laboratory personnel, janitorial staff, and emergency response personnel (e.g., security forces, fire department), as they may come in contact with bodily fluids, exposing them to blood borne pathogens. Blood borne pathogens are microorganisms present in human blood that can cause disease. Other susceptible occupations include wastewater treatment plant operators and plumbers that are exposed to water potentially contaminated with fecal matter and other bodily fluids, thus exposing them to biological threats. Existing OEH data is a good place to start gathering your initial information on workplace processes and potential biological threats.

Dissemination is the process by which infectious diseases or toxins are dispersed by persons who want to cause injury or illness to intended targets. Biological agents may be disseminated as aerosols, liquid droplets, or dry powders; however, the primary concern with biological agents is aerosolized agents, which pose inhalation and dermal contact hazards. The same routes of entry into the human body (inhalation, ingestion, absorption via dermal contact, or injection) are pertinent to the natural spread of diseases. Biological agents are dispersed using a variety of methods such as aircraft, boats, trucks equipped with sprayers, and individual handheld sprayers.

Analyzing biological threats

Once a biological threat has been identified, the first step is to determine the type of biological agent and the risk to base population. You do this by analyzing the threat in operational context. Observe the duties of the population and subpopulations involved, conduct interviews, and make observations. If you determine that an exposure pathway does not exist, then there is no risk of exposure. However, if you determine an exposure pathway *does* exist, you must analyze the threat further by gathering qualitative and quantitative data. Quantitative data for biological threats is difficult to obtain due to the variability of each of the links in the chain of infection. Unlike a safety hazard, not all exposures will yield the same result. For example, 100 percent of people that stick their fingers in front of a power saw will have their fingers cut off. However, there will be a much smaller percentage that will get sick from an anthrax exposure. This is due to the variability of the condition of each anthrax spore, how well the spores escape from their reservoir, what effect the environment has on the spores, how they are absorbed into the host, and the host's susceptibility to the spores. Additionally, quantifying data may not be as important as simply identifying the threat indeed is present.

Early detection and identification of a biological agent is important in providing the impulse to initiate protective postures and medical treatment. Sampling for biological agents may involve a number of different media such as air, water, soil, food, and human specimens such as blood, urine, and stool. In addition, there is a wide range of equipment available to identify/analyze biological

agents, but each has its limitations, either in scope of the analytes they can detect or because of limits of detection.

Potential samples (powders, liquids) can be screened at a site with detection equipment and collected for laboratory analysis. Sampling should be coordinated with the base laboratory and potentially the Laboratory Response Network (LRN) for positive identification. The CDC states, "The LRN is a national security asset, that with its partners, will develop, maintain, and strengthen an integrated domestic and international network of laboratories to respond quickly to biological, chemical, and radiological threats and other high priority PH emergencies need through training, rapid testing, timely notification and secure messaging of laboratory results."

There is equipment available to BE for providing presumptive results for biological agents. Additionally, laboratory equipment at certain bases can confirm identification of the agent. If the laboratory does not have this capability, they will coordinate analysis with an LRN agency.

Ten pieces of equipment used to collect, detect, and/or identify biological agents (along with their unique capabilities) are shown on the pages to follow (figs. 3–2 to 3–11).

HAZMAT ID

HAZMAT ID uses Fourier-Transform Infrared Spectroscopy (FT-IR) and an extensive on-board **spectral library** to rapidly identify solid and liquid chemicals based on their distinct molecular fingerprint.

This unit can detect **protein content** in sample material and will give a warning message "PROTEIN." This is an indication that a biological agent may be present which will require further analysis with an HHA or by a laboratory.

Equipment Owners: BE

Figure 3–2. HAZMAT ID.

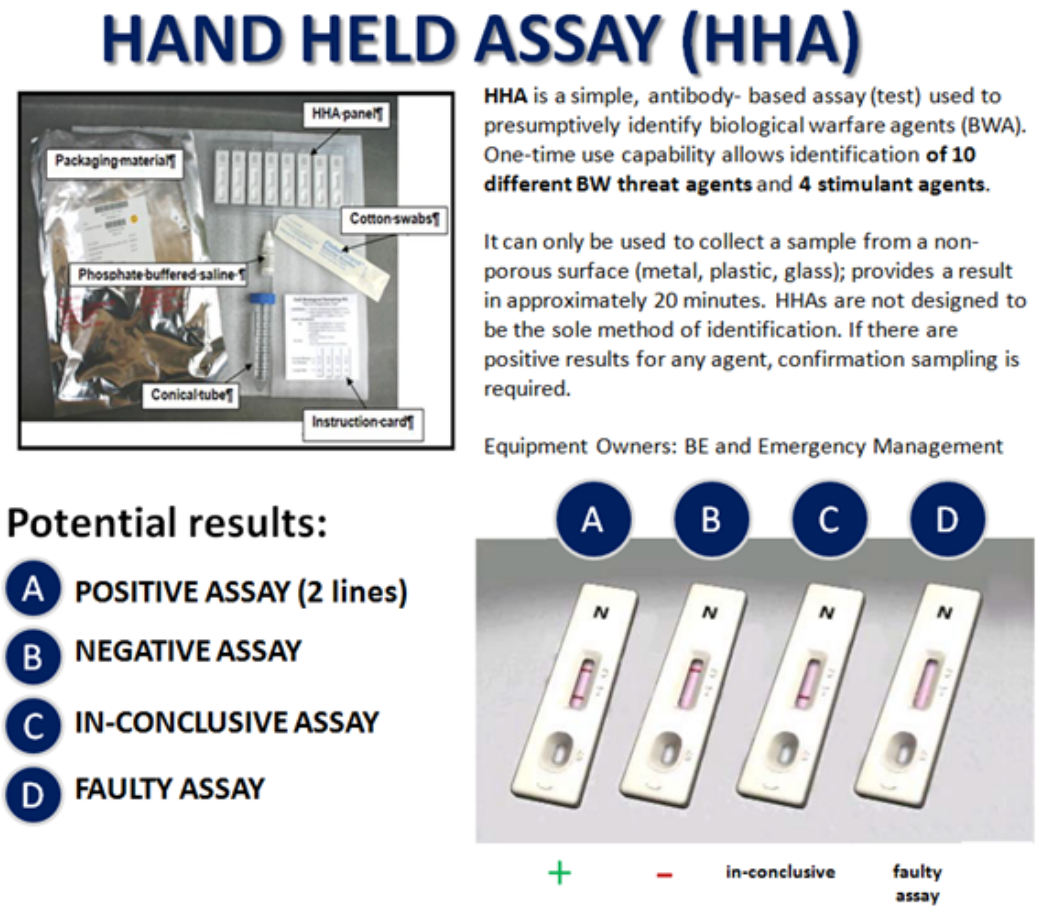


Figure 3–3. Hand Held Assay.

Hand held assay usage and results

The hand held assay (HHA) is a form of biological assay called immunochromatography and is designed to provide a quick and accurate presumptive identification of selected biological warfare agents. The HHA works on the principle of antigen/antibody interactions.

- Antigens are any foreign substance that, when introduced into the host, are capable of eliciting an immune response, which ultimately results in antibody production.
- Antibodies are molecules that are found in the blood and tissue fluids of mammals that are produced in response to a given antigen. Biologically, the role of the antibody is to bind the intruding foreign substance and facilitate its removal from the body.

HHA's exploit the exquisite sensitivity and specificity of antibodies to detect and differentiate microorganisms. These antibodies are able to physically grab on to a portion of an antigen with their antigen-binding site. The HHA is easy to use but, in order to be effective, must be used correctly and under the right circumstances. HHAs should not be used under the following conditions:

- Sampling porous surfaces. Porous surfaces contain grooves that can trap an agent thereby lowering the concentration available for testing.
- Sampling in areas where a lot of dust/dirt is collected. Dirt and dust may contain inhibitors that effect the reliability of the HHA.

- Soil sampling. Soil may contain microorganisms that have similar antigenic properties to a bio warfare agent and cause a false positive. Soil also contains numerous inhibitors that could adversely affect the HHA result.
- When the HHA has been removed from its protective packaging prior to initiating a test. The HHA has a nitrocellulose membrane that can absorb humidity from the air and lead to an inconclusive test result.

XMX/2L-MIL Bio-Aerosol Sampler

XMX/2L-MIL Bio-Aerosol Sampler is a stationary unit that must have a power source. It is used for separating aerosol particulates and preparing samples. By nature of its high mass flow concentrator system design, it is capable of operating under harsh field conditions.

It is designed to collect concentrations in the respirable range (1 to 10 microns) in a short amount of time.

The particles are collected in a vial containing phosphate buffered solution. The solution can be used for subsequent analysis (HHA, PCR, culturing).

Equipment Owners: BE and EM

Figure 3–4. XMX/2L-MIL Bio-Aerosol Sampler.

DRY FILTER UNIT

The DRY FILTER UNIT is a portable aerosol sample collector that needs a power source: it is designed for use in a building or limited area. The high volume sampler **collects aerosols onto a dry filter for analysis** using HHA or laboratory analysis.

The filter is collected with gloves and placed in a container. It can be cut into smaller pieces and placed in a buffered solution for analysis with HHA or by a laboratory.

Equipment Owners: EM

Figure 3–5. Dry Filter Unit.

RUGGED ADVANCED PATHOGEN IDENTIFICATION DEVICE (RAPID)

RAPID is a unit used by laboratory personnel. It is a real-time polymerase chain reaction (PCR) system designed to identify biological agents.

It allows for a quick (normally within a couple of hours), safe and accurate field identification of **five agents**: Anthrax, Tularemia, Plague, Salmonellosis, and Botulism.

Equipment Owners: Medical Laboratory

Figure 3–6. Rugged Advanced Pathogen Identification Device.

Chemical/Biological Sampling Kit (QuickSilver)

The Chemical/Biological Sampling Kit is a highly efficient and adaptable field sampling collection kit; it contains all required components in a backpack.

It is designed to take up to **six solid, liquid and/or wipe samples and six biological samples**.

Equipment Owners: BE and EM

Figure 3–7. Chemical/Biological Sampling Kit (Quicksilver).

High volume biological air samplers

The HHA is a form of biological assay called immunochromatography.

JOINT BIOLOGICAL AGENT IDENTIFICATION AND DIAGNOSTIC SYSTEM: (JBAIDS)

JBAIDS. Laboratory instrument system; provides medical leaders/commanders with rapid and specific identification of biological threat agents with high sensitivity.

It is an open platform that **analyzes 32 samples in 30 minutes**. Samples can be clinical (blood, sputum, feces) or other sources (aerosols, powders).

Equipment Owners:
Medical Laboratory

Figure 3–8. Joint Biological Agent Identification and Diagnostic System.

PORTAL SHIELD

PORTAL SHIELD. Automated networked biological detection system (consisting of variable number of biological sensors forming a network) specifically designed for fixed sites.

It detects and identifies a maximum of **10 biological warfare agents** simultaneously in approximately **25 minutes**.

Equipment Owners: EM

Figure 3–9. Portal Shield.

BIOCAPTURE 650

BIOCAPTURE 650. Handheld battery operated aerosol collector. Has a rotating impactor, fluid chamber, and fluid lines that provide a **pre-assembled sample vial** that can **immediately be used** for analysis.

It is designed to collect **submicron** and **micron** (0.5 to 10 microns) airborne particles and soluble vapors in a short amount of time.

Particles are rinsed from collection chamber with phosphate buffer solutions into a removable sample vial. Solution can be used for subsequent analysis (HHA, PCR, culturing.

Equipment Owners: EM

Figure 3–10. Biocapture 650 (aka Fido B1).

BIOVERIS M1M

BIOVERIS M1M TOXICITY DETECTOR. Used by medical laboratory personnel, this instrument uses electro-chemiluminescence technology to rapidly identify toxins and harmful organisms.

It allows for immediate confirmation of presence or absence of 11 biological agents including Anthrax, Ricin, Salmonella, E-coli, Tularemia, and Botulinum Toxin.

Equipment Owners: Medical Laboratory

Figure 3–11. Bioveris M1M.

Communicating biological risks

After initial detection, BE plays an important role by providing an HRA. Identifications of specific agent(s), source, contamination boundaries and quantifications, where possible, are key responsibilities of BE data collection in conducting the HRA. The primary purpose for assessing health risks from biological agents is to give the commander information to decide which critical operations may be accomplished at a given location.

With biological agents, it is rare to find an established standard or environmental limit to compare against exposure. Regardless, the commander will still require a qualitative threat assessment despite the lack of standards. In some cases, depending on the importance of conducting an operation with less than optimal control measures, the commander may be willing to accept some risks if the operational need is important.

When determining the impact on mission operations, evaluate biological threats for their potential to cause incapacitation as well as lethality. A large number of ill patients may overwhelm the medical and evacuation infrastructures, and will almost certainly create panic and disruption in the effected population. The commander will ultimately balance the importance of the current mission (e.g., training, deployment, war fighting, responding to terrorism, or disaster) against the risks posed by the operational impacts (e.g., grounding pilots, delaying missions, or operational readiness).

Analyzing a biological threat and associated risk will likely be a joint effort. In some cases, you may partner with Emergency Management to collect biological samples. Sample analysis will initially occur using the methods and equipment available in your flight equipment inventory. Perform the formal threat assessment with other medical personnel. Since food and water are both likely media to spread a biological threat, you will interface with PH. To fully assess the health effects and risks, you will engage medical professionals and recommend ways of addressing the health risk. Because standards for exposure to biological health threats are rare, you will usually work with other medical personnel and relay on professional judgment to formulate control recommendations.

220. Biological health threat controls

Whether in garrison or in a deployed environment, if biological hazards are present and cannot be immediately eliminated, control measures must be implemented as soon as possible to reduce exposures to personnel. The specific control options (engineering, administrative, and PPE) will depend on availability in conjunction with the specific type of biological agent. You will recall earlier that if one of the links in the chain of infection is broken, the infection/disease cannot spread. Therefore, the goal of control measures is to break the chain of infection.

Engineering controls

Engineering controls refer to methods of isolating, removing, or preventing the transmission of biological hazards. These controls typically can target the source, the reservoir, or the health threat. At times, they mainly target the means of transmission. Examples of engineering controls include the following:

- Puncture-resistant sharps disposal containers.
- Splatter guards.
- Disinfecting drinking water.
- Negative pressure ventilation systems.
- Ventilated biological safety cabinets.

Two main examples of engineering controls are shelter-in-place and collective protection systems.

Shelter-in-place

A shelter provides a physical barrier that keeps contamination outside and away from the people inside a tent, building, and so forth. It usually consists of taping plastic sheets over windows, doors, ventilation inlets/outlets, and other routes of air entry into the shelter location. Turning off the ventilation system will stop air from coming into the building. Restricting flow of air into a shelter increases its value as a biological shelter.

Collective protection system

A collective protection system protects those inside a building, room, shelter or tent against contamination through the combination of impermeable structural materials, air filtration equipment, air locks, and over-pressurization. Collective protection systems enable personnel to work or gain rest and relief without wearing IPE.

Administrative controls

These controls typically attack the chain of infection at the means of transmission or susceptible host link because they involve changing behaviors. Administrative controls to reduce exposure to biological health threats and include the following actions:

- Hand hygiene and sanitation (frequent washing and using alcohol-based hand sanitizers).
- Food and water sanitation (safe food preparation, water purification, food/water preparation, effective waste disposal).
- Immunoprophylaxis (prevention of disease by administration of vaccines or serum containing large quantities of specific antibodies).
- Chemoprophylaxis (administration of medicines to prevent disease).
- Proper labeling of biohazards and biohazardous areas.
- Marking contamination in a CBRN environment.
- Isolation/quarantine.
- Restriction of movement of personnel.
- Social distancing (not shaking hands or having other close contact with co-workers).
- Masking the patient to prevent spread of contagion.
- Time (environmental degradation).
- Distance (from agent).
- Proper handling of used needles and other sharps instruments, including proper disposal and prohibiting the recapping of needles.
- Following procedures for collecting and transporting potentially infectious fluids and tissues according to approved safe practices.
- Limiting access to work areas where biological hazards are in use.
- Performing procedures carefully to minimize the creation of splashes or aerosols.
- Not eating, drinking, smoking, handling contact lenses, applying cosmetics, or storing food for human use in the work area.

Personal protective equipment

PPE use prevents biological threats from reaching the host. This method of control focuses on breaking the pathway between the source and host by creating a barrier between them. PPE prevents a biological agent from reaching the workers' airway, skin, mucous membranes, and clothing. If PPE is to be effective, the user must wear it properly. PPE includes the following:

- Protective gloves.
- Apron, lab coats, gowns, and shoe covers.
- Face shield, goggles and glasses with side shields.
- Respiratory protection (in healthcare settings, an N95 or higher filtration is required).

The recommendations for PPE for emergency response situations, both in garrison and deployed, are based upon the anticipated level of exposure associated with different biological threats. HAZMAT Response Level A, B, and C categories may be appropriate for response to biological hazards. OSHA categories are based on the degree of protection afforded. For example, level A is selected when the greatest level of skin, respiratory, and eye protection is required and the hazard is unknown. Use Level C protection when the air contaminants have been identified, the concentrations have been measured, and an air-purifying respirator is deemed adequate to remove the contaminants, or when liquid splashed or other direct contact will not have an adverse effect or be absorbed through any exposed skin.

In addition, the currently fielded chemical protective equipment, which includes the protective mask, the Joint Services Lightweight Integrated Suit Technology (JSLIST), protective gloves, and multi-purpose overboots (MULO), can also be used to protect members against an airborne biological agent attack.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

218. Categories and characteristics of potential biological health threats

1. Describe where viruses are typically found.

2. Match examples of agents in column A with the proper biological hazard agent category in column B. Column B items may be used once, more than once, or not at all.

Column A	*Column B*
____ (1) Rocky Mountain spotted fever.	a. Bacteria.
____ (2) Hepatitis A-D.	b. Fungi.
____ (3) Aspergillus.	c. Parasites.
____ (4) Anthrax.	d. Rickettsia.
____ (5) Common cold.	e. Viruses other than arboviruses.
____ (6) West Nile fever.	f. Arboviruses.
____ (7) Legionella.	
____ (8) E. coli.	

3. What must happen in order for infection to occur?

4. List, in order of progression, the events known as the chain of infection.

5. What is the primary difference between a direct and an indirect mode of transmission?

219. Identifying and analyzing biological health threats

1. What process can be used to identify potential biological threats?

2. What sources can be used to identify biological health threats?

3. List five examples of occupations that have a greater chance of coming into contact with biological threats.

4. Match the equipment in column B with the detection capabilities in column A. Each item column B may be used only once.

Column A	*Column B*
____ (1) Laboratory instrument system that provides rapid and specific identification of 32 samples.	a. Portal Shield.
____ (2) Intended to be stationary unit, it separates aerosol particulates for preparing samples.	b. HHA.
____ (3) Allows for quick (within a couple of hours) field identification of five agents.	c. XMX/2L-MIL Bio-Aerosol Sampler.
____ (4) For collecting samples from nonporous surfaces. One- time use allows identification of 10 different threat agents.	d. HAZMAT ID.
____ (5) Near real time detection of biological agents and early warning of biological attacks/incidents.	e. JBAIDS.
____ (6) Automated networked biological detection system. Identifies a maximum of 10 biological warfare agents simultaneously.	f. RAPID.
____ (7) Portable aerosol sample collector. Collects aerosols onto a dry filter for analysis using HHA or laboratory analysis.	g. Chemical/Biological Sampling Kit (QuickSilver).
____ (8) Adaptable field sampling collection kit. Contains all	h. Dry Filter Unit.
____ (9) required components to take up to six solid, liquid and/or wipe samples and six biological samples.	i. Joint Biological Standoff Detection System.
____ (10) Rapidly identifies chemicals and protein content. May require further analysis with HHA or laboratory.	

5. The formal biological threat assessment will be performed with which other organizations?

220. Biological health threat controls

1. What is the goal of control measures?

2. Which type of controls are methods of isolating, removing, or transmitting the transmission of biological hazards?

3. Match the description of biological controls in column A to the category in column B. Items in column B may be used more than once.

Column A	*Column B*
____ (1) Rocky Mountain spotted fever.	a. Engineering controls.
____ (2) Hepatitis A-D.	b. Administrative controls.
____ (3) Aspergillus.	c. Personal protective equipment.
____ (4) Anthrax.	
____ (5) Common cold.	
____ (6) West Nile fever.	
____ (7) Legionella.	
____ (8) E. coli.	

Answers to Self-Test Questions

218

1. In the host's bodily fluids.
2. (1) a, d.
   (2) e.
   (3) b.
   (4) a.
   (5) e.
   (6) f.
   (7) a.
   (8) a.
3. The pathogen (microorganism able to cause disease) must get from the source to the susceptible host.
4. Pathogen, reservoir, escape from reservoir, transmission through environment, portal or entry, susceptible host.
5. Direct transmission is exposure through direct physical contact between an infected person and an uninfected person (e.g., handshake, hug, kiss, etc.). Indirect transmission is where there is no direct human-to-human contact.

219

1. OEHSA process.
2. DOEHRS, NCMI, intelligence reports (enemy capabilities), after-action reports for the area, epidemiological data, US Army Public Health Command, disenfranchised employees, extremist groups, natural disasters.
3. Nurses, technicians, doctors, laboratory personnel, janitorial staff, and emergency response personnel (e.g., security forces, fire department).
4. (1) e.
   (2) c.
   (3) f.
   (4) b.
   (5) i.
   (6) a.
   (7) h.

(8) g.
(9) d.

5. PH and medical professionals.

220

1. To break the chain of infection.
2. Engineering controls.
3. (1) b.
   (2) a.
   (3) c.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

47. (218) Which microorganisms are totally dependent on their hosts for replication?
    a. Viruses.
    b. Bacteria.
    c. Eukaryotes.
    d. Prokaryotes.

48. (218) Anthrax is an example of which biohazardous agent?
    a. Fungi.
    b. Prions.
    c. Bacteria.
    d. Arboviruses.

49. (218) Which route of exposure is the *most* commonly encountered cause of occupational disease?
    a. Injection.
    b. Ingestion.
    c. Inhalation.
    d. Absorption.

50. (218) A period that can last for days, weeks, or months when a biological threat can be transmitted from person to person is known as
    a. resistance.
    b. contagiousness.
    c. an incubation period.
    d. the communicability period.

51. (219) What process can be used to identify potential biological threats associated with the mission and the workplace?
    a. Health risk estimate.
    b. Operational risk management.
    c. Prioritize special assessments.
    d. Occupational and environmental health site assessment (OEHSA).

52. (219) Which piece of equipment would be used to take up to six solid, liquid, and/or wipe samples and six biological samples?
    a. QuickSilver.
    b. Portal Shield.
    c. Joint biological standoff detection system.
    d. Joint biological agent identification and diagnostic system (JBAIDS).

53. (219) Which piece of equipment would be used to detect and identify a *maximum* of 10 biological warfare agents simultaneously in approximately 25 minutes?
    a. QuickSilver.
    b. Portal Shield.
    c. XMX/2L-MIL Bio-Aerosol Sampler.
    d. Hazardous material identification (HAZMAT ID).

54. (220) What is the goal of control measures?
    a. Break the chain of infection.
    b. Change personnel behaviors.
    c. Eliminate the chain of infection.
    d. Implement the use of personal protective equipment (PPE).

55. (220) Which type of controls *typically* attacks the chain of infection at the means of transmission or susceptible host?
    a. Engineering.
    b. Administrative.
    c. Shelter in place.
    d. Collective protection.

Unit 4. Chemical Hazards

THERE ARE countless potential chemical hazards that can harm workers and cause mission degradation on every Air Force installation. This unit will discuss how to identify, analyze and control chemical hazards in Air Force work centers.

221. Chemical hazards

As a bioenvironmental engineer (BEE), it is your responsibility to identify all of the potentially hazardous chemicals that individuals may be exposed to on an installation/site and provide recommendations, up through your chain of command, so the SEG and/or PAR will not be overexposed. Our discussion under this section will deal with the types of chemical hazards that you may deal with in-garrison or deployed and the characteristics of those chemical hazards.

Before making chemical hazard control recommendations, they will first need to be characterized. In other words, the first step is to determine the toxicological properties that make a particular substance or chemical hazardous.

The majority of occupational health hazards arise from inhaling chemical substances in the form of gases, vapors, and particulates or by skin contact with the chemical substance. Consider the following chemical forms: gases, vapors, and particulates.

Gases

A gas refers to a substance that is naturally in the gaseous state at normal temperature and pressure; that is, 25 degrees (°) Celsius (C) and 29.92 inches of mercury (in Hg) or 750 millimeters of mercury (mm Hg).

Gas	Industrial Process
Chlorine	Water Treatment Facilities
Carbon Monoxide	Combustion Engines

Vapors

A vapor is the gaseous form of a substance that is a liquid or solid at normal room temperature and pressure. Gases and vapors are often grouped together because their behavior is so similar. Both will expand and contract with changes in temperature and pressure. Both spread out (diffuse) rapidly to fill a room, enabling quicker exposure to the chemical. Both forms can enter the body quite easily and cause rapid toxic action(s).

The use of solvents often generates vapors. Further, solvents are liquids in which a solute can be dissolved. An example of a solvent is water while salt is a solute; and as you know, salt easily dissolves in water. Solvents are very useful both to transport solutes and to clean materials. In many instances (such as painting activities), solvents work best if they evaporate relatively quickly, leaving behind an even application of the chemical substance.

Solubility is very important in understanding the potential hazard of a solvent as it affects the mode of the following:

- Absorption of the substance into the body.
- Distribution of the substance throughout the body.
- Storage of the substance in various tissues.
- Eliminations of substance from the body.

Solvent vapors enter the body mainly by inhalation, although some skin absorption can occur. Fat soluble solvent vapors are absorbed from the lungs into the blood and are distributed mainly to tissues with a high content of fat and lipids, such as the central nervous system (CNS), liver, and bone marrow. Examples of solvents include aliphatic and aromatic hydrocarbons, alcohols, aldehydes, ketones, chlorinated hydrocarbons, and carbon disulfide. Occupational exposures to solvents can occur in many different activities to include degreasing of metals and painting. A working knowledge of the physical properties, nomenclature, and effects of exposure is absolutely necessary to ensuring a proper assessment of a solvent exposure.

Vapor	Industrial Process
Methylene Chloride	Printing activities and painting
Toluene	Painting and Stripping

Particulates

PM suspended in air is commonly known as an aerosol. PM can be separated into the following two categories:

- Liquid aerosols: Mists and fogs.
- Solid aerosols: Fumes, smoke, fibers, and dusts.

When PM is inhaled and deposited into the lungs, it can produce rapid local tissue damage, some slower tissue reactions, chemical transfer to the bloodstream, or eventually disease.

Particulates	Industrial Process
Silica Dust (solid aerosol)	Abrasive Blasting operations
Pesticides (liquid aerosol)	Pesticide application

When talking about identifying a chemical hazard, it is important to understand that we will be dealing with both pure forms of chemicals, such as acetone, and/or mixtures of chemical products. When assessing the hazards of a pure form of chemical, it is not necessary to determine its chemical composition, as it is pure. A very different circumstance occurs when a chemical product is a mixture of chemicals. Once again, refer to the preceding example for the example of paint. Paint itself is not a chemical that can be evaluated. Since paint is a composite mixture a chemical, each constituent, or component chemicals, must be evaluated to determine the individual and collective hazards present.

The following table summarizes important chemical characteristics to be considered when determining the potential for a chemical to be a health threat.

Chemical Form/Property	Is The Chemical A Solid, Liquid, Or Gas?
Vapor pressure (VP) (measured in mm Hg)	How easily will a liquid evaporate? Liquids that evaporate easily have higher VPs in air and can build up quickly.
Vapor density (air = 1)	What is the weight of a vapor or gas compared to the weight of an equal volume of air? Vapor density greater than 1 indicates the vapor is heavier than air and will accumulate close to the ground.
Solubility rate	What is the quantity of a substance, by weight, that will dissolve in water at room temperature?
Specific gravity (H20 = 1)	What is the ratio of the weight of a volume of the substance to the weight of an equal volume of water? Specific gravity greater than 1 indicates the liquid is heavier than water.
Particle Size	How large is the particle size of the chemical?
Volatility	What is the percent of a liquid or solid (by volume) that will evaporate at an ambient temperature of 70° Fahrenheit (F)? This indicates the tendency or ability of a liquid to vaporize.
Manner of use	How is the chemical used? This can be a factor in the level of hazard. The following are some examples of chemical application methods: • Spraying vs. brush painting—Brush painting is normally less hazardous (chemical has less chance of becoming airborne). • Pouring—Splash hazard may occur (potential contact hazard). • Sweeping—Dry sweeping can cause chemical contaminant to become airborne (potential inhalation/contact hazard). • Heating—When certain chemicals are heated they can become a vapor hazard (potential inhalation/contact hazard).

When determining whether a chemical produces a threat, there are several sources of information available to assist you in initially identifying the chemical composition. SDS, if available, are normally your primary source for chemical-specific information.

222. Safety data sheets

OSHA Standard Title 29 CFR 1910.1200, *Hazard Communication*, aligns with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) SDS requirements.

OSHA renamed the material safety data sheets (MSDS) to simply SDS. OSHA's hazard communication standard and the hazard communication program will be discussed in Volume 5.

SDSs are important tools to use; they contain a wealth of information about a specific chemical or product such as the following:

- Ingredients.
- Hazards.
- Safe procedures for handling, storing, and disposing potentially hazardous chemicals in the work place.
- Control measures, emergency response actions.

SDSs must be readily available to workers for all hazardous chemicals in their work place. OSHA's Hazard Communication Standard requires that chemical manufacturers or suppliers provide users with an SDS for each chemical covered by the standard with the first shipment of a hazardous chemical, and with the first shipment following an SDS revision. If an SDS is not provided, it is the responsibility of the workplace supervisor to request the SDS from the manufacturer or supplier. SDSs also may be available for government procured items in the Hazardous Material Information Resource System (HMIRS). HMIRS is a DOD database containing SDSs for procured HAZMATs and products.

In Title 29 CFR 1910.1200, Appendix D, *Safety Data Sheets (Mandatory)*, requires that all SDSs include the information shown in the following table. Sections 12–15 are not mandatory.

Section	SDS Heading	SDS Subheading
1	Product and company identification	(a) Product identifier used on the label. (b) Other means of identification. (c) Recommended use of the chemical and restrictions on use. (d) Name, address, and telephone number of the chemical manufacturer, importer, or other responsible party. (e) Emergency phone number.
2	Hazards identification	(a) The hazard classification of the chemical in accordance with paragraph (d) and Appendix A of §1910.1200. **NOTE:** There are four acute toxicity hazard categories that rank from one (1) to four (4), where one (1) denotes highest toxicity hazard. (b) Signal word, hazard statement(s), symbol(s), and precautionary statement(s) in accordance with paragraph (f) of §1910.1200. **NOTE:** Hazard symbols may be graphical reproductions in black and white or the name of the symbol (e.g., flame, skull, and crossbones.) (c) Describe any hazards not otherwise classified that have been identified during the classification process. (d) Where an ingredient with unknown acute toxicity is used in a mixture at a concentration ≥ 1% and the mixture is not classified based on testing of the mixture as a whole, a statement that X% of the mixture consists of ingredient(s) of unknown acute toxicity is required.
3	Composition/ information on ingredients	**Substances** (a) Chemical name. (b) Common name and synonyms. (c) Chemical Abstracts Service (CAS) number and other unique identifiers. (d) Impurities and stabilizing additives, which are themselves classified, and which contribute to the classification of the substance. **Mixtures** In addition to the information required for substances: (a) The chemical name and concentration (exact percentage) or concentration ranges of all ingredients which are classified as health hazards in accordance with paragraph (d) of §1910.1200. (1) Are present above their cut-off/concentration limits. (2) Present a health risk below the cut-off/concentration limits. (b) The concentration (exact percentage) shall be specified unless a trade secret claim is made in accordance with paragraph (i) of §1910.1200, when there is batch-to-batch variability in the production of a mixture, or for a group of substantially similar mixtures (See A.0.5.1.2) with similar chemical composition. In these cases, concentration ranges may be used. **For All Chemicals Where a Trade Secret is Claimed** Where a trade secret is claimed in accordance with paragraph (i) of §1910.1200, a statement that the specific chemical identity and/or exact percentage (concentration) of composition has been withheld as a trade secret is required.
4	First-aid measures	(a) Description of necessary measures, subdivided according to the different routes of exposure (i.e., inhalation, skin and eye contact, and ingestion). (b) Most important symptoms/effects, acute and delayed. (c) Indication of immediate medical attention and special treatment needed, if necessary.

Section	SDS Heading	SDS Subheading
5	Fire-fighting measures	(a) Suitable (and unsuitable) extinguishing media. (b) Specific hazards arising from the chemical (e.g., nature of any hazardous combustion products). (c) Special protective equipment and precautions for fire fighters.
6	Accidental release measures	(a) Personal precautions, protective equipment, and emergency procedures. (b) Methods and materials for containment and cleaning up.
7	Handling and storage	(a) Precautions for safe handling. (b) Conditions for safe storage, including any incompatibilities.
8	Exposure controls/personal protection	(a) OSHA PEL, ACGIH TLV, and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the safety data sheet, where available. (b) Appropriate engineering controls. (c) Individual protection measures, such as PPE.
9	Physical and chemical properties	(a) Appearance (e.g., physical state, color, etc.). (b) Odor. (c) Odor threshold. (d) Power of hydrogen (pH) balance. (e) Melting point/freezing point. (f) Initial boiling point (BP) and boiling range. (g) Flash point. (h) Evaporation rate. (i) Flammability (solid, gas). (j) Upper/lower flammability or explosive limits. (k) VP. (l) Vapor density. (m) Relative density. (n) Solubility. (o) Partition coefficient: n-octanol/water. (p) Auto-ignition temperature. (q) Decomposition temperature. (r) Viscosity.
10	Stability and reactivity	(a) Reactivity. (b) Chemical stability. (c) Possibility of hazardous reactions. (d) Conditions to avoid (e.g., static discharge, shock, or vibration). (e) Incompatible materials. (f) Hazardous decomposition products.
11	Toxicological information	Description of the various toxicological (health) effects and the available data used to identify those effects, including: (a) Information on the likely routes of exposure (inhalation, ingestion, skin and eye contact). (b) Symptoms related to the physical, chemical and toxicological characteristics. (c) Delayed and immediate effects and also chronic effects from short- and long-term exposure. (d) Numerical measures of toxicity (such as acute toxicity estimates). (e) Whether the hazardous chemical is listed in the National Toxicology Program (NTP) Report on Carcinogens (latest edition) or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest edition), or by OSHA.

Section	SDS Heading	SDS Subheading
12	Ecological information (non-mandatory)	(a) Ecotoxicity (aquatic and terrestrial, where available). (b) Persistence and degradability. (c) Bioaccumulation potential. (d) Mobility in soil. (e) Other adverse effects (such as hazardous to the ozone layer).
13	Disposal considerations (non-mandatory)	Description of waste residues and information on their safe handling and methods of disposal, including the disposal of any contaminated packaging.
14	Transport information (non-mandatory)	(a) United Nations (UN) number. (b) UN proper shipping name. (c) Transport hazard class. (d) Packing group, if applicable. (e) Environmental hazards (e.g., Marine pollutant (Yes/No). (f) Transport in bulk according to Annex II of Marine Pollution (MARPOL) 73/78 and the Intermediate Bulk Container (IBC) code. (g) Special precautions, which a user needs to be aware of, or needs to comply with, in connection with transport or conveyance either within or outside their premises.
15	Regulatory information (non-mandatory)	Safety, health and environmental regulations specific for the product in question.
16	Other information	The SDS date of preparation or the last revision.

The following scenario emphasizes the significance of using SDSs when conducting an HRA involving potentially hazardous chemicals.

SDS scenario

An HRA is conducted at the structural maintenance shop. During the facility walk around, workers are observed using a type of clear liquid to wipe down aerospace ground equipment (AGE) prior to painting. The liquid is poured onto a rag and applied by hand. Workers are wearing some type of protective gloves during the process. After talking to the workers, it is discovered the chemical's product name is ChemSolv. The SDS for ChemSolv is acquired for review. Review the SDS document (presented in the Processes table above) in preparation for answering the questions that follow.

ChemSolv

Section 1. Product and Company Identification

Product Name:	ChemSolv	Supplier:	CHEM-R-US
Product Use:	Solvent	Emergency:	24 Volytile St Fairborn, OH, USA 999–911–9911

Section 2. Hazards Identification

Health	Environmental	Physical
Acute toxicity (oral) – Category 4 Acute toxicity (inhalation) – Category 4 Skin corrosion/irritation – Category 2 Eye damage/irritation – Category 2	Aquatic toxicity – unknown	Flammable liquid – Category 2

Symbols**:** flame, skull and crossbones, corrosion, health hazard

Hazard Statements	Precautionary Statements
DANGER! Highly flammable liquid and vapor. Harmful if swallowed. Harmful if inhaled. May cause drowsiness or dizziness. May cause respiratory irritation. May cause damage to kidney. Causes skin and eye irritation. Causes damage to CNS through prolonged or repeated exposure.	Keep away from heat/sparks/open flames/hot surfaces. No smoking. Wear protective gloves/protective clothing/eye protection. Do not eat, drink, or smoke while using this product. Wash hands after using this product.

Section 3. Composition/Information on Ingredients

Hazardous Ingredient	Weight %	CAS No.	Chemical Formula
Methyl ethyl ketone	80	78–93–3	CH_3-CH_2-CO-CH_3
Acetone	20	67–64–1	CH_3-CO-CH_3

4. First Aid Measures

First aid - Skin contact:	Wash off with plenty of water. Remove contaminated clothing.
First aid - Eye contact:	Rinse out with plenty of water for at least 5 minutes with the eyelid open. Seek medical attention.
First aid - Ingestion:	Do not induce vomiting. Drink plenty of water. Take active carbon. Seek medical attention.
First aid - Inhalation:	Move to fresh air. Seek medical attention.

ChemSolv

5. Fire Fighting Measures

Extinguishing media:	Dry chemical powder, foam, carbon dioxide, or water spray.
Special hazards:	Formation of explosive mixture with air possible.
Protective equipment:	Self-contained breathing apparatus see also section 8.
Flash point:	7°C
Auto-ignition:	404°C
Lower explosive limit:	1.4 vol % at 200°F
Upper explosive limit:	11.4 vol % at 200°F

6. Accidental Release Measures

Personal precautions:	See section 8.
Spill response:	Do not allow spill to enter sewer/waste water system. Absorb spill with non-combustible liquid-absorbent material and place in approved container for disposal. At large accidental release contact local authorities.

7. Handling and Storage

Handling:	Use only in a well-ventilated area. Wash thoroughly after handling. Avoid contact with eyes, skin and clothing. Electrically ground containers and equipment when handling this product. Use non-spark tools.
Storage:	Tightly closed in original container in a well-ventilated area. Keep away from sources of ignition and heat.

8. Exposure Controls and Personal Protection

Chemical Name	ACGIH	NIOSH	OSHA
Methyl ethyl ketone	TLV-TWA: 200 ppm TLV-STEL: 300 ppm	REL-TWA: 200 ppm IDLH: 3000 ppm	PEL-TWA: 200 ppm

IDLH = immediately dangerous to life and health
ppm = parts per million.
STEL = short term exposure level.
TWA = time weighted average.

Personal Protective Equipment

Eye protection:	Chemical safety goggles.
Hand protection:	Appropriate protective gloves to prevent skin exposure.
Clothing:	Appropriate protective clothing to prevent skin exposure.
Respiratory protection:	A full-face piece or half mask equipped for organic vapors/mists may be needed. Refer to Title 29 CFR 1910.134 for OSHA respirator requirements.

9. Physical and Chemical Properties

Appearance:	Colorless liquid with a fruit-like odor
Boiling Point:	80 °C
Formula Weight:	72.11 grams per mole (g/mol)
pH (Liquids Only):	5.5
Melting Point:	–87 °C
Vapor Pressure:	71.2 mm Hg
Vapor Density:	2.5
Solubility in Water:	292 grams per liter (g/L)
Specific Gravity:	0.8050
Evaporation Rate:	2.7 (butyl acetate=1)

10. Stability and Reactivity:

Stable:	Yes
Conditions to avoid:	Heat, incompatible ignition sources, and contact with ignition source.
Materials to avoid:	Oxidizing agents, reducing agents, and caustics and strong bases.
Hazardous Decomposition Products:	Carbon dioxide, carbon monoxide, peroxides, irritating, and toxic vapors.

ChemSolv	
11. Toxicological Information	
Acute toxicity:	Lethal dose $(LD)_{50}$ (oral, rat): 2737 milligrams per kilogram (mg/kg). LD_{50} (dermal, rabbit): >8000 mg/kg. Lethal concentration $(LC)_{50}$ (inhalation, rat): 20 milligrams per liter per 4 hours (mg/L/4h).
Inhalation:	Inhalation may cause headache, dizziness, and at higher concentrations, vomiting and coma.
Skin contact:	Drying-out effect resulting in chapped skin. Prolonged or repeated exposure may cause eczema.
Eye contact:	Vapors may be irritating.
Ingestion:	Illness, vomiting.
16. Other Information	
NFPA:	Health: 1 Flammability: 3 Reactivity: 0 NFPA = National Fire Protection Association

Review of the document allows identification and knowledge to assist in making determinations for identification and control of the hazards associated with ChemSolv. What section provides the answer(s) for each of the following questions (fig. 4–1)?

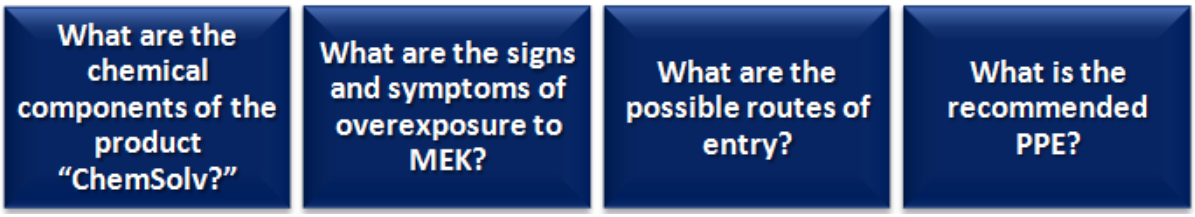


Figure 4–1. SDS Exercise Questions.

1. What are the chemical components of the product called ChemSolv?

   The answer is in Section 3, Composition. Many industrial chemical products are mixtures; the SDS identifies the ingredients of those mixtures. SDS Section 3 allows you to determine exactly what chemicals are present and in what percentage (by weight). In this example, the solvent is 80 percent methyl ethyl ketone (MEK) and 20 percent acetone.

2. What are the signs and symptoms of overexposure to MEK?

   The answer is in Section 2, Hazards Identification. Looking at this section you should be able to determine that the signs and symptoms of overexposure could be any of the following: Irritated or burning eyes, irritated nose and throat, headache, dizziness, nausea, weakness, and loss of consciousness. Be aware that information on an SDS is a guide and requires verification with other sources specific to application and use of the chemical. These referenced include the NIOSH Pocket Guide, ACGIH TLV Booklet, AFIs, and so forth.

3. What are the possible routes of entry?

   The answer is in Section 2, Hazards Identification and Section 11, Toxicological Information. By reviewing these sections, you should be able to determine that inhalation, ingestion and skin contact are possible routes of entry.

4. What is the recommended PPE?

   The answer is in section 8, Exposure Controls and Personal Protection. This section recommends the following PPE when handling ChemSolv: Chemical Safety Goggles, appropriate protective gloves and protective clothing. The SDS also recommends following OSHA respirator regulations found in Title 29 CFR 1910.134. It is important to be aware that specific PPE recommendations

will be made using factors such as how workers actually use the chemical, how much is used, where it is used, and others.

Upon completion of this exercise, the value of SDS documentation should be obvious. SDSs can provide many of the answers needed to accomplish the goals of an HRA and are irreplaceable resources to the BE field.

223. Substance specific standards

OSHA established PEL for approximately 400 chemicals. Most PELs were adopted in 1970 from TLVs set by the ACGIH. Only about two dozen PELs have been updated or adopted since. PELs are airborne exposure limits that are meant to protect most workers from diminished health, functional capacity, or life expectancy. However, for some chemicals adherence to the PEL might not be enough. For those chemicals where additional measures are needed to protect workers, OSHA has developed substance specific standards (sometimes referred to as expanded standards).

When conducting a routine OEH assessment, it is important to determine if a work place uses any chemicals regulated by OSHA's substance specific standards. If chemicals with substance specific standards are used in the work place, time should be spent researching the applicable standards to ensure all of the requirements are taken into account.

OSHA's expanded standards contain information on specific requirements such as the following:

- Applicable PELs.
- Exposure monitoring.
- Establish a regulated area.
- Methods of compliance.
- Control methods.
- Post warning signs (verbiage and location).
- Worker training.
- Worker notification.
- Recordkeeping and documentation.

If air sampling results indicate exposure levels greater than the PEL, most of these requirements *must* be adhered to and implemented. A majority of OSHA's substance specific standards are found in the OSHA General Industry Standards (1910 series). During the routine OEH assessment, it is important to perform a thorough review of the shop's chemical inventory; chemicals should be properly identified. Chemicals that have OSHA substance specific standards are considered very hazardous. It is BE's responsibility to make sure workers are properly protected when using these chemicals. The following is a listing of the current OSHA General Industry substance specific standards.

OSHA Substance Specific Standards

- 1910.1001 Asbestos.
- 1910.1002 Coal tar pitch volatiles.
- 1910.1003 13 Carcinogens, including:

4-Nitrobiphenyl; alpha-Naphthylamine; Methyl chloromethyl ether; 3,3'-Dichlorobenzidine and its salts; bis-Chloromethyl ether; beta-Naphthylamine; Benzidine; 4-Aminodiphenyl; Ethyleneimine; beta-Propiolactone; 2-Acetylaminofluorene; 4-Dimethylaminoazobenzene; N-Nitrosodimethylamine.

- 1910. 1004 alpha-Naphthylamine.
- 1910.1006 Methyl chloromethyl ether.

- 1910.1007 3-Dichlorobenzidine (and its salts).
- 1910.1008 bis-Chloromethyl ether.
- 1910.1009 beta-Naphthylamine.
- 1910.1010 Benzidine.
- 1910.1011 4-Aminodiphenyl.
- 1910.1012 Ethylenemine.
- 1910.1013 beta-Propiolactone.
- 1910.1014 2-Acetylaminofluorene.
- 1910.1015 4-Dimethylaminoazobenzene.
- 1910.1016 N-Nitrosodimethylamine.
- 1910.1017 Vinyl chloride.
- 1910.1018 Inorganic arsenic.
- 1910.1025 Lead.
- 1910.1026 Chromium VI.
- 1910.1027 Cadmium.
- 1910.1028 Benzene.
- 1910.1029 Coke oven emissions.
- 1910.1030 Bloodborne pathogens.
- 1910.1043 Cotton dust.
- 1910.1044 1,2-dibromo–3-chloropropane.
- 1910.1045 Acrylonitrile.
- 1910.1047 Ethylene oxide.
- 1910.1048 Formaldehyde.
- 1910.1050 Methylenedianiline.
- 1910.1051 1,3-Butadiene.
- 1910.1052 Methylene Chloride.

Workers exposed to a chemical with a substance specific standard must be protected and monitored according to the specific standard. For example, depending on the requirements specified in the standard, the BEE may have to conduct full-shift breathing zone sampling, short term exposure monitoring, biological monitoring, and potentially other types of exposure monitoring. Depending on the personal monitoring results, additional monitoring, including medical surveillance, may be required. It is important to review the specific standard, as it may identify exceptions to the requirements.

224. Identifying and analyzing chemical hazards based on route of exposure

Whether you are in-garrison or at a deployed location, your expertise is critical in identifying and analyzing all potential or existing chemical threats and sources of release. The degree of risk when exposed to a given substance depends on the magnitude and duration of exposure. The health risk is

determined not only by the toxicity of the chemical itself, but by the conditions of exposure (what, how, where, how much, and how long). Routine OEH assessment and OEHSA are BE's primary tools for identification of exposures to potential chemical hazards.

Identifying chemical hazards by route of exposure

Chemical hazard identification begins with defining the processes occurring in and around the work environment or area of concern, along with an understanding of the materials and equipment being used in the processes. Most hazardous chemicals should have already been identified during routine OEH assessment and documented in DOEHRS.

There are several resources readily available to identify chemical hazards, including the following:

- Existing routine OEH assessment and special OEH assessment reports—These will indicate the type(s) of chemicals previously identified and assessed in the work place.
- Existing OEH data in DOEHRS, including the OEHSA survey report. Every hazard in a shop associated with a process should be documented in DOEHRS.
- HAZMAT reports and inventories produced by the Enterprise Environmental, Safety, and Occupational Health Management Information System (EESOH-MIS).
- SDS may provide information on the chemical composition of mixtures that helps to identify if any components of a chemical product are hazardous.
- Worker interviews may reveal information about process hazards. For example, a worker may know that a chromium-based primer had been used in the past on old parts that are now being refurbished during sanding or blasting operations. These processes can generate significant chemical threats as the old paint and primer are removed.
- Medical evaluations might also help identify exposures. Physical exams, some lab tests (such as bloodwork and/or urinalysis), and possibly x-rays can further aid in recognition of an individual's uptake of a chemical indicating a potential chemical threat. PH can provide epidemiological data of this nature.

After identification of potential chemical threats, you then move on to the chemical hazard analysis step to assess the risk to personnel associated with the exposure.

Analyzing chemical hazards by route of exposure

The analyzing of chemical threats considers toxicological properties of the chemicals, exposure pathways, qualitative or quantitative data, exposure duration and frequency to assess the associated risk of the exposure (fig. 4–2). Identifying the ingredients of the potential chemical threats is the first step to analyzing a chemical hazard. Your primary source of locating ingredient information is the SDS. Some manufacturers will not release proprietary ingredients to the general public. However, as a health professional, you are authorized access to this information and you may have to contact the manufacturer to obtain it.

Figure 4–2. Chemical Threat Considerations.

After identifying the ingredients, research the toxicological effects of each ingredient to determine if the chemical poses a potential health concern. Specific questions will need to be answered, such as:

- Are any ingredients a contact, absorption or inhalation hazard?
- What are the target organs?
- What are the occupational exposure limits (OEL)?
- What are the OELs based on?

There are a number of resources available for this research, including the following:

- OSHA publications.
- NIOSH Pocket Guide.
- International Chemical Safety Data Cards.
- Adopted Values in the ACGIH TLV booklet.
- Agency for Toxic Substances and Disease Registry.
- United States Air Force School of Aerospace Medicine (USAFSAM) technical reports.
- If SDSs are available, they are normally your primary sources for chemical-specific information.

Once chemicals have been identified that could potentially cause adverse health effects, it must be determined if a completed exposure pathway exists. The toxicity of a chemical is irrelevant if personnel never have an opportunity to come into contact with the chemical. If a potential chemical threat has a route of entry into the body and the exposure pathway is complete, the threat poses a risk to personnel and is a chemical of concern. You must then assess the associated risk posed by the chemicals of concern. In many situations, this means you will need to conduct sampling.

There are many different aspects to analyzing a chemical health threat/risk. Some questions to answer include: How will the health threat affect personnel? Could it make them sick in the short-term (acute hazard) or long-term (chronic hazard)? How will operational capability be impacted? Let us look at how you would analyze chemical threats by routes of entry.

Analyzing chemical contact hazards

For contact hazards, the target organs are the skin, eyes, and mucous membranes. Chemicals that pose a contact hazard do not have to make it into the bloodstream. There are inherent chemical properties that will allow you to anticipate if a particular chemical poses a significant contact hazard. Knowing these properties is the first and vital step in preparation for your assessment. Chemicals are the predominant causes of dermal contact hazards in the work environment. Chemical agents may be divided into two groups—primary irritants and sensitizers.

Primary irritants

Primary irritants cause about 80 percent of all occupational skin contact injuries. Dermatitis caused by a primary irritant is referred to as irritant contact dermatitis, because the skin irritation is normally confined to the area of direct contact. This reaction alters the chemistry of the skin by dissolving a portion of it, precipitating the protein of the cells, or by some other chemical reaction. The damage can range from tissue destruction (chemical burn) to inflammation (dermatitis), depending on the strength of the agent and the duration of the exposure. Dermatosis caused by substances or conditions present in the work environment are largely preventable, but only through combined management and workers' efforts. **NOTE:** It is important to remember dermatosis does not cause inflammation of the skin.

Most inorganic and organic acids act as primary irritants. Certain inorganic alkalis (or acids), such as nitric acid, sulfuric acid, chloroform, methylene chloride, and sodium hydroxide, are skin irritants. Organic solvents include many substances, such as chlorinated hydrocarbons, petroleum-based

compounds, ketones, alcohols, and terpenes, which irritate the skin. The effects of exposure to chemical agents include the following: acne, loss of pigmentation, increased pigmentation, photosensitization, inflamed skin, and tumors. The following table describes three primary irritant categories:

Type of Solvent:	Actions:
Keratin solvents	All of the alkalis (organic and inorganic) injure the keratin layer when concentration and exposure times are adequate. These agents soften the keratin cells and succeed in removing many of them. At the same time, they bring about considerable water loss from the keratin layer, resulting in dry, cracked skin. This prepares the way for secondary infection and at times, the development of allergic sensitization.
Keratin stimulants	Several chemicals stimulate the skin so that it undertakes growth patterns that can lead to tumor or cancer formation. Certain petroleum products, a number of the coal tar-based materials, arsenic, and some of the chlorinated hydrocarbons can stimulate the epidermal cells to produce these effects (nodules).
Fats and oil solvents	The skin is composed of multiple, lipid-containing layers. Just as organic solvents dissolve oily and greasy industrial oils, they also remove the skin's surface lipids and disturb the keratin layer of cells, so that they can no longer maintain their water-holding capacity. Workers exposed each day to the action of the organic solvents develop exceedingly dry and cracked skin.

Sensitizers

Some primary skin irritants also sensitize. Certain irritants sensitize a person, so that dermatitis develops from a very low concentration of a compound that could have previously been handled without any problem. Examples of substances that have the potential to sensitize include turpentine, formaldehyde, chromic acid, and metals like mercury, nickel, and platinum. Other chemicals can sensitize the skin to light. Known as photosensitizers, these chemicals include coal tar, fluorescent dyes, and hexachlorophene.

When trying to determine whether or not a chemical is going to cause contact hazards during an industrial process, refer to the SDS along with the Adopted Values Table in the ACGIH TLV booklet to aid in the decision. According to this booklet, the designation "Skin" in the "Notations" column refers to the potential significant contribution to the overall exposure by the cutaneous route, including the mucous membranes and the eyes, either by contact with vapors or by direct skin contact with the substance. Some materials capable of causing irritation, dermatitis, and sensitization in workers are not considered relevant when assigning a skin notation. However, note that the development of a dermatological condition could significantly affect the potential for dermal absorption.

In order to properly assess contact hazards associated with industrial processes and environmental exposures, obtain knowledge of the properties of the chemicals as well as the activities where exposures can occur. The following table lists examples of chemicals, indicates if they are primary irritants and sensitizers, lists the chemical's impact on the skin, and the type of activity in which the chemical is typically found.

Chemical	Primary Irritant	Sensitizer	Impact on Skin	Activity/Occupations
Acetic acid	Yes	No	Dermatitis and ulceration	Printing and dyeing, vinyl plastic makers
Chromic acid	Yes	Yes	Ulcers and local anesthetic effect	Electroplaters and dyers
Sodium hydroxide (alkalis)	Yes	No	Severe corrosion of the skin, loss of fingernails	Petroleum refiners, plastic manufacturing
Sodium silicate (alkalis)	Yes	No	Blisters, ulcers and corrosion of skin	Detergents and cements
Acetone (solvent)	Yes	No	Dry (defatted) skin	Spray painters, mechanics
Turpentine (solvent)	Yes	Yes	Dermatitis	Painters, artists
Pyrethrum (insecticide)	No	No	Dermatitis, severe burns	Soil contamination

Analyzing chemical absorption hazards

Skin absorption is the major route of occupational exposures for a plethora of compounds such as industrial cleaners and solvents, chemical intermediates, lipid-soluble pesticides, and the historically important polychlorinated biphenyls (PCB). The ACGIH therefore recognizes the importance of dermal exposure by designating some compounds with a skin notation attached to the TLV.

The skin is composed of multiple lipid-containing layers. The outermost layer, the stratum corneum, functions as the primary protective barrier. In order for percutaneous (i.e., through the skin) absorption to occur, the chemical must pass through this tough layer and reach the living epidermis. Chemicals that are soluble with lipids (i.e., fats) and with water pass through the skin the easiest. Lipid soluble chemicals pass through the dermis more readily than water soluble chemicals. Some of the more common lipid-soluble materials encountered in industry are organic solvents such as acetone, benzene, hexane, hydrazine, methanol, phenol, toluene, and trichloroethylene. When a lipid soluble chemical gains access to the dermis, rapid and complete absorption usually occurs.

Chemical absorption can take place in varying degrees through any area of the outer body, to include intact skin, mucous membranes, and through the eyes. Additionally, absorption can occur from touching surfaces (e.g., doorknobs, tabletops, paperwork, tools), repetitive/extended wear of contaminated clothing and/or PPE (e.g., uniform, gloves, coveralls), or by contact with aerosolized or gaseous substances. Note that mixtures and/or solutions could significantly enhance the potential for a skin absorption hazard, even from substances otherwise not considered hazardous. As a general rule, fat-soluble liquids are readily absorbed through the skin.

The following table provides types of contacts and explains skin absorption exposures. You should assess the situation to determine if there is a potential for contact, completing the exposure pathway.

Type of Contact:	Explanation:
Direct contact	Direct contact exposures result from direct involvement with the process that generates the contaminant(s). Examples range from direct immersion, to spills onto the skin, to the transfer of contaminants from hands and/or fingers to other body parts.
Indirect contact	Indirect contact results from contact with contaminated surfaces, either within the original work area, or through materials transported to other locations. Indirect contact can be the result of inefficient or sloppy work practices, insufficient separation between work areas, or the lack of proper hygiene/housekeeping practices. In turn, the contaminant can be spread from work area to non-work areas (e.g., lunch and break rooms or administrative offices), and result in the contamination of a worker's skin, clothing, tools, or equipment.
Vapor or aerosol	Vapor or aerosol exposure to the skin, eyes, and mucous membranes occurs when aerosols settle or condense onto workers' skin, and cause subsequent dermal absorption. Large diameter aerosols,>0.50 micrometers (μm), tend to fall onto workers, versus smaller aerosols, which tend to remain suspended in the air.

Research into additive systemic effects of chemical absorption was affected by understanding that the more common chemical exposure routes (i.e., inhalation, ingestion, and contact) are much more apt to contribute larger doses, resulting in subsequent acute or chronic effects. After all, the skin has long been thought to be an effective barrier against contaminants. Obviously, this is not always the case. When performing air sampling, the results do not accurately represent the total dose (or exposure) if the chemicals in question are also absorbed through the skin. As the skin does protect against many chemicals, and the amount/rate of absorption is highly variable, studies to accurately gauge severity of absorption hazards are ongoing, though quickly developing.

When a substance contacts the skin, one of the following four actions is likely to occur:

1. The skin, with its associated film of lipids (fatty oils) and sweat, may act as an effective barrier against penetration, injury, or other disturbances.
2. The substance can react with the skin surface and cause primary irritation or inflammation, such as dermatitis (contact hazard).
3. The substance can penetrate the skin and join with tissue protein to sensitize the skin (contact hazard).
4. The substance can penetrate the skin, enter the bloodstream, and act as a potential systemic poison (absorption hazard).

When a substance penetrates the skin and enters the bloodstream, it is considered an absorption hazard. You should note that the skin's absorption rate will vary, depending on the person and the area contacted. For example, the back of the hand and the skin of the abdomen have twice the potential for absorption as the forearm, while areas containing larger masses of hair follicles (e.g., the scalp and forehead) have up to four times the absorption potential. The armpit shows a four- to seven-fold increase, and the skin of the scrotum allows almost total absorption. Additionally, the development of dermatological conditions or damage in any of these areas can significantly affect the potential for dermal absorption.

Monitoring absorption hazards

Dermal exposure monitoring is a growing area not yet as well developed in comparison to inhalation exposure monitoring. There are two main categories for dermal exposure monitoring according to OSHA: environmental monitoring (direct) and biological monitoring (indirect).

Environmental (direct) dermal monitoring

Environmental monitoring measures the degree of exposure to the body or the actual exposure. One dermal exposure monitoring method involves attaching gauze, cellulose, or charcoal pads to, or under, clothing to collect aerosols deposited onto the body. The pads are then sent to a laboratory for

analysis. The location of the media in relation to the individual's body is dependent on the specific process performed. The clothing worn by the worker can also be collected and analyzed. Cotton clothing is usually recommended for this technique. Although the clothing may not accurately simulate skin absorption, the cotton fibers will collect and hold the contaminant until analysis, and is therefore a good representation of the possible exposure to the outer dermal layers.

Another exposure monitoring method involves the actual collection of contaminants present on the individual's skin. Collection is performed through the use of either skin wipes or skin washing. Skin wipes consist of wetted filters, wipes, or sponges swiped against the surface of the skin. While this can measure direct dermal contact, it may not represent true adsorbed dose, and may not quantify all that was on the skin (depending on how effectively the wetted media removes and retains the contaminant). Skin washing involves rinsing the skin's surface with a solvent, such as alcohol or soapy water, and collecting the subsequent rinsate in a polyethylene bag. This technique can be advantageous since it collects materials from otherwise hard to reach areas, such as under nails and within skin folds. As with skin wiping, this technique may not quantify true absorbed dose, or remove all existing contaminants.

Exposure may be assessed by direct observation using a chemical's fluorescent properties. Some compounds fluoresce naturally under ultraviolet (UV) light. Other compounds can be made to fluoresce with the introduction of another material. Either way, the resulting fluorescence can be inspected for distinct exposure patterns, and relative concentrations can be compared. This technique allows for instant assessments, and the ability to detect very small amounts. Use caution to not introduce additional contaminants/irritants through this process, and to limit the exposure to UV light, which can be harmful.

Biological monitoring measures the absorbed dose from all routes of exposure, including dermal exposure. Estimate the significance of exposure via the dermal absorption route by comparing the measured concentration of a chemical in a worker's blood or urine to the concentration expected from inhalation exposure alone. Biological monitoring is more invasive to the worker, and therefore typically reserved for high hazard chemicals where dermal exposure is expected to be a major contributor to overall biological burden.

Analyzing chemical inhalation hazards

The inherent properties of chemical compounds can be key indicators to help you anticipate an inhalation hazard. The majority of occupational health hazards arise from inhaling chemical substances in the form of gases, vapors, and particulates or by skin contact with the chemical substance. The following paragraphs provide key indicators.

Physical state

The physical state refers to the substance being a solid, liquid, gas or a vapor. Chemicals in different physical states behave differently in the atmosphere; this will affect the potential for an inhalation exposure. A chemical that is readily airborne will obviously have more of an inhalation potential than a chemical that is not.

Vapor pressure and boiling point

VP and BP help identify how easily substances will volatize (become airborne). These physical characteristics are commonly listed on the SDS or found in the NIOSH Pocket Guide. The VP of any chemical compound directly relates to the temperature. For example, lower BP temperatures usually indicate a higher VP. Chemicals with a high VP will have an increased risk of producing high vapor concentrations in the air. Simply put, if the VP is high or the temperature is high, vapor inhalation may be a concern.

Vapor density

Vapor density tells us what will happen to the vapor upon release. We classify chemicals according to vapor density in the following two ways:

- Chemical vapors and gases heavier than air.
- Chemical vapors and gases equal to or lighter than air.

Using air as a reference point, we assign it a value of 1.0 for vapor density; we can use a chemical's vapor density to judge the expected behavior of the chemical vapors or gases. High concentrations of chemicals that have a vapor density greater than 1.0 will tend to sink and accumulate in low-lying areas. However, air movement can prevent chemicals with a high vapor density from settling. The same concentration of a chemical that has a vapor density less than 1.0 will travel up and away from the ground and disperse into the surrounding environment. Additionally, chemicals that have the same vapor density as air tend to disperse uniformly into the air.

Identifying and analyzing chemical threats exercise

To identify and analyze potential chemical health threats, you must not only be familiar with the *specific chemical properties* (to anticipate potential hazards), but you must also be familiar with the *toxicological properties* of the chemical and *how the chemical is used*. These concepts can be applied to the following scenario:

You are reviewing a HAZMAT approval request from the AGE shop with the following activity description:

> *"After scuffing the paint on the aerospace ground equipment, the worker wipes down the equipment with a rag dipped in cleaner (NSN: 8010–00–181–8079)."*

Recognize that this situation presents a potential chemical threat to the users—an organization is requesting a HAZMAT to wipe down equipment to satisfy a new workload. Therefore, threat analysis is required.

Step one

The initial step is to identify the ingredients in the chemical/product of concern. Reviewing the SDS for the cleaner identifies the constituents in the following table:

Constituent Name	CAS Number	Make-up Percentage	Physical Form	VP / Boiling Point (BP)
C6-Rich Oxo-alcohol Acetates	88230–35–7	Not Listed	Liquid	VP=Unk; BP=327 ºF
2-Butanone	78–93–3	28%	Liquid	VP=78 mm; BP=175 ºF
Toluene	108–88–3	11%	Liquid	VP=21 mm; BP=232 ºF
N-Butyl Acetate	123–86–4	5%	Liquid	VP=10 mm; BP=258 ºF
Xylene	1330–20–7	5%	Liquid	VP=7 mm; BP=292 ºF
Ethyl benzene	100–41–4	<2%	Liquid	VP=7 mm; BP=277 ºF

From reviewing the SDS, you read that the cleaner has multiple liquid ingredients. Applying the concepts we have discussed, you learned that liquids evaporate (volatize). Based on the VP and the BP data provided, it looks as if some of the ingredients will volatize more readily than others; therefore, the ingredients would likely be present in higher concentrations. However, keep in mind that highest concentration does not mean most toxic. Toxicological data is needed to further analyze the threat associated with the cleaner.

Step two

The next step is to research each individual constituent to determine which of them may pose a threat (without considering control measures). Research produces the information in the following table:

Constituent Name	OEL	Mode of Entry	Target Organ	Other Information
C6-Rich Oxo-alcohol Acetates	No information available	No information available	No information available	No information available
2-Butanone	TWA 200 ppm	Inhalation, Ingestion, Contact	Eyes, skin, resp sys, Central Nervous System	Prevent skin and eye contact Suspected teratogen
Toluene	TWA 200 ppm C 300 ppm	Inhalaton, Absorption, Ingestion, Contact	Eyes, skin, resp sys, CNS, liver, kidneys	Prevent skin and eye contact
N-Butyl Acetate	TWA 150 ppm	Inhalation, Ingestion, Contact	Eyes, skin, resp sys, CNS	Prevent skin and eye contact
Xylene	TWA 100 ppm	Inhalation, Absorption, Ingestion, Contact	Eyes, skin, resp sys, CNS, GI tract, blood, liver, kidneys	Prevent skin and eye contact
Ethyl benzene	TWA 20 ppm	Inhalation, Ingestion, Contact	Eyes, skin, resp sys, CNS	Prevent skin and eye contact

The toxicological data on all the ingredients indicate following:

1. All of the ingredients affect the body via inhalation, ingestion, and contact.
2. Toluene and xylene can also be absorbed.
3. Butanone is a suspected teratogen. You now need to determine if an exposure pathway exists based on this toxicological data and the way the cleaner is used. Since we know some of the ingredients volatilize, air becomes an exposure pathway.
4. Inhalation is an exposure route for all the ingredients; in sufficient quantities, it is possible that the cleaner can pose a potential health threat to personnel by inhalation exposure.
5. The application method is by hand; as a result, contact becomes an exposure pathway.
6. Toxicological data confirms that contact and absorption are routes of exposure; therefore, the cleaner poses a potential health threat via these routes as well.

For the purpose of this illustration, we will visit the work location (an AGE shop) to observe the process first hand, and take note of the work performed, and investigation results.

The work included scuff-sanding equipment in preparation for painting. Results of investigation revealed the following:

- The cleaner is sprayed on the equipment rather than dipped into a rage and wiped.
- The technician mentioned that the spray allowed for faster application of the cleaner, thereby completing the process more quickly.
- From the workers' perspective, saving time is important.

Results of investigation (determination)

1. By changing the manner of use, the potential for an inhalation hazard significantly increases.
2. Since completed exposure pathways have been determined, it is necessary to identify the requirement of a special assessment. This will allow the gathering of quantitative data so control recommendations may be made.

NOTE: In many cases, the sampling data determines the control recommendation. On other occasions, however, control measure recommendations will occur without having quantitative sampling data.

225. Chemical hazard controls

After establishing an exposure profile for a chemical threat by conducting an HRA, information needed to formulate potential control methods should be available. The following table recalls information previously learned in the Health Risk Controls Overview section (control options).

Type of Control	Approaches and Examples
Engineering	Source modification—Changing hazard source to make it less hazardous (e.g., wetting dust particles or lowering temperature of liquids to reduce off-gassing and vaporization).
	Substitution—Substituting a less HAZMAT, equipment, or for a more hazardous one (e.g., use of soap and water in place of solvents, use of automated instead of manually operated equipment).
	Process change—Changing a process to make it less hazardous (e.g., paint dipping in place of paint spraying).
	Isolation—Separating employees from hazardous operations, processes, equipment, or environments (e.g., use of control rooms, physically separating employees and equipment, barriers placed between employees and hazardous operations).
	Ventilation—Two fundamental approaches include general exhaust (dilution of air contaminants) and local exhaust (capture of air contaminants).
Administrative	Management involvement, hazard communication and training of employees, posting hazard warning signs, rotation of employees, air sampling, biological sampling, medical surveillance.
PPE	Gloves, aprons, face shields, respirators, etc.

Controls for skin contact hazards

Just as with any other hazard, there are many options on how to control a contact hazard. Control contact hazards using the same order of priority: engineering, administrative, and PPE.

The best way to control dermatitis is to prevent skin contact with offending substances. If there is no exposure, there will be no dermatitis. This may be easier said than done, however. Plan operations and engineer to assure minimal contact with any irritants. Enclosure guards and ventilation systems may be necessary to control exposures. Before introducing any new activity or procedure, and before adoption of any new or different substance in an established process, the base BEE needs to carefully consider every aspect of the operation for possible or known dermatitis hazards, including those that resulting from trace impurities. After identifying the hazards, institute and build suitable engineering controls into the work activity or operations.

The following example shows how the use of engineering controls helped reduce and/or eliminate occupational dermatosis. This example comes from the 1998 Report of the OSHA Advisory Committee on Cutaneous Hazards.

Process: Powdered Epoxy Spraying Operations (Powder coating)
Scenario: A manufacturer of household washing machines began using an epoxy material as a finishing surface on its products. The epoxy came in powdered form. The powder was sprayed on the parts to be assembled, which were then baked in an oven to form an extremely hard surface. The powder spraying process was automated and was contained inside a ventilated booth. The parts passed through the booth hanging from an overhead conveyor. Overspray was exhausted out the bottom of the booth and collected in barrels; some overspray remained on the inside walls of the booth. The only worker in the area during the spraying was an operator who sat inside an enclosed control booth and thus was not exposed to the epoxy powder. On the midnight shift, however, when production stopped, a clean-up crew entered the area to perform a number of duties, including the following: 1. They used compressed air to blow out the overspray that had accumulated on the inside walls of the spray booth. 2. They dumped barrels of exhausted spray back into the supply system for reuse. 3. They swept the floors and other surfaces outside the booth to clean some spray that had escaped the booth. Problem: Despite proper PPE use, several members of the cleanup crew broke out in rashes after the cleanup operations. An injury/illness investigation was conducted. The investigation determined that the powder was very fine and the slightest turbulence caused it to become airborne. Consequently, a great concentration of epoxy dust was in the air. The cleanup crew was equipped with respirators, hair covers, boots, and complete coveralls. Solution: Changing the overspray exhaust system to return the overspray directly into the supply system eliminated one major source of exposure to epoxy dust. A shop vacuum replaced the use of compressed air and sweeping, thus reducing dust exposure. After this change in the way workers carried out their task, no cases of dermatitis recurred.

Substituting materials

Substituting materials can greatly minimize hazardous conditions. For example, dry sodium and potassium hydroxide are now available in virtually dust-free form. By practically eliminating the airborne dust from these chemicals, the contact hazard (and inhalation hazard) reduces drastically.

Personal protective equipment

Protective clothing, gloves, and equipment are used to protect against hazards when substitution and engineering controls are inadequate or not feasible.

Protective gloves

Protective gloves come in a variety of materials (e.g., butyl rubber, Viton® rubber, neoprene, and nitrile) and styles. Before you recommend a specific type of glove, you must first identify the constituents in the chemicals that can potentially contact a person's skin. Secondly, ensure the glove(s) you recommend are made of a material that will adequately protect workers' skin against the constituents. The SDS of the chemical product may recommend a certain type of glove be worn when workers use that chemical. This is a good starting point for your research; however, you should confirm the gloves you recommend will afford adequate protection by researching published glove selection information. The Quick Selection Guide for Chemical Protective Clothing and glove manufacturers' websites are good places to begin. Glove fit and dexterity must be considered; if gloves do not adequately fit, workers will not wear them.

Eye goggles/face shield

Eye and face protection safeguards users from splash hazards. OSHA Title 29 CFR 1910.133, *Eye and Face Protection*, requires that workers use appropriate eye or face protection when exposed to eye or face hazards from liquid chemicals, acids or caustic liquids, chemical gases or vapors. For chemical splash or irritating mists, appropriate protection include unvented chemical goggles, indirect-vented chemical goggles, or indirect-vented eyecup goggles.

Direct vented goggles and spectacle-type eye protection do not provide protection against liquid exposures and should not be used. For severe chemical exposures workers should wear a face shield and goggles since a face shield is designed to protect the face not the eyes.

The following are general guidelines to use when selecting eye/face protection:

- Select only protection that meets the standards listed in ANSI Z87.1–2003, *Occupational and Educational Personal Eye and Face Protection Devices*.
- Select protection that is adequate against the specific chemical hazards identified from the HRA.
- Select protection that is as comfortable to wear as possible.
- Select protection that does not restrict workers' vision in any way.
- Select protection that is durable, easy to clean, and easy to disinfect.
- Select protection that does not interfere with the use/functioning of other PPE.

Chemical contact hazards via substances or conditions in the work place can and will cause skin diseases. Occupational skin diseases can occur in workers of all ages, in any work setting, and cause a great deal of illness, personal misery, and reduced productivity. Many consider this type of disease trivial and insignificant, but occupational skin disorders can result in complex impairment. This is due to large surface areas of skin often being directly exposed to the environment.

Control of absorption hazards

Controlling absorption hazards is similar to controlling contact hazards. Ultimately, the most effective method of avoiding exposures to chemicals with recognized absorption potentials is by using engineering controls such as substituting a product with one not containing the hazardous substance.

Administrative controls (such as changes in work practices and method of application) can be very effective in reducing the risk of workplace exposures to hazardous substances. An elementary example of this is the substitution of application methods from spray (or aerosol) to brush (or pour), allowing better control of the product used. Further, the integration of mandatory housekeeping and personal hygiene practices can greatly reduce risk. Regularly wipe down work areas and equipment and make sure workers wash exposed skin upon completion of specified tasks.

Incorporate the use of PPE when contact is unavoidable. One such example is the use of barrier creams. While mainly used for mildly irritating substances, it can offer some resistance to skin absorption. Be careful when using products such as these to assure proper application on clean skin and full coverage. Barrier creams are not to be used for acids or alkalis and are not considered a substitute for gloves. In the end, chemical protective clothing, such as gloves, apron, goggles and boots are the barriers of choice.

Control of inhalation hazards

The first method of control is the use of engineering controls that can include any of the following: source modification, substitution of materials or equipment, process change, isolation, ventilation, worker rotation, and respiratory protection.

Source modification

Source modification is basically looking at a process involving a chemical hazard and determining if the source of the hazard can be changed and/or modified to make it less hazardous. For example, years ago it was common practice for vehicle maintenance personnel to clean dust from brake parts using compressed air. This cleaning method generated significant dust and potentially exposed personnel to asbestos in the dust. A simple modification to have workers clean brake parts by wetting the parts with water rather than using compressed air significantly reduces the source of the threat—airborne brake dust.

Substitution of materials or equipment

When considering substitution as a method of control, it is best to first determine if there is a material that is less toxic to do the job. Substitute materials may function equally well or may provide results that are better or worse than those achieved with the HAZMAT currently being used. It may be necessary to give up some production efficiency in order to obtain the required reduction of hazardous exposure to the worker. The one instance when material substitution is not an option is when a technical order requires a specific material.

The next consideration is whether engineering or design changes on existing equipment can reduce the hazard. Examples of such substitution include the use of machine guarding on existing mechanical equipment, and the substitution of automated equipment for manual methods. The addition of the catalytic converter to the automobile to reduce the emission of pollutants is an example of making changes to existing equipment to reduce the hazard potential. This type of approach has led to the use of electric-powered lift trucks in place of gasoline-powered trucks.

Process change

Consider whether the process can be changed, thus removing the hazard exposure. Perhaps there a less harmful way to do the job. It may be possible to change the overall process or the procedures used within the process and thus eliminate the worker's exposure to HAZMATs or operations. For example, when applying paint to a part using a spray gun, consider the possibility of changing to an alternative process such as dipping the part in a paint bath or flow coating the part. The dipping process typically generates less airborne particulates and vapors than spray painting. Fewer contaminants in the air equate to reduced potential exposure to toxic materials.

Isolation

Isolation can occur in a number of ways. First, separate the source of the hazard exposure from the area of concern; this may be accomplished by removing the source and placing it in another location where people are unlikely to come in contact with it. A second method is to enclose or shield the source with physical barriers. Although the source remains in the area, it is removed from the population. Bead blasting booths are a good example of this control method where the entire process, parts to be blasted and the blasting material, are contained within a large housing.

It is possible to automate many processes so that workers are rarely, if ever, exposed. Another method of isolation is the relocation of toxic or flammable materials stored in the production area to a separate storage location.

Other examples of isolation methods are tank farms that are used for storing toxic industrial chemicals (TIC)/toxic industrial materials (TIM) in areas apart from populated areas. The automated processes used in chemical processing and petroleum refining are also examples. Another common type of isolation is the removal of the worker to a control room that is separated from the processing area such as the control booth inside a 'hush house.' Hush houses are large facilities used for testing aircraft engines.

Ventilation

Mechanical ventilation is a commonly used engineering method for controlling exposure to airborne threats. Ventilation can be an effective means of removing air pollutants from the breathing zone of personnel. For instance, using the example of paint dipping previously described, chemicals in dip tanks will still release vapors. Mechanical ventilation employed at the tank can remove these vapors (fig. 4–3). A properly designed system is usually capable of keeping exposures to near-zero levels.

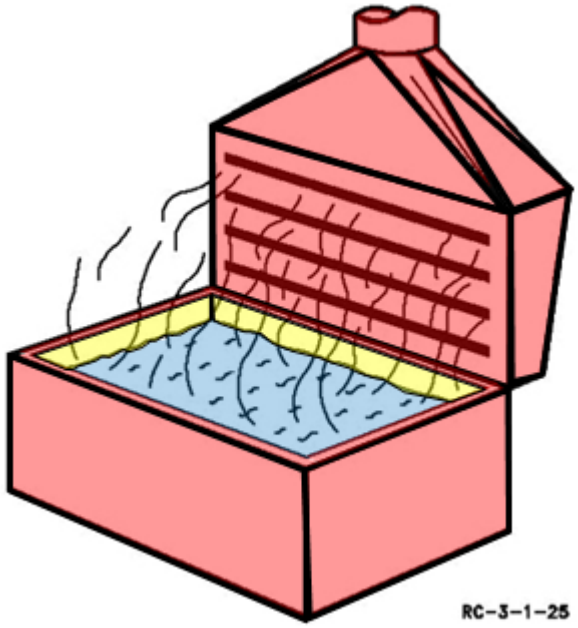


Figure 4–3. Mechanical Ventilation Employed at a Dip Tank.

Worker rotation

Rotate work schedules to reduce or limit exposures to chemical threats/risks by limiting the amount of exposure time. However, exercise caution when using worker rotation; even though it keeps exposure levels below regulatory limits, the result will be a larger number of exposed workers. Additionally, OSHA does not allow the use of worker rotation as a method of reducing exposures in some instances, such as cadmium.

Respiratory protection

The two primary types of respirators are air purifying and atmosphere supplying. Air purifying respirators filter a chemical out of the surrounding air by using a cartridge/filter that is specific to a certain chemical or class of chemicals. Atmosphere supplying respirators provide clean air (from a source other than the contaminated air) to the face piece of the respirator. You will learn more about respiratory protection program requirements later in the course.

226. Considerations for determining regulated areas for chemical hazards

OSHA has established substance specific standards for certain chemicals deemed to require more worker protection than other potentially hazardous chemicals. Some of these standards require establishing what is known as a regulated area. A regulated area restricts access to specific hazardous chemicals/materials that exceed allowable exposure limits (e.g., PEL, TWA, and action level), as stated in the relevant standard. If workers use or are exposed to any of the OSHA substance specific chemicals/materials, as part of your HRA you will conduct sampling to determine the workers' exposure. If sampling results exceed the allowable limit, it is the workplace supervisor's responsibility to establish a regulated area. Your responsibility will be to assist the workplace supervisor to determine the need for a regulated area, and establish its boundaries.

The list that follows contains common criteria for regulated areas. Emphasize review of each substance specific standard to determine the applicable criteria if a regulated area must be established. Although some standards might list similar criteria, you must thoroughly read through the OSHA standard for specific criteria relevant to the substances or chemicals of concern. For example, many of the standards include specific wording that must be included on regulated area warning signs. Further,

the standards contain applicable exposure limits, which if exceeded, mandate the establishment of a regulated area.

- The area must be clearly identified (i.e., warning signs posted) at all entrances and made known to all workers in or adjacent to the area.
- Delineate and segregate the area from the rest of the work area in a manner that minimizes/limits the number of workers exposed to the specific chemical.
- The area must have access controlled by either administrative or physical means.
- Maintain daily rosters of authorized personnel entering and exiting the area.
- The supervisor must ensure that workers do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- Establish and maintain the regulated area according to the criteria of the OSHA substance specific standard.
- Monitor and protect in accordance with the specific standard the workers potentially exposed to a substance.

To help you get a better idea of the requirements of a regulated area, let us take a look at a scenario involving one of the OSHA substance specific standards, Title 29 CFR 1910.1048, *Formaldehyde*.

Your assigned medical group has a medical laboratory where technicians are occupationally exposed to formaldehyde when performing specimen collection, analysis, and preservation techniques. You conducted air sampling on the representatively exposed worker when he or she was conducting these tasks throughout the day. You determined this individual to have a representative potential formaldehyde exposure. The sample results indicate the worker's exposure to airborne formaldehyde levels exceed the TWA. OSHA regulation Title 29 CFR 1910.1048(e) specifies the following requirements concerning regulated areas:

- The employer shall establish regulated areas where the concentration of airborne formaldehyde exceeds either the TWA or the STEL and post all entrances and access ways with signs bearing the following information:

  DANGER

  FORMALDEHYDE

  IRRITANT AND POTENTIAL CANCER HAZARD

  AUTHORIZED PERSONNEL ONLY

- The employer shall limit access to regulated areas to authorized persons trained to recognize the hazards of formaldehyde.
- An employer at a multiemployer worksite who establishes a regulated area shall communicate the access restrictions and locations of these areas to other employers with work operations at that worksite.

Remember, just because a chemical falls under one of OSHA's substance specific standards, it does not require establishing a regulated area. You will need to research the standard to determine if a regulated area is required. The applicable standard will outline all the specific regulated area requirements. It is BE's responsibility to communicate the requirements and provide guidance to the workplace supervisor in order to ensure the work place is in compliance with the standard.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

221. Chemical hazards

1. What is the first step before you can make chemical hazard control recommendations?

2. Why are gases and vapors usually grouped together?

3. Why is it important to have a working knowledge of a chemical's physical properties, nomenclature, and exposure effects?

4. Why is paint itself not a chemical you can evaluate?

222. Safety data sheets

1. If an SDS is not provided with the first shipment of a hazardous chemical, how is one obtained?

2. When must carcinogenic chemicals be listed on an SDS?

3. What part of an SDS provides information on how to handle an accidental chemical spill?

4. Where on the SDS would you look to determine if there are any PPE requirements when working with a specific chemical?

223. Substance specific standards

1. Why did OSHA develop/publish substance specific standards?

2. When must the requirements contained in a substance specific standard be implemented?

224. Identifying and analyzing chemical hazards based on route of exposure

1. On what two factors does the degree of risk of exposure to a given substance depend?

2. When do you begin identifying chemical threats?

3. What is the primary source for locating chemical ingredient information?

4. After having identified the chemicals that could potentially cause adverse health effects, what is the next step?

5. What percentage of occupational skin contact injuries are caused by primary irritants?

6. When would you use indirect dermal monitoring?

7. What are the most commonly recognized routes of exposure when considering occupational hazards?

8. What effect does high VP or high temperature have on a chemical?

225. Chemical hazard controls

1. What is the next step to take once it is determined that a chemical process poses a risk to personnel?

2. Simply stated, what is the best way of controlling chemicals that can cause dermatitis?

3. What must be done before you can recommend a specific type of protective glove?

4. Why should direct vented eye goggles not be used for protection against liquid chemical exposures?

5. Explain the reason why occupational skin disorders can result in complex impairment to workers.

6. What are four examples of administrative controls for a chemical absorption hazard?

7. When is using substitution as an engineering control not an option?

8. Using a bead blasting booth is an example of what type of engineering control?

9. Why use caution when implementing worker rotation to reduce or limit exposures to chemical threats?

226. Considerations for determining regulated areas for chemical hazards

1. How does a regulated area limit workers' exposures*?*

2. What publication would you reference to determine if a work area requires the establishment of a regulated area?

Answers to Self-Test Questions

221

1. Determine what it is about a substance or chemical that makes it hazardous.
2. They behave similarly. For example, both will expand and contract with changes in temperature and pressure. Both spread out (diffuse) rapidly to fill a room, enabling quicker exposure to the chemical. Both forms can enter the body quite easily and cause rapid toxic action(s).
3. To ensure a proper assessment of a solvent exposure.
4. Paint is a composite mixture; the component chemicals must be evaluated to determine both the individual and collective hazards present.

222

1. The workplace supervisor must request it from the manufacturer or supplier.
2. If the concentration of the chemical is ≥ 1%.
3. Accidental release measures.
4. Exposure controls section.

223

1. To provide additional measures to protect workers that use chemicals where adherence to the PEL is not enough.
2. If air sampling results indicate exposure levels greater than the PEL.

224

1. The magnitude and duration of exposure.
2. When you define the processes occurring in and around the work environment or area of concern, along with an understanding of the materials and equipment being used in the processes.

2. 3. SDS.

4. To determine if a completed exposure pathway exists.

5. About 80 percent.
6. It is typically reserved for high hazard chemicals where dermal exposure is expected to be a major contributor to overall biological burden.
7. Inhaling chemical substances in the form of gases, vapors, and particulates or by skin contact with the chemical substance.
8. The chemical has an increased risk of producing high vapor concentrations in the air so that vapor inhalation may be a concern.

225

1. Obtain information needed to formulate potential controls.
2. Prevent skin contact with the offending substance(s).
3. Identify the constituents in the chemicals that can potentially contact a person's skin.
4. They do not provide the necessary protection.
5. Because large surfaces of skin are often directly exposed to the worker's environment.
6. Housekeeping and personal hygiene practices, regularly wiping down work areas and equipment, and washing exposed skin upon completion of specified tasks.
7. When a specific material is required by a technical order.
8. Isolation.
9. A larger number of workers will be exposed to the chemical threat.

226

1. It restricts access to specific hazardous chemicals/materials that exceed allowable exposure limits (e.g., PEL, TWA, and action level), as stated in the relevant standard.
2. The OSHA standard for specific criteria relevant to the substances or chemicals of concern.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

56. (221) A solvent is a
    a. liquid that a solute can be dissolved in.
    b. vapor that enters the body by inhalation.
    c. solid that can cause "rapid" toxic action.
    d. particulate that a solute can be suspended in.

57. (221) How do solvent vapors *mainly* enter the body?
    a. Ingestion.
    b. Injection.
    c. Inhalation.
    d. Skin contact.

58. (222) If a safety data sheet (SDS) is *not* provided with the initial shipment of a hazardous material (HAZMAT), who *must* request it?
    a. Public health (PH).
    b. Ground safety.
    c. Workplace supervisor.
    d. Bioenvironmental engineering (BE).

59. (223) What document would specifically address actions that *must* be taken for regulated chemicals considered very hazardous?
    a. Substance specific standard.
    b. Hazard communication standard.
    c. Workplace hazardous chemical inventory.
    d. Hazardous material (HAZMAT) vulnerability assessment.

60. (224) When identifying inhalation hazards of chlorine, you would infer from its vapor density of 2.47 that high concentrations of chlorine would
    a. rise into the air.
    b. evaporate slowly.
    c. sink to the ground.
    d. evaporate quickly.

61. (225) Which type of control is air sampling?
    a. Personal protective equipment (PPE).
    b. Administrative.
    c. Engineering.
    d. Ventilation.

62. (225) Which control *removes* the hazard from the work area?
    a. Personal protective equipment (PPE).
    b. Worker rotation.
    c. Administrative.
    d. Elimination.

63. (226) Your sampling determines workers are exposed to hazardous chemicals that exceed allowable exposure limits; therefore, if stated in the relevant standard, what should be established?
    a. Regulated area.
    b. Restricted area.
    c. Remediation area.
    d. Requirements area.

64. (226) Who is responsible for providing guidance so the work place will be in compliance with the substance specific standard?
    a. Occupational Safety and Health Administration (OSHA).
    b. Bioenvironmental engineering (BE).
    c. Workplace supervisor.
    d. Commander (CC).

Please read the unit menu for unit 5 and continue ➔

Student Notes

Unit 5. Physical Hazards

SOUND PLAYS an important role in people's lives every day, whether it is verbal communication, music, or a warning noise. Some sounds give us pleasure, like when we listen to music; others allow us to identify different things by their specific sounds, such as a species of bird. Sound is even more important when it provides a warning as when a diesel truck is bearing down on us and blows its horn.

When sound is unwanted, it becomes noise. The sounds of a well-running engine or the crack of rifle fire can be music to some people and noise to others. Beyond mere annoyance, intense noise, found on almost any Air Force base, is responsible for one of the most prevalent occupationally-related health problems: noise-induced hearing loss. Occupational hearing loss costs the US government an estimated $242.4 million per year in disability alone. Properly identifying, assessing, and controlling noise exposures can help prevent these hearing loss claims, while protecting the health of the workers. The hearing conservation program (HCP) is a component of the OEH program. Its purpose is to reduce or eliminate hazardous noise exposure to workers and protect workers from the harmful effects of hazardous noise, while enhancing combat and operational capabilities.

5–1. Noise

What is your role as a BE technician in the USAF HCP? How does sound travel? What is a frequency, a wavelength (λ), power, and intensity, and what bearing do they have on the effects produced by sound? What are the effects of noise on the worker? What type of surveys will you perform? What controls will you recommend to protect the worker? Understanding the answers to these questions will help you accurately identify, assess, and control this hazard as well as help

you better explain to commanders and workers the consequences of noise exposure and the need for its control.

227. Roles and interactions of a BEE in the Air Force hearing conservation program

The role of BEEs in the HCP is to identify and assess worker exposure to sources of hazardous noise. Additional responsibilities are to determine hazardous noise areas and make recommendations to control exposures. AFI 48–127 is the governing AF publication. It gives a detailed description of each agency's responsibilities in the program and outlines hazardous noise surveillance requirements, personnel and equipment standards, hearing protection, hazardous noise controls, and fitness and risk evaluations. [1]

To have an effective HCP, a BEE must work closely with other Air Force and installation agencies/personnel. BE's roles and responsibilities are unique to the individual agencies it interacts with.

United States Air Force School of Aerospace Medicine

The United States Air Force School of Aerospace Medicine (USAFSAM) has a major role in providing consultative services to measure, evaluate, and recommend controls and solutions for occupational noise concerns within the AF. They have specialized noise-measuring equipment to monitor and record various types of noise of physiological significance or which might interfere with successful conduct of AF operations. Other responsibilities include the following:

- Maintaining an information repository of noise-producing equipment characteristics typically found in AF industrial work places.
- Serving as the principal coordinator of occupational noise studies conducted during weapon systems development.
- Appointing and maintaining an AF HCP office with a least one audiologist as the AF HCP manager (HCPM).
- Providing training to support the HCP.

BEE consults with USAFSAM occupational noise and HCP experts for information and data. BE may also request assistance through a MAJCOM in order to evaluate unique or unusual occupational noise problems.

Wing commanders

Wing commanders, in coordination with an AF community noise program, run an integrated installation hazardous noise reduction and protection program. This program includes noise control by operational means, building design, and land use planning. Wing commanders ensure that the HCP status and program effectiveness are addressed annually as part of a wing's environmental safety and occupational health (ESOH) council. A BEE may provide input for this annual review, serve as a consultant, and is a member of this council in most cases.

Squadron commanders and workplace supervisors

Squadron commanders and workplace supervisors have several important responsibilities in the USAF HCP. As with other occupational health programs, they ensure that the work place complies with all OSHA, DOD, and AF HCP requirements. The following are some of their key responsibilities:

- Participating in the review of the workplace hazards as process owners to identify actions taken to mitigate hazardous noise.
- Eliminating exposure to potentially hazardous noise and protecting the hearing of assigned personnel (by engineering controls).

- Properly marking hazardous noise areas and equipment (as identified by BEE) with signs and/or decals to alert personnel of the potential hazard.
- Informing BEE/PH staff of workplace equipment or practices and procedures involving potentially hazardous noise change.
- Ensuring compliance and availability of approved hearing protection devices (HPD) for workers exposed to hazardous noise.
- Instructing personnel on the HCP, care/hygiene, and proper use of their approved HPDs.
- Ensuring workers with an occupational exposure to hazardous noise complete an initial/reference audiogram and receive HCP training from PH.
- Conducting initial and annual workplace-specific HCP training on shop or unit hazardous noise exposures and equipment.
- Notifying each employee exposed at or above the 8-hour TWA of 85 A-weighted decibels (dB[A]) of the noise monitoring results performed by BE.

Employees with hazardous noise exposure

Employees must comply with all hazardous noise control measures, whether at work or at a deployed location, including the proper use of HPDs. This includes advising others in the work place to wear HPD when exposed to hazardous noise or when working in or entering designated hazardous noise areas. They must attend appointments to receive annual occupational health medical exams (i.e., audiometric evaluation), taking the HPDs they use to their appointments. This includes any PPE worn in conjunction with HPDs (such as eyewear that could affect the fit of HPDs). Additionally, they should report new, or changes in, operating procedures that affect workplace hazardous noise exposure to the supervisor. The supervisor will then notify the BE Flight. They must also participate in noise exposure surveys and evaluations by wearing monitoring equipment as requested by BE.

Host installation and/or organizational safety staff

As with other occupational programs on an installation, you will work closely with safety personnel. Safety notifies BE of newly added noise hazard work tasks or areas noted during periodic safety inspections. BE will then perform the necessary HRA as required. Further, safety performs the job safety analysis to assist with the fitness and risk evaluation.

Aerospace medicine squadron/Air Reserve Component medical unit commander

The aerospace medicine squadron/Air Reserve Component medical unit commander is the manager for the occupational health program. He or she ensures a comprehensive HCP is available. Hearing conservation issues are considered through the OEHWG, just as any other occupational exposures. A BEE, along with PH personnel, will provide advice/consultation to the OEHWG.

Public health

PH has a leading role in the HCP. They perform audiometric testing, and track and monitor HCP occupational examination compliance of workers. Further, PH properly fits HPDs to personnel exposed to hazardous noise. A BEE may work with PH personnel on illness investigations related to reportable occupational hearing loss and on recommending audiometric examinations for personnel exposed to potentially hazardous noise.

Bioenvironmental engineering

According to AFI 48–127, BE assumes the following responsibilities:

- Performing noise surveys and dosimetry to quantify noise hazards and documenting the results in the DOEHRS-IH module.

- Working with a precision measurement equipment laboratory (PMEL) and/or biomedical engineering personnel to ensure proper calibration and certification of noise meters.
- Completing the SEG OEHED for the OEHWG, including the 8-hour TWA and required controls.
- Providing PH and shop supervisors the results of noise surveys, dosimetry, and required controls (i.e., engineering, administrative, and/or HPD).
- Assessing the adequacy of all controls used to reduce noise exposures, including hearing protectors and, in conjunction with the shop supervisor, the feasibility of engineering controls for hazardous noise equipment/areas.
- Assisting with fitness and risk evaluations upon request of provider.
- Reviewing facility and operations plans for new or modified facilities to ensure noise exposure control is appropriately considered.
- Conducting work place assessments to support occupational illness/injury investigations, claims for hearing loss, and areas where adverse hearing loss trends exists.
- Certifying the audiometric testing environment on an annual basis.

For all specific agency and individual responsibilities, refer to AFI 48–127. Remember, you are not alone in making the USAF HCP a success at your installation. You must work closely with other agencies and personnel to help ensure you have an effective program.

228. Physical properties of sound

Sound is part of the everyday sensory experience. Sound is a longitudinal wave, created by vibrating objects that spread through a medium (e.g., air) from one location to another. In air, sound is caused by minute changes in normal atmospheric pressure generated by anything from a power tool, an engine, a set of vocal cords, to even a chirping bird. Figure 5–1 illustrates the vibrations caused by a tuning fork.

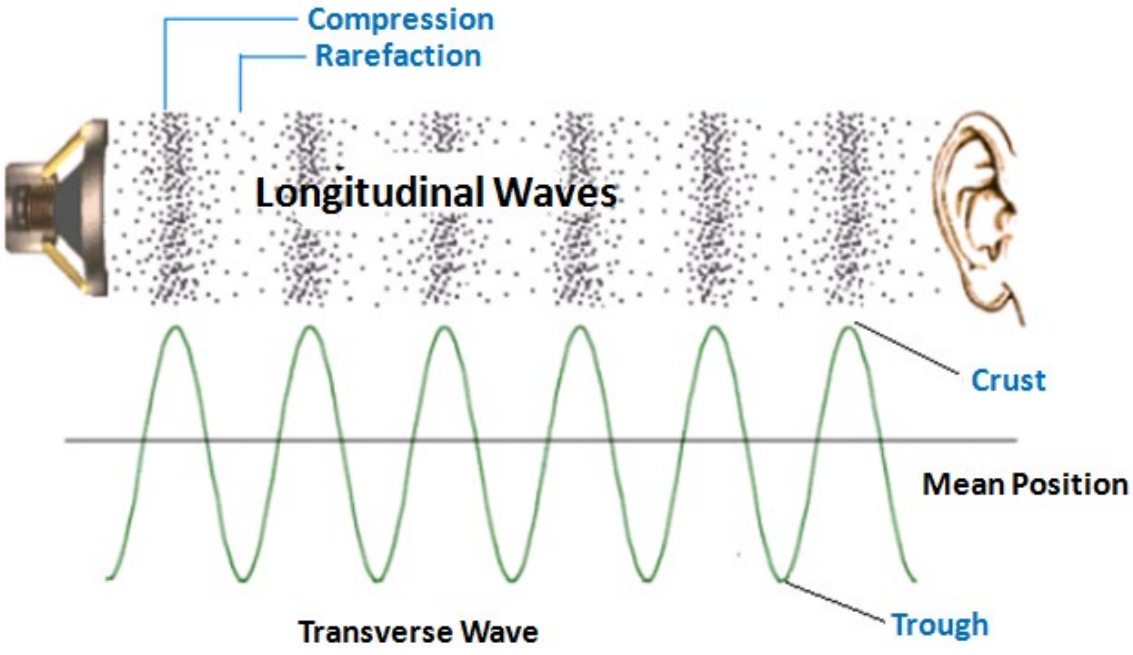


Figure 5–1. Sound Vibrations.

During this vibration, the surface of the tuning fork first bends in one direction and the air molecules next to it compress. This causes a slight increase in atmospheric pressure. As the fork

moves in the opposite direction, molecules near the fork's surface are drawn away from the surrounding air to create an area of lower atmospheric pressure. This process is known as rarefaction. The vibrating tuning fork repeats this process over and over, causing alternate areas of compression and rarefaction in the molecules near the fork. These air molecules, in turn, cause compression and rarefaction in the molecules next to them. This forms a repetitive wave-like motion known as a sound wave.

Sound waves can be described using several qualities such as frequency, wavelength, amplitude, and velocity.

Frequency

Frequency is a measure of how often a sound wave will repeat in a given amount of time. This is measured in cycles per second, otherwise known as Hz (Hz). Most people are able to hear sounds with frequencies ranging from 20–20,000 Hz, or the normal human range of hearing. [2] Sounds with a frequency of less than 20 Hz might be felt as a rumbling sensation rather than *heard* as a sound. When listening to loud music with strong bass tones, you hear the bass in the low end of the normal human range and feel the vibration of the sounds with frequencies than those you are able to hear. Frequencies above 20,000 Hz are typically undetectable by human ears; however, some animals can hear some of these ultrahigh frequencies. Dog whistles are designed at such a high frequency as to be almost impossible for humans to hear but are said to be quite loud to dogs.

For measurement purposes, frequencies are normally divided into octave bands. An octave band is defined as a range (or band) of frequencies extending from one frequency to exactly double that frequency. In other words, the upper frequency is twice the lower frequency. [3]

The octave band is labeled by the frequency in the center of that range. For example, the octave band ranging from 1,420 Hz to 2,840 Hz is known as the 2,000 Hz octave band. BE evaluates and identifies these bands of frequencies by each band's center frequency. For example, 1000 Hz identifies all frequencies in the band 707 – 1414 Hz rather than saying the 707 to 1414 Hz band, as 1,000 Hz is easier and faster to say. The following table contains examples of frequency bands and center frequency.

Frequency Band	Center Frequency (Octave Band)
22.2 Hz - 44.5 Hz	31.5 Hz
44.5 Hz - 89 Hz	63 Hz
89 Hz - 177 Hz	125 Hz
177 Hz - 354 Hz	250 Hz
354 Hz - 707 Hz	500 Hz
707 Hz - 1414 Hz	1000 Hz
1414 Hz - 2828 Hz	2000 Hz
2828 Hz - 5657 Hz	4000 Hz
5657 Hz - 11314 Hz	8000 Hz

A sound wave that can be characterized by one single frequency is a *pure tone.* The wave of a pure tone is shown in graphic form as a smooth, wavy line. We seldom hear pure tones in our daily lives. What we normally hear is a wide variety of different tones and amplitudes mixed together so that no single one is recognizable. This is called *complex sound.* A graph showing complex sound contains a large number of differently sized sharp peaks in a seemingly random pattern. Complex sounds with an extremely large number of different peaks are known as white

noise. Figure 5–2 illustrates these different types of sound waves in seconds (sec) and milliseconds (ms).

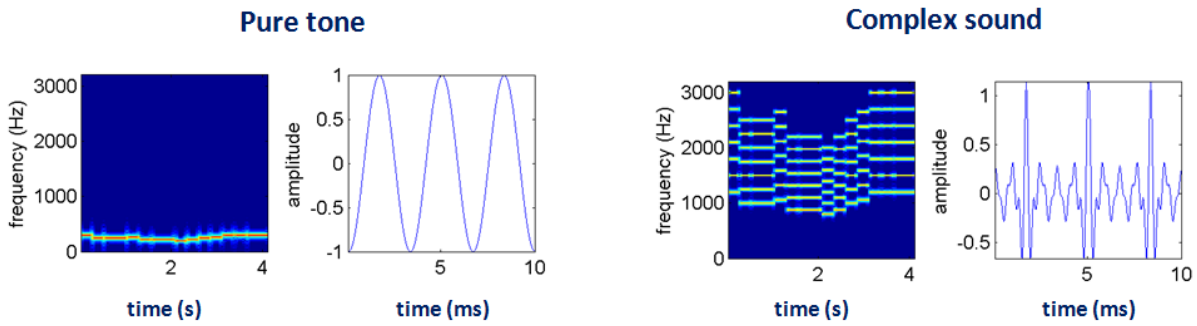


Figure 5–2. Pure tone and complex sound.

Wavelength

Wavelength is the distance from one point of a sound wave to an identical point on the next wave (fig. 5–1). It is the distance that a sound wave travels within one full cycle. Knowing the wavelength is valuable when recommending engineering controls, such as barriers, to contain long wavelength (low frequency) or short wavelength (high frequency) sounds.

Amplitude

The amplitude of a wave is the distance from top (crest) to bottom (trough) of a wave, when compared to normal atmospheric pressure (fig. 5–1). The amplitude of a sound wave is a measure of the sound's intensity. The higher the amplitude, the more intense the sound is. The amplitude (and intensity) of the sound waves decreases as sound waves travel away from the source.

This decrease in intensity is similar to the ripples in water after dropping a pebble in a pond. The ripples are higher where the pebble hit the water and then get smaller as they travel away. If a large rock is dropped in the water, the ripples start much larger but also get smaller as they travel away. In the case of a sound source, the sound waves push outward in all directions and gradually diminish as they exert their energy over larger areas (fig. 5–3).

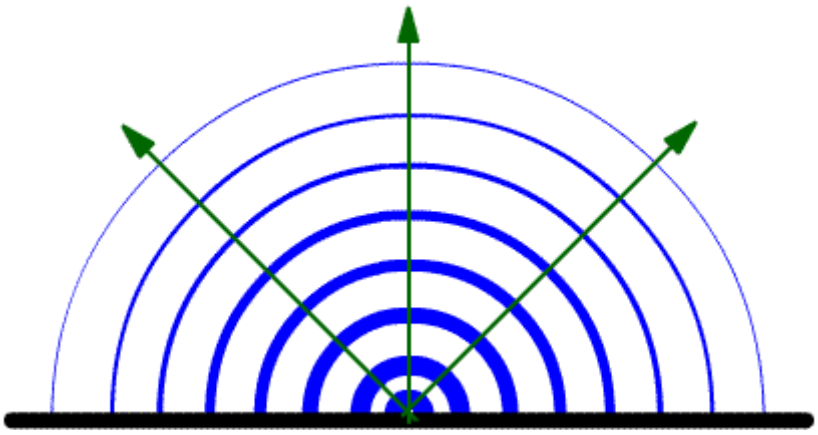


Figure 5–3. Decrease in sound amplitude with distance.

Velocity

Velocity is the speed of sound. The velocity of a sound wave is dependent on the elasticity and density of the material through which the sound travels. Velocity increases in solids and liquids because the ratio of elasticity to density is higher than it is in air. This allows a more rapid transfer of energy as the wave travels through the material. Because of this, sound always travels

much faster in water or solids than in air. The speed of a sound wave is always equal to the product of the wavelength and the frequency. By knowing any two of the three components of a sound wave (frequency, wavelength, and velocity), the formula can be manipulated in order to determine the third.

$$c = f \times \lambda$$

$$f = \frac{c}{\lambda}$$

$$\lambda = \frac{c}{f}$$

Why do we need to be familiar with the composition of sound? When assessing sound to determine if it is potentially hazardous noise, understand that noise exposure can cause certain health effects at different frequencies and intensities. The controls recommended for those exposures are also specific to the sound's frequency.

229. Quantities and units of sound

In their most basic forms, the two most common sound measurements are those concerned with quantifying both the magnitude of a sound field and the strength of a sound source. The sound field is the changes in density or particle velocity or particle displacement. Sound pressure is best understood when it is converted to the term a BEE measures and uses most often—the dB. The term intensity has been used quite a bit already, especially in conjunction with the amplitude of a sound wave. Although you have understood it to mean the strength of a sound, it has a very specific meaning in noise work and is only one means of quantifying sound. We now need to find out just what the different terms and units of measure really are and how they relate to each other.

Decibel

A dB (introduced in Unit 2) is a unit of measurement of sound level and describes sound pressure level (SPL) at a specified distance. It is a common logarithm (log) of a ratio used to manage the cumbersome numbers of the vast range of sound powers and pressures.

Sound power

When speaking of the strength of a sound source, you are actually talking about sound power, also called acoustical power. It is the total amount of sound that a source produces, not the amount of sound that reaches your ears. In actuality, the sound travels outward from the source in all directions and you only receive that small portion of the total that moves in your direction. Many items that might put out a great deal of noise, such as power tools, are rated according to the sound power they create. This can be useful in getting an idea of the degree of the noise hazard that such items may pose. You can even calculate the sound intensities and pressures that will exist at different distances from the source.

To understand the units used for sound power and provide a basis for those that will be used later, we must return to our earlier discussion of changes in atmospheric pressure—compression and rarefaction. Recall that these are caused by some vibrating surface that is the source of energy for the sound waves. The energy creates a force, which in turn creates the pressure variations of the sound. The unit of force we use is the newton (N). This is the force required to give a 1-kilogram (kg) mass an acceleration of 1 meter per second squared (m/sec^2). Force specifies the capability to move something but not the actual movement. It is easier to grasp this if you imagine trying to push a heavy cabinet but cannot budge it. You may expend a lot of energy and exert a lot of force without accomplishing anything. Work is done when you are able to move the cabinet some distance. We use the joule (J) as the unit of work (also as the amount of energy required to do the work) that is done when 1 newton of force results in a movement of 1 meter (m). Putting things

together, when you move a 1 kilogram mass a distance of 1 meter with acceleration of 1 meter per second squared, 1 joule of work is done. How long it takes to move the object is of no importance. The term or measurement meters per second squared does not relate to the time involved; it deals only with the amount of force applied. It may take a second or an hour to move the object, but the work done is the same. When you do specify the time taken to do a certain amount of work, you are talking about power—the rate at which work is performed. One person may struggle to move a cabinet across a floor and make very slow progress, while another person is able to move it quickly. The second person has the strength to apply more power. The 1-kilogram mass moved a distance of 1 meter with a force of 1 newton in 1 second (sec) results in 1 watt (W) of power being used. One watt is therefore 1 joule of work done in 1 second, or 1 joule per second (J/sec) (fig. 5–4). We now have the unit needed to quantify sound power.

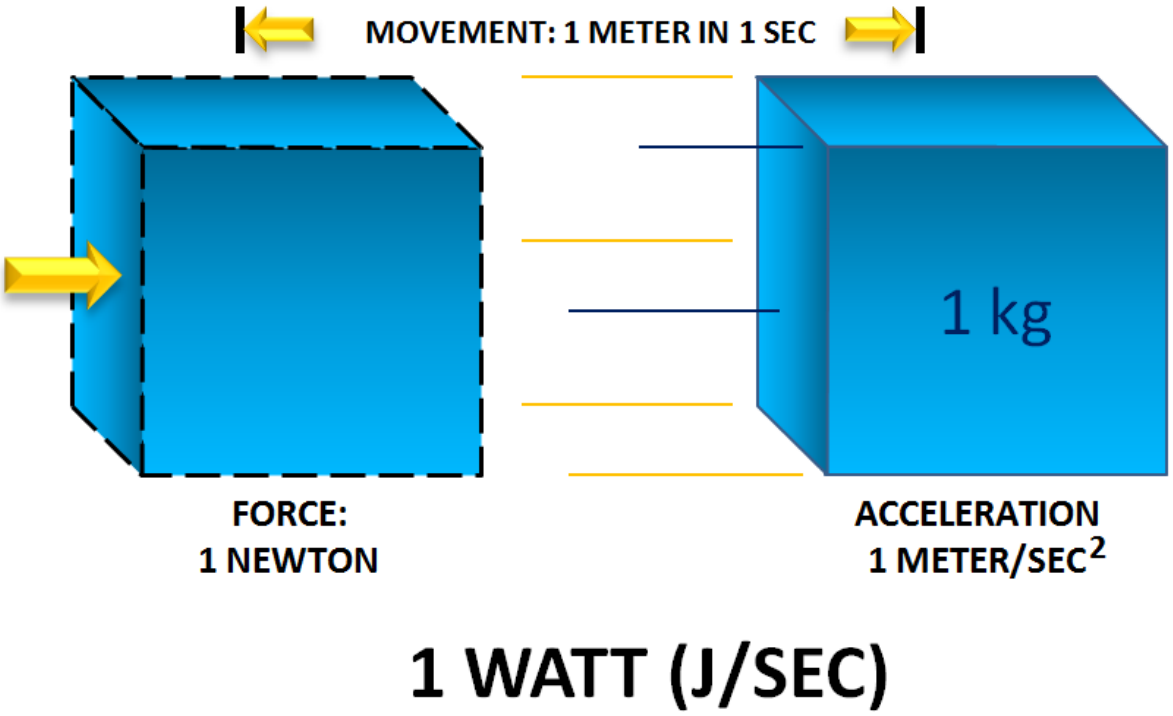


Figure 5–4. Units of Power.

Equipment is often rated according to the number of watts of sound power or acoustical power it can produce. The range of sound power that different items can produce is staggering. A whisper can be as low as 0.00000001 (10^{-8}) W; a jet engine with afterburner may produce 10,000 W or more. To handle unwieldy numbers like these, we use the dB, which is a common log of a ratio. The ratio of concern is some number of measured Ws over a reference quantity of watts. This tells us the relative strength of a source compared to the reference value (RE), or however many times as much power the source has than the reference quantity. DBs would have no meaning without some RE to form the basis. The RE for expressing sound power in dBs is 10^{-12} W, chosen because of its closeness to the minimum amount of sound that a human can hear at 1 foot from the source of this sound power. When the sound power is converted (in watts) to dBs, the result is referred to as the *sound power level.*

Note carefully that using the word *level* indicates that you are talking about dBs with some stated or implied reference. In texts and specifications concerning sound, the unit will appear as "dB RE 10^{-12} W," which means "decibels with a RE of 10^{-12} W." Without this notation, there could be confusion over just what the reference is, particularly since dBs are used in many other areas that have different references. You can see by referring to the following table that a vast range of

watts can be expressed by relatively small changes in dBs. A jet engine (10,000 W) can produce 1,000,000,000 times or more the sound power of a human voice (0.00001 W). The sound power levels, however, are 160 dB for the jet engine and 70 dB for the voice. Further, the sound power level of zero dBs is not an absolute zero since we are still dealing with some amount of power (10^{-12} W), however small. It is therefore possible to have minus values in the dB scale, such as –10 dB (10^{-13} W). The following table lists examples of the relationship of sound power and sound power level.

Sound Power (Watts)	Sound Power Level (dB)	Typical Examples
100,000 (10^5)	170	M16
10,000 (10^4)	160	Jet Engine, Afterburner
1000 (10^3)	150	
100 (10^2)	140	Rock Band
10 (10^1)	130	
1 (10^0)	120	Compressor
0.1 (10^{-1})	110	Power Mower
0.01 (10^{-2})	100	
0.001 (10^{-3})	90	Shouting
0.0001 (10^{-4})	80	Vacuum Cleaner
0.000,01 (10^{-5})	70	Conversation
0.000,001 (10^{-6})	60	
0.000,000,1 (10^{-7})	50	
0.000,000,01 (10^{-8})	40	Whisper
0.000,000,001 (10^{-9})	30	
0.000,000,000,1 (10^{-10})	20	
0.000,000,000,01 (10^{-11})	10	Light Breathing
0.000,000,000,001 (10^{-12})	0	

Sound intensity

The sound power produced by the jet engine may seem like quite a bit, and it certainly is; however, this is the total amount of sound the engine is putting out in all directions. Only a portion comes your way. The size of a portion naturally depends on how close you are to the source. This portion coming your way is the sound intensity, expressed as the amount of sound power per unit area. It can also be called power density. The unit we use is watts per square meter (W/m^2) at some distance of interest. Keep in mind that the number of square meters (m^2) to which the sound must spread out increases dramatically with small increases in distance. Since the sound goes in all directions, you can visualize it as a bubble rapidly expanding from the source. At a distance of 2 meters, the sound spreads out to a spherical area of 50 square meters; at 5 meters, the area becomes 314 square meters. A 15-meter distance yields an area of 2827 square meters. Figure 5–5 illustrates the relative sizes of these spheres along with the same areas spread out over square surfaces. The sound becomes quite diluted by distance, which is to say that the amplitude of the wave decreases rapidly.

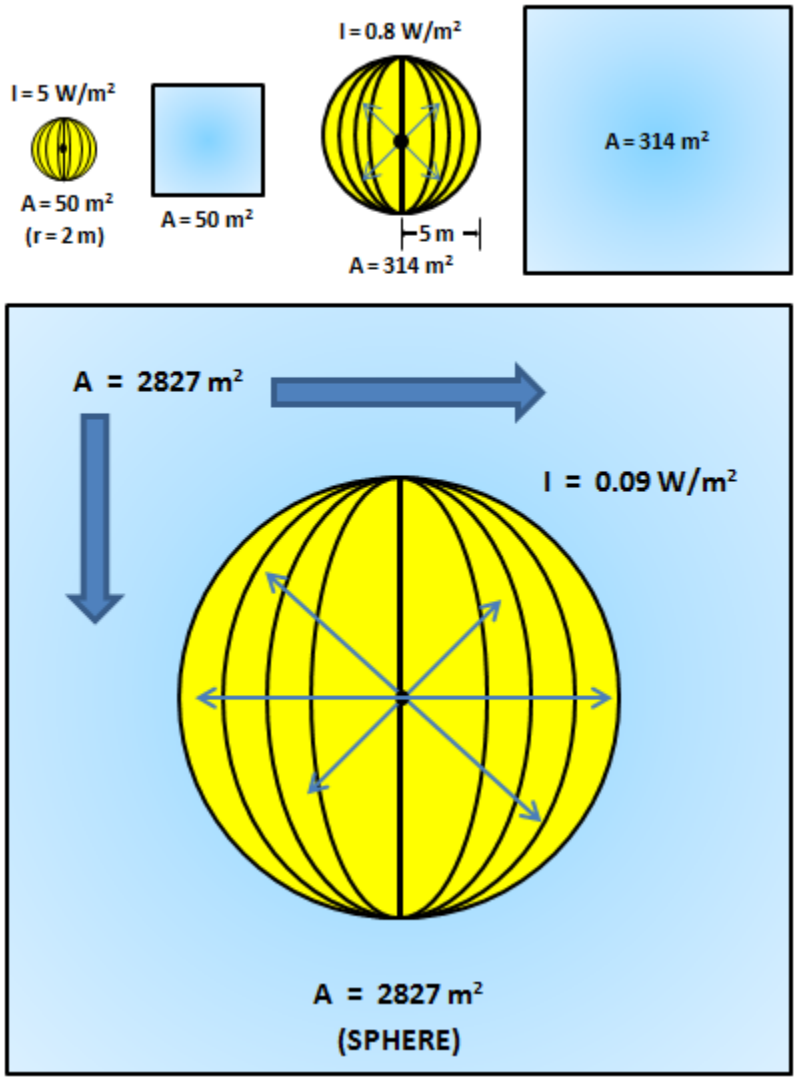


Figure 5–5. The Spread of Sound.

When measuring sound, the doubling-the-distance rule of thumb is sometimes used. If the distance from the source is doubled, subtract 6 dB; however, if the distance from the source is cut in half, add 6 dB. For example, 94 dB at 20 feet (ft) becomes 88 dB at 40 ft and 82 dB at 80 ft. What if you needed to know the level at 25 ft when it is 100 dB at 10 ft? In the absence of the convenient doubling of distance, we use another formula:

$$dB_2 = dB_1 - 20\log\frac{d_2}{d_1}$$

Where:
dB_1 = level at original distance.
dB_2 = level of interest at a new distance (feet or meters but both distances with the same units).
d_1 = original distance.
d_2 = new distance.

The practicality of this procedure is that you may have made sound level measurements at 10 ft where the workers are usually exposed, but someone wants to know the level where there are a

secondary group of workers or people frequently passing by. This formula enables you to quickly estimate the level at any distance.

Sound pressure

Often confused with intensity, the sound pressure is what we deal with most. It is the characteristic of sound that we actually measure and report when quantifying sound. It directly relates to the sound power and sound intensity—certain wattage at a given distance corresponds to a certain sound pressure. Sound pressure is the difference between normal atmospheric pressure and the actual pressure during compression and rarefaction. It is not related to wavelength or frequency. For example, a sound with a frequency of 1000 Hz may have very small pressure and be heard as a soft tone, or it could have a high pressure and sound loud.

The description of sound pressure units is similar to that of sound intensity units. Of the many units that can be used for pressure, the one used in sound terminology is newtons per square meter (N/m^2)—force (newtons) exerted over a certain area (square meters). They are also called pascals (Pa). You should be able to see the relationship of sound pressure to sound power from the previous discussion that built up to newtons and watts. In fact, you can use the sound power in watts to calculate the sound pressure in newtons per square meter.

Further, sound is sometimes sent out in one direction, somewhat like a flashlight beam, rather than radiating in all directions like a plain hanging light bulb. A loudspeaker is a good example of sound being concentrated in one direction through a narrow area. Pipes and tunnels concentrate sound even more, as evidenced by the efficiency of a stethoscope. Even free-field sound normally has higher intensities in some directions than others. The shape of the source, terrain features, temperature, humidity, and wind can all play a part (fig. 5–6).

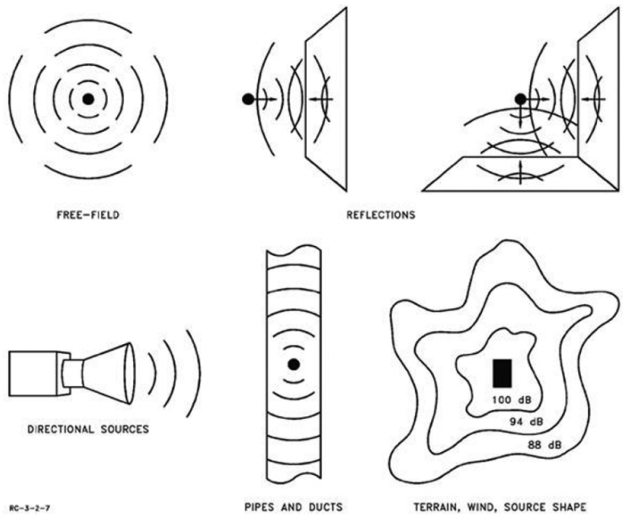


Figure 5–6. Direction of Sound

Weightings

The reference for SPL concerns human hearing specifically at 1000 Hz for a good reason: humans do not hear all frequencies with the same perceived loudness. For instance, a sound at 2000 Hz seems much louder to us than sounds with the same number of dBs at either 16,000 Hz or 31.5 Hz. A human can hear a SPL of 40 dB at 1000 Hz quite well. However, it takes 6.6 dB more than this at 16,000 Hz and 39.2 dB more at 31.5 Hz to hear these frequencies with the same perceived loudness. Sound measuring instruments are calibrated to respond to frequencies in the same way as the human ear. Different frequencies are weighted by different amounts so that they are all perceived to have the same loudness when they have the same number of weighted dBs.

Referring to figure 5–7, find the widest application in dB(A). That is, we must measure sound with this weighting when assessing hazardous noise. You can see that the A-weighting discriminates heavily against the lower frequencies. The weighting is not as sensitive to lower frequencies as it is to the higher ones. This is how the human ear responds to sound below 55 dB; however, A-weighted levels are used for all intensities. It correlates well with such effects as loudness, speech interference, annoyance, and hearing loss. A-weighted levels of 0 dB are obviously not true 0 dB levels (RE 0.0002 newtons per square meter) except at 1000 Hz. For instance, a level of 0 dB(A) at 31.5 Hz corresponds to a sound pressure of about 0.00182 newtons per square meter, which is more than 91 times the reference level. However, it still has the same loudness to us as 0 dB at 1000 Hz.

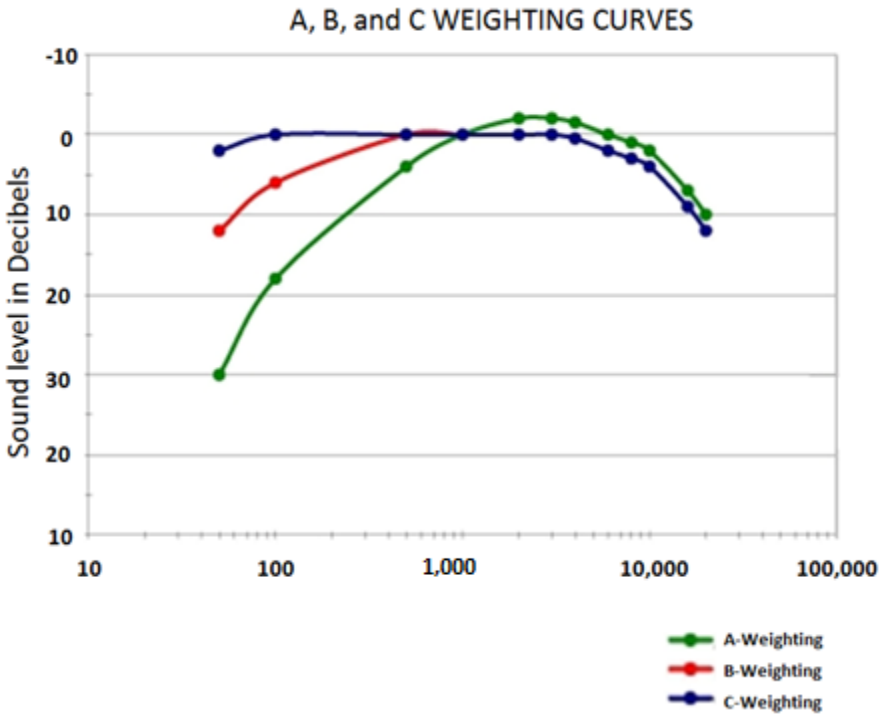


Figure 5–7. Weightings.

When no weighting is used, the instrument response is said to be flat (as on a graph), and 0 dB corresponds to 0.00002 newtons per square meter at all frequencies. Decibels C-weighted (dB[C]), is similar to a flat response. It is flat, such that 0 dB(C) = 0 dB, at all frequencies except the very low and very high, representing the relative response of human hearing to high sound levels (above 85 dB). More importantly, we use the C-weighting to find out if sound levels are more intense in the higher or lower frequencies without going to the trouble of an octave band analysis (OBA). You can easily see from figure 5–7 that the difference in response at low frequencies between the A- and C-weightings is significant. If we measure a higher dB(C) level than dB(A) level, the sound is predominantly low frequency—below about 600 Hz. A higher dB(A) level means that the sound is mainly in the higher frequencies and likely to be more hazardous to hearing. The sound must be centered around 1000 Hz when you find that both weightings have the same sound levels because 1000 Hz is where the weightings have the same value on figure 5–7. The C-weighting (and the flat response) aids us more in devising noise controls, while both the A- and C-weightings are needed to recommend proper hearing protection, as we will see later. A third weighting that you see on instruments, B, is not normally used.

Expressing an A- or C-weighting for each frequency is not of much use and you are unlikely to find an instrument that makes such measurements. What we actually measure is the overall A- or

C-weighted sound level; that is, the total weighted intensity of all the frequencies of the sound as a single value. Note the use of the term sound level (without the word pressure), which is the proper way to describe overall levels when a weighting is used. Therefore a sound level meter (SLM) measures overall weighted levels. An overall level with no weighting is the overall SPL, indicating that it represents the true combined sound pressure in dBs (RE 0.00002 newtons per square meter). You will see terms for the overall SPL shown on instruments and forms as "flat," "dB(A)P" (dBs, all pass), or simply "all pass." You should always specify what weighting (or flat) you have used so that there is no doubt. Many people do not know that the A-weighting is automatically assumed when no weighting is otherwise specified.

230. Effects of noise exposure

Hazardous noise exposure can cause a variety of health effects ranging from simple annoyance to serious bodily damage. One of the effects is noise-induced hearing loss. This usually has an insidious outcome that creeps up on you. The noise does not cause pain (although it certainly can) as it damages your hearing. Often, the loss of hearing is not readily noticeable by the affected person until it becomes severe. Because the loss is usually gradual, workers may have a complacent attitude toward exposures to loud noises and wearing of HPDs. A major goal of the HCP is to prevent hearing loss due to noise exposure. Effects of noise exposure can be broken down into auditory and non-auditory effects.

Auditory effects

Auditory effects refer to the effects of noise on the ear. The parameters of the noise to which individuals are exposed affect the pattern and magnitude of their inner-ear damage. Over-stimulation of hair cells by intense sounds damages them, most commonly in the high frequencies. When a large number of hair cells from a particular region are lost, a type of hearing loss is created in that region. Auditory effects of noise exposure include hearing loss, tinnitus, and acoustic trauma.

Hearing loss

Hearing loss due to noise, or sensorineural hearing loss, is the result of damage to the hair cells and accompanying degeneration of the nerve fibers in the ear. This loss of hearing is also known as a noise-induced hearing loss. The change in hearing, or threshold shift, can be temporary or permanent in nature. A temporary threshold shift refers to a temporary loss of hearing sensitivity. This loss can be a result of acoustic reflex, short-term exposure to high intensity noise, or simple neural fatigue to the inner ear. As long as the exposure does not continue, hearing sensitivity usually returns in a matter of hours or days. Noise-induced permanent threshold shift, as the name implies, refers to a permanent loss of hearing sensitivity. This is due to the destruction of sensory cells in the inner ear. This damage can be caused by long-term exposure to hazardous noise or acoustic trauma (defined below). Sounds from about 500 Hz–2000 Hz (speech frequencies) are more likely to cause a threshold shift than those in the lower frequencies.

Air Force workers who are occupationally exposed to potentially hazardous noise are entered into the HCP. Their hearing is monitored at designated intervals in order to help with early identification and prevention of hearing loss.

Tinnitus

Tinnitus is the condition in which people perceive sounds (e.g., ringing, roaring, whistling, humming, hissing, etc.) in one or both ears when there is no actual sound around them. Sometimes, this can be caused by a blow to the head or certain medications, but the predominant cause is long term exposure to hazardous noise. Although this is often temporary, there are some cases in which tinnitus can become permanent and debilitating.

Acoustic trauma

Acoustic trauma is the temporary or permanent hearing loss due to a sudden, extremely high intensity noise, such as an explosion.

Non-auditory effects

In addition to auditory effects, high noise levels can produce undesirable effects on the body other than hearing effects. These are known as non-auditory or whole body effects, and symptoms are similar to those associated with general reactions to stress. The sense of balance can be upset, and the pupils of the eyes may dilate. Intense sound may interfere with speech communication and sleep. This may cause nervousness, irritability, and hypertension (high blood pressure) and may increase fatigue and overall stress levels. Intense sounds below about 1000 Hz can be felt as a vibration. These low frequency sounds can stimulate nerves throughout the body, including those that influence the senses of touch and pressure.

Effects on job performance

Noise may have an adverse effect on job performance. It interferes with efficiency both directly and indirectly. Annoyance and the disruption of thought processes, particularly during the performance of complex tasks, are among the most common interferences. Noise also impacts voice communications. It may adversely affect telephone use, getting ideas across during conferences, and the ability to understand instructions. In some situations involving potential threats to personal safety, the inability to hear what is said could be deadly. Failure to hear malfunction warnings in an industrial process can have serious consequences.

Effects on community relations

Irritation and interference with daily activities due to noise is not limited to the work place. Effects of noise on the community include speech and sleep interference, annoyance and possible associated stress, and changes in the value of property situated near the noise source. Adverse community response to aircraft noise has often been a problem. While some people associate noise from a base with a feeling of security, others see it as a nuisance. Resolving community noise problems can be challenging.

BE may become involved in assessing community noise exposure. Procedures may differ for on- and off-base community noise. It is important to review the applicable standards and requirements for different activities, especially if separate local, regional, or state guidelines apply to the area.

231. Hazardous noise sources and areas

You now know the basic properties of sound and the adverse impact that noise can have. How much noise is too much? We need to define potentially hazardous noise, recognize what a potentially hazardous noise area is, and be familiar with Air Force noise standards to determine when workers are overexposed.

Define potentially hazardous noise and potentially hazardous noise areas

Potentially hazardous noise is exposure to steady-state noise having an 8-hour TWA noise level greater than or equal to 85 dB(A), or exposure to impulse/impact noise levels greater than 140 dB peak SPL, regardless of duration.

A potentially hazardous noise area is any area where personnel could be exposed to steady-state noise having an 8-hour TWA noise level greater than or equal to 85 dB(A), or exposure to impulse/impact noise levels greater than 140 dB peak SPL, regardless of duration.

Describe noise exposure standards

When assessing noise, two important concepts you need to understand are criterion level and exchange rate. The criterion level is the sound level allowed for an 8-hour exposure. This is used

as the basis for measurement of a noise standard. For the Air Force the criterion level is 85 dB(A). The Air Force exchange rate, also known as the doubling rate, is 3 dB. The exchange rate deals with the relationship between the sound level and the allowed exposure time. For every increase of 3 dB, the allowable exposure time is cut in half. Likewise, for every decrease of 3 dB, the allowable exposure time is doubled. The following table helps clarify this concept.

Sound Level (dB(A))	Time (hours [h])
94	1
91	2
88	4
85	8
82	16

Regulatory exposure limits for substances are set so the combination of concentrations and time durations are theoretically below the levels that produce injury to exposed individuals. This is the same for noise exposure limits. Noise exposure standards or limits are determined based on sound levels and duration of exposure. In other words, how many dBs for how long?

Like the civilian community, the Air Force adheres to various noise exposure standards or limits provided in AFI 48–127. Limits are established to help minimize noise exposures to protect workers' hearing and prevent whole body effects, as well as to determine criteria for pregnant workers and those exposed to music. The following table from AFI 48–127 lists a broad range of health protection criteria.

Item	Needed
Hearing Protection*	85 dB(A), 8-hours or equivalent exposure times (reference Table A2.2 in AFI 48-127).
Criterion Level	85 dB(A)
Exchange Rate	3 dB
Threshold Level	80 dB(A)
Maximum Level	115 dB(A)
Impulse Noise	$L_{IAeq100ms}$=85 dB(A). Reference MILSTD 1474E Appendix B in AFI 48-127 for impulsive noise requirements.
Whole Body Effects	No octave or one-third octave band level above 145 dB for frequencies from 1 Hz to 40 kHz.
Ultrasound*	Reference Table A2.3 in AFI 48-127.
Exposure to Music	
- Patrons	Equivalent Continuous Noise Level Leq. 2h < 90 dB(A).
- Employees*	Same as occupational standard.
- Air Force Musicians*	Same as occupational standard.
*Based on recommendations from the Threshold Limit Values for Chemical Substance and Physical Agents & Biological Exposure Indices published by the American Conference of Governmental Industrial Hygienists; the current edition of this annual publication will be applied. Applies for on and off duty exposure.	

Hearing noise exposure limits

As BE technicians, you will most often deal with hearing noise exposure limits intended to prevent damage to the hearing of exposed personnel. These noise exposure limits are sound levels and durations to which nearly all workers may be exposed without permanent adverse effect on their ability to hear and understand normal speech. The following limits are provided to give you an idea of the noise levels and exposure times allowed.

Limiting values for unprotected noise exposures:

85 dB(A) for 480 minutes (min) (8 h).

94 dB(A) for 60 min (1 h).

99 dB(A) for 19 min.

No unprotected exposure for sound levels >115 dB(A).

NOTE: Refer to AFI 48–127 for the complete Table A2.2 and other specific noise criteria.

To make sure we meet the limits and protect workers and the community, you will be performing various noise surveys, both at home station or while deployed. These may be measurements taken at a noise source or in a noisy area or a survey at a worker's hearing level to determine the average exposure over a full day. The results of these surveys are then compared to the limits in AFI 48–127 to determine if the noise is, indeed, potentially hazardous. However, before we can start an actual noise survey, we must first identify potentially hazardous noise sources.

Factors to consider when evaluating noise sources/areas

How does BE initially identify potential noise problems in a shop? What types of information are needed regarding potential noise sources?

The first stage in evaluating potential noise problems in a work place involves using an inventory to identify all noise-producing equipment. This can be done by reviewing the existing shop data in the OEHMIS, which currently is the DOEHRS. You can also identify noise problems by questioning the supervisor and workers and by thoroughly examining the shop. Some hand-held tools can be quite loud and may be kept stored away where they are not readily noticeable. There may also be a number of sources that are kept on the road, such as those that are stored in vehicles for on-site use.

An often neglected, but extremely important, part of assessing a potential noise problem is to find out if any workers in the shop have had complaints about the noise or changes in their hearing that may be due to noise exposure. You should consult with PH who is able to determine which shops have personnel with standard threshold shifts. If possible, it is also a good idea to question the shop supervisor and workers to find out if there is any noticeable hearing trouble attributable to the work or just complaints about the loudness in the area. A typical complaint in a noisy environment is that normal conversation is difficult or that people must shout to be heard within a few feet of one another.

The position of the workers and their actions may affect their noise exposures. You need to know the normal distance between the worker and the noise sources and whether the worker is stationary most of the time or moves around a lot. There are usually a number of different workstations for each worker. Additionally, there may be many positions within individual workstations. You should find out if a worker's presence is required in the noise field or if the equipment could operate automatically with occasional spot checks. Further, check the type of hearing protection in use to see that it fits, is properly used, and is sufficient to protect against the sound levels. Try to observe the workers enough to find out what activities may increase or decrease their exposures and if there are one or multiple noise sources.

List the details describing which machinery and processes performed cause the noise. See exactly what is accomplished. Determine what materials are used. Find out what references, such as

technical orders, are followed. Determine if the process is normal. If not, determine how it differs from the normal process. Thoroughly describe the techniques used. Find out the specific types of machines, their descriptions, any identifying numbers, and make sketches or take photographs. Identify the speeds, cycles, or materials used. Determine the condition of each machine/piece of equipment (e.g., age, maintenance required) that may play a part in noise production. Additionally, try to characterize the noise itself; for example, determine if it is a steady or intermittent noise source.

In general, information about the workroom is invaluable in finding out how the noise is distributed. You should sketch the room to show its shape, size, layout of equipment, workstations, and break areas. Identify the materials used in the construction of the walls, floor, and ceiling. Note any acoustical treatment (such as ceiling tiles) or the potential for treatment. Hardened materials such as concrete, cinder blocks, and steel can cause localized areas to reflect higher sound levels than if soft materials were installed. The closeness of a source to hardened materials is also a factor in creating higher noise levels at a worker's position. For example, a small room with hardened building materials may have higher noise levels than a large room with equipment located farther away from walls. Be sure to describe if secondary sources or spill-over noise from other areas contribute to the noise at a particular workstation. In your sketch of the room or facility, show the type and location of any shields/barriers or enclosures and describe whether they seem to be effective.

Gathering all this information on each noise source before taking any measurements will help you determine if a survey is necessary. Afterwards, prioritize your types of surveys, collect meaningful data, and make recommendations for better controls later, if needed.

Three types of noise surveys are necessary to evaluate the noise environment: noise source, worker exposure, and hazardous noise area. Equipment used for these surveys must conform to the appropriate ANSI standard, and only qualified personnel should conduct noise surveys.

The noise source survey is used to classify whether a particular noise source output exceeds the criterion level of 85 dB(A) and could present a potential exposure hazard to workers. The worker exposure survey is performed where the potential to exceed the hearing noise exposure limits in AFI 48–127 exists. We evaluate worker exposures by direct measurements with noise dosimeters or indirectly with noise exposure calculations. Our last survey type, the hazardous noise area survey, defines work areas where noise exposures are assumed hazardous based on routine operations. This survey can be used to define a work area enclosed by definite borders as a hazardous noise area or to identify a hazardous noise zone around a certain piece of equipment.

Now that you know the type of information to gather for a meaningful survey and the different types of noise surveys you may perform, you are ready to accomplish a noise assessment. You need to know what is producing hazardous noise.

232. Performing noise source surveys

In order to successfully eliminate potential exposures to hazardous noise, a BEE must determine if a problem does, in fact, exist. A noise source survey is used to classify whether a particular noise source exceeds the criterion level of 85 dB(A) and could present a potential exposure hazard to workers. This will identify if a process or piece of equipment is a hazardous noise producer. However, this does not determine if an individual is exposed to hazardous noise. Only intensity, not duration, is considered in this measurement.

Description of a sound level meter

The lightweight instrument shown in figure 5–8 is one example of a SLM. SLMs are used to perform a variety of sound measurements including noise source surveys, OBA (with an octave band filter for older meters), speech interference level surveys (with an octave band filter for older meters), and hazardous noise area surveys. Its main components are as follows:

- A microphone to *pick up* sound.
- An amplifier to *boost* the sound to levels the meter can use.
- An attenuator to *provide* different sound level scales (so the instrument is not overloaded when sound levels exceed the scale in use).
- An indicating meter to *display* readings, and weighting networks (A, B, and C) to provide the desired f response.

Some simple SLMs, like the one shown, cannot accurately measure impulse noise. Other SLMs have the capability to perform OBA as well as measure impulse noise. Regardless of the particular manufacturer and model, measurements will be made with equipment conforming to the appropriate ANSI standard.

Figure 5–8. Sound Level Meter.

There are three modes of operation or meter response times: fast, slow and impulse (not all SLMs have impulse response). Slow response is used to determine the average noise level for industrial type operations. It reduces the rapid, hard-to-read needle deflections to slower, easier-to-read deflections. OSHA requires measurements with slow meter response when checking for compliance with its regulations. Set the SLM on A-weighting with slow response to perform sound level measurements.

Capabilities and limitations of a sound level meter

SLMs are sensitive instruments that you must handle properly for optimum functioning. Take care with the microphone cable; never kink, stretch, pinch, or otherwise damage the cable. You may need to use the microphone windscreen to protect the microphone when the wearer will be outdoors or whenever there is significant air movement or dust inside a building. For example, the microphone windscreen should be used when cooling fans are in use or wind is gusting through open windows. Wind or dust blowing across the microphone of the SLM produces turbulence, which may cause a positive error in the measurement. The windscreen will not protect the microphone from rain or extreme humidity. Never use any type of covering over the microphone (e.g., plastic bag or plastic wrap) to protect it from moisture. These types of materials will distort the noise pickup, and the readings will be invalid. In addition, never try to clean a

microphone, particularly with compressed air, since damage is likely to result. Although dirt and exposure to industrial environments will damage the microphones, regular use of an acoustical calibrator will detect such damage so microphones can be replaced.

Various environmental factors can affect the performance of your noise-measuring instruments and their readings. Temperature, humidity, atmospheric pressure, and magnetic fields are some environmental factors you must take into consideration when using your SLM.

Temperature

Sound-measuring equipment should perform within design specifications over a temperature range of –20 °F to 140 °F (–29 °C to 60 °C). If the temperature at the measurement site is outside of this range, refer to the manufacturer's specifications to determine if the SLM or dosimeter is capable of functioning properly. Make sure you do not store your sound-measuring instruments in automobiles during hot or cold weather because this may cause warm-up drift or moisture condensation, and may weaken the batteries.

Humidity

Most noise instruments will perform accurately as long as moisture does not condense or deposit on the microphone diaphragm. If excessive moisture or rain is a problem in an exposure situation, refer to the manufacturer's instructions or other noise professionals for technical support.

Atmospheric pressure

Atmospheric pressure affects the output of sound level calibrators. When checking an acoustical calibrator, always apply the corrections for atmospheric pressure that are specified in the manufacturer's instruction manual.

Magnetic fields

Certain equipment, such as heat sealers, induction furnaces, generators, transformers, electromagnets, arc welders, and radio transmitters, generate electromagnetic fields that can induce current in the electronic circuitry of SLMs and noise dosimeters, and cause erratic readings. If instruments must be operated near such devices, the extent of the field's interference should be determined by consulting the manufacturer's instructions.

The importance of knowing your particular instrument and the manufacturer's instructions when using the equipment in extreme conditions cannot be overemphasized.

SLM preparation procedures

Before taking actual measurements, you must make sure your SLM is calibrated and at the proper settings. The SLM requires calibration before and after each period of measurement. This involves checking the meter reading against a known sound level with a calibrator and setting it to the proper level if it is incorrect. You start by installing the batteries in the SLM and calibrator and checking their function. Place the calibrator on the SLM microphone. Different microphones use different sizes of couplers, so use the coupler for your specific instrument that allows proper insertion of the microphone into the calibrator. Follow the manufacturer's instructions for calibrating and placing your SLM to the proper settings. Remember, your SLM should be set at A-weighting, slow response for noise source surveys. Be sure to allow for the environmental conditions at your location.

Noise source survey procedures

When performing noise source surveys, you should measure sound levels at the equipment operator's ear position but preferably with the operator at least three feet away. Test every position that the operator uses at every different workstation, while determining each noise source and measuring each differing sound level. A carpentry shop is an excellent example where you would have various different readings for a worker. Various workstations, such as the table saw,

band saw, and planer, each have different possible positions. Besides these fixed noise sources, there may be a number of noisy hand-held items. Each is likely to produce varying levels of sound, depending upon what is being worked on or speeds used. Imagine the difference in sound levels produced by a saw when it is powered-on but not cutting something, when it is cutting soft wood, or when it is cutting hard wood. Do not forget the possibility of mixed sounds, such as a level of 95 dB(A), when three machines are operating. Consider the following:

- The sound level does not change when machine A is turned off, which means that its contribution to the total noise level is not significant. You must still evaluate its noise level, if possible.
- Next, turn off machine B. The result is 93 dB(A) which is coming from machine C.
- With all three machines powered-on, turn off machine C. Results are 90 dB(A).
- We now know that machines B and C are the significant sources: 93 dB(A) + 90 dB(A) = 95 dB(A).

If turning off machine B had resulted in a level of 95 dB(A), you could decide that it too is insignificant compared to machine C. If you have evaluated the sound sources separately, you can calculate the total overall sound level. We will discuss how to determine the overall sound level later in this section.

Accurate measurements require care in how you hold the meter and read its indicator. First, you should stand to one side of the path of the sound so that your body does not interfere with the levels. Hold the SLM out in front of you in the sound path so that it is in a free-field.

The correct use of the microphone is extremely important in obtaining accurate measurements. A microphone is typically designed for use in a particular environment across a specific range of SPLs and frequencies. In addition, microphones differ in their directionality. For example, some are intended to be pointed directly at the sound, and others are designed to measure sound from a grazing angle of incidence. You must usually orient the axis of the microphone so that its angle of incidence is 70° to the sound source. This means that the source is at 0° and that the direction the microphone is facing is 70° to that—almost perpendicular to the source (fig. 5–9). This is the way random-incidence microphones are made to be used.

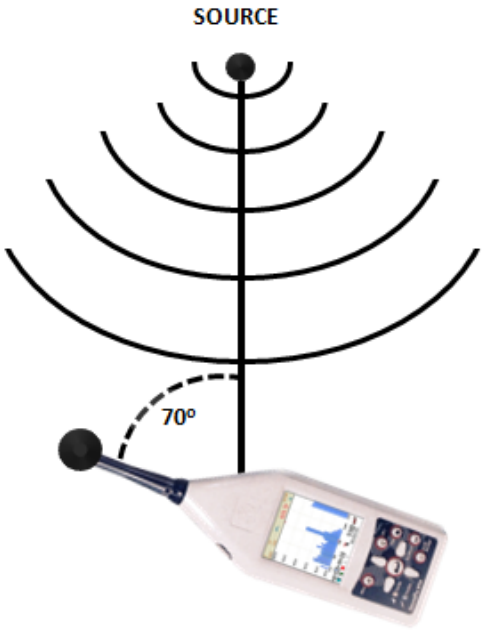


Figure 5–9. Orientation of Random-Incidence Microphone.

Perpendicular or free-field microphones are held at 0° or straight at the source. You should follow the SLM manufacturer's instructions regarding the type and size of microphone and its orientation toward a sound.

When you do not have any idea of the actual sound level, start the SLM at the highest range: 130–140 dB(A). Watch the indicator while slowly decreasing the range until the needle reads near the center of the scale. Quite often the reading will fluctuate considerably due to the variability of the sound level. A good way to handle this is to take readings roughly every 15 seconds for three to five minutes and calculate an average value using the following formula:

$$dB_{avg} = 10\log\left[\frac{10^{dB_1/10} + 10^{dB_2/10} + \ldots 10^{dB_n/10}}{n}\right]$$

Where:
dB_n = each noise reading.
n = number of readings.

For example, you took the following readings in dB(A) over three minutes:

92, 87, 96, 98, 85, 90, 97, 82, 99, 87, 102, 89.

$$dB_{avg} = 10\log\left[\frac{10^{dB_1/10} + 10^{dB_2/10} + \ldots 10^{dB_n/10}}{n}\right]$$

$$dB_{avg} = 10\log\left[\frac{10^{9.2}+10^{8.7}+10^{9.6}+10^{9.8}+10^{8.5}+10^{9}+10^{9.7}+10^{8.2}+10^{9.9}+10^{8.7}+10^{10.2}+10^{8.9}}{12}\right]$$

$$dB_{avg} = 10\log\left[\frac{43950844738.14}{12}\right]$$

$dB(A)_{vg}$ = 10log[3662570394.85].

$dB(A)_{vg}$ = 10 x 9.56.

$dB(A)_{vg}$ = 95.6 dB(A).

Reading and conditions

Each time you take a reading, observe the data screen for a number of seconds and record the level that is between the minimum and maximum readings when there is no significant fluctuation (readings do not differ by more than 6 dB). If the difference is more than this, record the minimum and maximum readings and the central tendency. Tell what the probable cause of the fluctuation is, such as machine cycling or pulsating equipment. Ignore the very high jumps that occur infrequently. When you finish measuring, recalibrate the meter, remove the batteries, and put the protective cap on the microphone.

Keep in mind conditions that can affect your readings, and note them when they occur. Remember wind or strong air currents from fans can give you false high readings, so a windscreen should be used in such circumstances. Placing the meter on or next to a vibrating surface or attaching the meter to a tripod and placing it on a vibrating platform can distort your readings.

Recording the results

Record the results of your SLM survey in OEHMIS (DOEHRS). Make sure to record your survey notes so that there will be no doubt as to what conditions existed and why you made various decisions. One of the biggest problems we encounter in industrial hygiene work is the lack of data

on exactly what was done and why—particularly when the person performing the survey has departed. Completely identify the area and tasks involved that have a bearing on the noise exposure. List the primary (if applicable) and secondary sources. Tell whether the noise is continuous or intermittent and if there is any significant contribution to exposures from impulse noise. Enter the location of each reading and your final measurement results for each (e.g., the averages you calculated at a particular location).

Noise calculations

How would you determine the combined noise level if you have multiple sources with the same dB level? What is the combined noise level from multiple sources with different dB levels?

Combined noise level of like sources

It is natural to assume that two noise sources of 100 dB each would together produce a total of 200 dB. In actuality, the combined level would only be about 103 dB. While the sound power really has doubled, the number of dBs has not.

Here is the basic rule for adding dBs: two identical sources (each with the same number of dBs) produce 3 dB more than a single such source. But what if you have more than two identical sources? Would three sources of 100 dB each produce 106 dB together? The following formula provides an exact method of adding dBs when all sources are identical:

$$dB_{total} = 10 \log n + dB_1$$

Where:
n = number of identical sources.
dB_1 = dB level of a single source.

Use this formula to perform the calculation based on three sources of 100 dB each. What would the actual sound level be?

Step 1 – Identify the correct formula:

$$dB_{total} = 10 \log n + dB_1$$

Step 2 – Replace the variables in the formula:

$dB_{total} = 10 \log 3 + 100.$

Step 3 – Log the "n":

$dB_{total} = 10 \times 0.477 + 100.$

Step 4 – Multiply the logged "n" by 10:

$dB_{total} = 4.77 + 100.$

Step 5 – Solve the equation:

$dB_{total} = 104.77$ dB.

Combined noise level of different sources

Most shops contain multiple sources of equipment that produce different sound levels. For this reason, the following formula is used to calculate the combined noise levels of different sources:

$$dB_{total} = 10Log(10^{\frac{dB_1}{10}} + 10^{\frac{dB_2}{10}} + ...10^{\frac{dB_n}{10}})$$

Where:

dB_1, dB_2, dB_n = dB reading of each different source.

Again, we will go through an example step-by-step using this formula. You completed noise source measurements and found there are three noise sources in a shop reading at 90 dB, 92 dB, and 104 dB. What is the combined noise level of the different sources?

Step 1 – Identify the correct formula:

$$dB_{total} = 10Log(10^{\frac{dB_1}{10}} + 10^{\frac{dB_2}{10}} + ...10^{\frac{dB_n}{10}})$$

Step 2 – Replace the dB_1 …dB_n in the numerator of the fractional exponent:

$$dB_{total} = 10Log(10^{\frac{90}{10}} + 10^{\frac{92}{10}} + 10^{\frac{104}{10}})$$

Make sure the dBs being added all have the same weighting.

Step 3 – Simplify the fractional exponent:

$dB_{total} = 10 \log (10^{9.0} + 10^{9.2} + 10^{10.4})$.

Step 4 – Add the quantities for the dB level calculated:

$dB_{total} = 10 \log (1{,}000{,}000{,}000 + 1{,}584{,}893{,}192 + 25{,}118{,}864{,}320)$.

Step 5 – Find the log of the new product:

$dB_{total} = 10 \log (2.77 \times 10^{10})$.

Step 6 – Multiply by 10 to arrive at the calculated dB:

$dB_{total} = 10 \times 10.44253868$.

$dB_{total} = 104.44$ dB.

233. Performing octave band noise surveys

At times you may need to know more about the noise than a single A-weighted sound level. You may want to gather more information about the frequencies of the sound. To do this you will perform an OBA. The results indicate the octave bands that contain the majority of the total sound power being radiated. This method will help you pinpoint the problem noise where you can concentrate your control efforts.

Purposes for performing octave band analysis noise surveys

An OBA, also known as an engineering noise survey, can be defined as a survey to gather more information on the energy of the sound over a range of frequencies. An OBA is used to accomplish the following:

- Determine engineering controls. Different control methods and materials that have specific noise-reducing properties at specified frequencies. OBA can save resources in identifying the cause of the noise problem and therefore simplifying the process of selecting controls. Customer confidence and survey credibility levels are reinforced by identifying and selecting those controls that work. If the recommendations you provide do not work or are not effective, customer confidence is diminished.
- Select HPD. OBA can measure the amount of attenuation (how much sound is weakened) offered by a hearing protection device in the octave bands responsible for most of the sound energy in a given situation.

- Measure the SPLs in audiometric booths. We will review these procedures later in this unit.
- Evaluate the whole body effects of sound. At certain high levels of sound, exposed persons may suffer adverse effects that do not involve the hearing organs.

Describe an octave band analyzer

The meter used to perform an OBA is a SLM with an octave band filter assembly used to analyze the frequency content of noise. It measures the total noise over ranges of frequencies to determine where the highs, mids, and lows. Octave band analyzers segment noise into its component parts by filtering out unselected frequency ranges and allowing measurement of specific bands of sound.

Recall from an earlier unit that an octave band is a range of frequencies whose highest frequency is twice the value of its lowest frequency, and the center frequency identifies the middle of an octave band. Octave band filter sets provide filters with the following center frequencies: 31.5; 63; 125; 250; 500; 1,000; 2,000; 4,000; 8,000; and 16,000 Hz. The noise of all frequencies in the octave band is measured when the octave band analyzer is set at the center frequency. For example, 31.5 Hz is the center of an octave band that ranges from 22 Hz–44 Hz. Noise of all frequencies between 22–44 Hz is measured when the octave band analyzer is set at 31.5 Hz.

An octave band analyzer, just like an SLM, must conform to ANSI standards.

Octave band analysis noise survey procedures

To perform the OBA, follow the same steps as for the noise source survey. Set the octave band meter at "Z" weighting, "Fast," and "SPL." This is called a dB all pass (flat or linear reading). The dB flat means that equal weighting is given to all frequencies.

Procedures for conducting an OBA are similar to those for the noise source survey using the SLM. The main difference is the frequencies at which measurements are taken. For SLMs with the octave band filters attached, measurements are taken for dB(A), dB flat, and one for each of the octave bands. With a digital octave band analyzer, readings are automatically taken for the required frequencies. Do not forget to record your findings.

As stated earlier, one of the purposes for performing an OBA is to determine the sound level in an audiometric booth.

Audiometric booth testing

We already know that BE plays an integral role in the Base HCP by performing various noise surveys, recommending controls, evaluating the effectiveness of controls, and recommending who should be placed in the HCP. However, one area often overlooked is our role in performing noise evaluations on audiometric booths.

Before we perform this type of evaluation, we must understand why we are performing tests on audiometric booths. All audiometric test booths contain some type of background noise levels. These levels are typically present due to noise from comfort ventilation systems, lighting, and general noise outside of the test booth created by personnel and day-to-day operations taking place in the area. As you can imagine, too much of this noise can make it difficult for the person being tested to hear and may ultimately impact hearing test results. To minimize this problem, we have maximum permissible ambient noise levels allowed in audiometric test booths. All audiometric booths require annual certification to ensure background noise does not exceed levels specified in AFI 48-127.

The purpose of performing a noise evaluation in an audiometric test booth is to determine what the background noise levels are inside of the booth. In order to perform this type of evaluation, we must use an ANSI Type 1 precision SLM with an octave-band filter like the octave band analyzer we discussed earlier. The SLM, OBA, microphone, and calibrator must each have been

professionally calibrated no more than one year before the date of the audiometric test booth noise evaluation.

Figure 5–10: 3M Quest model 1800 SLM.

More recently manufactured SLMs have built-in frequency analyzers and data storage (fig. 5–10). For these instruments, an OBA filter is not needed, but you will need compatible computer software with 1/1 octave frequency analysis. The SLM must be able to detect sound levels below the maximum allowable background levels specified in AFI 48–127 for all the octave bands (or ANSI S3.1, *American National Standard Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms).* Three dB below the maximum SPL is recommended. A typical Type 1 SLM with a minimum detectible sound level of 30 dB will not be suitable for testing audiometry booths.

Choose a time for the test when normal activities are occurring in the area around the booth. Conditions should be representative of typical audiometric testing conditions. Therefore, before conducting the ambient noise survey, set up the test environment as follows:

- Computer, audiometer, and tympanometer turned on.
- Lights turned on inside the booth.
- Lights turned off outside the booth.
- Ventilation system turned on inside the test booth.
- Sound room and hallway doors closed.

Set up the SLM and octave filter set for field measurements. The SLM must be field calibrated to adjust for the specific assemblage of SLM accessories (e.g., preamp, adopter, and microphone) used for testing. The following are typical calibrations settings:

- Turn the power switch of the SLM to “on” and check the batteries.
- Response: Slow.
- Weighting: Linear (Lin) or “Z.”
- Mode: SPL.
- Range: set according to manufactures directions for calibration, (e.g., 60–120).

- If the SLM has an OBA filter, the power switch on the filter is set to off.

Calibrate the SLM according to manufacturer's instructions. Refer to the following table to change the setting for testing the audiometry booth:

Audiometry Booth Testing Settings	
Function or Precondition	**Operation**
Range	Set to encompass the AFI 48-127 background testing criteria (e.g., 20–80).
SLM mode	Reset the SLM mode to LEQ.
If there is an OBA filter	• Turn the power switch on the OBA filter and set to manual. • Set the mode switch to 1/1. • Select the desired octave band, dial in slow response, and take the reading. Record results for each required octave band. • Turn the power switch on the OBA filter set to off.
For multiple station booths	Check levels at seats closest and furthest from the door, and record the higher values.
	Post-calibrate the SLM.

The tester should sit quietly inside the booth, with the OBA SLM's microphone held away from the body at head height. Take measurements at the octave bands of concern for an audiometric booth. These are 500, 1000, 2000, 4000, and 8000 Hz.

Refer to the following table for alternate measurement readings, which can be taken with the SLM in the booth while the test is outside, dependent upon certain things.

Alternate Measurement Readings	
Function or Precondition	**Operation**
The SLM display can be read from the booth window, or the SLM is equipped with a Bluetooth computer interface.	• Mount the SLM on the tripod, and adjust it so that the microphone is pointing upward. • Place the SLM in the test room at the approximate position the examinee's head will occupy during testing. • Position the tripod so that the meter display is visible through the window in the sound booth door.
To use an SLM with OBA filter	• Select a center frequency of 63 Hz (This will allow time to exit the room and close the door before taking readings). • Slide the POWER switch on the octave filter to AUTO. • Set the OBA filter to RUN. • Exit the sound booth and close the sound booth door. The meter will average the sound level for approximately 25 sec before advancing to the next frequency. The display will read "————" as the frequency changes. Continue measuring in the same way as the octave filter automatically advances to each successive frequency band. • Record average background noise levels at 500, 1k, 2k, 4k, and 8k Hz.

The ambient noise level should be within standards to ensure that the hearing test is conducted in an environment that will ensure valid and accurate test results. According to AFI 48-127, octave band measurements for audiometric booths should not exceed the following:

Frequencies and maximum levels					
Frequency (Hz)	500	1K	2K	4K	8K
Maximum Level (dB)	27	29	34	39	41

Compare your results to these acceptable SPLs. If all of the measurements taken fall below the criteria previously listed, then no further action is necessary, and the booth is monitored on an

annual basis. If the measurements exceed the standards previously listed, further action must be taken to attempt to bring the measured levels down to acceptable levels.

234. Performing worker exposure surveys

Performing noise dosimetry is the preferred method of evaluating individual noise exposures. There are two indirect methods used to determine worker exposure levels: calculating a compliance factor or calculating the equivalent continuous sound level (ECL) using noise survey data. The results are compared against the Air Force criteria of 85 dB(A) for an 8-hour TWA.

Calculating a compliance factor

The compliance factor calculation is an indirect method used to calculate worker exposure. The actual and allowable exposure times are used in this calculation. The following formula is used to determine if the exposure exceeds the standard:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \ldots\ldots \frac{C_n}{T_n}$$

Where:
C = the actual exposure time to a given level.
T = the times allowed at the level.

All occupational noise exposures above the threshold level of 80 dB(A) are used in the equation.

Results of the compliance factor calculation are a unit less number to be compared to one (1). If the result exceeds one (>1), the combined exposure should then be considered to exceed the standard.

- If the C/T calculation yields a value less than one (<1), the potential for overexposure to hazardous noise is low.
- If the C/T calculation yields a value greater than one (>1), the potential for overexposure to hazardous noise is high.

This calculation also helps to prioritize which work places require dosimetry.

In the compliance factor calculation, the actual time of exposure is obtained by asking the supervisors and personnel who are exposed to the noise source. The allowable exposure time may be determined by one of two methods:

1. Use the equation: $T = 480 \text{ X } 2^{(85 - L_A)/3}$

   Where:
   T = time (in minutes).
   L_A = A-weighted sound level.

OR

2. Cross-referencing the dB(A) level obtained during the noise source survey with Table 3 of AFI 48–127.

Consider the following example of determining the allowable exposure time using the equation. A noise source survey was performed and measurements revealed 88 dB(A). What is the allowable exposure time?

Steps 1 - Identify the correct formula:

$T = 480 \text{ X } 2^{(85 - L_A)/3}$.

Step 2 - Substitute the L_A with the measured dB(A) level:

$T = 480 \text{ X } 2^{(85 - 88)/3}$.

Step 3 - Subtract the measured sound level from 85:

$T = 480 \text{ X } 2^{(-3)/3}$.

Step 4 - Simplify the fractional exponent:

$T = 480 \text{ X } 2^{(-1)}$.

Step 5 - Solve for T:

T = 240 minutes.

Next, let us walk through an example using this calculation and time allowed obtained from Table 3 in AFI 48–127. A worker uses the following equipment for the time specified:

- Drill used 30 minutes/day at 94 dB(A).
- Sander used 6 minutes/day at 87 dB(A).
- Saw used 12 minutes/day at 86 dB(A).

What is their potential for noise overexposure?

Steps 1 - Identify the correct formula:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + ... \frac{C_n}{T_n}$$

Where:
C = time of exposure in minutes.
T = time allowed for the dB(A) measured (AFI 48-127, Table A2.2).

Step 2 - Identify the C values (exposure times in minutes) for each source above 80 dB(A) and plug into the formula.

$$\frac{30}{T} + \frac{6}{T} + \frac{12}{T}$$

- Drill used 30 minutes/day.
- Sander used 6 minutes/day.
- Saw used 12 minutes/day.

Step 3 - Identify the "T" (AFI 48–127, Table A2.2) and plug into the formula.

$$\frac{30}{60} + \frac{6}{302} + \frac{12}{381}$$

Step 4 - Divide the numerator by the denominator for each source and add the quotients

0.5 + 0.019867549 + 0.031496062 = 0.55.

What does this result indicate? The result was 0.55, which is less than one (< 1). This would indicate the potential for overexposure is low because the result is less than the compliance factor (< 1). Because these workers' potential for overexposure is low, the priority for noise dosimeter is low.

Calculating equivalent continuous sound level

A second indirect method to determine worker exposure is to calculate the average equivalent continuous sound level (L_{eq}). You may not need to perform a calculation as programs that calculate the L_{eq} are more prevalent in BE offices today. However, if you have exposures to two or more levels in one day, you can use the following formula to calculate the equivalent sound level for time period T (L_{et}).

$$L_{eqT} = 10Log\left[\frac{t_1 \times 10^{\left(\frac{L_1}{10}\right)} + t_2 \times 10^{\left(\frac{L_2}{10}\right)} + ...t_n \times 10^{\left(\frac{L_n}{10}\right)}}{T}\right]$$

Where:
L_{et} = Equivalent sound level for time period T.
L_i = sound level of each noise source above 80 dB(A).
T = total time period in minutes, usually 480 for 8-hour equivalent.
t = exposure times (in minutes) for each noise source.

The L_{et} calculation yields a TWA in dBs that is compared to the criterion level of 85 dB(A).

Example:
During a routine surveillance survey of the Phase Dock, BE identified a new inspection activity. As part of the evaluation process, a special survey has been scheduled. The special survey requires you to evaluate the noise sources associated with the phase activity and make appropriate recommendations. You have been provided with a list of noise sources with approximate daily operational times. You surveyed those sources with a SLM and obtained the following data.

Equipment	Survey Location	Maximum Daily Exposure	dB(A)
A2 Boom Generator	Source	20 min	90
A2 Boom Generator	Operator Location	5 h	86
High-speed Air Drill	Operator Location	30 min	94

Using the following steps to calculate the L_{eqT}, we will quantify the risk to the workers.

Step 1 - Identify the correct formula.

Step 2 - Identify the exposure time and dB(A) levels for each source above 80 dB(A).

Step 3 - Convert exposure time into minutes or hours. Ensure time units in the numerator and denominator match.

Step 4 - Replace the T with the exposure time. Place the dB(A) level in the numerator of the fractional exponent.

Step 5 - Simplify the fractional exponent.

Step 6 - Add the 3 quantities located in the numerator and divide by the denominator.

Step 7 - Find the log of the new product.

Step 8 - Multiply by 10 to achieve the L_{eqT}.

Use the noise source information and follow the above steps:

Step 1 - $L_{(eqT)}$ formula.

$$L_{eqT} = 10Log\left[\frac{t_1 \times 10^{\left(\frac{L_1}{10}\right)} + t_2 \times 10^{\left(\frac{L_2}{10}\right)} + ...t_n \times 10^{\left(\frac{L_n}{10}\right)}}{T}\right]$$

Step 2 – [20 min at (@) 90 dB(A)), (5 h @ 86 dB(A), (30 min @ 94 dB(A)] are the exposure times and levels

Step 3 - Convert units to minutes [20 min @ 90 dB(A)), (300 min @ 86 dB(A)), (30 min @ 94 dB(A)]

Step 4 - $$L_{eqT} = 10Log\left[\frac{20\times10^{\left(\frac{90}{10}\right)} + 300\times10^{\left(\frac{86}{10}\right)} + 30\times10^{\left(\frac{94}{10}\right)}}{480}\right]$$

Step 5 - $$L_{eqT} = 10Log\left[\frac{2\times10^{10} + 1.19\times10^{11} + 7.53\times10^{10}}{480}\right]$$

Step 6 - $$L_{eqT} = 10Log\left[\frac{2.143\times10^{11}}{480}\right]$$

Step 7 – $$L_{eqT} = 10Log\left[446458333.3\right]$$

Step 8 - $$L_{eqT} = 10\times8.649$$

$$L_{eqT} = 86.49$$

What does this result indicate? The shop monitored exceeds the 85 dB(A) for 8-hour criteria.

As stated earlier, noise dosimetry is the preferred method of evaluating individual noise exposures. It is important to consider both intensity and duration when evaluating an individual's true exposure to hazardous noise. Noise dosimetry does just that. It takes into account the intensity and duration of an exposure enabling comparison of results to the AF criterion level of 85 dB(A) for 8 hours. Noise dosimetry provides a more accurate measurement of a worker's true average daily exposure to noise.

Ideally, a worker would be monitored with a dosimeter for entire shifts; however, this is not always possible for various reasons. All significant exposures are integrated into a total dose which represents the average exposure level or ECL for the period monitored. As a minimum, federal regulations require all continuous and intermittent levels from the range of 80 dB(A) to 130 dB(A), and impulse noise to be integrated. Because dosimeters have an upper limit to their measuring capabilities, an actual ECL could be higher than indicated when a dosimeter reads its maximum value. This upper limit may be 130 dB(A), 140 dB(A), or higher, depending upon the instrument. The threshold is the cutoff at which lower levels are disregarded for integration into the total dose. Levels below 80 dB(A), the normal threshold (the cutoff at which lower levels are disregarded for integration into the total dose) for the Air Force, do not make a significant contribution to hazardous noise exposure.

Purpose for performing noise dosimetry

Noise dosimetry is primarily performed to quantify worker exposure and determine if personnel need to be enrolled in the HCP. The decision to place an individual on the HCP is based on the likelihood of routine exposure exceeding 85 dB(A) as an 8-hour TWA. The data collected during noise dosimetry can also be used to classify employees' noise exposures in order to prioritize noise control efforts and to define and establish hearing protection practices and controls.

TWA noise levels are determined for all AF workers who routinely work in hazardous noise areas. The levels are checked at least once and must be rechecked within 30 days of any change in operations affecting noise levels according to DOD and Air Force guidance.

Noise dosimeter description

A dosimeter is like an SLM except that it stores sound level measurements and integrates these measurements over time. This provides an average noise exposure reading for a given period of time, such as an 8-hour workday. Some dosimeters record a dose that you must convert to an ECL. Advanced types are self-contained units that provide the dose, the ECL, and additional data. Some current dosimeters (fig. 5–11) allow connection to a computer in order to program the dosimeter and save the results.

Figure 5–11. Noise Dosimeters.

When using a dosimeter, a microphone is attached to the employee's clothing, and the exposure measurement is read at the end of the desired time period. At the end of the time period, it has measured noise levels in the locations in which the employee traveled. The monitoring result for one employee is representative of the exposures of other workers in the area.

A dosimeter can be used as an integrated SLM. This means that instead of (or in addition to) sampling a worker's exposure throughout the shift, a dosimeter can be used to spot check levels just as a SLM does. The difference is that the dosimeter gives the average level over some period of interest, such as 30 seconds.

Due to the various kinds of noise dosimeters found at the different bases, be sure to become familiar with the one used at your installation. In other words, make sure you know how it operates, its capabilities, and limitations. Regardless of the manufacturer or model, dosimeters must be certified intrinsically safe (will not create a spark) when used in confined space areas. Therefore, always check the manufacturer's instructions or the back of the dosimeter to determine if the dosimeter is classified intrinsically safe.

When assessing certain areas, such as classified areas, make sure dosimetry monitoring will not be a problem. Dosimeters are authorized for use in sensitive, compartmented information facilities; however, you will need to obtain local clearance before performing the dosimetry. Occasionally, workers and supervisors are concerned that the dosimeter is recording all conversations. To alleviate those concerns, let the shop know that the dosimeter does not record any voices, only sound.

Noise dosimeter preparation

Your dosimeter should be set at certain parameters for your measurements to be compared to Air Force standards. One of these is the criterion level which is the sound level allowed for an 8-hour exposure. The Air Force criterion level is 85 dB(A). Another parameter is the exchange rate, also known as the doubling rate. The Air Force exchange rate is 3 dB. As previously discussed, for every increase of 3 dB, the allowable exposure time is cut in half. Likewise, for every decrease of 3 dB, the allowable exposure time is doubled. Finally, the threshold level should be set at 80 dB(A). Remember, the threshold is the cutoff at which lower levels are disregarded for integration into the total dose. These values can be found in AFI 48–127 and are provided here again for your ease.

Criterion Level: 85 dB(A) Threshold Level: 80 dB(A) Exchange Rate: 3 dB.

These parameters should be checked before each use. Always make sure previous exposure data is cleared so it will not be added to the current monitoring period.

You should make and document the same observations concerning the noise environment that you did during the noise source survey. This might sound like duplication, but you need to be able to explain why doses are significantly higher or lower on a given day. This will help confirm the existence of previously recorded conditions. You should also describe worker actions during the dosimetry period to be able to compare if worker noise conditions change in the future and to determine if a new survey is required.

Worker exposure survey procedures

AFI 48–127 states that where the potential exists to exceed the noise exposure limits specified in the standard, worker exposures shall be evaluated by direct measurements with noise dosimeters or indirectly with exposure calculations. TWA noise levels shall be determined for all AF workers routinely working in hazardous noise areas at least once and within 30 days of any change in operations affecting noise levels.

The time when dosimetry is done should be representative of normal work periods. You would not want to sample while the area being surveyed is having an inspection, working under a temporarily increased or reduced workload, or doing anything different from the normal mission.

After checking the dosimeter to make sure it is functioning properly, the proper parameters are set and you have performed the proper calibration, attach the dosimeter to the worker’s belt, or place it in a shirt pocket. Clip the microphone to the worker’s collar. Proper positioning of the microphone is necessary to obtain accurate measurements. The microphone is usually located on the collar and remains in that position for the entire workday (fig. 5–12). The microphone must be placed in the worker’s hearing zone. OSHA defines the hearing zone as a sphere with a two-foot diameter surrounding the head. Place the microphone as close as possible to the worker’s ear closest to the noise source. Keep the microphone in a vertical position.

Figure 5–12. Placement of Dosimeter Microphone.

Position and secure any excess microphone cable so it does not snag on anything or cause inconvenience to the worker. The cable may be placed underneath the worker's outer shirt.

The true validity of the data you obtain can depend heavily upon how well you instruct the worker on what is going on and what to do or not do. Tampering with and misunderstanding the purpose of the dosimeter are among the biggest problems encountered. Fully explain its purpose and the importance of the data it collects while tactfully discouraging tampering. Letting the worker know what the data will be used for can sometimes prevent interference. Information to discuss should include not removing or playing with any part of the equipment, keeping it away from operating machinery, taking care to avoid banging the microphone, no yelling or singing into the microphone, and other instructions that may apply to a specific situation. Make sure the worker is aware that the dosimeter merely measures the sound level; it does not record any noises or conversations. Above all, stress that work should be performed as usual during the shift and that no action should be taken to intentionally or deliberately increase or decrease the exposure. You may also inform them that the equipment is government property and that any damage or loss will be investigated.

Turn the dosimeter on and then lock out the controls so that any intentional or unintentional touching will not interfere with results. Do not leave the dosimeter at the start of the shift and pick it up at the conclusion. Check the equipment periodically to ensure it is operating properly and that the dosimeter and microphone remain in the proper position. Do not forget to recalibrate at the end of the monitoring period.

Recover all the data from the dosimeter and record it in the OEHMIS database, DOEHRS.

Noise calculations

There may be times where you will have to perform some noise calculations to get the information you need.

Converting exposure values in dose percent to a daily equivalent continuous sound level

The majority of noise dosimeters provide the equivalent sound level in dB(A). Some dosimeters display the noise exposures as a percent of daily dose which must be converted to the daily

equivalent sound level. The following equation can be used to convert a dosimeter reading as a dose percent to the daily ECL.

$$ECL = 10\log\left[\frac{8}{T}\times\frac{D}{100}\right]+85$$

Where:
ECL = average daily equivalent continuous sound level.
T = time dosimeter was operated (hours).
D = dosimeter reading (dose percent).

The following are the steps in the calculation:

Step 1 – Identify the correct formula.

Step 2 – Substitute the T and D with the information collected.

Step 3 – Simplify the quantities within the brackets.

Step 4 – Find the log of the quantities within the brackets.

Step 5 – Multiply the result of the log by 10.

Step 6 – Add 85 to the product.

Here is an example of this calculation. We will convert a 7-hour dosimeter dose reading of 90% to the equivalent daily sound level.

$$ECL = 10\log\left[\frac{8}{T}\times\frac{D}{100}\right]+85$$

$$ECL = 10\log\left[\frac{8}{7}\times\frac{90}{100}\right]+85$$

$$ECL = 10\log\left[1.14\times 0.9\right]+85$$

$$ECL = 10\log\left[1.026\right]+85$$

$$ECL = 0.11147+85$$

$$ECL = 85.11$$

This means that the dosimeter measured a TWA of 85.11 dB(A) over the 7 hours.

Calculating equivalent continuous sound level greater than eight hours

For work shifts over eight hours, the measured average noise exposure should be adjusted to an 8-hour equivalent exposure level using the following formula:

$$L_{eq}8Hr = L_{eqT}+10\log\frac{T}{8}$$

Where:
L_{eq}8 Hr = equivalent sound level for an 8-hour period.
T = length of the work shift in hours.
L_{eqT} = measured sound level for the period.

To perform this calculation, use the following the steps:

Step 1 – Identify the correct formula.

Step 2 – Substitute the T and L_{eqT} with the information collected.

Step 3 – Simplify the fraction T/8.

Step 4 – Log the T/8.

Step 5 – Multiply the log T/8 by 10.

Step 6 – Add L_{eqT}.

Here is an example. The result of noise dosimetry for a 10-hour work shift is 98.62. What is the $L_{eq}8Hr$?

Step 1 – Identify the correct formula.

$$L_{eq}8Hr = L_{eqT} + 10\log\frac{T}{8}$$

Step 2 – Substitute the T and L_{eqT} with the information collected.

$$L_{eq}8Hr = 98.62 + 10\log\frac{10}{8}$$

Step 3 – Simplify the fraction T/8.

$$L_{eq}8Hr = 98.62 + 10\log(1.25)$$

Step 4 – Log the T/8.

$$L_{eq}8Hr = 98.62 + 10(0.096910013)$$

Step 5 – Multiply the log T/8 by 10.

$$L_{eq}8Hr = 98.62 + 0.96910013$$

Step 6 – Add the L_{eqT}.

$$L_{eq}8Hr = 99.589$$

Worker noise exposure is computed and reported regardless of any attenuation provided by HPDs. Remember, results are compared to the Air Force criteria of 85 dB(A) as an 8-hour TWA. Results are used to help determine if personnel should be placed on the HCP. If results are equal to or exceed 85 dB(A), enter personnel into the HCP. If results are below 85 dB(A), entrance into the HCP is not required.

Once you have completed your noise surveys and have your results, you must determine the appropriate noise control measures to recommend.

235. Recommending noise controls

Noise control is an art form—a collection of principles and techniques that can be applied to a given noise exposure situation based on an understanding of acoustical physics and the environment. The type of information needed to analyze the noise environment adequately enough to formulate an effective control strategy often includes following:

- Type of noise (e.g., continuous, intermittent, impulsive, or varying).
- Changes in noise levels over time.
- Frequency distribution of major noise events.
- Noise sources (e.g., location, power, directivity).

- Noise propagation pathways, through air or through structure.
- Room acoustics (reverberation).

Benefits of noise control

The goal of implementing noise control should be to use engineering methods to reduce noise exposure to levels that would remove personnel from the HCP. In those situations where noise exposure cannot be practically controlled below 85 dB(A), exposure should be reduced as low as is practicable.

The benefits of noise reduction are as follows:

- Reducing noise-induced permanent threshold shifts.
- Reduced compensation costs.
- Improved communications.
- Reduced absenteeism and injuries.

Paths of sound travel

It is important to know the source and path sound travels when recommending effective measures to control the noise. As with chemical health risk hazards, physical ones, such as noise, also use the *source-path-receiver* methodology and the controls hierarchy to determine controls. Sound travels in two paths: direct and reflected.

Direct path

In this path, sound travels directly to the ear from the source to the receiver. However, it does not necessarily have to travel in a straight line. It could be omni-directional, in all directions, or by the path of least resistance (fig. 5–13).

Figure 5–13. Direct Path.

Reflected path

Noise may reflect off other surfaces (fig. 5–14); in this path, sound waves rebound from surfaces. For example, smooth walls tend to act as sound mirrors. In other words, smooth walls reflect sound better than rough ones. A good example of reflected noise would be an echo.

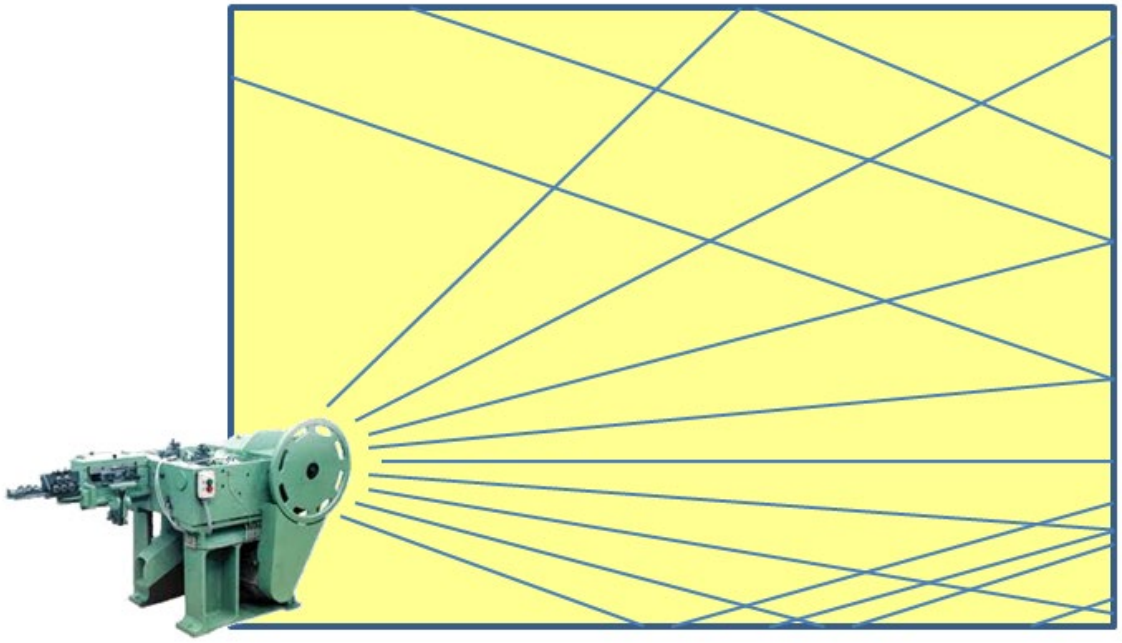


Figure 5–14. Reflected Path.

As we look at control options, we must remember that the sound level measured will be the combination of sound coming directly from the source, plus reflected sounds.

Controls at the source, path, and receiver

Noise can be controlled at the source, path, or receiver. Engineering controls are at the source or the path. Administrative controls are usually at the path or receiver, and PPE, the last resort, is at the receiver.

The controls you choose are heavily dependent on the frequency range of the sound generated, which is why an OBA is so important. Higher frequency noise is easier to control than noise with lower frequency because, as you can see in figure 5–15, low frequency noise penetrates obstacles much more efficiently.

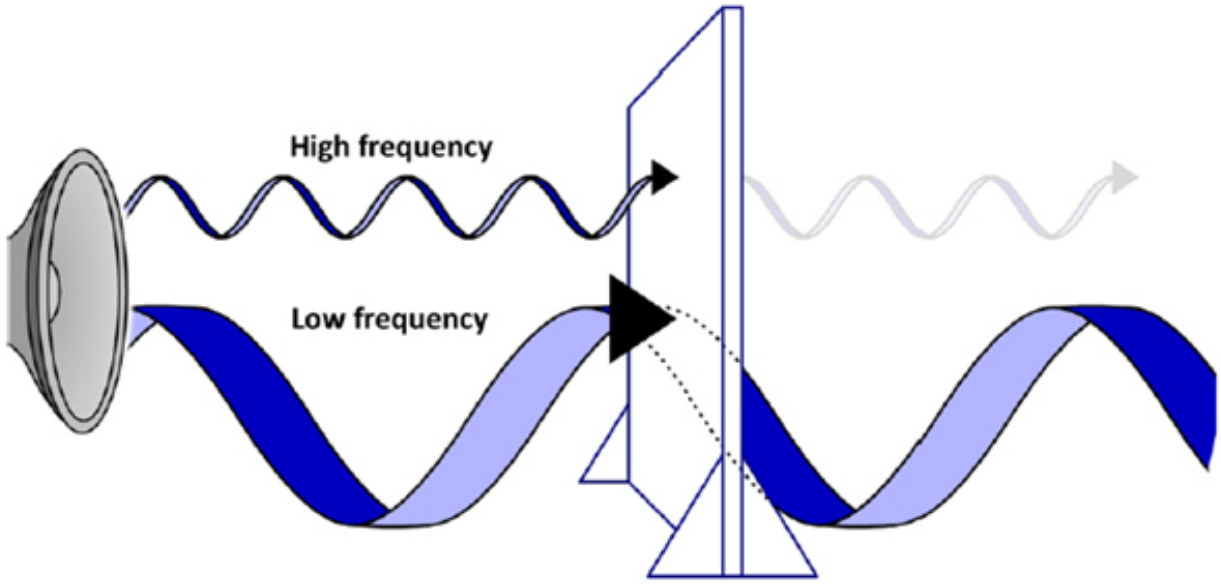


Figure 5–15. Noise Interaction with Solids.

Mostly likely you have heard a car stereo from a distance away; normally, what you hear are the bass tones. These tones are low frequency sound and you hear them first because they penetrate the outside of the car the easiest.

If you remember the hierarchy of controls, you will recall that we should always look at engineering controls first. With that in mind, let us look at some of the possible controls at the noise source.

Source

Controlling noise at its source is often the most reliable and permanent solution and should therefore always be considered first. For information on noise characteristics of noise-producing equipment typically found in AF industrial work places, and examples of control technologies, contact the ESOH Service Center. Examples of controlling noise at its source include process substitution, product substitution, and machine treatments.

Process substitution

Process substitution is an engineering control that includes process elimination, process changes, and design changes. Design changes include using different tools, workstations, or equipment. Substituting quieter methods is also effective and can be more economical than other engineering controls. A simple example is using pliers to bend metal rather than a hammer. The following list of substitutes is by no means all-inclusive, but it points out the kinds of noise-reduction methods you may choose.

- Welding instead of riveting.
- Compression riveting instead of pneumatic riveting.
- Grinding instead of chipping.
- Conveyers instead of chutes.
- Use cutting fluid in machining processes.
- Change from impact action (e.g., hammering a metal bar) to progressive pressure action (e.g., bending a metal bar with pliers).
- Replace mechanical limit stops with micro-switches.
- Replace circular saw blades with damped blades (fig. 5–16).

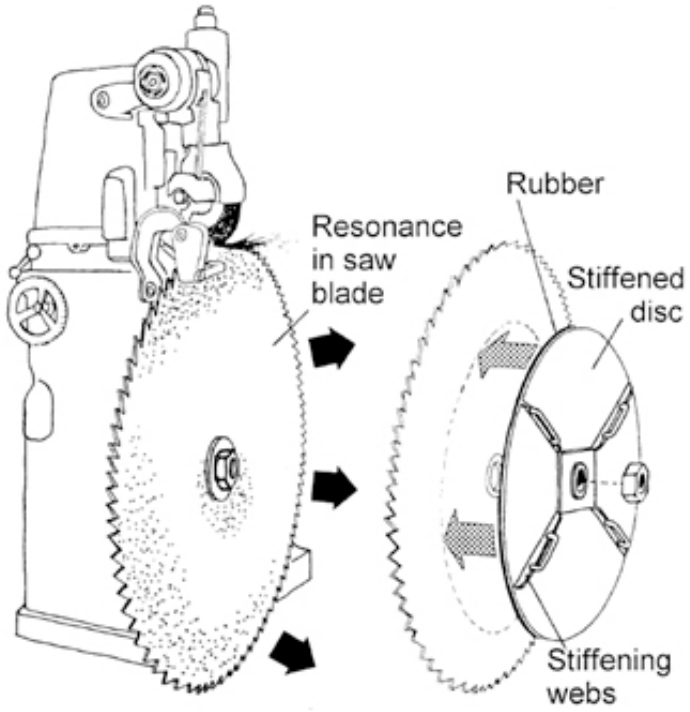


Figure 5–16. Damping of a Circular Saw.
(Source: Swedish Council for Work Life and Social Research, Noise control (in Swedish), 1977.

You must take care to look at all aspects of the substitution when recommending process substitution. Is it still effective in completing the mission efficiently? Are you trading one hazard for another? In the case of the welding versus riveting example in the previous list, the welding may reduce the noise hazard but may introduce new potential hazards from the welding process.

Product substitution

The Air Force requires that new equipment being considered for purchase must have the lowest noise levels that are technologically and economically feasible. For example, low noise impact tools and air compressors are commercially available. Some manufacturers even provide noise data, such as estimated sound intensity levels, to potential buyers. This does not take the place of performing your own readings after the equipment is installed, but can help you research your recommendations. The following are examples of product substitution:

Product Substitution	
Specification of quiet equipment	
Substitution of materials	Plastic material may be used in place of metal. A good example is the replacement of steel sprockets in chain drives with sprockets made from flexible polyamide plastics.
Substitution of equipment	• Electric for pneumatic (e.g., hand tools). • Stepped dies rather than single-operation dies. • Rotating shears rather than square shears. • Hydraulic rather than mechanical presses. • Presses rather than hammers. • Belt conveyors rather than roller conveyors.

Even if deemed necessary to replace good but noisy equipment, there may be advantages other than lower sound levels that outweigh the expense. The newer equipment might be more productive, consume less energy, or provide better quality control. The exchange for quieter products may be more cost-effective, making your recommendation more acceptable to the user. Machine treatments include reducing the driving force, isolating the responding surface, and reducing the surface response.

Machine treatments

Reducing equipment vibration, and thus the accompanying noise, can be done in a number of ways. Simple maintenance is all that is needed in many cases. Unfortunately, too often is neglected until a problem becomes severe. Malfunctioning or poorly maintained equipment makes more noise than properly maintained equipment.

Reduce the driving force: The first and most direct method is to reduce the driving force, which is the mechanical disturbance creating the vibration. Rotational forces, such as those produced by motors, can be controlled by reducing speeds, replacing worn parts, balancing, alignment, or lubrication. Sliding forces can also be decreased with lubrication or other means of lessening friction. Impact forces can be reduced by many of the substitution methods discussed previously, such as less force over a longer period, or exchanging components such as gears for quieter parts. Adding material also helps. Fiber gears can be placed between metal gears, and cushioning can be used to control the impact of banging tools or falling parts. If the noise is from turbulent flow of air or liquid, changes can be made to reduce the obstacles in the path of the flow or make those obstacles more aerodynamic.

Isolate the responding surface: When modification of the driving force is not practical, you should attempt to isolate the responding surface. This is the surface that the machine hits or slides across. Metal machine guards, grilles (e.g., those at floor level on refrigerators), and equipment casings are typical examples of isolation methods. Other situations may call for simple solutions such as rubber washers or cushions placed around the responding surfaces.

Reduce surface response: Increasing the mass of the surface is one way to cut down vibration, because materials with greater thickness or density vibrate much less. A method of reducing response in thin, resonant surfaces is to deaden them with damping materials like rubber or elastic compounds that absorb noise. Certain foil tapes are especially useful on very thin metal panels. Damping works best to control higher frequencies, which is one reason it is sometimes a good idea to combine this control with a substitution that shifts the noise to the upper octave bands. The material usually must cover most of the vibrating surface to be effective.

If controlling the noise at the source is not effective, consider controlling it in its path.

Path

The direct path of noise, the open space between the noise source and the worker, is the most obvious path in which to place controls. However, you should not forget about the possibility of reflected noise from walls or other surfaces. Methods used to control noise in its path include shields/barriers, enclosures, and room treatments.

Shields and barriers

An acoustical shield, such as one shown in fig. 5–17, usually attached to a machine, is a solid piece of material placed between the worker and the noise source. An acoustical barrier is a larger piece of material and is normally free standing. Both barriers and shields function by deflecting the flow of energy away from the worker. They are most effective during the following:

- The worker is close to the noise source.
- The smallest dimension of the shield or barrier is at least three times the wavelength contributing most to the noise exposure.

- Ceiling and other nearby reflective surfaces are covered with sound absorbing material. Otherwise, you may need to deal with reflected noise from other surfaces.
-
- Walls that have two layers with an air gap between them attenuate much better and provide much more transmission loss or noise reduction than single layer walls.

Figure 5–17. Sound Barrier.

Enclosures

Enclosures are barriers that are wrapped around a machine. They may be partial enclosures that leave the top or one side open, or total enclosures that cover the entire machine. Total enclosures provide much more sound reduction, but may cause heat buildup that may cause damage to the machine.

Room treatments

Reflected noise can be prevented by the use of acoustically absorbent materials. The materials are applied directly to the wall or ceiling surface. Additionally, materials can be suspended from the ceiling in the form of hanging baffles. Gaskets designed with noise-attenuating capabilities can be used to seal doorways.

Receiver

Receiver controls are the least reliable and least permanent solution. Controls applied to the receiver should always be considered as the option of last resort.

Control options at the receiver are rather limited. We can move the receiver away from the source by moving the source or the operation. Another option is using administrative controls including establishing and marking an 85 dB(A) line, job rotation, work time limits, preventive maintenance, housekeeping, and training.

Lastly, after researching all other control options, we can consider PPE such as earmuffs or plugs.

Labeling Requirements for Areas and Equipment

Proper labeling of hazardous noise areas and equipment is a type of administrative control. AFI 48–127 requires a hazardous noise area with any exposure at or above 85 dB(A) to be clearly identified by signs located at entrances to, or the borders of, the area. Signs will have the following message (figs. 5–18 and 5–19):

CAUTION

HAZARDOUS NOISE AREA

HEARING PROTECTION REQUIRED

Figure 5–18. Hazardous Noise Area Sign.

Air Force Visual Aid (AFVA) 48–101, Caution-Hazardous Noise Area-May Cause Hearing Loss-Hearing Protection Required, may be used for this purpose. Additional wording such as “When machines are operating” or “Within 25 feet of operating band saw” may be added at the bottom of the caution sign to accurately identify the noise hazard area. Whenever such modifications are required, a BEE will specify the exact wording to be used. In addition, all personnel must wear hearing protection in a hazardous noise area when hazardous noise sources are operating, regardless of the exposure duration.

In addition to an AFVA 48–101, hazardous noise sources will be labeled where possible with an AFVA 48–103, 48–104, and/or 48–105 to warn operators of the need to wear hearing protection.

Squadron commanders and workplace supervisors, in consultation with a BEE, will make sure each tool or piece of equipment producing noise levels greater than or equal to 85 dB(A), including vehicles, will be conspicuously marked, where feasible, to alert personnel of the potential hazard. The exception to this is when an entire space is designated a hazardous noise area and the equipment is stationary.

Figure 5–19. Hazardous Noise Source Sign.

Due to noise generating equipment such as AGE and aircraft, flight lines, are often designated hazardous noise areas. Depending on the type of aircraft and configuration, double hearing protection (earmuffs and plugs) may be recommended or required. Check for the policy at your installation and always be prepared to protect yourself to the level required by the workers there.

236. Verifying adequacy of hearing protection devices

As mentioned earlier, controlling noise at the receiver by recommending PPE should be the last alternative, and used only when other controls are impractical or not feasible. The maximum possible sound attenuation provided by HPDs is limited by human body and bone conduction mechanisms. Even though a particular device may provide outstanding values of noise attenuation, the actual noise reduction may be less because the noise surrounding the head and body bypasses the hearing protector and is transmitted through tissue and bone pathways to the inner ear. Air leaks and HPD vibration may also affect the noise attenuation of the HPD.

Use and limitations of hearing protection devices

The use of PPE depends on strict adherence to training and guidance. In order for HPDs to be effective, workers must know exactly when and where to wear them, what protection devices are needed (to include their limitations), and how to clean, maintain, and properly store their HPDs. In addition, the proper fit and wear of the HPD is essential to attaining adequate attenuation. For example, if an earplug is not inserted properly and a good seal obtained, there will be less noise reduction. The noise attenuation provided by HPDs varies between wearers, even when the wearers are highly skilled at fitting the HPDs to their ears.

Double hearing protection

The term *double hearing protection* for earplug and earmuff combinations can be misleading. The phrase is often used to mean that double layers of PPE must be worn. Double protection is advisable when 8-hour TWA exposures exceed 105 dB(A). The attenuation provided from earplug and earmuff combination wear will be less than the sum of their individual attenuation values. Never add individual HPD attenuation values or double the amount of attenuation provided by one or the other of the HPDs to derive a combination value. Add 3 dB to the highest noise reduction rating (NRR) of the plug or earmuff to estimate the combined protective rating, if actual attenuation data for the combination is not available. When HPDs are required, a BEE must determine which HPDs will provide the attenuation required to protect the workers.

Methods of estimating noise attenuation for hearing protection devices

When selecting HPD, we focus on the dB(A) levels obtained during our initial noise survey and attempt to lower (attenuate) the exposure to or below an acceptable level. For example, if an individual is operating a band saw that produces 95 dB(A), a BEE should attempt to bring the

exposure level below the AF criterion level of 85 dB(A). Assuming engineering and administrative controls are unfeasible or insufficient, a BEE must provide the worker with an HPD that would attenuate at least 10 dB. The two methods available to determine attenuation factors for HPDs include octave band method and the NRR.

Octave band method

The octave band method (also called NIOSH Method #1) is the preferred method to calculate HPD noise attenuation when the 8-hour TWA exceeds 94 dB(A). It involves calculating attenuated sound levels at each octave band. Subtract two standard deviations from the manufacturer's mean attenuation values for the at-the-ear noise level calculation. The estimated at-the-ear sound levels at each octave band are then compared to the A-weighting scale. Next, they are added logarithmically for the A-weighted SPL. This will be discussed in detail later in this unit.

Noise reduction rating

The NRR is the preferred method of estimating HPD noise attenuation when the 8-hour TWA is less than 94 dB(A).The NRR assumes equal noise levels in each octave band. To determine the at-the-ear A-weighted SPL using the NRR method, first subtract 7 dB from the manufacturer advertised NRR. Next, subtract the adjusted NRR from the measured A-weighted SPL of the noise source. This is reflected in the following formula:

SPL in dB(A) - (NRR–7 dB) = presumed exposure.

The following procedure will step through the octave band and NRR estimated noise attenuation methods.

Steps in performing the octave band method calculations for estimating noise attenuation

First, perform an OBA of the noise source and list the results. Next, refer to the HPD manufacturer's literature or NIOSH database and website (NIOSH Hearing Protector Device Compendium, http://www.cdc.gov/niosh/topics/noise/hpcomp.html) for attenuation information. For the sake of our discussion, we will provide you with the necessary information.

Step 1 - List the measured SPL results from each frequency of the OBA. The noise source sound levels (dB) were:

Frequency (Hz)	125	250	500	1K	2K	4K	8K
SPL Results (dB)	85	87	86	90	94	96	94

Step 2 - List the hearing protection device *mean attenuation* from the manufacturer's literature or NIOSH database and website.

Mean HPD Attenuation (dB)	19.6	24.8	32.6	38.6	38.9	38.8	40.7

Step 3 - List the HPD standard deviation from the manufacturer's literature or NIOSH website.

Std Deviation	2	2.4	2.2	1.7	1.7	1.7	2.3

Step 4 - Multiply the standard deviation by 2 (Step 3 × 2)

Std Deviation × 2	4	4.8	4.4	3.4	3.4	3.4	4.6

Step 5 - Subtract the Std Deviation × 2 from manufacturer's mean attenuation (Step 2 – Step 4)

Adjusted Attenuation (dB)	15.6	20	28.2	35.2	35.5	35.4	36.1

Step 6 - Subtract the adjusted mean attenuation from the SPL results (Step 1 – Step 5)

Adjusted SPL Results (dB)	69.4	67	57.8	54.8	58.5	60.6	57.9

Step 7 - List the A-weighting correction factors (these values are constants).

dB(A) correction factor	–16.1	–8.6	–3.2	0	1.2	1.0	–1.1

Step 8 - Add the adjusted SPL results to the A-weighted correction factor to calculate the A-weighted attenuated noise (Step 6 + Step 7).

dB(A)	53.3	58.4	54.6	54.8	59.7	61.6	56.8

Step 9 - Finally calculate the overall dB(A) level. Add the dB(A) from each octave band together using the following formula:

$$SPL = 10\log\left[\text{antilog}\left(\frac{SPL_1}{10}\right) + \text{antilog}\left(\frac{SPL_2}{10}\right) + ... + \text{antilog}\left(\frac{SPL_n}{10}\right)\right]$$

Where SPL_n= the attenuated sound pressure level in dB(A) for each octave band.

$$SPL = 10\log\left[10^{5.33} + 10^{5.84} + 10^{5.46} + 10^{5.48} + 10^{5.97} + 10^{6.16} + 10^{5.68}\right]$$

For our example, the final attenuated SPL is 66.39 dB(A); as a result, the HPD will attenuate the noise levels to below the standard.

Steps in performing the noise reduction rating method

The NRR was created in an attempt to describe hearing protection factors via a single number. It was proposed to simplify complex attenuation data for the general public and was made a legal requirement by the EPA for the manufacturers of hearing protection.

First, locate the NRR for the HPD you are evaluating from the manufacturer's literature or the NIOSH website. The HPD we will use in our example has an NRR of 17.

Use the following NRR formula:

dB(A) – (NRR – 7) = presumed exposure.

Our measurement of the generator was 98 dB(A). Plugging the information into the formula provides the following:

98 – (17–7) = 88 dB(A).

In this example, our presumed exposure was 88 dB(A), so the HPD will not attenuate the noise levels to below the standard.

For an 8-hour noise exposure, the HPDs provided *must* be capable of attenuating worker noise exposure below a TWA of 85 dB(A), IAW AFI 48–127. At-the-ear exposure is calculated by a BEE, and normal ear level exposure is recommended to be between 76–84 dB(A) during an 8-hour exposure period. Care must be taken to avoid over protection. Excessive attenuation may cause the worker distress resulting in non-compliance with wear of the HPDs. If too much noise is attenuated, the worker may not be able to hear their co-worker talking to them, giving instructions or calling out warnings.

Once an HPD is found that adequately protects the worker, your work is not done. Remember that PPE is supposed to be a temporary measure; you should still continue to find more appropriate measures using the hierarchy of controls.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

227. Roles and interactions of a BEE in the Air Force hearing conservation program

1. Describe the squadron commanders' and workplace supervisors' responsibilities in the Occupational Noise and HCP.

2. Describe BE's responsibilities in the occupational noise and hearing conservation program.

228. Physical properties of sound

1. How does a sound source cause variations in atmospheric pressure?

2. Explain the difference between a pure tone and complex sounds.

3. What characteristic or quality of a sound wave represents the speed of sound?

229. Quantities and units of sound

1. Describe sound pressure and state its unit of measure.

2. What does weighting mean in relation to sound?

230. Effects of noise exposure

1. Describe auditory effects of noise.

2. Describe non-auditory effects of noise.

231. Hazardous noise sources and areas

1. What noise levels define potentially hazardous noise?

2. Distinguish between criterion level and exchange rate.

3. What is the purpose of noise exposure limits?

4. What information about the workroom should you gather to help when evaluating noise sources/areas?

232. Performing noise source surveys

1. When must you calibrate a SLM?

2. To what setting do you set the SLM to perform a noise source survey?

3. Where should you position the microphone of a SLM when taking noise source survey measurements?

233. Performing octave band noise surveys

1. What are the purposes for performing OBA noise surveys?

2. What measurements do you take with an octave band analyzer?

3. You have performed an OBA in an audiometric booth. All of your octave band measurements were below the limits established in AFI 48–127. How often will you monitor the audiometric booth?

234. Performing worker exposure surveys

1. What is the primary purpose for performing noise dosimetry?

2. At what parameters should your dosimeter be set?

3. When do you perform noise dosimetry?

235. Recommending noise controls

1. Name the ways noise can be controlled at the source.

2. Name ways noise can be controlled in its path.

3. How should a hazardous noise source be labeled?

4. How and where must a hazardous noise area be labeled?

236. Verifying adequacy of hearing protection devices

1. When should you use the octave band method for determining HPD noise attenuation?

2. When should you use the NRR method of estimating HPD noise attenuation?

3. With an air drill noise measurement of 102 dB(A) and an NRR of an HPD of 22, use the noise reduction method to determine attenuation.

5–2. Ergonomics

Ergonomics is the science of fitting workplace conditions and job demands to the capabilities of the working population. The word *ergonomics* comes from two Greek words: *ergo* which means *work* and *nomos* which means *laws*.

237. Ergonomic hazards

The field of ergonomics uses our knowledge of the limitations and capabilities of the human body and focuses on designing jobs for the people that must perform them. Essentially, jobs are fitted to the person. An effective and successful fit assures high productivity, prevention of illness and injury risks, and increased satisfaction among the workforce. Fit the job to the worker, not the worker to the job.

Through AFMAN 91–203, *Air Force Occupational Safety, Fire, and Health Standards,* the AF is committed to providing a safe and healthy work place for all personnel. This AFMAN outlines responsibilities in the occupational safety program and includes ergonomic safety. Additionally, some installations have separate publications further outlining responsibilities and program requirements, but all of the Air Force follows guidance published by OSHA.

Note that there are currently no federal standards specifically addressing ergonomic safety. Guidance has been published by OSHA and other safety and health related agencies; however, these guidelines are considered voluntary. The OSHA General Duty Clause, on the other hand, is enforceable by law and can be applied to ergonomic hazards. This directive states:

> ***"Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or likely to cause death or serious physical harm to his employees."***

The General Duty Clause can be found in Section 5(a) (1) of the OSH Act of 1970. It is often cited when a workplace hazard exists for which there is no specific standard and can apply to ergonomic hazards. Reducing ergonomic hazards such as awkward posture, repetitive motions, body fatigue, discomfort, and pain can reduce workplace injuries, increase productivity and improve morale, all of which improve mission effectiveness.

Ergonomic occupational injuries and illnesses

Many occupational injuries and illnesses can be attributed to poor ergonomic conditions, poorly designed job tasks, or equipment. These lack application of proper ergonomic principles in their design. The CDC and OSHA describe these ergonomic related illnesses as work-related musculoskeletal disorders, often abbreviated as WMSD. To explain WMSDs properly, let us break the term into its components and discuss each.

To start with, MSDs are disorders of the musculoskeletal system. That means that they are related to the muscles, nerves, tendons, ligaments, and joints of the body. Typically, MSDs are not sudden injuries, but are rather illnesses that develop gradually over time. This process can take weeks, months, or even years. MSDs are commonly a result of repeated mechanical stresses on the body, which can result in the loss of mobility and/or strength. Work-related means that the person's occupation played a role in the development of the condition, or made a pre-existing condition worse. Therefore, from the individual components of the term, a work-related musculoskeletal disorder for the purposes of this unit can be described as follows:

> *Disorders of the musculoskeletal system that have developed gradually over time, and which can be attributed, either completely or in part, to a person's occupation and related workplace conditions.*

It is critical to understand that WMSDs are *not* disorders that occur from a single event or accident, but are rather illnesses that develop gradually from chronic workplace and occupational conditions. Acute injuries, on the other hand, are physical trauma that can be related to a single event and involve an immediate onset of pain (e.g., sprains or fractures).

The following table describes some MSDs associated with persistent workplace conditions:

Work Related Disorder	Description
Carpal tunnel syndrome	A disorder of the hand characterized by pain, weakness, and numbness in the fingers, caused by nerve compression in the wrist. Carpal tunnel syndrome occurs when the median nerve is compressed within the carpal tunnel area. The nerve can be trapped when the tendons become inflamed or swell when the sheath becomes irritated and inflamed. This may result from direct pressure on the nerve from hard, sharp edges of work surfaces or tools, repetitive motion, and/or awkward wrist postures.
Low back pain	Currently felt to be a WMSD where repeated bending, lifting, and twisting of the lower back results in cumulative micro-trauma. An aggravating event (i.e., slip, trip, fall, awkward lift) often causes an acute episode to occur.
Tendonitis	An irritation (inflammation) of a tendon resulting from repeated tensing of that muscle/tendon group. Some of the fibers of the tendon may fray, tear or thicken.
Lateral epicondylitis (tennis elbow)	An irritation (inflammation) of the finger/wrist extension and forearm supinator muscle's tendons attached on the outside of the elbow from activities that have jerky throwing motions or impact such as hammering.

Work Related Disorder	Description
Medial epicondylitis (golfer's elbow)	Inflammation and pain over the outer side of the elbow involving the lateral epicondyle of the humerus and usually resulting from excessive strain on and twisting of the forearm.
Tenosynovitis	An irritation (inflammation) of the tendon and the lining of the smooth sheath surrounding the tendon resulting from repeated movement of the tendon in the sheath.
Synovitis	An irritation (inflammation) of the inner lining of the membrane of the capsule surrounding a joint (joint capsule).
Stenosing tenosynovitis (trigger finger)	Results from a tendon surface becoming irritated and rough. If the tendon sheath also becomes inflamed and presses on the tendon, a progressive constriction of the tendon can occur, resulting in a loss of free movement in that joint area. For example, trigger finger is a condition where the tendon sheath of the affected finger is sufficiently swollen so that the tendon becomes locked in the sheath, and attempts to move the finger will result in a jerking or snapping painful motion in that finger.
Vibration syndrome (white finer or Raynaud's phenomenon…also known as Hand-Arm Vibration Syndrome)	Abnormal constriction of the blood vessels of the fingers; characterized by recurrent episodes of finger blanching due to complete closure of the digital arteries. The condition is caused in part by forceful gripping and prolonged use of vibrating tools.

(Excerpt from The Occupational Environmental: Its Evaluation, Control, and Management Book, Chapter 28.)

A pro-active role in ergonomics will help to increase productivity, safety, health, and job satisfaction and to decrease WMSDs work-related injury/illnesses. To begin, it is important to identify where in the work place there is a risk of ergonomic hazards.

Identifying risk factors

While it is possible to define a chemical dose, a mechanical dose is not so well defined. There are specific risk factors that can be found in the work place which are known to increase the potential for development of ergonomically related injury/illnesses. The presence of a risk factor can elevate the likelihood of WMSD development, but it does not guarantee that one will develop. Risk factors are simply indicators or flags that assist us in recognizing the potential for ergonomic hazards in the work place. Although it is not possible to define and measure the stress dose itself, it is possible to identify and reduce or eliminate the factors associated with tissue trauma. Risk factors include, but are not limited to vibration, repetition, awkward and/or static postures, forceful exertion and heavy lifting, contact stress, and temperature. [4]

Vibration

Many workers are exposed to occupational whole-body vibration or hand-arm vibration (fig. 5–20). Exposure to whole-body vibration (driving tractor/large vehicles) has been linked to degenerative changes in the spine, arthritic back pain, intestinal ailments, prostate trouble, and hemorrhoids. Hand-arm vibration has been linked to degenerative changes in the joints and tendons of the hands and arms. The reflex constriction of muscles associated with hand-arm vibration exposure (i.e., pneumatic hammer) can severely reduce blood flow, resulting in hand-arm vibration syndrome (also known as dead fingers or white fingers). Hand-arm vibration syndrome is a gradual progressive process that may involve years of exposure to hand-arm vibration.

Figure 5–20. Example of Vibration, Circular Sanding.

Repetition

Repetition is the act of performing the same activity more than once (fig. 5–21). The exposure to repetitive motion alone can increase the risk of upper extremity WMSDs, but pose an even greater risk when combined with other risk factors. Repetitive motion becomes problematic when tissues are not given sufficient recovery time. If a motion is repeated frequently for an extended amount of time, fatigue and muscle strain can set in.

Figure 5–21. Example of Repetitive Task, Shoveling.

Awkward and static posture

Body posture can be used as a key factor in determining what joints and muscles are used when performing a task. Awkward posture is likely within the natural range of motion. Awkward posture is a joint angle (position) outside neutral posture, and/or at the extreme end of the normal range of motion. Neutral posture is typically considered to be close to 0 degrees joint angle. The exception is that elbows, when at 90 degrees, are considered neutral for hand activities. Similarly, when knees are at 90 degrees, they are considered neutral for sitting activities. Non-neutral

postures place the muscles in less functional positions, making them more vulnerable to WMSDs (fig. 5–22).

An example of an awkward position is when a munitions loader must perform the task of securing the munitions beneath the wing of the aircraft. This is a manipulative task with sustained bending and twisting and a limited amount of space. Studies have shown that restrictions placed on the body posture during a task can result in a decrease in the ability of the body to perform the desired task.

Along with awkward positions, a static or prolonged posture can also lead to WMSDs. When we hear the word static, we immediately think of an object being at rest; however, when it comes to ergonomics, it can also refer to muscles contracting for an extended period of time. When we hold a particular position with limited movement of muscles for a continuous amount of time, we are placing a strain on our body. For example, a dental worker is often required to sit in a stooped or bent-over position while working with their patients. If this position is maintained, the potential for WMSDs is highly increased.

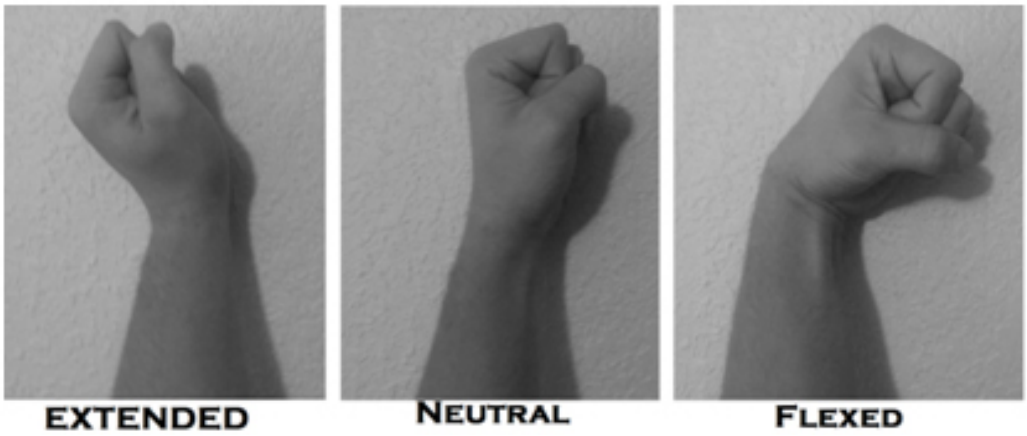


Figure 5–22. Example of non-neutral postures.

Forceful exertion and heavy lifting

Strong evidence indicates that low back pain can be associated with forceful movements and lifting. Heavy physical work can be defined as work that has high energy demands or requires some measures of physical strength. A situation may arise where the task requires an increasing force to be used and where a higher degree of stress is placed on the muscles, tendons, ligaments, and joints involved (fig. 5–23). While injury may result immediately, injury it is more often a result of prolonged or recurrent tasks of the same type where there has been inadequate time for damaged tissues to repair themselves. The prevalence of pain in the lower back of workers with jobs that have heavy physical demands has been shown to be higher than a matched group of workers in jobs with light physical demands. Let us refer back to the munitions loader. The posture does not directly affect the weight of the object. However, in order to accommodate the starting and ending points of the activity, awkward postures may be employed to lift the object. This leads to the use of less than optimal muscle groups with excessive force to accomplish the task of loading the munitions onto the aircraft.

Figure 5–23. Example of Forceful Exertion.

Contact stress

The direct pressure on soft tissue caused by external surfaces is called contact stress (fig. 5–24 and 5–25). Repeated or continuous contact with a hard object may create pressure over one area of the body, which can inhibit nerve function and blood flow. One example would be the handle of a screwdriver that digs into the palm of the hand, placing pressure on nerves and tendons beneath the surface of the skin. Other examples are resting wrists and forearms against the edge of the desk while keyboarding, or resting elbows on a table surface when performing assembly work.

Figure 5–24. Example of Contact Stress, Contact Pressure.

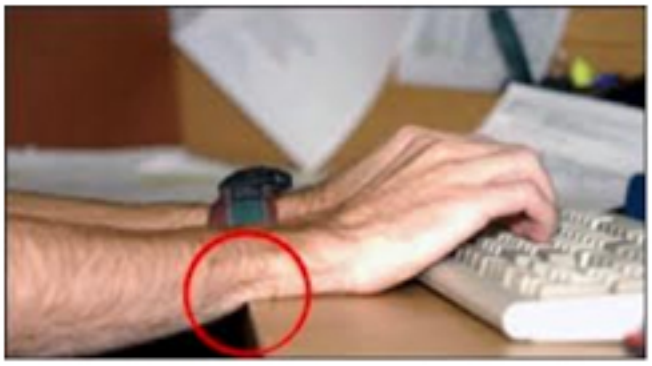


Figure 5–25. Example of Contact Stress, Resting Wrist.

Temperature

Extreme exposures to heat and cold may not only contribute to physical stress but psychological stress as well. The presence of temperature extremes is a risk factor that is secondary to most of the others previously discussed. However, it should be noted that extreme heat exposure could cause heat fatigue that can impair skill and sensorimotor performance. Under cold temperatures, muscles show an increase in activation, perhaps due to a reduction in blood flow. Therefore, more muscle force may be exerted in cold temperatures than in comfortable temperatures to perform the same task. Although gloves can be worn as protection from the cold, they can decrease hand strength and dexterity, increasing the musculoskeletal load because the hand muscles will increase exertion to compensate for the effects of the gloves.

Non-physical risk factors

Not all risk factors are limited to being purely physical in nature. Many can be termed psychosocial as well. This term can be used to describe those factors that affect a worker mentally, thus affecting the ability to perform a desired task. Work pressures, such as deadlines and uncertainty of job security, can influence the physical factor of force and speed of motions. For example, workers may increase the force and pace in response to work pressures.

238. Analyzing ergonomic hazards

Your goal in performing an ergonomic assessment should be to identify excessive job demands that can hasten the development of WMSDs and diminish performance. As a result, you must determine the link to a specific part of the job or environment—the root cause. Remember, the risk factors are of greatest interest and concern when recognizing and evaluating workplace ergonomic hazards. As stated earlier, there are various guidelines for evaluating ergonomic hazards, such as AFMAN 91–203. BEEs have been trained on conducting HRAs to evaluate potential health risks to workers; therefore, this same process should be used to evaluate potential ergonomic risks to workers. An HRA is the process of identifying, evaluating, and implementing courses of action (controls) to reduce risk to human health. The success of the assessment requires the willingness by leadership in the work place to commit time, resources, and moral support to achieving ergonomic goals. An ergonomic assessment generally begins with investigating ergonomic hazards using a workplace analysis.

Workplace analysis

The American Industrial Hygiene Association (AIHA) describes workplace analysis as the examination of the work place to identify existing hazards as well as the conditions and operations in which changes might occur to create hazards. A workplace analysis can be considered an HRA. The determination to perform a workplace analysis can be driven by an occupational illness/injury investigation, worker's complaint, or merely part of a walkthrough survey to proactively identify hazards. In addition, follow-up surveys to evaluate the effectiveness of control measures will also be conducted. In general, the fundamental elements of a workplace analysis are similar to the HRA process: identifying, evaluating, and implementing courses of action to reduce risk to human health.

Accomplishing the ergonomic assessment

Once a decision has been made that a particular work place and/or activity needs further evaluation, there are a number of steps that should be taken. The first step in performing an ergonomic assessment is to gather information about the work place. This is the identification process of an HRA. The information needed for workplace analysis can come from job descriptions, interviews, and conducting a walk-thru survey. Some of the questions to answer include:

- How many workers are employed in each job?
- What are the characteristics of the workforce (e.g., gender, age, etc.)?

- What are the primary tasks involved in each job?
- What is the established work rate and how is it determined?
- What opportunities are there for workers to rotate to other jobs?
- How many hours do employees work each week, is the work organized into shifts, and how much overtime (if any) is required?

The answers to these questions can be useful in identifying resources needed to conduct further analysis, devise an appropriate timeline for completion of the effort, and identify the necessary equipment needed to gather data for workplace analysis. The following equipment items can be useful:

- Cameras and film to record work postures and motions.
- Tape measures and rulers for measuring workstation dimensions and reach distances.
- Force gauges and spring scales for measuring the force of exertions and weight of tools or objects.
- Videotape/camera for documenting work stresses.

There are many advantages to using equipment. For example, after the activities are recorded on video or camera, more than one analyst can review the tape(s). Features like video slow motion and playback can help the analyst measure task duration and observe fast movements. Job activities recorded before and after controls are implemented can be compared to determine how effective the changes are. Additionally, videos and photos can be used for training workers.

The second step in performing an ergonomic assessment is identifying ergonomic risk factors (mentioned earlier) using the following assessment approaches or combination. This is the evaluation process of the HRA. There are two basic approaches to analyzing an activity: a work-methods study and the use of a checklist. [4]

Work-methods study

A work-methods study can be described as the systemic recording of existing and proposed ways of doing work accompanied with the critical examination of data. Describing the job in a series of elements (e.g., reach, hold, assemble, inspect) can help the observer determine which ones may be risk factors for MSD. Once the elements that can increase the probability are identified, recommended solutions can be assigned.

Checklists

Checklists are another way to gather information. A checklist is easy to use because it involves a qualitative method that quickly evaluates job risk factors. However, checklists are not quantitative and in some instances, they may not tell what the real risk factors are. A good checklist will provide BE technicians with enough detail that they are able to derive an effective solution. Remember that checklists are not a substitute for BE technicians' best tools, their brains. Use checklists as a guideline and reminder tool.

An example of a checklist is the one contained in DOEHRS. This checklist provides information about potential ergonomic hazards involved in a particular work process. If it is uncertain if an ergonomic hazard exists with a particular process, a set of screening questions can be accessed in DOEHRS. The checklists are tools developed to help BEEs identify risk factors for WMSDs, establish intervention priorities, and select practical control methods for ergonomic hazards.

BE personnel are mandated to use DOEHRS to document all information relating to OEH HRAs. [5] This requirement means you must use the DOEHRS ergonomic checklists for all ergonomic assessments. Checklists are available to perform assessments on both administrative and industrial work places.

While conducting your assessment, be sure to collect enough information to describe the job being performed in order to identify potential ergonomic risk factors. For the best accuracy, work processes should be disturbed as little as possible during observation. Consider observing several workers performing the same activity since different workers often use different methods to accomplish the same task. Additionally, try to visit the shop at different times of the day. This can help in determining if fatigue influences the way work is performed.

Informal discussions with the workers and supervisors can provide valuable information. Workers who perform daily activities are often the best source of information about the potential ergonomic hazards. Supervisors and/or team-leaders can also provide information about operations and proposed changes.

All of this information can determine ergonomic risks factors in the work place. Finally, remember to document the assessment. It is also important to remember that through this entire information gathering session, you are to identify possible solutions.

239. Ergonomic controls

Once data is collected and results are interpreted, it is time to implement courses of action to reduce risk to human health.

The best solution to ergonomic problems are those in which safe and healthful working conditions are a natural result of the job design, and are independent of specific worker capabilities or worker techniques. As an OEH risk assessor, you must be able to identify ergonomic hazards and recommend a control to reduce or even eliminate the hazard. As with any hazard, you will recommend engineering, administrative, and PPE controls to eliminate and reduce ergonomic hazards. The foundational tenant of controlling ergonomic hazards is to fit the job to the worker.

Types of controls

Engineering controls are the primary (and preferred) control methods because they are permanent and typically more effective than administrative or PPE controls. Proper work methods reduce and/or avoid awkward posture, static posture, repetitive motion, and excessive force. Workstations need to be designed for specific tasks and would ideally be easily adjustable. Tools must fit properly, promote neutral postures, promote use of reasonable force, and reduce direct contact stress. Examples of engineering controls include the following:

- Changing the transportation methods for materials, parts, and products (e.g., mechanical assistance like hoists, conveyor belts, and proper handles on boxes).
- Changing the process or product to reduce worker exposures to risk factors (e.g., easy-connect electrical terminal, addition of conveyor belt, packaging end product in smaller/lighter box).
- Modifying containers and parts presentation for easier reach (e.g., tilted bin or lazy Susan).
- Changing workstation layout via placement of workplace components (e.g., locate most frequently used tools and materials within reach and height adjustable benches as shown in fig. 5–26, provided on OSHA's website for their ergonomic solutions).

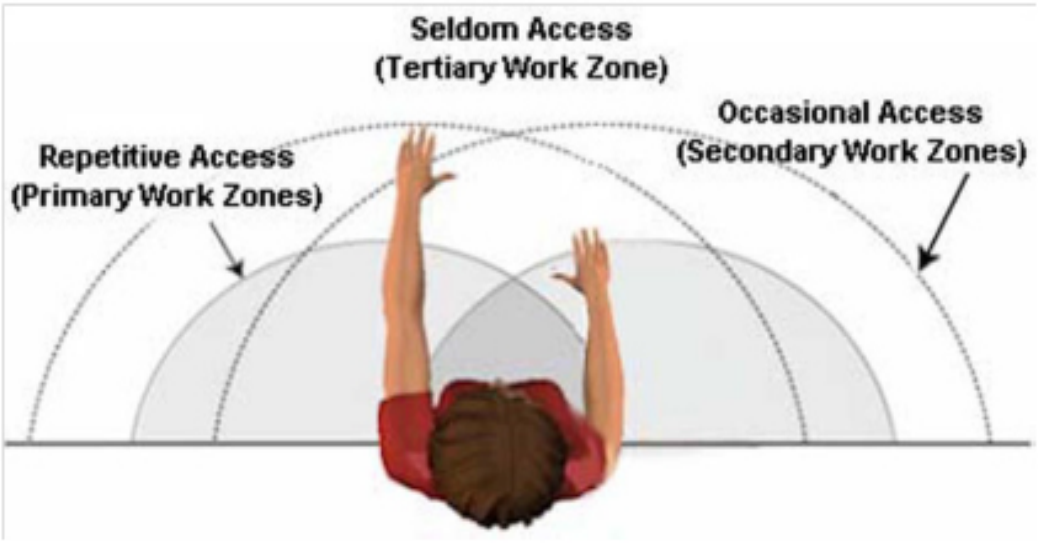


Figure 5–26. Example of recommended zones for workplace components. (Source OSHA Ergonomic Solutions).

Administrative controls are management-dictated work practices and policies dealing with how work is structured to reduce or prevent exposures to ergonomic risk factors. Administrative control strategies include, but are not limited to the following:

- Implementing job rules and procedures.
- Increasing job rotation to reduce the duration and severity of exposure.
- Training workers to recognize risk factors and employ proper work techniques.
- Increasing cycle time to reduce repetition frequency.
- Maintaining a preventive maintenance program for equipment.
- Increasing the number of employees assigned to a task.
- Providing rest pauses to relieve fatigued muscle-tendon groups.

Some of the benefits to administrative controls include the following:

- They can be implemented quickly, often at low cost, making them useful as temporary measures while awaiting engineering control implementation.
- They can be implemented when engineering controls may not be possible or practical.
- The education and training continues to be beneficial to workers even after an engineering control has been implemented.

Use PPE as the principal means of control only as a last resort, when neither engineering nor administrative controls are possible, or in the event of emergencies. It is considered the least effective form of ergonomic hazard control. Examples of PPE include vibration gloves, and kneepads. The PPE does not eliminate the hazard or reduce the time of exposure. It simply reduces the amount of exposure by placing a barrier between the hazard and the worker. You may find workers wearing back belts, also known as back supports, with the idea that they prevent back injuries. In accordance with AFMAN 91–203 there is no definitive proof that back support belts serve any protective function; therefore, the Air Force does not recognize back support belts as PPE. However, as a medical intervention, a physician may prescribe this device following injury and/or during rehabilitation. In addition, other PPE such as respirators, earplugs, safety goggles, hard hats, and gloves may actually make stressors worse if incorrect or ill-fitting PPE is selected. Equipment should be provided in a variety of sizes, to accommodate the physical requirements of workers on the job, and not contribute to extreme postures and excessive force.

Evaluation of controls

Once controls have been implemented, it is important to remember to evaluate their effectiveness. NIOSH recommends that follow up occur no sooner than 1–2 weeks after control implementation, and a month is preferred. [5] The evaluation of the controls can be broken down into short-term evaluations and long-term indicators. The short term evaluation may be as simple as returning to the work and talking with the workers or re-performing an HRA. The best source of control effectiveness is the worker. The worker performing the job, presenting the ergonomic hazard while utilizing the control, provides valuable input regarding the control's effectiveness. In addition, the worker's acceptance of the changes or control is important to the success of the control implemented. Remember, ergonomics is defined as the science of fitting workplace conditions and job demands to the capabilities of the working population. In other words, fitting the job to the worker. Therefore, if it is determined that the control was ineffective or additional information is needed, re-perform the HRA with the checklist originally used to identify the ergonomic risk in the first place.

Monitoring control effectiveness in reducing or eliminating ergonomic risk factors does not stop at short-term evaluations. OSHA defined ergonomic surveillance as "the on-going, systematic collection, assessment and interpretation of health incidence and exposure data in the process of describing and monitoring ergonomics hazards." There are long-term indicators that can identify control effectiveness over a longer time period through the OEHWG process. These long-term indicators of control success may include the following:

- Reductions of musculoskeletal disorder incidence rates.
- Reductions in musculoskeletal disorder severity rates.
- Increase in productivity of the quality products and services.
- Reductions in job turnover or absenteeism.
- Reductions in workers compensation claims.
- Reductions in workers complaints of discomfort.

Remember that there is no ergonomic standard currently in existence, only guidance on how to evaluate and control an ergonomic hazard. Use the HRA process of identifying, evaluating, and implementing courses of action (controls) to reduce risk to human health. This process of identifying potential ergonomic risks is executed by knowing and understanding various WMSDs, evaluating the work place for ergonomic risks, and providing recommended controls (i.e., engineering, administrative and PPE) to reduce or eliminate the risk. Finally, an evaluation of control effectiveness needs to be conducted using short-term evaluation or long-term indicators.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

237. Ergonomic hazards

1. Define a work-related musculoskeletal disorder.

2. Ergonomic risk factors include what type of hazards?

238. Analyzing ergonomic hazards

1. What questions should you ask while gathering information for an ergonomic assessment?

2. How can you help determine if fatigue influences the way work is performed?

239. Ergonomic controls

1. List some examples of engineering controls that you might recommend for ergonomic hazards.

2. What are some benefits of administrative controls?

3. What types of long-term indicators can be used to determine control effectiveness?

5–3. Thermal Stress

Air Force personnel perform duties in both hot and cold environments (fig. 5–27). The ability of personnel to conduct effective and sustained combat operations depends largely on their physical and mental health. Air temperatures may vary from approximately –40° to 115°F in different regions of the United States. Personnel may experience even more extreme temperatures when deployed to other countries. The Air Force document that addresses thermal stress is AFI 48-151, *Thermal Injury Prevention Program*.

Figure 5–27. Treating heat stroke.

240. Thermal stress hazards

Thermal stress is caused by either a rise or fall in the body's core temperature. Thermal stress, both hot and cold, is a major concern and can affect the worker in many ways. These affects can have a detrimental effect upon mission success by degrading both individual and collective performance. The risk of thermal injury can be determined through an HRA of the thermal stress placed upon personnel as a function of air temperature, wind speed, and humidity. BE personnel play an important role in identifying, analyzing, and controlling thermal stress hazards. Before we proceed, we need to define some thermal stress terms, including heat stress, heat strain, and cold stress.

- Heat stress is the net heat load to which a worker may be exposed from the combined contributions of metabolic cost of work, environmental factors, and clothing requirements. Heat stress can result in heat-induced illnesses such as heat cramps, heat exhaustion, or heat stroke.
- Heat strain is the overall physiological response resulting from heat stress. The physiological adjustments are dedicated to dissipating excess heat from the body.
- Cold stress refers to environmental and/or personal conditions that tend to remove body heat and decrease body temperature.

Sources of thermal stress

We often think of heat and temperature as being the same thing, but this is not true. Heat is energy, and temperature is the result of the heat applied to some object. For instance, you can apply a great deal of heat to a large tank of water, and its temperature may not raise much. Applying the same amount of heat to a small container of water would result in it having a very high temperature. Heat energy can flow to the body or from the body causing thermal stress. Too much heat flowing to the body can cause heat stress. On the other hand, too much heat flowing from the body can cause cold stress. The human body must be able to handle these heat gains and losses caused by the environment, as well as, the heat it generates.

Environmental sources

Heat is transferred in several ways which may be either by conduction, convection, or radiation. Conduction of heat occurs when the body is in direct contact with a hot or cold object, such as a metal tank or engine. Anyone that has grabbed a hot object or held an ice cube with bare hands has experienced heat conduction. In the occupational setting, a good example is seen when maintenance people must lean and stretch over parts of an aircraft that has been heated by the sun. Heat will flow from the warmer substance to the cooler substance. The rate of heat transfer depends on the difference in temperatures between the skin and the other substance, the thermal conductivity of the substance that the person contacts, and the clothing that may separate the person from the substance.

Convection is the transfer of heat or cold to the body by air. The direction of heat flow depends on the temperature difference between the skin and air. If air temperature is greater than skin temperature, then convection is positive and heat flows from the air to the skin. It may be due to heat from an object such as jet exhaust or sunlight heating the ambient environment. If air is cooler than the skin, convection is negative and heat flows from the body. The rate of convection heat exchange depends on the magnitude of the temperature difference, the amount of air motion, and clothing.

Radiation, or radiated heat, is actually infrared radiation, which is invisible but similar to visible light. In fact, an object which becomes extremely hot is sometimes said to be "red hot" because some of the intense energy enters the visible spectrum. Although the object may have a red glow, you still cannot directly see the heat being radiated. This heat transfer does not involve direct contact with an object or exposure to heated air. You get an idea of this when you remember

sitting in the shade on a hot summer day. It may have been hot in the shade, but stepping into the sunlight—our main source of radiant heat—caused an even greater sensation of heat. The rate of heat transfer depends on the average temperature of the surrounding solid surfaces, skin temperature and clothing.

Metabolic rate

People can normally take the heat on very warm days without serious trouble. However, once some physical activity begins the tolerance to heat drops quickly. The body creates heat even at rest, but the amount becomes greater as activity increases. You have experienced metabolic heat during physical training. Pay attention to this phenomenon the next time you train with your squadron. Assess your body's physiological responses as you perform warm-up exercises and then strenuous physical activity. Under normal conditions, the body can rid itself of excess metabolic heat. The rate of metabolism depends directly on the rate and type of external work demanded by the job.

Body's response to heat

The human is a warm-blooded mammal. It maintains a fairly constant internal temperature even though it is being exposed to varying environmental temperatures. To keep internal body temperatures within safe limits, the body must get rid of excess heat, primarily by varying the rate and amount of blood circulation through the skin and the release of fluid onto the skin by the sweat glands. These responses are kept in balance by the brain and automatically occur when the temperature of the blood exceeds 98.6ºF.

In the process of lowering internal body temperature, the heart begins to pump more blood, blood vessels expand to accommodate the increased flow, and the microscopic blood vessels (capillaries) that thread through the upper layers of the skin begin to fill with blood. The blood circulates closer to the surface of the skin, and the excess heat is lost to the cooler environment. If heat loss from increased blood circulation through the skin is not adequate, the brain continues to sense overheating and signals the sweat glands in the skin to shed large quantities of heat from the body.

If the temperature of the skin approaches the body's core temperature, cooling becomes more difficult. If air temperature is as warm as or warmer than the skin, blood brought to the body surface cannot lose its heat. Under these conditions, the heart continues to pump blood to the body surface, the sweat glands excrete liquids containing electrolytes onto the surface of the skin and the evaporation of the sweat becomes the principle effective means of maintaining a constant body temperature. However, sweating does not cool the body unless the moisture is removed from the skin by evaporation. Under conditions of high humidity, the evaporation of sweat from the skin is decreased and the body's efforts to maintain an acceptable temperature may be significantly impaired. In extreme cases, these body responses can leave a significant impact on an individual's ability to perform the job.

With so much blood going to the external surface of the body, relatively less goes to the muscles, the brain, and internal organs. Strength declines and fatigue occurs sooner than it would have otherwise. Alertness and mental capacity also may be affected. Workers who must perform delicate or detailed work may find their accuracy suffering, and others may find their comprehension and retention of information lowered. The following table identifies some heat related disorders mentioned in AFI 48-151.

Heat Stress related Disorder	Description
Heat illness	Heat illness is an all embracing term and applies to an individual who becomes incapacitated as the result of a rise in core body temperature. Individuals experiencing dizziness or confusion, nausea or vomiting, staggering, disturbed vision, and confusion, collapse or loss of consciousness during physical activity in a hot environment or while wearing protective clothing, should be presumed to be suffering from heat illness.
Heat stroke	Heat stroke is the most serious heat-related disorder. It occurs when the body's temperature regulation fails and is unable to get rid of excess heat and the body temperature rises to critical levels. Heat stroke is a medical emergency.
Heat exhaustion	Heat exhaustion is a milder form of heat-related illness. It is caused by excessive exposure to heat and depletion of body fluids.
Heat syncope	Heat syncope (fainting) is the result of exposure to high temperatures. It may be associated with exercising in heat, and with the pooling of blood in the legs and skin from prolonged static posture and heat exposure.
Heat cramps	Heat cramps are muscle pains or spasms that may occur during or following strenuous physical activity. Heat cramps are attributed to electrolyte imbalance caused by sweating without adequate fluid or salt intake.
Heat rash	Heat rash, also known as prickly heat, is a common problem in hot environments. Small bumps appear, where the clothing is restrictive, and there is an itching or a prickling sensation. It is caused by prolonged, uninterrupted sweating and inadequate hygiene practices.
Sunburn	Sunburn is painful and can impair body heat loss by reducing the ability to sweat, degrading performance and increasing the risk of heat casualties. Altitude and reflective surfaces such as fresh ice, snow, sand, metal, concrete and wind, increase the risk and severity of sunburn.

Risk factors

As with any hazard, we must become familiar with its risk factors in order to be successful in the identification phase.

Workplace-related risk factors

Heat stress in the work place can be recognized in terms of workplace risk factors and the effects it has on workers. When performing an evaluation, consider the following workplace risk factors:

- Hot environments—If the work place is generally considered as being hot by workers and supervisors, then heat stress may be present.
- High work demands—If the demands for physical work are high, heat stress may be a factor in environments that are considered comfortable by casual observers (those not exerting themselves in the environment).
- Protective clothing requirements—The added weight of personal protection equipment/clothing may increase the metabolic heat load and therefore the level of heat stress.

Individual risk factors

There is wide variation in human tolerance to heat stress. It is possible to identify factors that cause particular individuals to become heat casualties. The following personal factors must be considered when assessing individual heat injury risk:

- Obesity.
- Lack of physical fitness and/or lack of sleep.
- Recent alcohol intake.
- Concurrent mild illness (e.g., diarrhea, viral illness, fever).
- Dehydration.
- Medication or illegal drugs.

We have covered various heat stress-related topics; now let us look at cold stress.

Body's response to cold stress

Cold stress is fundamentally a different kind of problem than heat stress. While adaptive mechanisms (e.g., sweating and acclamation) are crucial during heat-stress exposures, protection from cold environments is typically much easier, as most people do not usually allow themselves to be exposed to the cold for very long without protection. Behavior is the primary human response that prevents excessive exposure to cold stress.

In order to anticipate an exposure to cold stress successfully, we must understand what influences an exposure. Air temperature and air speed are two climatic factors that influence the rate of heat exchange between a person and the environment. As the difference between skin and ambient temperature increases, the rate of heat loss from exposed skin increases. The equivalent chill temperature (ECT), also known as wind chill index, was developed by the US Army to account for both the air temperature and air speed based on empirical observations of the time for water to freeze. It has been updated by the National Weather Service (NWS).

The body responds to cold exposure through two major mechanisms designed to conserve energy and increase body heat production. The first response to cold stress is to conserve body heat by reducing blood circulation to the skin. This effectively makes the skin an insulating layer. Because heat is lost from the exposed body surface faster than it is replaced, skin temperature drops. The reduced blood flow and fall in skin temperature contribute to the cause of peripheral cold injuries to the fingers, toes, ears, and nose. Personnel are to be encouraged to eat a normal diet incorporating moderate carbohydrate and fat intake. The second response is shivering, which increases the rate of metabolism. Shivering is a good sign that the cold stress is significant and that hypothermia may be present. However, it is relatively weak as a protective mechanism.

Cold stress may lead to a number of different cold stress-related disorders. The following table from AFI 48-151 identifies some disorders.

Cold Stress Related Disorders	Description
Hypothermia	Hypothermia is a serious health condition that develops as the rate of heat loss exceeds heat production. It is defined as a core temperature below 95 °F or skin temperature that approaches 30 °F, causing frostbite, known as freezing cold injuries.
Frostbite	Frostbite occurs when the skin/tissue freezes; commonly in the extremities, particularly the feet and hands, and tips of the nose and ears. It usually occurs at temperatures of 30 °F or lower; however, it may occur above freezing temperatures, depending on wind chill factors.
Frostnip	Frostnip is a milder cold injury that does not cause tissue loss, only tissue damage. It is the reversible freezing of superficial skin layers and is usually marked by numbness and whiteness of the skin.
Trench foot	Trench foot is also known as immersion foot, and is a cold injury sustained by tissues exposed to cold, wet conditions for prolonged periods of time. It can occur in any tissue, but is most common in the foot. These injuries may occur because of actual immersion, or by the creation of cold and wet conditions, such as prolonged walking on boggy ground or sweating in impervious boots.
Raynaud's Disorder	Raynaud's Disorder is not considered a freezing or non-freezing cold injury. It is a disorder affecting the arteries. It is mentioned here because cold, at a severity that does not affect normal people, may cause severe arterial vasoconstriction in people with this disorder. In severe cases, this may lead to digital ulceration and tissue loss.
Muscle injury	Muscle and tendon tears may occur when a person is cold, since muscle action is inefficient and may be uncoordinated in concert with joint stiffness.
Shivering	Cold causes shivering that can produce a performance deficit in manual skills that require steadiness.
Reduced manual dexterity	Cold impairs coordination, reduces visual acuity, general alertness, and slows reflexes. Individuals are prone to making mistakes in the cold and may misinterpret sights and sounds. Prolonged hypoxia, or exposure to cold, can cause hallucinations, particularly at altitude.

Risk factors

We must become familiar with its risk factors in order to be successful in the identification phase.

Workplace-related risk factors: Cold stress in the work place can be recognized in terms of workplace risk factors and the effects it has on workers. If the work place or work location is generally considered as being cold by workers and supervisors, then cold stress may be present.

Individual risk factors for cold injury

Systematic review of accidental cold injury has identified the following individual risk factors that must be considered:

- Alcohol.
- Psychotropic medication.
- Insufficient clothing.
- Wetness from either the environment or sweat.
- Lean body mass.
- Physical exhaustion.
- Concomitant illness.

Since individual risk factors affect performance under adverse thermal conditions, we need guidance on the proper evaluation of thermal stress hazards. As a BE journeyman, you will be responsible for taking measurements of both heat and cold stress, analyzing that data and

recommending measures to keep workers as safe, healthy, and comfortable as possible. Let us consider the roles you will have in relation to these responsibilities.

241. Roles and interactions in thermal stress situations

Several organizations and functions play a role in determining and controlling thermal stress; however, BE Flight personnel carry the most duties and responsibilities.

Bioenvironmental engineering

BE performs initial surveillance to detect or identify ambient threats or hazards that pose potential health risks. You ensure physical hazards (including thermal stress, generated from industrial-type operations, or due to geographic location), are immediately assessed to determine potential and actual pathways and exposures. In deployed operations, these threats may exist immediately upon bed-down and increase in scope as sites develop and transition into sustained operations.

Heat stress

Base BE personnel are usually responsible for wet bulb globe temperature (WBGT) measurements and must specify in local instructions where estimations are to be taken. The data collected is to be compared to REs used to implement administrative and personnel procedures to directly reduce thermal strain and subsequent thermal stress at the work place.

You should establish normal, expected, and average WBGT index measurements for occupationally heat-exposed personnel in indoor environments or confined spaces. When the forecast outside temperature reaches 85 °F as a daily high, WBGT measurements are to be taken a minimum of four times, evenly spaced, during the hottest part of the day.

Meteorological/weather staffs, in conjunction with BE personnel, are to jointly determine the fighter index of thermal stress (FITS) zones based upon the WBGT measurement. The FITS is a measure of the thermal stress experienced by aircrew in fast jet aircraft, with canopies and environmental control systems, engaged in combat sorties at low level (see fig. 5–28). Squadron operations flights then determine the zone applicability within the aircrew working environment and provide appropriate warnings to the aircrew.

Dry Bulb Temperature	Zone	Dew Point Temperature								
(°F)		30	40	50	60	70	80	90	100	>110
70		70	73	76	81	86	X	X	X	X
75		74	77	80	84	89	X	X	X	X
80	NORMAL	77	80	83	87	92	98	X	X	X
85		81	83	86	90	95	101	X	X	X
90		84	87	90	93	98	104	110	X	X
95		88	90	93	96	101	108	112	X	X
100		91	93	96	99	104	109	115	122	X
105	CAUTION	94	96	99	102	107	112	118	124	X
110		97	99	102	105	109	114	120	126	133
115		100	102	105	109	112	117	123	129	136
120	DANGER	104	105	108	111	115	120	125	131	138

Figure 5–28. Fighter index of thermal stress.

Cold stress

According to AFI 48-151, BE personnel will obtain outside ground temperature and winds speed from the installation weather office and determine the wind chill temperature and frostbite risk level (FRL). BE notifies the installation command post of the resulting FRL. The command post shall relay the information using the base communication networks as needed.

The thermal stress assessment is performed using the WBGT Index, the results are compared to the criteria, and recommendations are made to control thermal stress hazards. This information is provided to commanders and supervisors. In turn, commanders and supervisors make decisions based on this information to reduce/prevent thermal stress hazards and associated injury/illness.

The following is an example of how players work together during military unique operations where thermal stress considerations are used to dictate mission oriented protective posture (MOPP) levels. The senior Air Force commander assesses risk and directs protective measures for all forces within the airbase AOR. Unit commanders determine the need to reduce protective postures in order to enable a more rapid focus on mission continuation or restoration. They use information from various sources for initial hazard assessment. They next contact the emergency operations center to obtain authority from the senior AF commander to reduce their MOPP level. Within the emergency operations center, civil engineer readiness and medical personnel, including BE, evaluate conditions (e.g., type of hazards present in sectors or zones, weather conditions) and develop the appropriate recommendation(s). This recommendation is presented to the senior AF commander who approves and authorizes unit commanders to reduce the MOPP level.

242. Analyzing thermal stress hazards

Like any hazard BE deals with, we are going to perform an HRA to evaluate potential health risk to workers; therefore, this same process is used to evaluate potential thermal stress factors to workers. You will identify, evaluate, and implement *courses of action* to reduce risk to human health. During the times when tasks must be performed under adverse thermal stress conditions, you must be able to determine if thermal stress is present and the extent by gathering data, taking measurements, and making recommendations based on these measurements, in an effort to keep workers as safe, healthy, and as productive as possible.

Heat stress assessments

Heat stress assessments combine four thermal components: air temperature, humidity, air speed, and radiant heat.

The WBGT Index offers a useful, first-order index of the contribution of the environment to heat stress. Thermal stress indices that account for the thermal environment provide guidance to commanders from which they can judge the risk of injury to their personnel against mission requirements. Therefore, the measurement of the WBGT Index must closely relate to training or working conditions.

BE uses the WBGT Index to perform a base-wide evaluation of the existing conditions to which personnel may be exposed. You begin monitoring when the forecast exceeds 85 °F. At that time, a minimum of four measurements (evenly spaced in time) are taken during the hottest part of the day. The results are then compared to the tables in AFI 48–151 and reported to the commander. The data collected is used to implement administrative and personnel procedures to directly reduce thermal strain and subsequent thermal stress at the work place.

Equipment and supplies needed to perform a WBGT are as follows:

1. WBGT apparatus/kit.
2. Tripod or stand to mount or suspend thermometers for unrestricted airflow.
3. Distilled water.

4. Equipment instructions (if using a digital WBGT kit).

Steps for collecting thermal condition measurements

The WBGT apparatus is an instrument for providing information on hot weather risks. There are three different thermometers that make up the apparatus (fig. 5–29).

Figure 5–29. WBGT Kit.

A dry bulb (DB) thermometer has its bulb shielded from the radiant heat (direct rays of the sun). It is used to measure the ambient air temperature. The DB must be shielded to avoid recording radiant heat. DB temperature = ambient air temperature.

A stationary wet bulb (WB) thermometer is exposed to the sun and prevailing wind. It is used to measure the evaporative effect of the ambient air temperature. It is wetted with distilled water prior to each reading. WB moisture in the air temperature = evaporative effect.

A similarly exposed black globe (BG) thermometer has a black sheath over the bulb. For a digital apparatus, the sheath and bulb are inside a transparent perforated plastic shield. For field apparatus, it is usually a 15-centimeter (cm), or 6-inch, diameter hollow copper sphere painted with a matte black finish or equivalent. The BG thermometer must be exposed for 25 minutes before the first reading. The BG temperature is equivalent to radiant heat (sun).

The WBGT kit is enclosed in an aluminum case. The threaded hole in the bottom is used to attach the case to a standard lightweight photographer's tripod (fig. 5–30).

Using the kit to assess thermal conditions is a fairly straightforward matter. The steps are as follows:

1. Gather equipment and supplies.
2. Select a suitable location and set up the WBGT apparatus. Readings should be taken at a location representative of the conditions to which workers are exposed.
3. Extend the legs of the tripod. Extend the neck of the tripod so the mounting device is between 3 to 5 feet above ground level.

4. Mount the WBGT apparatus to the tripod by securing with the mounting screw. All kits need to be mounted to allow for unrestricted airflow. Ensure the device is secure. Open the kit.
5. Position the kit with the thermometers' bulb ends toward the sun shielding the DB from direct sunlight and exposing the BG to direct sunlight. Lift the thermometer assembly up and out using the "lift here" tab.

Figure 5–30. WBGT Kit with Tripod.

6. Wet the WB wick thoroughly (the one with the white sock) with distilled water. Ensure it is completely saturated. The wick is cotton and about 5-inch long with a knot 1 inch from one end. The end nearer the knot is pushed into the reservoir and the other end is slipped on the thermometer bulb. The water reservoir should be filled with distilled water.
7. Allow the apparatus to stabilize in the sun for 25 minutes before taking a reading.
8. Properly take/record the WB, DB, and BG temperatures.

These temperature readings are used to calculate the WBGT index as described in the following paragraphs.

Regardless of the instrument used to obtain the WBGT, ensure there is unrestricted airflow around the device. If it is a model with the globe on the end, orient the instrument so that the globe end is towards the sun.

The WBGT index is calculated in one of two ways.

Steps for calculating a WBGT index using a slide calculator

Use the WBGT Index calculator (fig. 5–31) included with the field instrument for outdoor purposes. Follow the instructions on the right side of the calculator (slide rule type device included in the kit).

1. Set the WB temperature at the DB temperature.
2. Read the WBGT index at the BG temperature.

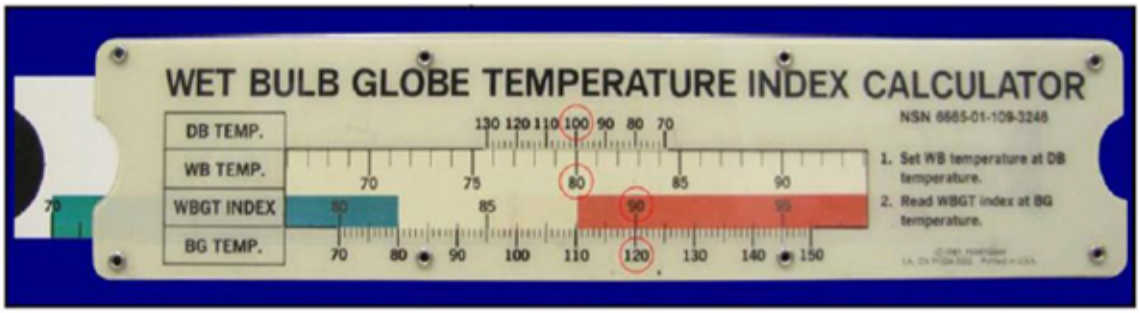


Figure 5–31. WBGT Index Calculator.

Consider the following example: Assume for purposes of instruction that the BG temperature reading is 120°, the WB temperature reading is 80°, and the DB temperature is 100°.

1. Move the 80 WB temperature scale so that it is directly under 100 DB temperature.
2. Find the 120 BG temperature.
3. Read the WBGT Index scale at the point directly above the BG temperature reading.
4. If performed correctly, the WBGT index should read 90.

Steps for calculating a WBGT index using a formula

There are two WBGT calculations: one for measurements collected outdoors with a solar load and one for measurements collected indoors or outdoors without a solar load. Solar load refers to when the WBGT instrument is placed directly in the sun. Solar load should not be used when the instrument is in the shade or under a covered outdoor area.

Outdoors with solar load: $WBGT = 0.7T_{wb} + 0.2T_{bg} + 0.1T_{db}$.

Indoors/Outdoors without solar load: $WBGT = 0.7T_{wb} + 0.3T_{bg}$.

Where: T_{wb} = WB temperature.
T_{db} = DB temperature.
T_{bg} = BG temperature.

NOTE: The DB temperature is not used with the indoor/outdoor without solar load calculation.

The WBGT results are used to determine the thermal stress levels or stages. These levels are displayed around the installation using a color-coded system such as flags or boards, as highlighted in the table below. It is important to determine how the WBGT index is disseminated throughout fixed bases and at deployed locations. Warning systems may vary based on many factors, such as size of the installation, number of personnel, base layout, and communication systems available. At many installations, you will call the command post with the WBGT results. The command post then disseminates this information throughout the installation. The appropriate flag is posted at various locations, such as the fitness center. Some installations convey information via electronic signs, public address systems, cable TV, and computer network systems. At deployed locations, options may vary depending on resources available. The following table provides the temperatures and stages during which flags are displayed.

Stage	Temperature Range	Flag Color
1	78–81.9 °F WBGT	No Flag Required
2	82–84.9 °F WBGT	Green

Stage	Temperature Range	Flag Color
3	85–87.9 °F WBGT	Yellow
4	88–89.9 °F WBGT	Red
5	90 °F WBGT and higher	Black

The combination of excessive heat and sustained activity can cause body temperatures to rise rapidly. In order to prevent a dangerous increase in body temperature, heat production must be minimized in the work place and rest periods increased. In very hot and humid conditions, reducing the duration of physical activity may be the only way to prevent dangerous increases in body temperature. Work schedules must be tailored to fit the mission, climate, and physical condition of personnel. Identifying appropriate work/rest (W/R) cycles and replacing fluids will help prevent heat-related disorders. WBGT results are used to help determine fluid replacement requirements and appropriate W/R cycles, which can be seen in the following table.

WORK and REST REGIME PER HOUR	WORKLOAD		
	LIGHT	MODERATE	HEAVY
Continuous Work	86	80	77
75% Work / 25% Rest	87	82	78
50% Work / 50% Rest	89	85	82
25% Work / 75% Rest	90	88	86

First, workload intensity must be determined (see AFI 48–151 for descriptions of each workload category). Once you have determined the appropriate workload intensity, find the current WBGT on the table under that workload, then look to the left in the temperature row to see what the W/R cycle is. As an example, if the workload is moderate and the WBGT is 85°F, the W/R cycle would be 50% work and 50% rest. Remember that when performing work/exercise in the ground crew ensemble (chemical protective overgarment [CPO]), fire-fighting gear, or other similar restrictive or impermeable clothing, 10°F should be added to the WBGT before using the tables. Add 15°F to the WBGT if also wearing combat armor on top. If combat armor is worn alone in humid climates, it adds only 5°F to the WBGT.

A comprehensive heat injury prevention and management program will follow the principles of risk management by identifying hazards, assessing the hazards in terms of severity, probability, and implementing appropriate controls to abate the hazards. Spot-checking and supervision must be employed to ensure control measures are being implemented. Units train using risk-management principles; therefore, the same framework should be applied to prevent heat weather injuries. In identifying, assessing and making decisions regarding heat injury prevention, considerations may contribute or present a heat related hazard. These include high heat category, especially on sequential days; high-exertion level of training, especially on sequential days; lack of acclimation and other individual risk factors, which include the following:

- Lack of quality sleep.
- Poor fitness.
- Overweight.
- Minor illnesses (such as cold symptoms).
- Prescribed or over-the-counter medications/supplements/dietary aids.
- Use of alcohol within the last 24 hours.
- Prior history of heat illness.
- Skin disorders (such as heat rash and sunburn).

- High temperatures at night/rest overnight.

Cold stress assessments

Operations in cold regions of the world expose personnel to the hazards of cold stress and the consequent risk of hypothermia, freezing and non-freezing injuries. For any given air temperature, wind increases the potential for body heat loss, skin cooling, and decreased internal body temperature. The likelihood and severity of injury will increase with prolonged exposure to lower temperatures and greater air velocity, whether it is due to man-made wind such as vehicle speed or propeller-generated wind, or actual wind. Man-made wind worsens the wind chill effect of natural wind.

The wind chill temperature index integrates wind speed and air temperature to provide an estimate of the cooling power of the environment and the associated risk of cold injury (fig. 5–32). Cold injury prevention relies upon minimizing exposure and reducing heat loss by using clothing. You are responsible for determining the Wind Chill Index zones of risk and displaying colored flags or boards on-base in order to minimize the risk of cold injury to personnel.

Wind (mph)	Temperature (°F)																	
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Note: Frostbite times are for exposed cheek skin.

Frostbite Times ►	30 minutes	10 minutes	5 minutes

Figure 5–32. Wind Chill Temperature Index.
(Source, AFI 48–151, Thermal Injury).

LEGEND:
FROSTBITE RISK
LOW—freezing is possible, but unlikely (WHITE)
HIGH—freezing could occur in 10–30 min (LIGHT GREY)
SEVERE—freezing could occur in 5–10 min (MEDIUM GREY)
EXTREME—freezing could occur in <5 min (DARK GREY)

To determine the wind chill temperature index, knowledge of both the wind speed and temperature are needed. BE personnel will obtain outside ground temperature, and wind speed from the installation weather office and determine the wind chill temperature and FRL. The wind chill temperature index chart uses wind speed in knots and miles per hour (mph) and temperature in degrees F. To find the wind chill temperature on the table, find the row corresponding to the wind speed, and then read across until reaching the column corresponding to the air temperature. In addition, use the chart in figure 5–33 to determine length of time until cheek frostbite occurs.

Wind Speed (mph)	Air Temperature (°F)											
	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	>120	>120	>120	>120	31	22	17	14	12	11	9	8
10	>120	>120	>120	28	19	15	12	10	9	7	7	6
15	>120	>120	33	20	15	12	9	8	7	6	5	4
20	>120	>120	23	16	12	9	8	8	6	5	4	4
25	>120	42	19	13	10	8	7	6	5	4	4	3
30	>120	28	16	12	9	7	6	5	4	4	3	3
35	>120	23	14	10	8	6	5	4	4	3	3	2
40	>120	20	13	9	7	6	5	4	3	3	2	2
45	>120	18	12	8	7	5	4	4	3	3	2	2
50	>120	16	11	8	6	5	4	3	3	2	2	2

Note: Wet skin could significantly decrease the time for frostbite to occur.

FROSTBITE RISK
LOW – freezing is possible, but unlikely (WHITE)
HIGH – freezing could occur in 10-30 minutes (LIGHT GREY)
SEVERE – freezing could occur in 5-10 minutes (MEDIUM GREY)
EXTREME – freezing could occur in <5 minutes (DARK GREY)

Figure 5–33. Time in Minutes until the Occurrence of Cheek Frostbite in the Most Susceptible 5 Percent of Personnel (Source, AFI 48–151, Thermal Injury).

Once all data for the cold stress assessment has been obtained, you can reference the following table to determine recommended working practice. Communicate this information to the commander and supervisor.

Frostbite Risk Level	Preventive Measures
Low	Recommended W/R cycle: 50 minutes of work/10 minutes of warming. Increase surveillance with self- and buddy-checks. Wear appropriate layers and wind protection for the work intensity. Cover exposed flesh if possible. Wear vapor barrier (VB) boots below 0°F. Provide warming facilities below 20°F. Avoid sweating.
High	Recommended W/R cycle: 40 minutes of work/20 minute of warming. Mandatory buddy-checks every 20–30 min. Wear appropriate layers and all-purpose environmental clothing system (APECS). Protect head, face and hands. Cover exposed flesh. Wear VB boots below 0°F. Provide warming facilities. Avoid sweating.

Frostbite Risk Level	Preventive Measures
Severe	Recommended W/R cycle: 30 minutes work/30 minutes of warming. Mandatory buddy-checks every 10 minutes. Wear appropriate layers and APECS or cold weather parka. Protect head, face, and hands. Wear VB boots. Provide warming facilities. Work groups of no less than two personnel. No exposed skin. Stay active. Avoid sweating.
Extreme	Mission critical work only due to extreme risk. Keep task duration as short as possible. Wear appropriate layers, cold weather parka and wind protection. Protect head, face and hands. Wear VB boots. Provide warming facilities. Work groups of no less than two personnel. No exposed skin. Stay active. Avoid sweating.

As with heat injury, a comprehensive cold weather injury prevention and management program will follow the principles of risk management by identifying hazards, assessing the hazards in terms of severity, probability, and implementing appropriate controls to abate the hazards. Cold-casualty prevention can only be achieved by using the information provided in the following table:

Type of Training	Description
Airman and leadership education	Assessing cold stress. Recognizing cold injuries. Limiting the effects of cold through clothing, shelter, and nutrition. Evaluating the impact of cold on the mission (for example, tasks take longer, more Airmen fatigue, likeliness of increased mistakes).
Life and career experience, including	Understanding that true effectiveness in cold environments only comes with experience. Practicing the clothing principles of layering and staying dry. These principles must be tailored to the individual, and must be practiced so that Airmen will learn when to dress down (before sweating begins) and when to add layers (before shivering begins). When using equipment in the cold: • Everything takes longer. • Special tools and/or clothing may be necessary. Planning for longer missions.
The posting of cold-casualty prevention information	
Establishing standard operation procedures for routines	
Training	Clothes that are appropriate and worn properly. Health and nutrition must be sustained. Airmen will protect each other. Leadership initiatives will be practiced.

243. Recommending thermal stress controls

Measures should be taken to minimize or alleviate thermal stress hazards, both hot and cold, which may impact safety, productivity, and mission accomplishment. Once measurements are taken, preventive measures and/or controls must be determined and recommended to leadership. The implementation of these measures will be determined by the commander and supervisors based on health risks, mission requirements, and resources.

Heat stress

It is important to consider the hierarchy of controls and decide which will be most effective (in this order): engineering, administrative, and/or PPE. Engineering controls are the most desirable, but are sometimes impractical. You must know the options available in order to make effective recommendations for controlling thermal stress.

Engineering controls

Engineering controls for heat stress are directed toward reducing physical work demands, reducing external heat gain from the air and hot surfaces, and enhancing external heat loss by increasing sweat evaporation and decreasing air temperature.

Dilution ventilation

Dilution ventilation brings in a supply of cooler air from another area and reduces the temperature in the work area by diluting the hot air with cooler air. This can be accomplished with general area ventilation, or local (spot) ventilation, such as fans.

Active cooling

Mechanical refrigeration, evaporative cooling, or a water chiller can be used to reduce the temperature of supplied air for dilution ventilation. Cool rooms are an example of providing a local area for cooling near work areas. By spending some time of the work cycle in the cooler area, the effective exposure to heat stress is reduced.

Shielding

If a source of radiant heat is well defined (i.e., boiler plant) and localized, it can be effectively controlled by shielding.

Administrative controls

Administrative controls change the way work is performed in order to limit exposures or risks. For heat stress, they are directed toward limiting exposures so that increases in heart rate and core temperature do not exceed accepted limits. Administrative controls are described in the following paragraphs:

Acclimatization

The process of acclimatization is characterized by a series of physiological adjustments that occur when an individual is exposed to a hot climate. In other words, the body adapts to the hot environment over a period of time. Acclimatization is usually achieved through a schedule of increasing exposures and occurs during the first 10–14 days of heat exposure. An individual is considered acclimatized if he or she has undertaken regular exercise for longer than 10 days in the same environmental conditions as the proposed activity.

Pace of work

Methods to reduce the metabolic rate can go a long way toward reducing heat stress. The rate is reduced when the same amount of work is performed over a longer period of time. Any idle time inherent in the work process should be spent in cooler areas to realize the full benefit.

Sharing work

Another way to reduce metabolism is to share or distribute the work among other workers. This may require some work be postponed to another time.

Scheduling of work

Supervisors may schedule work to reduce the contribution of environmental heat to heat stress. This includes scheduling non-essential work to cooler times of the day.

Work times, self-determination, and personal monitoring

Predetermined work times are assigned to a worker or crew before a job begins. They are allowed to extend the work time with the knowledge that heat stress will eventually affect their ability to work, and stop working at the first sign of heat strain. Workers/supervisors may also lower peak work demands and make the work demands lighter. For example, workers may level out work demand over time.

Fluid replacement

In hot environments, a great deal of water is lost from the body in the form of sweat. This water must be replaced to prevent adverse effects from heat. Refer to the water intake guidelines provided in the tables below. Drinking water is a must in order to prevent heat injury. Water should be cool, potable, and from a safe source. Workers should drink small quantities at frequent intervals. Urine color, not thirst, is a reliable indicator of an individual's hydration status. Personnel should drink enough water to ensure their urine remains colorless. Carbohydrate/electrolyte beverages and flavoring may be used to enhance palatability and, as a result, encourage fluid consumption. It is better to drink non-caffeinated fluids, since caffeine increases water requirements. AFI 48–151 requires that all personnel be informed of the potential risks of over hydration and potential electrolyte imbalance.

Heat Cat/Flag Color	WBGT (°F)	Easy Work		Moderate Work		Hard Work	
		Work/Rest Cycle	Water Intake (quarts per her [qt/h])	Work/Rest Cycle	Water Intake (qt/h)	Work/Rest Cycle	Water Intake (qt/h)
1	78–81.9	No Limit	0.5	No limit	0.75	40/20 min	0.75
2	82–84.9	No Limit	0.5	50/10 min	0.75	30/30 min	1.0
3	85–87.9	No Limit	0.75	40/20 min	0.75	30/30 min	1.0
4	88–89.9	No Limit	0.75	30/30 min	0.75	20/40 min	1.0
5	>90	50/10 min	1.0	20/40 min	1.0	10/50 min	1.0

Heat Cat/Flag Color	WBGT (°F)	Easy Work		Moderate Work		Hard Work	
		Work/Rest Cycle	Water Intake (qt/h)	Work/Rest Cycle	Water Intake (qt/h)	Work/Rest Cycle	Water Intake (qt/h)
1	78–81.9	No Limit	0.5	50/10 min	0.75	30/30 min	0.75
2	82–84.9	No Limit	0.5	40/20 min	0.75	30/30 min	1.0
3	85–87.9	No Limit	0.75	30/30 min	0.75	20/40 min	1.0
4	88–89.9	50/10 min	0.75	20/40 min	0.75	10/50 min	1.0
5	**>90**	**40/20 min**	**1**	**10/50 min**	**1.0**	**Not allowed**	**Not allowed**

Diet, life-style, and general health

Adequate sleep, a good diet, exercise, and a healthy lifestyle, including no abuse of alcohol or drugs, are important to lowering the risk of a heat-related disorder.

Awareness training

Awareness training is an essential feature of heat stress management and should be conducted for both employees working in heat-related jobs/environments and for their supervisors. Training should address the following:

- Description of heat stress—environment, work demands, and clothing.
- Physiological responses, including acclimatization.
- Recognition of, and first aid for, heat-related disorders.
- Heat stress hygiene practices, such as an individual's actions to reduce the risks to a heat disorder (e.g., fluid replacement, diet, terminating heat exposure at the first symptom of a heat-related disorder). Emphasis should be placed on individual responsibility.
- Overview of heat stress policy and guidelines.
- Workplace/unit/base policy.
- Management responsibilities.
- Employee responsibilities.

Personal protective equipment

PPE provides protection for individual workers. For heat stress, PPE is primarily in the form of personal cooling, but can include reflective clothing for high-radiant heat conditions. Keep in mind that PPE is used as a last resort, when other control measures are not feasible or available. Examples include the following paragraphs:

Circulating air systems

Circulating air as a personal cooling method consists of circulating air under the clothing and around the torso. It is a delivery of air to the individual either through a high-pressure air line and a pressure reducer, or by a portable (self-contained) blower. This increases the amount of convective and evaporative cooling of the body.

Circulating water systems

A second type of personal cooling is a system that circulates cool water through tubes and channels around the body. The system virtually covers the whole body or only portions of the back and chest.

Ice garments

Ice vests can be used to control heat strain by removing body heat from the skin to the packets of ice. The vests provide good mobility, with some bulk around the torso. The ability to cool, and the length of time an ice vest is effective, depends on the rate of work, the amount of ice, and the design of the particular garment.

Reflective clothing

Reflective clothing is designed to reduce the amount of heat reaching the individual and is best suited for sources of high radiant heat. There is a trade-off, in that it reduces sweat evaporation and could actually increase the level of heat stress of the worker.

Cold stress

For specific jobs, the control of cold stress on workers is also accomplished through engineering and administrative controls and PPE.

Engineering controls

Engineering controls for cold stress reduce heat loss from the person as a whole or from exposed skin. They include the following:

- General or spot heating including hand warming.
- Minimizing air movement (e.g., shielding, adjusting ventilation).
- Reducing conductive heat transfer (e.g., no metal chairs or un-insulated tools).
- Redesigning equipment.
- Processes to control systemic and local cold stress.
- Providing temporary shelter (preferably heated) for essential outdoor work.

Administrative controls

Administrative controls for cold stress that help reduce the exposure time, allow individual control over the work, and provide for mutual observation include the following:

- Providing for work/warm cycles—resting in warm areas.
- Scheduling work to warmest times.
- Moving work to warmer areas or indoors where possible.
- Assigning additional workers to a task and operating a rotational duty system.
- Encouraging self-pacing and extra breaks as required.
- Using the buddy system and emphasizing mutual observation.
- Allowing for productivity reductions and extra effort from protective clothing.
- Curtailing non-essential tasks when necessary and mission permits.
- Knowing the signs and symptoms of cold-related disorders.

Personal protective equipment

PPE is fundamental in managing cold stress. PPE includes the following:

- Properly selected insulating clothing. Cold-weather clothing protection is based on the principles of insulation, layering, and ventilation. Personnel can vary their clothing to regulate protection and stay comfortable.
- Layer clothing experience has shown that several layers of clothing are typically better than one heavy layer. The clothing must allow the sweat to leave the skin of the worker and evaporate.
- Workers should wear water barriers to external liquids, such as Gortex® or rain gear.
- Appropriate active warming systems, such as hand/foot warmers, and gloves/mittens.

AFI 48–151 provides a list of recommended preventive measures:

Frostbite Risk Level	Preventive Measures
Low	Recommended W/R cycle: 50 minutes work/10 minutes warming. Increase surveillance with self- and buddy-checks. Wear appropriate layers and wind protection for the work intensity. Cover exposed flesh if possible. Wear VB boots below 0 °F. Provide warming facilities below 20 °F. Avoid sweating.
High	Recommended W/R cycle: 40 minutes work/20 minutes warming. Mandatory buddy-checks every 20–30 minutes. Wear appropriate layers and APECS. Protect head, face and hands. Cover exposed flesh. Wear VB boots below 0 °F. Provide warming facilities. Avoid sweating.
Severe	Recommended W/R cycle: 30 minutes work/30 minutes warming. Mandatory buddy-checks every 10 minutes. Wear appropriate layers and all-purpose environmental clothing system (APECS) or cold weather parka. Protect head, face and hands. Wear VB boots. Provide warming facilities. Work groups of no less than two personnel. No exposed skin. Stay active. Avoid sweating.
Extreme	Mission critical work only due to extreme risk. Keep task duration as short as possible. Wear appropriate layers, cold weather parka and wind protection. Protect head, face and hands. Wear VB boots. Provide warming facilities. Work groups of no less than two personnel. No exposed skin. Stay active. Avoid sweating.

When providing thermal stress control recommendations, it is important to effectively communicate the health risk to commanders and supervisors. The controls are just recommendations. The implementation of the controls will be determined by the commander and supervisors based on health risks, mission requirements, and resources.

244. Health/medical effects of extended individual protective equipment/chemical protective overgarment wear

Wearing IPE/CPO (protective mask, overgarment, hood, gloves, glove inserts, overboots and field gear, or any combination of these) increases the heat burden on the body. Some personnel may also require additional specialized equipment, such as body armor, load bearing equipment, and field accessories to perform their mission, further increasing the heat stress. IPE/CPO and other protective garments prevent the transfer of air and moisture. This restricts normal heat loss

mechanisms because of their high insulation and low permeability to water vapor. These effects occur even when ambient temperature and humidity are relatively low.

In addition to heat-related problems already mentioned, wearing IPE/CPO causes performance degradation from increased heat and mental stress, loss of visual and tactile acuity, and reduced hearing. When performing work/exercise in the ground crew ensemble, fire-fighting gear, or other similar restrictive or impermeable clothing, 10 °F should be added to the WBGT before using the tables. If also wearing combat armor, add 15 °F to the WBGT. The addition of 10–15°F to the WBGT greatly affects W/R cycles and fluid requirements. Refer to the tables on FRLs and preventive measures.

Like heat stress, cold stress can also have an impact on the worker and the work place. Consequently, the effects of cold-related exposures are described in the following paragraphs.

Frostbite

Heavy work increases sweat accumulation in the gloves, degrading the insulation, and increasing frostbite susceptibility in the fingers. Gloves limit the ability to visually inspect for signs of cold injury. Wearing the CPO with heavy cold weather clothing creates the unexpected situation where heat exhaustion becomes a possibility for Airmen working hard, even in subzero temperatures as low as –22 ºF. The added insulation and decreased ventilation of chemical, biological, and radiological (CBR) protective clothing can result in heavy sweating and wetting of the clothing during hard physical activity. When this activity ceases, large heat losses ensue, and finger and toe temperatures can decrease significantly.

Protective masks

In extremely cold temperatures (–20 ºF and below), the protective mask becomes very rigid and is difficult to don. When donned at these temperatures, the protective mask causes instantaneous frostbite on the face. Frostbite occurs when the face comes in contact with the metal rivets on the inside of the mask. Eyepiece fogging is very common when protective masks are worn in cold weather. The drinking tube on the M17-series mask will become unusable when temperatures are below freezing.

Chemical protective rubber gloves

Individuals, whose tasks require a high degree of manual dexterity, may be unable to wear cold weather gloves or mittens over the chemical protective rubber gloves.

Although medical personnel have an active input in the prevention and treatment of thermal stress and casualties, the multi-disciplinary approach of utilizing BE, PH, weather, and operations personnel in establishing and monitoring the thermal environment, provides a comprehensive assessment of risk to personnel. The overall approach to thermal injury prevention and risk management involves administrative as well as physical techniques.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

240. Thermal stress hazards

1. List the signs and symptoms of heat illness.

2. What is the most serious heat-related disorder?

3. List the work-related risk factors to consider when accomplishing a heat stress evaluation.

4. What climatic factors influence the rate of heat exchange between a person and the environment?

5. What are the physiological responses to cold stress?

241. Roles and interactions in thermal stress situations

1. At what outside daily high temperature are WBGT measurements taken and how often?

2. What offices/personnel are involved in determining the FITS zones and notifying the aircrews?

3. Who approves and authorizes unit commanders to reduce the MOPP level?

242. Analyzing thermal stress hazards

1. List the equipment and supplies needed to perform a WBGT.

2. No matter what device is used to obtain a WBGT, how should it be positioned?

3. How should the device be oriented if you use the WGBT model with a globe on the end?

4. At what temperatures is a red flag is displayed?

243. Recommending thermal stress controls

1. List the hierarchy of thermal stress control measures in order of precedence.

2. Which engineering control involves using a fan to reduce the temperature in a work area?

3. List the administrative controls for thermal stress.

4. What form of control is used when a worker varies the amount of clothing worn in a cold climate?

244. Health/medical effects of extended individual protective equipment/chemical protective overgarment wear

1. How does the extended wear of IPE/CPO affect the determination of WBGT?

2. Explain the possible injuries that can occur when personnel don protective masks in extremely cold temperatures.

3. Describe how wearing chemical protective rubber gloves can hinder a person's protection from cold weather.

Answers to Self-Test Questions

227

1. (1) Participate in the review of the workplace hazards as process owners to identify actions taken to mitigate hazardous noise.
   (2) Eliminate exposure to potentially hazardous noise and protecting the hearing of assigned personnel (by engineering controls).
   (3) Properly mark hazardous noise areas and equipment with signs and/or decals to alert personnel of the potential hazard.
   (4) Inform BEE/PH staff of workplace equipment or practices and procedures involving potentially hazardous noise change.
   (5) Ensure compliance and availability of approved HPD for workers exposed to hazardous noise.
   (6) Instruct personnel on the HCP, care/hygiene, and proper use of their approved HPDs.
   (7) Ensure workers with an occupational exposure to hazardous noise complete an initial/reference audiogram and receive HCP training from PH.
   (8) Conduct initial and annual workplace-specific hearing conservation training on shop or unit hazardous noise exposures and equipment.

(9) Notify each employee exposed at or above the 8-hour TWA of 85 dB(A) of the noise monitoring results performed by BE.

2. (1) Perform noise surveys and dosimetry to quantify noise hazards and document the results in DOEHRS-IH module.
   (2) Work with a PMEL and/or BE personnel to ensure proper calibration and certification of noise meters.
   (3) Complete the SEG OEHED for the OEHWG, including the 8-hour TWA and required controls.
   (4) Provide PH and shop supervisors the results of noise surveys, dosimetry, and required controls (i.e., engineering, administrative, and/or HPD).
   (5) Assess the adequacy of all controls used to reduce noise exposures, including hearing protectors, and, in conjunction with the shop supervisor, the feasibility of engineering controls for hazardous noise equipment/areas.
   (6) Assist with fitness and risk evaluations upon request of provider.
   (7) Review facility and operations plans for new or modified facilities to ensure noise exposure control is appropriately considered.
   (8) Conduct workplace assessments to support occupational illness/injury investigations, claims for hearing loss, and areas where adverse hearing loss trends exists.
   (9) Certifying the audiometric testing environment on an annual basis.

228

1. The surface of a sound source first bends in one direction and the air molecules next to it become compressed. This causes a slight increase in atmospheric pressure. As the sound source moves in the opposite direction, molecules near its surface are drawn away from the surrounding air to create an area of lower atmospheric pressure. This process is known as rarefaction. The vibrating sound source repeats this process over and over, causing alternate areas of compression and rarefaction in the molecules near the source. These air molecules, in turn, cause compression and rarefaction in the molecules next to them. This forms a repetitive wave-like motion, known as a sound wave.
2. A pure tone is a sound wave characterized by one single frequency. Complex sound is a wide variety of different tones and amplitudes mixed together so that no single one is recognizable.
3. Velocity.

229

1. It is what is actually measured and reported when quantifying sound; additionally, it is the difference between normal atmospheric pressure and the actual pressure during compression and rarefaction. It is expressed in newtons per square meter or pascals.
2. Sound measuring instruments are calibrated to respond to frequencies in the same way as the human ear. Different frequencies are weighted by different amounts so that they are all perceived to have the same loudness when they have the same number of weighted dBs.

230

1. Auditory effects include hearing loss, tinnitus and acoustic trauma. Hearing loss due to noise is the result of damage to the hair cells and accompanying degeneration of the nerve fibers in the ear. The change in hearing, or threshold shift, can be temporary or permanent. Tinnitus is the condition in which people perceive they hear sounds (e.g., ringing, roaring, whistling, humming, hissing, etc.) in one or both ears when there is no actual sound around them. Acoustic trauma is the temporary or permanent hearing loss due to a sudden extremely high intensity noise, such as an explosion.
2. Non-auditory effects are undesirable effect on the body other than hearing effects. They are also known as whole body effects. Symptoms are similar to those associated with general reactions to stress. There may be an upset sense of balance, dilated pupils, speech and sleep communication problems, increased fatigue, nervousness, irritability, high blood pressure and overall stress levels. Noise may have an adverse effect on job performance and community relations.

231

1. Steady-state noise having an 8-hour TWA noise level greater than or equal to 85 dB(A), or impulse/impact noise levels greater than 140 dB peak SPL, regardless of duration.
2. The criterion level is the sound level allowed for an 8-hour exposure and is used as the basis for measurement of a noise standard. The AF criterion level is 85 dB(A). The AF exchange rate (doubling rate), is 3 dB. The exchange rate deals with the relationship between the sound level and the allowed exposure time. For every increase of 3 dB, the allowable exposure time is cut in half. For every decrease of 3 dB, the allowable exposure time is doubled.
3. They are sound levels and durations to which nearly all workers may be exposed without permanent adverse effect on their ability to hear and understand normal speech.
4. You should sketch the room to show its shape, size, layout of equipment, workstations, and break areas. Identify the materials used in the construction of the walls, floor, and ceiling. Note any acoustical treatment (such as ceiling tiles), or the potential for treatment. Describe if secondary sources or spill-over noise from other areas contribute to the noise at a particular workstation. In your sketch of the room or facility, show the type and location of any shields/barriers or enclosures and whether they seem to be effective.

232

1. Before and after each period of measurement.
2. A-weighting, slow response.
3. When performing noise source surveys, you should measure sound levels at the equipment operator's ear position but preferably with the operator at least 3 feet away. You must usually orient the axis of the microphone so that its angle of incidence is 70° to the sound source. This is the way random-incidence microphones are made to be used.

233

1. (1) Determine engineering controls.
   (2) Select HPD.
   (3) Measure the SPLs in audiometric booths.
   (4) Evaluate the whole body effects of sound.
2. Measurements are taken for dB(A), dB flat, and one for each of the octave bands.
3. Annually.

234

1. To quantify worker exposure and determine if personnel need to be enrolled in the HCP.
2. (1) Criterion Level: 85 dB(A).
   (2) Threshold Level: 80 dB(A).
   (3) Exchange Rate: 3 dB.
3. TWA noise levels shall be determined for all AF workers routinely working in hazardous noise areas at least once and within 30 days of any change in operations affecting noise levels.

235

1. Process substitution, product substitution and machine treatments.
2. Shields and barriers, enclosures, and room treatments.
3. Where possible with an AFVA 48–101, 48–103, 48–104, and/or 48–105 to warn operators of the need to wear hearing protection.
4. Each tool or piece of equipment producing noise levels greater than or equal to 85 dB(A), including vehicles, will be conspicuously marked, where feasible, to alert personnel of the potential hazard. The exception to this is when an entire space is designated a hazardous noise area, and the equipment is stationary.

236

1. When the 8-hour TWA exceeds 94 dB(A).
2. When the 8-hour TWA is less than 94 dB(A).
3. Using the formula dB(A) – (NRR – 7) provides 102 dB(A) – (22 – 7) = 87 dB(A).

237

1. Disorders of the musculoskeletal system that have developed gradually over time, and which can be attributed, either completely or in part, to a person's occupation and related workplace conditions.
2. Vibration, repetition, awkward and/or static postures, forceful exertion and heavy lifting, contact stress, and temperature.

238

1. How many workers are employed in each job? What are the characteristics of the workforce (e.g., gender, age, etc.)? What are the primary tasks involved in each job? What is the established work rate and how is it determined? What opportunities are there for workers to rotate to other jobs? How many hours do employees work each week, is the work organized into shifts, and how much overtime (if any) is required?
2. By visiting the shop at different times during the day.

239

1. Change the transportation methods, change the process or product, modify containers or parts presentation for easier reach, and change workstation layout.
2. They can be implemented quickly, often at low cost, making them useful as temporary measures while awaiting engineering control implementation. They can be implemented when engineering controls may not be possible or practical. The education and training continues to be beneficial to workers even after an engineering control has been implemented.
3. Reductions of musculoskeletal disorder the incidence rates, severity rates, job turnover or absenteeism, workers compensation claims, workers complaints of discomfort, and an increase in productivity of the quality products and services.

240

1. (1) Dizziness or confusion.
   (2) Nausea or vomiting.
   (3) Staggering.
   (4) Disturbed vision.
   (5) Confusion, collapse or loss of consciousness.
2. Heat stroke.
3. Hot environments, high work demands, and protective clothing requirements.
4. Air temperature and air speed.
5. The first physiological response to cold stress is to conserve body heat by reducing blood circulation to the skin; the second physiological response is shivering, which increases the rate of metabolism.

241

1. At 85 °F, WBGT measurements are to be taken a minimum of four times, evenly spaced, during the hottest part of the day.
2. Meteorological/weather staffs, BE personnel, and squadron operations flights.
3. The senior AF commander.

242

1. (1) WBGT apparatus/kit.
   (2) Tripod or stand to mount or suspend thermometers for unrestricted airflow.
   (3) Distilled water.
   (4) Equipment instructions (if using a digital WBGT kit).
2. Ensure there is unrestricted airflow around the device.
3. Orient the instrument so that the globe end is towards the sun.
4. 88–89.9 ºF.

243

1. Engineering, administrative, and PPE.
2. Dilution ventilation.
3. Acclimatization, pace of work, sharing work, scheduling of work, work times, self-determination, personal monitoring, fluid replacement, diet, life-style, and general health, as well as awareness training.
4. PPE.

244

1. When performing work/exercise in the ground crew ensemble, fire-fighting gear, or other similar restrictive or impermeable clothing, 10 °F should be added to the WBGT before using the tables. Add 15 °F to the WBGT if also wearing combat armor. The addition of 10–15 °F to the WBGT greatly affects W/R cycles and fluid requirements.
2. In extremely cold temperatures (–20 ºF and below), the protective mask becomes very rigid and is difficult to don. When donned at these temperatures, rivets in the protective mask cause instantaneous frostbite on the face.
3. Individuals whose tasks require a high degree of manual dexterity may be unable to wear cold weather gloves or mittens over the rubber gloves.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

65. (227) Upon conducting a noise survey of an Air Force (AF) industrial workplace, identifying concerns, and developing questions about noise characteristics on a new piece of equipment, who would you consult for information on this noise source?
    a. Wing safety.
    b. Aerospace medicine squadron commander.
    c. Environmental Safety and Occupational Health (ESOH) council.
    d. United States Air Force School of Aerospace Medicine (USAFSAM).

66. (227) Who is responsible for the proper fitting of hearing protection devices (HPD)?
    a. Wing safety.
    b. Public health (PH).
    c. Workplace supervisor.
    d. Bioenvironmental engineering (BE).

67. (227) Which office is responsible for conducting noise surveys and dosimetry?
    a. Public health (PH).
    b. Wing safety.
    c. Bioenvironmental engineering (BE).
    d. United States Air Force School of Aerospace Medicine (USAFSAM).

68. (228) The distance from one point of a sound wave to an identical point on the next wave is known as the
    a. velocity.
    b. amplitude.
    c. frequency.
    d. wavelength.

69. (229) The amount of sound power per unit area is known as sound
    a. wave.
    b. intensity.
    c. weighting.
    d. power level.

70. (229) The characteristic of sound that we measure and report when quantifying sound is called the sound
    a. weightings.
    b. intensity.
    c. pressure.
    d. power.

71. (229) What weighting is used to measure sound when assessing hazardous noise?
    a. A-weighting.
    b. B-weighting.
    c. C-weighting.
    d. Flat weighting.

72. (230) Whole body effects are also known as
    a. non-auditory effects.
    b. auditory effects.
    c. threshold shifts.
    d. hearing effects.

73. (231) On what two factors are hazardous noise exposure limits based?
    a. Auditory and non-auditory effects.
    b. Sound levels and duration of exposure.
    c. Control methods available and sound levels.
    d. Number of workers and control methods available.

74. (231) What type of survey is used to classify whether a particular piece of noise-producing equipment exceeds the criterion level of 85 A-weighted decibels (dB[A]) and could present a potential exposure hazard to workers?
    a. Noise source.
    b. Noise dosimetry.
    c. Worker exposure.
    d. Hazardous noise area.

75. (232) What sound level meter response time would you select to determine the average noise levels for industrial type operations and when taking Occupational Safety and Health Administration (OSHA) compliance measurements?
    a. Fast.
    b. Slow.
    c. Impulse.
    d. Moderate.

76. (232) When performing a noise source survey, at what weighting and response time should you set your sound level meter?
    a. Flat, medium response.
    b. C-weighting, fast response.
    c. A-weighting, fast response.
    d. A-weighting, slow response.

77. (232) What environmental factors may affect the performance of noise measurement instruments and their readings?
    a. Wind chill index, altitude, density, and humidity.
    b. Wind chill index, temperature, humidity, and barometric pressure.
    c. Temperature, humidity, atmospheric pressure, and magnetic fields.
    d. Density, wet bulb globe barometer, moisture, and atmospheric pressure.

78. (232) At what angle to the sound source *must* you hold a random incidence microphone when collecting sound level readings?
    a. 0 degrees.
    b. 45 degrees.
    c. 70 degrees.
    d. 90 degrees.

79. (233) What can be used to evaluate the whole body effects of sound?
    a. A noise dosimeter.
    b. An audiometric booth.
    c. An octave band analysis.
    d. An acoustic trauma meter.

80. (233) What parameters *must* you set the octave band analyzer before performing the octave band survey?
    a. Z-weighting, fast, sound pressure level (SPL).
    b. C-weighting, slow, impulse.
    c. Z-weighting, slow, impulse.
    d. A-weighting, fast, SPL.

81. (233) How often are audiometric test booths monitored when all measurements taken are within the Air Force (AF) criteria?
    a. Monthly.
    b. Annually.
    c. Quarterly.
    d. Bi-annually.

82. (234) At what exchange rate in decibels (dB) should a noise dosimeter be set for measurements to be compared to Air Force (AF) standards?
    a. 1 dB.
    b. 3 dB.
    c. 80 dB.
    d. 85 dB.

83. (234) Which is the conversion needed by noise dosimeters that indicate the daily dose as a percentage?
    a. Compliance factor.
    b. Average daily factor.
    c. Time weighted average.
    d. Daily equivalent sound level.

84. (235) What type of noise control should be considered first?
    a. Path.
    b. Source.
    c. Surface.
    d. Receiver.

85. (235) What type of machine treatment control at the source is the *most* direct method used to reduce noise hazards associated with equipment vibration?
    a. Isolate the source.
    b. Reduce the driving force.
    c. Build a barrier to enclose the source.
    d. Move the worker away from the source.

86. (236) How is attenuation estimated to combine the noise reduction rating (NRR) for earplugs and earmuffs worn together?
    a. Subtract 3 decibels (dB) from the highest NRR of the plug or earmuff.
    b. Subtract 10 dB from the combined NRR of the plugs and earmuffs.
    c. Add 3 dB to the highest NRR of the plug or earmuff.
    d. Add the two NRRs together.

87. (237) What occupational illness gradually develops from chronic exposure to poor ergonomic conditions in the workplace?
    a. Ergonomic injury disorder.
    b. Musculoskeletal injury disorder.
    c. Workplace occupational disorder.
    d. Work-related musculoskeletal disorder (WMSD).

88. (237) How can the presence of ergonomic risk factors affect the likelihood of work-related musculoskeletal disorders (WMSD)?
    a. Ensuring.
    b. Reducing.
    c. Elevating.
    d. Eliminating.

89. (238) What is the *first* step in performing an ergonomic assessment?
    a. Gather information about the work place.
    b. Know how many workers are employed in each job.
    c. Establish the characteristics of the work force (i.e., gender and age).
    d. Determine if there are opportunities for workers to rotate between jobs.

90. (239) Which type of ergonomic control is implementing a preventive maintenance (PM) program for equipment?
    a. Process.
    b. Engineering.
    c. Administrative.
    d. Personal protective equipment (PPE).

91. (239) What would be considered an indicator of long-term ergonomic hazard control success?
    a. Providing a safe and healthy workplace.
    b. Redesign of workplace conditions and processes.
    c. Implementing recommended controls and procedures.
    d. Reductions in musculoskeletal disorder incidence rates.

92. (240) Reversible freezing of superficial skin layers usually marked by numbness, whiteness of the skin, and possible itching or pain is known as
    a. frostnip.
    b. frostbite.
    c. chilblain.
    d. hypothermia.

93. (241) Provided with the fighter index of thermal stress (FITS) zone, which office is responsible for determining the zone applicability within the aircrew working environment and provide appropriate warnings to the aircrew?
    a. Bioenvironmental engineering (BE).
    b. Meteorological/weather staff.
    c. Squadron operations flight.
    d. Public health (PH).

94. (241) Which office is responsible for the determination of wind chill index zones and notifying the installation command post of the resulting frostbite risk level (FRL)?
    a. Public Health (PH).
    b. Squadron operation flight.
    c. Meteorological/weather staff.
    d. Bioenvironmental engineering (BE).

95. (242) The thermal components used to assess heat stress are air temperature,
    a. humidity, and air speed.
    b. air speed, and radiant heat.
    c. humidity, air speed, and radiant heat.
    d. barometric pressure, humidity, and air speed.

96. (242) Which is an important precaution with the black globe thermometer before the measurements are taken?
    a. Unshielded from radiant heat and wetted with distilled water.
    b. Exposed for 25 minutes before reading.
    c. Unshielded from radiant heat.
    d. Shielded from radiant heat.

97. (242) When calculating a wet bulb globe temperature (WBGT) index, which situation requires the formula that does *not* use the dry bulb temperature?
    a. Indoors with solar load.
    b. Outdoor with solar load.
    c. Indoors/outdoors with solar load.
    d. Indoors/outdoors without solar load.

98. (243) What is the hierarchy of thermal stress controls?
    a. Engineering, administrative, and personal protective equipment (PPE).
    b. Engineering, PPE, and administrative.
    c. Administrative, engineering, and PPE.
    d. PPE, administrative, and engineering.

99. (243) What type of administrative control includes a schedule of increasing exposure and occurs during the first 10 to 14 days of heat exposure?
    a. Pace of work.
    b. Acclimatization.
    c. Personal monitoring.
    d. Scheduling of work.

100. (244) What illnesses can Airmen potentially suffer from when working hard while wearing the chemical protective over garment (CPO) with heavy, cold weather clothing?
    a. Cold stress.
    b. Heat stress.
    c. Hypothermia.
    d. Heat exhaustion.

Glossary of Abbreviations and Acronyms

@	at
°	degree
µg/m^3	microgram per cubic meter
µm	micrometer
λ	wavelength
ACES OP	Automated Civil Engineer System Operations
ACGIH	American Conference of Governmental and Industrial Hygienists
AF	Air Force
AFI	Air Force instruction
AFIS	Air Force Inspection System
AFMAN	Air Force manual
AFOSH	Air Force Occupational Safety and Health
AFPAM	Air Force pamphlet
AFPD	Air Force policy directive
AFR	Air Force Reserve
AFSAS	Air Force Safety Automated System
AFSC	Air Force specialty code
AFTTP	Air Force tactics, techniques, and procedures
AFVA	Air Force visual aid
AGE	aerospace ground equipment
AHLTA	Armed Forces Health Longitudinal Technology Application
AIHA	American Industrial Hygiene Association
AL	action level
ALARA	as low as reasonably achievable
ANG	Air National Guard
ANSI	American National Standards Institute
AOME	Aerospace and Operational Medicine Enterprise
AOR	area of responsibility
APECS	all-purpose environmental clothing system
ASTM	American Society for Testing and Materials
AT	antiterrorism
BE	bioenvironmental engineering
BEE	bioenvironmental engineer
BEI	biological exposure index
BG	black globe
BP	boiling point
c	velocity
C	Celsius; time of exposure (in minutes)
CAS	Chemical Abstracts Service
CBR	chemical, biological, and radiological

CBRN	chemical, biological, radiological, and nuclear
CBRNE	chemical, biological, radiological, nuclear and high-yield explosives
CC	commander
CCIP	commander's inspection program
CCIR	commander's inspection report
CDC	Centers for Disease Control and Prevention
CE	civil engineering
CFR	Code of Federal Regulations
cm	centimeter
CNS	central nervous system
COA	course of action
CPO	chemical protective overgarment
CSM	conceptual site model
DB	dry bulb
dB	decibel
dB(A)	decibels A-weighted
dB(C)	decibels C-weighted
DD	Department of Defense (used with forms)
DOD	Department of Defense
DODD	Department of Defense directive
DODI	Department of Defense instruction
DODM	Department of Defense manual
DOEHRS	Defense Occupational and Environmental Health Readiness System
DOEHRS-EH	Defense Occupational and Environmental Health Readiness System – Environmental Health
DOEHRS-IH	Defense Occupational and Environmental Health Readiness System – Industrial Hygiene
DOEHRS-IR	Defense Occupational and Environmental Health Readiness System – Incident Reporting
DOT	Department of Transportation
DRI	direct reading instrument
EAP	exposure assessment priority
ECL	equivalent continuous sound level
ECT	equivalent chill temperature
EESOH-MIS	Enterprise Environmental, Safety, and Occupational Health Management Information System
EHRA	environmental health risk assessment
EM	emergency management
EMF	electro-magnetic frequency
EPA	Environmental Protection Agency
ERP	Environmental Restoration Program
ESOH	environmental safety and occupational health
ESOHCAMP	Environmental, Safety and Occupational Health Compliance Assessment Management Program

f	frequency
F	Fahrenheit
F&ES	fire and emergency services
FHP	force health protection
FITS	fighter index of thermal stress
FPCON	force protection condition
FRL	frostbite risk level
ft	feet
g/L	gram per liter
g/mol	gram per mole
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
GSU	geographically separated unit
h	hour
HAF	Headquarters Air Force
HAZCOM	hazard communication
HAZMAT	hazardous material
HCP	health care provider; hearing conservation program
HCPM	hearing conservation program manager
HHA	hand held assay
HHQ	higher headquarters
HHSC	health hazard severity category
HIPPA	Health Insurance Portability and Accountability Act
HMIRS	Hazardous Material Information Resource System
HMMP	hazardous material management program
HPD	hearing protection device
HRA	health risk assessment
HRM	health risk management
HVAC	heating, ventilation, and air conditioning
Hz	hertz
IARC	International Agency for Research on Cancer
IAW	in accordance with
IBC	intermediate bulk container
IDLH	immediately dangerous to life and health
IG	inspector general
IH	industrial hygiene
in Hg	inches of mercury
IP	interservice publication
IPC	illness probability category
IPE	individual protective equipment
J	joule
J/sec	joule per second
JBAIDS	joint biological agent identification and diagnostic system
JSLIST	Joint Services Lightweight Integrated Suit Technology

kg	kilogram
L_A	A-weighted sound level
LC	lethal concentration
LD	lethal dose
L_{eq}	equivalent continuous sound level
LER	longitudinal exposure record
L_{et}	equivalent sound level for time period T
L_i	sound level of each noise source above 80 decibels A-weighted
LIN	linear
log	logarithm
LRN	Laboratory Response Network
m	meter
m/sec^2	meter per second squared
m^2	square meter
MAJCOM	major command
MARPOL	marine pollution
MEG	military exposure guideline
MEK	methyl ethyl ketone
mg/kg	milligram per kilogram
mg/L/4h	milligram per liter per 4 hours
MGA	major grading area
MICT	Management Internal Control Toolset
min	minute
mm Hg	millimeters of mercury
MOPP	mission oriented protective posture
Mph	mile per hour
ms	millisecond
MSD	musculoskeletal disorder
MSDS	material safety data sheet
MULO	multi-purpose overboots
MUNSS	munitions support squadron
N	newton
NARP	nuclear weapon accident response procedures
N/m^2	newton per square meter
NCMI	National Center for Medical Intelligence
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NRC	Nuclear Regulatory Commission
NRR	noise reduction rating
NSI	nuclear surety inspection
NTP	National Toxicology Program
NWS	National Weather Service
OBA	octave band analysis

OEH	occupational and environmental health
OEHED	occupational and environmental health exposure data
OEHMIS	occupational and environmental health management information system
OEHSA	occupational and environmental health site assessment
OEHWG	occupational and environmental health working group
OEL	occupational exposure limit
OHRA	occupational health risk assessment
OSH	occupational safety and health
OSHA	Occupational Safety and Health Administration
Pa	pascal
PAH	polycyclic aromatic hydrocarbon
PAR	population at risk
PCB	polychlorinated biphenyl
PEL	permissible exposure limit
pH	power of hydrogen
PH	public health
PM	particulate matter; preventive maintenance
PMEL	precision measurement equipment laboratory
PPE	personal protective equipment
ppm	part per million
PRP	personnel reliability program
QA	quality assurance
QAE	quality assurance evaluator
qt/h	quart per hour
RAC	risk assessment code
RAM	radioactive material
RAPID	rugged advanced pathogen identification device
RE	reference value
RM	risk management
SAC	self-assessment checklist
SAF	Secretary of the Air Force
SDS	safety data sheets
sec	second
SEG	similar exposure group
SLM	sound level meter
SPL	sound pressure level
STEL	short term exposure level
t	exposure time (in minutes)
T	total time (in minutes)
TB	tuberculosis
TIC	toxic industrial chemical
TIM	toxic industrial material
TLV	threshold limit values

TMIP	Theater Medical Information Program
TWA	time weighted average
UEI	unit effectiveness inspection
USAF	United States Air Force
USAFSAM	United States Air Force School of Aerospace Medicine
USAMRIID	United States Army Medical Research Institute of Infectious Diseases
USAPHC	United States Army Public Health Command
UV	ultraviolet
VA	vulnerability assessment
VB	vapor barrier
VP	vapor pressure
W	watt
W/m^2	watts per square meter
W/R	work/rest
WB	wet bulb
WBGT	wet bulb globe temperature
WMSD	work-related musculoskeletal disorders
WRRB	work request review board
XRF	x-ray fluorescence

Student Notes

AFSC 4B051
4B051 02 2009
Edit Code 4