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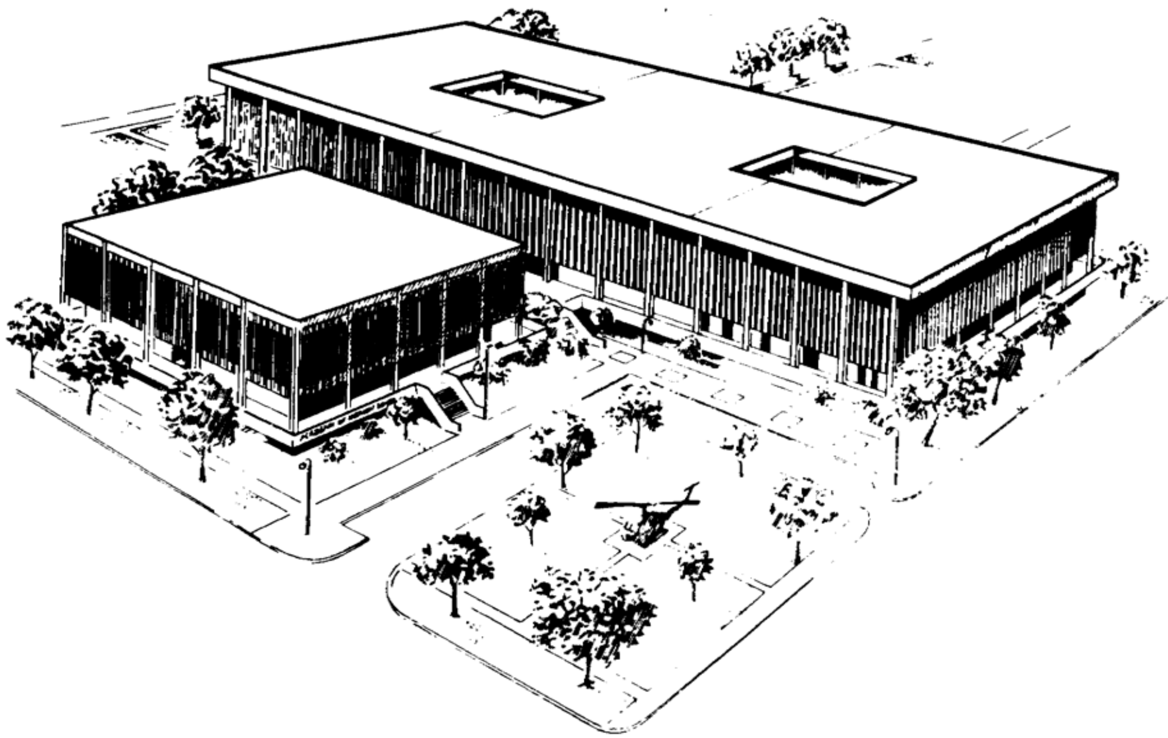

OCCUPATIONAL HEALTH AND INDUSTRIAL HYGIENE

SUBCOURSE MD0165 EDITION 100

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CORRESPONDENCE COURSE OF THE U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL

SUBCOURSE MD0165

OCCUPATIONAL HEALTH AND INDUSTRIAL HYGIENE

INTRODUCTION

For centuries, practitioners of medicine were concerned primarily with the treatment of illness and injuries. Only in the 19th century did we begin to recognize the importance of preventing illness and injury. Even so, emphasis on the effects that people's working environments have on their health has played a secondary role in the medical field until quite recently.

While medical science was in its infancy, the pioneering Hippocrates recognized and described the toxic effects of lead on those who worked with the metal. In our own country, not until the mid-1900's was anything substantially done to protect the health of working men. In the United States, over 100,000 persons still die annually from job-related causes.

Occupational health encompasses many programs of inspection, medical surveillance, and education. One of the major elements of occupational health is industrial hygiene, which is concerned with the identification, evaluation, and elimination or reduction of health hazards associated with the work environment. The major health hazards with which we are concerned are noise and toxic substances. As a preventive medicine specialist, you will be involved in the identification and evaluation of health hazards and in the evaluation of measures designed to control them.

Subcourse Components:

This subcourse consists of four lessons as follows:

Lesson I. Introduction to Occupational Health.

Lesson 2. Control of Toxic Substances.

Lesson 3. Noise and the Conservation of Hearing.

Lesson 4. Ventilation.

Credit Awarded:

Upon successful completion of this subcourse, you will be awarded 19 credit hours.

Materials Furnished:

Materials provided include this booklet, an examination answer sheet, and an envelope. Exercises and solutions for all lessons are contained in this booklet. You must furnish a #2 pencil for marking the examination answer sheet.

Procedures for Subcourse Completion:

You are encouraged to complete the subcourse lesson by lesson. When you have completed all of the lessons to your satisfaction, fill out the examination answer sheet and mail it to the U.S. Army Medical Department Center and School in the envelope provided. Be sure that your name, rank, social security number, and return address are on all correspondence sent to the U.S. Army Medical Department Center and School. You will be notified by return mail of the examination results. Your grade on the examination will be your rating for the subcourse.

Study Suggestions:

Here are some suggestions that may be helpful to you in completing this subcourse:

--Read and study each lesson carefully.

--Complete the subcourse lesson by lesson. After completing each lesson, work the exercises at the end of the lesson, marking your answers in this booklet.

--After completing each set of lesson exercises, compare your answers with those on the solution sheet that follows the exercises. If you have answered an exercise incorrectly, check the reference cited after the answer on the solution sheet to determine why your response was not the correct one.

--As you successfully complete each lesson, go on to the next. When you have completed all of the lessons, complete the examination. Mark your answers in this booklet; then transfer your responses to the examination answer sheet using a #2 pencil.

Student Comment Sheet:

You can provide us with your suggestions and criticisms by filling out the Student Comment Sheet at the back of this booklet and returning it to us with your examination answer sheet. In this way, you will help us to improve the quality of this subcourse.

LESSON ASSIGNMENT

LESSON 1 Introduction to Occupational Health.

TEXT ASSIGNMENT Paragraphs 1-1 through 1-15.

LESSON OBJECTIVES After completing this lesson, you should be able to:

1-1. List the three objectives of the Army Occupational Health Program.

1-2. Select the three most serious health hazards found on Army installations.

1-3. Select the statement which best describes the responsibilities of managers and supervisors.

1-4. List the subprograms that comprise the ram. Army Occupational Health Program.

1-5. Select the statement, which correctly describes the procedures involved with health hazard information module.

1-6. Identify the three phases of an industrial hygiene program.

1-7. Select the statement that best describes the environmental factors that are measured, the types of injuries that may occur when preventive measures are not followed, and what managers and supervisors should do to help prevent them.

1-8. Select the statement which best describes the three types of surveys and types of safety markings and signs.

SUGGESTION After reading this lesson, complete the lesson exercises before proceeding to lesson 2. These exercises will help you to achieve the objectives.

LESSON 1

INTRODUCTION TO OCCUPATIONAL HEALTH

1-1. HISTORICAL BACKGROUND

a. Occupational health is the science of fostering health and diminishing illness arising from the individual job relationship. Put another way, it might be thought of as the science of protecting the health of workers through the control of the work environment. A worker and his environment are inseparable; they react with each other in the form of a give and take relationship. Ideally, the worker would move through his environment, molding it to his desires. In actual practice, of course, this is not possible. It is more realistic to visualize both the worker and his environment as being mutually interdependent, each affecting, and being affected by the other.

b. Prior to the turn of the present century, there was little concern for the health and well being of the worker. At the dawn of civilization, life was largely a struggle for existence; merely being alive was an "occupational hazard." The passage of time, with the attendant stratification of social classes, saw the slave class performing all the common labor. This practice continued until relatively recent times. Mankind's natural inclination towards war provided a steady supply of slave labor. The idea of actually doing manual labor was so disdainful to many people that at one period in their culture law prohibited Egyptians from performing such work. Considering this attitude on the part of society, it is not surprising that no efforts were made to control the working environment in order to provide a healthful, safe, comfortable place in which to work.

c. As early as the fourth century B.C., Hippo crates recognized and recorded the effects of lead toxicity in mining operations. It appears to have been a purely academic interest because there was no concern shown for workers in the mines then and afterwards. However, some 500 years later, Pliny the Elder, a Roman scholar, referred to the dangers inherent in working with zinc and sulfur; he also described a protective mask made from an animal bladder to be used by laborers subjected to large quantities of dust or lead fumes.

d. As centuries went by, only lip service was given to reducing the environmental hazards associated with certain occupations throughout the world. In the second century A.D., Galen, the famous Greek physician who lived in Rome, recognized the threat posed to copper miners by acid mists. However, nothing concrete was done to alleviate the hazardous conditions until 1473 when Ulrich Ellen bog published his landmark pamphlet on occupational diseases and hygiene. In 1556 Georgius Agricola, a German scholar, described the hazards associated with the mining industry and suggested mine ventilation and protective masks for miners. In the late 18th century, Percival Pott's recognition of soot as one of the major causes of scrotal cancer provided a major impetus to the passage of the Chimney-Sweepers Act of 1788. However, in spite of these isolated instances, very few truly significant safeguards for workers had been developed.

e. It was not until the English Factory Acts of 1833 were passed that government showed any real interest in the health of workers. Following England's lead, several other European countries instituted worker's compensation acts; these laws tended to stimulate the adoption of increased factory safety precautions and the inauguration of medical services in industrial plants. The adoption of worker's compensation acts in Europe was an important factor in the development of occupational health and industrial hygiene programs in the United States. After adopting similar laws in this country, it became apparent that it was more profitable to prevent accidents through enhancement of the working environment than to pay compensation to accident victims.

f. As the United States grew into one of the world's leading industrial powers, the US Public Health Service assumed a position of leadership in the evaluation of diseases encountered by workers and in developing measures to control these diseases, as well as fostering an interest in occupational diseases by state agencies, universities, industry, and unions. Our country passed and enacted on many Federal, state, and local environmental laws and regulations to protect people.

g. Today the objectives of the Department of the Army (DA) Occupational Safety and Health (OSH) Program are to:

(1) Ensure that workers are suited for their jobs physically, mentally, and Psychologically.

(2) Ensure that workers are provided a safe, healthful work environment, free from recognized health hazards.

(3) Reduce economic loss to the government and the worker caused by compensation claims due to physical deficiency, sickness, and injury.

(4) Ensure proper medical care and rehabilitation of the occupationally ill and injured.

(5) Prevent decreased combat readiness caused by occupational illness and injury of military personnel. This is the most important of the program objectives.

1-2. GENERAL ORGANIZATION FOR PROGRAMS, THEIR REGULATIONS AND BACKGROUNDS

a. **President of the United States**. The President of the United States signed Executive Order 12196 establishing Occupational Health (OH) Programs for all Federal employees, to include active duty military personnel. This order is the basis for the Department of Defense (DOD) policy and guidance to DA. Our Congress passed and enacted Public Law 91-596, The Occupational Safety and Health Act (OSHA) of 1970.

b. **Department of Defense**. Department of Defense Instructions (DODI) have provided definitive policy for implementation of OSH programs. DODI 6050.5, 6055.1, 6055.5, and 6055.12 are key documents that establish program organization, responsibilities, and staff relationships.

c. **Secretary of the Army (Installations, Logistics, and Environment).** Overall, the Assistant Secretary of the Army (SA) (Installations, Logistics, and Environment) (ASAIL&E)) through the Deputy Assistant Secretary of the Army (DASA) (Environmental, Safety, and Occupational Health (ESOH) has the ultimate responsibility for the Army's environmental programs, and overall policy and guidance authority concerning all Army environmental matters. Industrial hygiene is an integral part of the DA OSH programs. Some new and stricter enforcement of existing safety and occupational health standards require greater understanding and clarification of command and individual responsibilities. These responsibilities require personnel to take essential preventive measures to combat and eliminate industrial hygiene problems or hazards. For example, OSHA may request that the Corps of Engineers (COE) or Director of Engineering and Housing (DEH) (depending on the organizational structure for that location) construct an enclosure for a machine to reduce the noise.

d. **Department of the Army.** The DA programs are specified in Army Regulations. (AR) 40-5, Preventive Medicine, and 385-10, Army Safety Program. Department of the Army is responsible for the policies and procedures to preserve, protect, and restore the quality of the workplace environment and the people working there.

e. **Installation Occupational Safety and Health Program**. Personnel and activities responsible for supporting and monitoring the OSH Program include the following:

(1) Installation level.

(a) Post preventive medicine (PVNTMED) service. The post preventive medicine service is involved in all elements of the program and is part of the installation United States Army Medical Center (MEDCEN) or medical department activity (MEDDAC).

(b) Post safety officer. The post safety officer is the installation coordinator of the entire safety program. Usually, the installation OSH manager serves on the installation Commander's staff.

(c) Audiologist. The audiologist is a consultant for the Hearing Conservation Program personnel.

(d) Director of Engineering and Housing. The DEH provides manpower and resources to eliminate health hazards through engineering construction, additions, and/or changes.

(e) Hospital Laboratory. The hospital laboratory provides analytical service for the medical surveillance program.

(f) Optometrist. The optometrist is a consultant to the Occupational Vision Program personnel.

(g) Alcohol and Drug Abuse Control Office. These office personnel provide counseling referral of information to other program participants.

(h) Military or Directorate of Civilian Personnel (DCP) Office. The personnel office schedules medical examinations and educational training and handles job transfers, compensation claims, and complaints.

(2) Department of the Army staff (Assistant Secretary of the Army for Installation and Logistics overall program manager).

(a) Office of the Surgeon General (OTSG). The PVNTMED Consultants Office of the OTSG performs these functions:

1 Serves as the proponent of AR 40-5 and Technical Bulletin (TB) Medical (MED) 500 series.

2 Establishes policies for the Army Occupational Health Program (AOHP) and specifically the Industrial Hygiene (IH), Occupational, and Aviation Medicine.

3 Develops OH standards.

(b) Army Safety Manager. The Army Safety Manager performs these functions :

1 Serves as the proponent of AR 385-10.

2 Serves as the overall supervisor of the Army Safety Program.

3 Supervises the US Army Safety Center.

(3) Major command staff.

(a) Surgeon's office. The Surgeon's personnel coordinate the major command (MACOM). Medical Program and perform liaison to supporting organizations.

(b) Safety office. The Safety office coordinates for the MACOM Safety Program and perform liaison to supporting organizations.

(4) Health Services Command).

(a) Directs the health aspects of the program in continental United States (CONUS) through Health Services Command (HSC) Pam 40-2.

(b) Provides resources to operate the program.

(c) Acts as a consultant to MEDDAC and MEDCEN PVNTMED Service.

(d) Evaluates the program through the Inspector General (IG).

(5) Supporting organizations.

(a) United States Army Environmental Health Agency (USAEHA).

1 Provides field surveys, consultation, and laboratory analysis.

2 Provides services to installations worldwide through three Direct Support Activities (DSA), which are named: Direct Support Activities South, located at Fort McPherson, Georgia; DSA West, located at Fitzsimmons Army Medical Center, Colorado; and DSA North, located at Fort Meade, Maryland.

(b) Tenth Medical Laboratory, Landstuhl, Germany. This laboratory supports Europe, Near East and Africa.

(c) United States Army Pacific Environmental Health Engineering Agency, Sagami Japan. This agency provides support to Japan, Korea, Hawaii, and all of the Far East.

(d) United States Army Safety Center, Fort Rucker, Alabama. This center provides worldwide accident prevention, safety engineering, and accident investigation consultation.

(6) Table of organization and equipment units.

(a) Division Preventive Medicine Section. Services provided include: identification of PVNTMED problems, train unit field sanitation teams (FST), and back up company-level preventive medicine measures (PMM) which go beyond the capacity of the unit because of complexity, scope, and/or specialization.

(b) Division safety officer.

1 Performs as the division safety program consultant to organic and non-organic units.

2 Coordinates safety matters within the safety chain.

(c) Division commander and IG. The commander is responsible for all that is done or is not done. The IG serves as the commander's eyes and ears and seeks to resolve problems.

(7) Corps of table of organization and equipment units resources. Corps PVNTMED teams (sanitation and entomology) provide the same services to the corps as division PVNTMED sections do for a division.

f. **United States Army Environmental Hygiene Agency**. The commander, United States Army Environmental Hygiene Agency (USAEHA) will provide worldwide support to PVNTMED programs for the Army through consultation, supportive services, investigations, and training.

g. **Corps of Engineers or Director of Engineering and Housing**. The Corps of Engineers (COE) or Director of Engineering and Housing (DEH) has primary staff responsibility to the ASA to direct, coordinate, and manage the environmental programs within the Army. The DEH or COE's main thrust is toward the non-human side such as: planning, building, restoring, and repairing buildings, land, air, oil as opposed to OSHA and/or PVNTMED personnel, who are mainly concerned with the human factors such as how the machine's noise affects the soldier's or Civil Service worker's hearing, what causes the accident or illness, is there a trend, and how can the problem be alleviated.

h. **Installation, Activity, and Unit Commanders**. The installation, activity, and unit commanders are accountable to establish organizational structure to plan, execute, and monitor workplace environmental health and safety programs. They are to promote general health and safety and ensure that the workplace occupational and environmental health programs, within their commands, are followed. Commanders and their staffs' responsibilities are to ensure that supplies, equipment, facilities, land, air, water, and substances are not injurious or hazardous to personnel. If illness, injury, or hazards are noted, then on or offsite surveys and investigations (or whatever is deemed appropriate for the situation) are to be conducted by trained personnel to find the cause, trend, or problem. If found unacceptable or inadequate, then action is to be taken until the problem is corrected and satisfactory standards are once again met.

NOTE: Tenants are considered activity or unit commands. Both Federal and non-Federal (such as an infantry or medical unit, a directorate or agency) housed on an installation must comply equally with the requirements of the Federal, state, and local solid waste and hazardous waste management laws, regulations, and Army policies. Under new and changing laws, all supervisory and manager personnel are now responsible, not just the commander.

i. **Chain of Command**. Within the chain of command and depending upon the size of the installation or geographical region, the safety officer or the preventive medicine officer (usually a physician) carries out the safety and health programs. If the region or installation is normal size or small but special circumstances exist (which is normally the case), then both should be present and oversee their responsible areas. The safety officer usually receives the bulk of the inquiries and complaints plus reports (accident, illness, and so forth); and, therefore, serves the hub to orchestrate which action office(s) (for example: COE, DEH, or Preventive Medicine Officer) should receive the item(s). The preventive medicine officer or preventive medicine specialist would sample possible substandard water, evaluate, and correct the problem so that it once again meets requirements. This will be discussed later.

1-3. ARMY OCCUPATIONAL HEALTH PROGRAM

a. One of the programs under the Department of defense (DoD) is the OSH Program. The Army Occupational Health Program (AOHP) is based on law, policy, and regulation of the OSHA of 1970, appendix, para 1 of Public Law 91-596 (Appendix A of this subcourse contains a list of important references that you may wish to review). (Further referrals to the list will not be made). The program has the same goal, providing a safe and healthful work place for all workers.

b. The overall AOHP promotes health and reduces risk of illness arising from the individual's work environment. This includes special preventive measures for both military and civilian personnel who are exposed or potentially exposed to toxic materials, infectious agents, or other hazardous influences of the work environment.

c. The Occupational Safety and Health Act (OSHA) standards are:

(1) Department of Defense and DA OSH standards are to be followed at military and non-military workplaces whether or not OSHA standards have been issued.

(2) Occupational Safety and Health Act standards, including temporary emergency medical standards with minor adaptations, need to conform to DA administrative practices.

(3) Alternate workplace standards, based on publications relating to workplace exposure criteria, may be used in lieu of existing OSHA standards or when no OSHA standards exist. All work place standards used by the Army must be equal to or more stringent than those of OSHA in 29 Code of Federal Regulations (CFR) 1910, 1917, and 1926 and include consensus standards such as the threshold limit values published by the American Conference of Governmental Industrial Hygienists.

(4) Follow any other statutory regulatory workplace standards issued by Federal agencies.

(5) Special DA OSH standards developed for military-unique equipment, systems, and operations are to remain in effect.

d. As a minimum, the OHP will include the following elements:

(1) Inventory of chemical, biological, and physical hazards in the work environment of all installation activities, including medical treatment facilities (MTF) and research and development activities.

(2) Job related medical surveillance.

(3) Administrative medical examination.

(4) Employee education job-related health hazards.

(5) Treatment of occupational illness and injury and emergency treatment of non-occupational illness and injury.

(6) Hearing conservation.

(7) Occupational vision.

(8) Pregnancy surveillance.

(9) Job related immunizations.

(10) Illness absence monitoring.

(11) Chronic disease surveillance.

(12) Epidemiologic investigation of occupational illness and injury and illness absence monitoring.

(13) Maintenance of occupational health (OH) medical and administrative records and reports.

(14) Industrial hygiene surveys and safety and health inspections.

(15) Other services include: group counseling on specific problems or habits affecting health; disease screening; and voluntary periodic health examinations on an age-related basis.

e. The specific objectives of the AOHP are to:

(1) Ensure that all eligible personnel, both military and civilian, are physically, mentally, and psychologically suited to their work.

(2) Ensure that physical and mental health is maintained during the period of their service or employment.

(3) Reduce economic loss caused by physical deficiency, sickness, and injury of military personnel and civilian employees.

(4) Ensure proper medical care and rehabilitation of the occupationally diseased and injured.

(5) Prevent decreased combat readiness caused by occupational illness and injury to military personnel.

f. While the emphasis seems to be placed on the economic gain to the Government, it is important to note that the worker who sustains an injury or develops an illness, whether job related or not, suffers an economic loss due to non-employment, which impacts on his family and perhaps even on his community as well. The elimination or reduction of job related injuries and illness might be thought of as the end goal of the AOHP.

1-4. RESPONSIBILITIES

a. Managers and supervisors at all levels are responsible for:

1) Keeping informed of occupational health hazards and requirements in activities under their control.

(2) Training employees in appropriate safety practices.

(3) Enforcing the use of protective clothing and equipment, and other workplace procedures and practices.

(4) Providing the Directorate of Civilian Personnel (DCP) officer with health and safety information necessary for effective job classification and placement actions.

b. Safety personnel at all echelons of command have the overall staff responsibility for OSHA compliance (AR 385-10) and maintain expertise relative to the safety aspects.

c. The installation or activity commander is responsible for the health aspects of OSHA on the installation and must provide the services to maintain them.

d. The appropriate DCP is responsible for establishing a system for identifying individual civilian employees who are recipients of any particular occupational health service and for notifying them when they are scheduled to receive it; for example: periodic job related health examination. The system will include identifying new employees as well as those changing jobs into and out of the program. This may be accomplished by annotating manual records or coding automatic records. Because the DCP, the safety officer, and the medical treatment facility (MTF) are all involved, it may be necessary to establish a written standing operating procedures (SOP) to delineate respective responsibilities. Coordination with the military unit of assignment is required to ensure scheduling of active duty personnel for job-related examinations.

e. Installation labor relations advisors are responsible for ensuring that occupational health service specified in labor agreements are within the capabilities and resources of the health care provider. Provisions of existing agreements need to be considered when changes in services are deemed necessary.

f. The Surgeon General (TSG), through the preventive medicine professionals on his staff, provides technical guidance and assistance Army-wide. In addition, he is responsible for accomplishing the following:

(1) Initiating policies, preparing directives, and providing technical advice on matters pertaining to occupational health hazards and practices.

(2) Making inspections, analyzing reports, and maintaining records necessary to ensure the effectiveness of occupational health programs.

(3) Maintaining liaison with the US Public Health Service and other governmental and/or private agencies concerned with occupational health.

1-5. SOURCES OF SUPPORT

a. Technical surveys and consultant assistance are available from the US Army Environmental Hygiene Agency (USAEHA), upon request through command channels.

b. In emergencies, information concerning the composition of the solvents may be obtained from the nearest Poison Information Center. The telephone number nearest Poison Information Center should be prominently posted so as to be readily available at all facilities that might receive cases for emergency care.

c. National Institute of Occupational Safety and Health (NIOSH) provides training in OH and IH subjects as well as authorizing studies and recommended procedures addressing OH and IH issues.

1-6. SCOPE OF THE ASSOCIATION OF OCCUPATIONAL HEALTH PROFESSIONALS

The Association of Occupational Health Professionals (AOHP) is comprised of a group of preventive measures or subprograms. These preventive measures and elements are described in succeeding paragraphs; they should be thought of as the minimum essential elements of a comprehensive occupational health program.

a. **Inventory of Health Hazards**.

(1) An inventory of health hazards is the basis for any OHP. Without knowledge of potential exposures, a sound medical monitoring program cannot be accomplished. The inventory must be updated periodically and include:

(a) Location. Exact information depicting the site (division, branch, building number, room number, and so forth).

(b) Operation. Description of the operation and the number of employees involved.

(c) Exposure. Occupational health hazards (chemical, biological, and physical, including radiological), both potential and actual, and positions with medical fitness requirements.

(d) Controls. The type of control measures in use and the adequacy of these measures.

(e) Identification. Identification of personnel at risk to health hazards.

(2) The physician responsible for the OHP will review the inventory of health hazards to determine the specific pre-placement and/or periodic medical monitoring examination requirements for each exposure.

(3) A supplemental job category inventory will be maintained for positions requiring a level of physical fitness for the employee to perform effectively and with safety to himself/herself and others; that is., firemen and mobile equipment operators.

(4) Health personnel, to include physicians and nurses, must visit work areas on a regular basis to obtain first hand information concerning the nature of the various work operations and to maintain liaison with personnel and safety officials, supervisors, and workers.

(5) Typically, the industrial hygiene personnel who work for the Installation Medical Authority (IMA) assemble this inventory. They can be augmented or completely substituted by the Preventive Medicine Specialist (MOS 91S).

b. **Industrial Hygiene Surveys.** Industrial hygiene surveys will be conducted by industrial hygiene personnel to evaluate operations or practices involving actual or potential health hazards US Army Environmental Hygiene Agency (USAEHA) may provide assistance in the form of special studies, consultations, or comprehensive surveys. This corresponds to the second phase of classic industrial hygiene evaluation. Quantification is essential. The current American Conference of Government Industrial Hygienists (ACGIH) threshold limit values (TLV)'s will be used whenever they impose a more stringent limit than OSHA or when OSHA has not promulgated a standard for a particular substance under 29 CFR 1910.1000. The evaluation of exposures will include operations that have:

(1) Chemicals

(2) Pesticides

(3) Radiation, (ionizing and non-ionizing).

(4) Noise hazards.

(5) Eye hazards.

(6) Biological hazards.

(7) Ergonomic hazards (human/operation interface).

(8) Other environmental conditions.

c. **Health Examinations.** Health examinations constitute the second basic element of an occupational health program. Such examinations include pre-placement, periodic job related, and administrative examinations together with voluntary health maintenance examinations, as personnel and other resources permit. Priorities of care within Army MTF, as defined in AR 40-3, place job-related health examinations within category 1, and voluntary health examinations in category five. In many instances, the health examinations may not require extensive physical examination by a physician and may be accomplished most expeditiously by the occupational health nurse with appropriate minimal input from the occupational health physician. Such delegation of functions facilitates optimal use of the professional skills of both physician and nurse.

(1) Pre-placement examinations. Pre-placement examinations will be provided in accordance with Federal Personnel Manual (FPM) Chapter 339, 24 Mar 69, and whenever medical evaluation is necessary for work assignment. Pre-placement examinations may be required for new hires, job transfers, oversea assignments, or promotions. The new employee should be referred to the occupational health services for in processing and initiation of the medical record. At this time, the employee should be provided, or scheduled for a baseline health screening to include a health history, audiogram, vision screening, and blood pressure reading.

(2) Periodic job-related examinations. These examinations are an essential component of the health examination program. The inventory of health hazard assessments is the basis for this program because the examination will be specific to the exposure, operation, or physical fitness requirements involved.

(3) Administrative examinations. Fitness for duty, disability retirements, and other administrative health examinations will be provided as needed and will include those items depicted in Appendix A.

(4) Voluntary health maintenance examinations. The majority of man-day losses are attributable to non-occupational illnesses and injuries. Accordingly, any examination, which can reduce absenteeism and promote health is cost effective. Health maintenance examinations are of value for the early detection of disease and consequent reduction in disability. Such examination may be provided when resources permit and may be accomplished in a number of ways, including the use of the nursing health appraisals.

(5) Physical examination coordination. All occupational related examinations for active duty (AD) military and civilian employees should be coordinated through the occupational health service to ensure performance of all required tests and review of results with referral to the occupational health physician as indicated.

(6) Follow-up. A follow-up system should be developed and maintained for all health examination and screening programs to identify and report on their effectiveness and ensure indicated counseling and referral support.

d. **Treatment of Illness and Injuries**. The care of the acutely ill and injured is the third principal element of an occupational health program. Civilian employees on TDY as well as personnel assigned to the local installation are eligible for such treatment.

(1) Job-related illnesses and injuries. Employees with job-related illnesses and injuries are provided emergency and follow-up care in accordance with AR 40-3 and AR 40-5. In cases of traumatic injury, a specific determination will be made and noted on appropriate U.S. Department of Labor Compensation (USDLC) forms as to the degree and probable duration of disability.

(2) Non-occupational illnesses and injuries. Emergency treatment or limited palliative treatment of non-occupational conditions is authorized by AR 40-5 and will be provided to prevent loss of life, relieve suffering, or reduce absenteeism. Employees requiring definitive treatment of non-occupational health problems should be referred to their personal physician or other appropriate health resources.

(3) Emergency care after duty hours. Provisions will be made for medical care of emergencies during non-duty hours of the MTF, if individuals are employed on other than normal day shifts.

(4) First aid. Utilization of first aid kits when professionally staffed and appropriately equipped health care facilities are readily available is not in the best interest of the employee. This practice also results in failure to report occupational injuries and loss of epidemiological data. If local medical personnel determine that first aid kits are needed at certain work areas, injuries incurred and treatments given will be reported to health clinic personnel for recording in the employee's medical record.

e. **Illness Absence Monitoring**.

(1) A policy of encouraging referral of employees to the occupational health clinic prior to leaving work because of illness will be considered. Benefits to be derived from such a policy include appropriate disposition of ill employees, opportunities for health education, and increased awareness on the part of occupational health personnel of the types of health problems employees are having. Additionally, man-hours can be conserved if palliative treatment is given for an acute minor illness before it becomes serious so that the employee is able to remain on the job.

(2) Policies related to health clearance of employees prior to returning to work after illness or injury should be determined by the nature of the work performed, the individual health needs of the employee, the supervisor's recommendations, and the capabilities of the occupational health staff. Interviewing employees following a significant illness or injury helps to bring employees with special health problems to the attention of occupational health personnel and ensures that employees do not return to work before they are able. As a rule, having employees clear through the health clinic after illness absence in excess of five working days will meet this health support objective without unnecessarily burdening the occupational health staff. Special requirements for clearance will be instituted for employees engaged in patient care and food service activities to ensure that these individuals do not return to work when capable of transmitting a communicable illness.

f. **Chronic Disease or Disability Surveillance**. Employees with chronic disease or disability should be identified through such procedures as a review of Standard Form (SF) 177, routing medical examination, or mass screening programs. The OH staff will maintain a list of all chronically ill or disabled persons that could affect or be affected by their work assignments. Medical records of such personnel should be coded and include relevant clinical information regarding the patient's condition and the name of his/her private physician.

g. **Immunization Program**. Appropriate immunizations should be provided to employees potentially exposed to infectious disease because of the work environment or required foreign travel.

h. **Pregnancy Surveillance Program**. Leave policies for the pregnant worker will be consistent with legal and regulatory provisions which prohibit placing a pregnant employee on mandatory leave at an arbitrary or specified time because of pregnancy. Policies should be adopted encouraging pregnant workers to report to the health clinic as soon as the pregnancy is determined. At that time, the impact of employment upon the pregnancy will be evaluated. Employees not under the care of a physician will be encouraged to seek medical supervision and arrangements for follow-up should be made if indicated.

i. **Epidemiological Investigations**. Epidemiological investigations will be conducted when situations develop suggesting the possibility of an increased disease or injury rate attributable to occupational hazards.

j. **Alcohol and Drug Abuse Prevention and Control Program**. A program for evaluation, diagnosis, counseling, and referral of civilian employees will be established in accordance with AR 600-85, 1 December 1981. Where applicable, the occupational health physician or the designated military physician will evaluate and, if appropriate, refer individuals to the civilian program coordinator (CPC) and the Alcohol and Drug Abuse Prevention and Control Program (ADAPCP) in accordance with local guidelines.

k. **Employees Health Education**. Factors such as the type of work performed, the nature of hazards found in the work environment, and distinctive characteristics of the work force should form the basis of health education programs.

(1) Educational activities may be divided into two categories:

(a) Those concerned with health implications of the job.

(b) Those related to general health maintenance and health promotion.

(2) The OSH Act and the DOD OSHA criteria require that employees be apprised of identified health hazards to which they are exposed, relevant symptoms, appropriate emergency treatment, and responsibility for using protective clothing or equipment. Additionally, provisions should be made for providing employees information concerning occupational health services. Supervisors should be provided initial and periodic orientation and guidance regarding their responsibilities for the health of employees and areas for coordination with the OH staff.

l. **Radiation Protection Program**. There are ionizing and non-ionizing radiation sources of potential occupational exposure. An occupational radiation area is any area (accessible to personnel) that contains sources of ionizing or non-ionizing radiation that could deliver a significant dose to at least a major portion of the body. An ionizing radiation source is particles, gamma rays, x-rays, or neutrons; any natural or artificial isotope or device capable of producing alpha particles, beta Non-ionizing radiation sources include microwave radiation and laser radiation. Sources of non-ionizing radiation include lasers, microwaves, radars, and lasers. A separate inventory is maintained and a surveillance program will reflect the occupational exposures within the command. There are other sources of non-ionizing radiation, which include: microwave oven, leakage, high intensity ultraviolet, infrared, visible, ultrasound, and radio frequency.

(1) An inventory of radiation sources and dosimeters used for monitoring will be maintained as appropriate. Radiation exposure records for Department of the Army personnel are maintained at the US Army Ionizing Radiation Dosimetry Center at Lexington Bluegrass Army Depot (LBAD). Reports of monthly or quarterly Dosimetry results are mailed to the users with updates on a quarterly and annual basis. Locator cards are placed in the health record to indicate that the Dosimetry records are maintained at either location. Usually, these current records of exposure are located at preventive medicine. Civilian employees and military personnel will receive appropriate periodic medical surveillance (AR 40-14).

(2) Laser radiation refers to light amplification by stimulated emission of radiation. A laser creates an intense beam of optical radiation that can be hazardous for considerable distances. Employees, with occupational exposure to laser radiation sources will be appropriately identified and included in the pertinent medical surveillance program as stated in Technical Bulletin (TB) MED 279.

(3) Microwave radiation are varying electromagnetic fields in the frequency range of 10 KHz to 300,000 MHZ with corresponding wavelengths of 30 KM to 1 millimeter (ml). Employees with occupational exposure to microwave radiation sources will be identified and provided appropriate medical surveillance as in TB MED 523.

m. **Occupational Vision Program.** An occupational vision program is an essential part of the periodic health examination program as outlined in TB MED 506.

n. **Hearing Conservation Program.** The prevention of hearing loss from exposure to noise requires identification and evaluation of noise-hazardous areas and/or equipment. Posting of these same noises hazardous areas with appropriate caution signs, installing engineering control measures, and using hearing protection devices may be necessary. Pre-placement and periodic monitoring the audiometer of personnel identified as working in noise hazardous areas supplemented by health education and supervision and discipline of personnel may be in order. The hearing conservation program is outlined in TB-MED 501 and DA Pam 40-501.

o. **Inspections.** All workplaces, including offices, will be inspected at least once annually to determine if any unsafe or unhealthy conditions exist. In depth surveys performed by USAEHA will complement the inspections and provide an excellent health hazard data base for follow-up surveys and inspections. If a condition exists that cannot be evaluated by medical personnel, a request for support should be submitted through the established support channels. Every effort should be made to coordinate all occupational health and/or industrial hygiene surveys and inspections with the respective safety offices.

p. **Occupational Safety and Health Committees or Council.** An effective OHP is an interdisciplinary effort and requires the support and cooperation of both the providers and users of OHS. Participation by OH and industrial hygiene personnel is essential to the full utilization and success of both the hospital and installation safety and health committee or council. In addition to key providers of services, the committee or council will include management and employee representation from organizations being served to include representatives of recognized employee unions, as appropriate. The installation safety and health committee or council offers an effective means of ensuring coordination between the various staff elements. It is recommended that the committee or council meet on a regular basis either monthly or quarterly.

1-7. INTRODUCTION TO INDUSTRIAL HYGIENE

a. **Defining Industrial Hygiene.** Industrial hygiene (IH) is that science and art devoted to the recognition, evaluation, and control of those environmental factors or stress, arising in or from the work place, which may cause sickness, impair health and well being, or cause significant discomfort and inefficiency among workers or among the citizens of the community. Industrial hygiene primarily involves:

(1) The recognition of environmental hazards and stresses associated with work and work operations, and the understanding of their effects on man and his well being in the work place and the community.

(2) The quantitative evaluation, through training and experience, of the magnitude of these hazards and stresses is to determine the actual potential for harm to man's health and well being.

(3) The prescription of methods to control or reduce such factors and stresses when necessary to alleviate their effects.

b. **Recognition.** Recognition of environmental hazards and stresses that influence health requires a familiarity with work operations and processes. The categories of hazards most frequently of interest are:

(1) Chemical in the form of liquid, dust, fumes, mist, vapor, or gas.

(2) Physical energy, such as electromagnetic and ionizing radiation, noise and vibration, and extremes of temperature and pressure.

(3) Biological, such as insects and mites, molds, yeasts, fungi, bacteria, and viruses. (Infectious agents presenting a risk or potential risk to our well-being.)

(4) Ergonomic, such as body position in relation to task, monotony, boredom, repetitive motion, worry, work pressure, and fatigue. The effect of these four areas of stress on man's health and well being must be recognized. It is important to know whether such stresses are dangerous to life and health, whether they produce an

acceleration of the aging process, or whether they will cause only significant discomfort and inefficiency.

c. **Evaluation.** Evaluation of the magnitude of the environmental factors or stresses arising in or from the work place is essential in order to predict the probable effect on health and well being. The industrial hygienist, by virtue of training and experience and aided by quantitative measurements of the chemical, physical energy, biological, or ergonomic stresses, can render an expert opinion as to the "healthfulness" of the environment, either for short periods or for lifetime exposure.

d. **Prescription of Corrective Procedures.** When necessary to protect health, control measures are based on a good evaluation of the environmental factors of stresses. Among control measures most frequently used are:

(1) Isolation of a process or work operation to reduce the number of persons exposed.

(2) Substitution of a less harmful material for one that is more dangerous to health.

(3) Alteration of a process to minimize human contact..

(4) Ventilation and air cleaning to provide an atmosphere safe for human occupancy.

(5) Reduction of exposure to radiant energy by shielding, increasing distance, and limiting time.

(6) Wet methods to reduce emission of dusts to the atmosphere such as in abrasive blasting, lathing, and grinding operations.

(7) Good housekeeping, including cleanliness of the work place, proper waste disposal, adequate washing, toilet and restroom facilities, healthful drinking water and eating facilities, and control of insects and rodents.

(8) Personal protective devices to be worn, such as special clothing, eye, hearing, and respiratory protective equipment.

1-8. ESSENTIAL INDUSTRIAL HYGIENE PROGRAM ELEMENTS

The items listed in this paragraph are the minimum essential elements required for an installation IH program. The elements listed are required by Federal law, AR, and policy or are based upon consensus standard and good IH practice. Figure 1-1 is a possible IH health hazard.

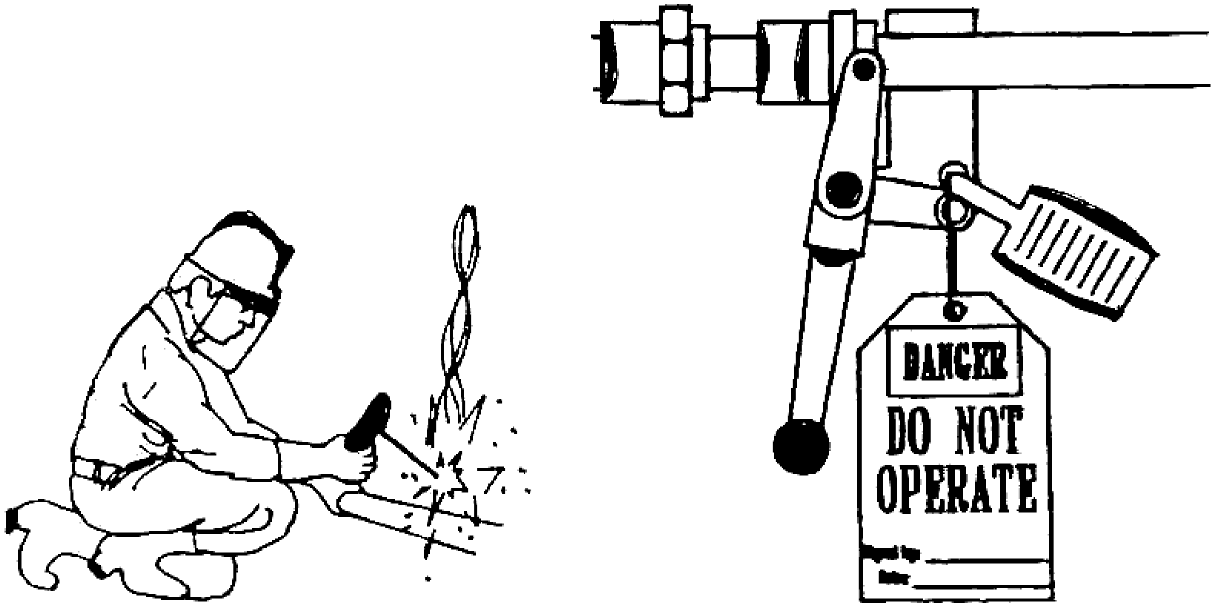


Figure 1-1. Possible IH Health Hazards

a. **Implementation Plan.** A plan must be developed that lists IH functions, resources available, and a prioritized schedule for accomplishing the required tasks. Implementation plans should include the following:

(1) List of prioritized program activity requirements such as sampling, ventilation monitoring, and surveys.

(2) Quarterly or monthly schedule of activities to accomplish requirements.

(3) List of activities that cannot be accomplished with available resources.

(4) Additional support needed from other sources such as USAEHA.

b. **Health Hazard Information Module.**

(1) Establishing and maintaining a current inventory of OH hazards is the key element of the Occupational Hazards Program. Inventories contain detailed information on operations, exposures, and controls. The maintenance of Health Hazard Information Module (HHIM) should be the first priority in the implementation plan. The information obtained from the HHIM should be used to establish air-sampling schedules, determine ventilation measurement requirements, request assistance from USAEHA, plan medical monitoring, and prioritize actions. The inventory process is used to recognize OH hazards prior to their evaluation and control. Figure 1-2 shows the flow of the Industrial Hygiene Program.

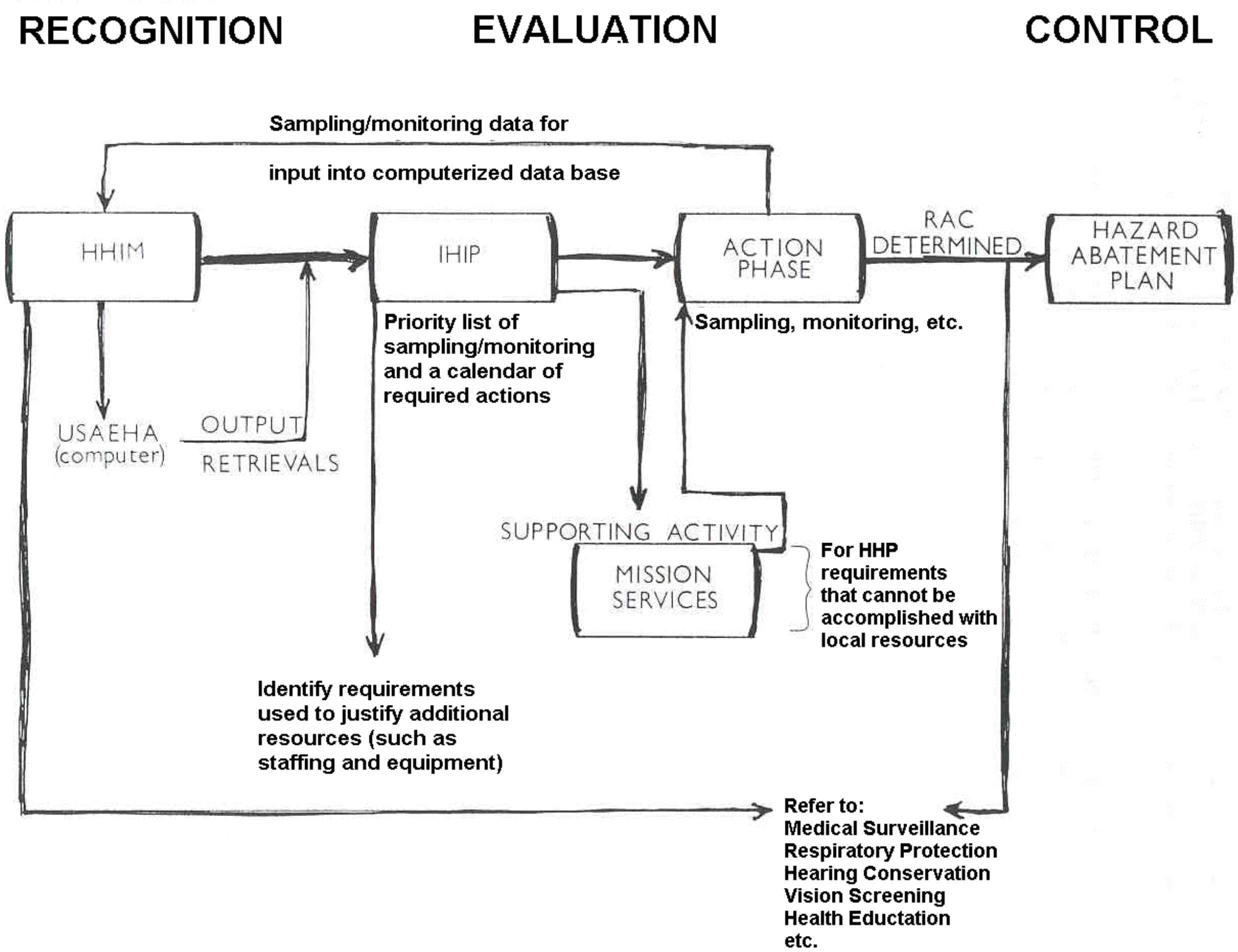


Figure 1-2. Flow of the Industrial Hygiene Program.

(2) A toxic chemical inspection and inventory should be part of the HHIM for each operation. Material Safety Data Sheets (MSDSS) must be kept for all toxic chemicals used in the work place.

(3) Data retrieval programs have been developed (for use by installation IH personnel) which allow retrieval based on: operation, existing hazards, worker's social security number (SSN) and name, and Risk Assessment Code (RACs). Additionally, output programs have been developed which detail comprehensive exposure data and information on OSHA regulated substances and operations. Equipment training and calibration information is also available.

c. **Hazard Evaluation.** Potential occupational hazards identified during the inventory process will require evaluation to determine degree of hazard severity. Air sampling and ventilation measurements are the most common means of evaluation. The suspected chemical, physical, or biological agent should be studied with respect to the operation process, and workers to determine the evaluation procedure necessary. USAEHA, Industrial Hygiene Division, may be contacted for information concerning hazard evaluation or detailed sampling instructions.

d. **Medical Risk Assessment Code and Occupational Health Hazard Abatement.** Risk assessment codes must be assigned to every hazard evaluated in accordance with DODI 6055.1 and AR 385-10. Risk assessment codes(s) are used to prioritize funding for corrective action at all levels. Hazards with a RAC of 1 or 2 must be controlled before funding lesser hazards. Risk assessment codes generated by the industrial hygienist must reflect a comprehensive evaluation of the particular health hazard to include sampling (if warranted). Identified health hazards (which have been sufficiently assessed) will be entered into the installation abatement plan by written report to the local DA OSH manager. AR 385-10 contains detailed information on hazard abatement procedures.

e. **Record Keeping.**

(1) A record must be kept on all IH activities, to include health hazard inventories, evaluations of hazards, existing health hazard control measures, and recommendations for improvements. Records should be maintained in bound notebooks or other permanent documents. All records must comply with DOD and OSHA standard requirements. Department of Defense policy is to maintain all records for 40 years. Records of worker exposures must be maintained in such form that they can be included in the worker medical record and used to apprise the worker of exposures. Data, which show no worker exposure, are as important, if not more so, than exposure data and the relationship of the period sampled to the employee's exposure for the shift(s) sampled must also be documented. Full shift samples are the best way to accomplish this.

(2) Records of toxic chemicals used and records of hazardous devices or processes should be kept so those potential problems may be identified. These records should be kept as part of HHIM. Ventilation flow rates, noise levels, and process variables should also be maintained to show effects of control measures.

f. **Design Review.** A thorough review of the plant, process and operational changes, and new design can prevent many potential OSH problems. The local IH staff should be in the design review process for all installation activities. In areas of highly technical or unusual designs, USAEHA can be requested to provide assistance. AR 420-10 is the authority for medical review.

g. **Respiratory Protection.** An ongoing Respiratory Protection Program must meet all the OSHA standards. Supervisory, safety, and preventive medicine personnel should jointly develop an installation program that meets legal requirements. Detailed program information can be found in OSHA standards, AR 11-34, USAEHA Technical Guide (TG) 171, and the NIOSH Guide to Respiratory Protection. Respiratory Protection will be discussed in detail in another lesson.

h. **Hearing Conservation.** Hearing conservation program requirements are detailed in DODI 6055.3, AR 40-5, TB MED 50l, and USAEHA TG 170. The IH personnel will conduct annual noise surveys, assign RAC's to noise hazardous areas, keep noise survey data, identify exposed personnel, and recommend noise control measures. The OH clinic or audiologist is responsible for audio-metric examinations and evaluation of effects on exposed personnel.

i. **Occupational Vision.** Industrial hygiene personnel should define eye hazard areas during the annual HHIM update, ensure areas are posted with warning signs and provide the OH clinic with a list of eye hazard locations and personnel working in the areas. Program responsibilities are AR 40-5, AR 385-32, TB MED 506, and 29 CFR 1910.133.

1-9. WORKER EDUCATION/TRAINING

A program of education and orientation of new employees to acquaint them with the potential hazards in the work place is a joint IH, safety, and supervisory responsibility. Close coordination between responsible personnel, employee representatives, and employees is necessary to ensure employees are specifically informed about potential hazards, preventive measures, and proper cooperation of process and control equipment. Local health and safety committee should meet and regular on the job training should be used to educate workers. Safety personnel have access to numerous publications on worker training and should be asked for help in establishing a safety program.

1-10 RESPONSIBILITIES OF THE INDUSTRIAL HYGIENIST

a. Develop and keep current annual industrial hygiene (IH) input for the OHP document to clearly define goals and objectives in the IH area.

b. Establish and maintain the Health Hazard Information Module (HHIM) Database of the Occupational Health Management Information System (OHMIS).

c. Develop an IH implementation plan for the allocation and application in IH resources.

d. Perform IH evaluations of industrial workplace hazards, provide technical guidance and support for the hazard communication, asbestos abatement, installation OSH programs, and perform other responsibilities as stated in TB MED 503.

1-11. ENVIRONMENTAL PHYSIOLOGY

a. Army personnel are subject to exposure to extremes of climate and altitude, which can have serious effects on their health, well being, and efficiency. Virtually nothing can be done to control the climate, the weather, or the altitude at which soldiers must function. However, much can be done to prevent harmful effects on personnel from exposure to these extremes and subsequent deterioration of performance.

b. Heat injuries are the result of excessive elevation of body temperature and/or water electrolyte imbalance due to inadequate replacement of fluid lost through perspiration. The danger of heat injuries is much greater for freshly exposed unacclimatized personnel than it is for seasoned troops. In normal individuals, a physiologic adjustment occurs over a prevention and treatment of heat injuries period of 2 to 3 weeks. Careful attention to heat indices is one of the most effective ways of preventing heat injuries. FM 21-10 and TB MED 507 provide valuable guidance on the prevention and treatment of heat injuries.

c. The wet-bulb globe temperature (WBGT) index is a single numeral by which the effects of air temperature, air movement, relative humidity, and radiant heat can be expressed for certain types of activities. This index of environmental factors is obtained by: (1) measuring the air temperature, the air movement and relative humidity, and the radiant heat; (2) multiplying the air temperature reading by 0.1, the air movement and relative humidity reading by 0.7, and the radiant heat reading by 0.2; and then (3) adding the three resulting numerals. For example, if the air temperature is 90ºF, the air movement and relative humidity reading is 80ºF, and the radiant heat reading is 100ºF, the WBGT index would be 85 for Fahrenheit readings and 29.7 for Celcius readings: (°F-32 = ºC).

90ºF	(32°C) x 0.1	=	9.0	32oC x 0.1	=	3.2
80ºF	(27°C) x 0.7	=	56.0	27oC x 0.7	=	18.9
100ºF	(38°C) x 0.2	=	20.0	38oC x 0.2	=	7.6
	WBGT Index	=	85.0			29.7

The several environmental factors are measured with the illustrated devices set up in the area where exposure is to take place (see Figure 1-3 to view equipment needed to perform the WBGT index).

(1) Air temperature (dry-bulb temperature) is measured with a dry-bulb thermometer shielded from the direct rays of the sun.

(2) Air movement and relative humidity (wet-bulb temperature) are measured with a wet-bulb thermometer. (See the WBGT kit at Figure 1-4.) A wet-bulb thermometer is a regular thermometer which has a mercury bulb covered by a wet wick. The mouth of a water bottle, in which the wick is placed, should be about three-fourths of an inch below the tip of the thermometer bulb. The higher the relative humidity and the slower the air movement, the closer the wet-bulb reading will be to the dry-bulb reading.

(3) Radiant heat (globe temperature) is measured with a thermometer inserted into the center of a hollow, flat black, 6-inch copper globe exposed to the full effects of the sun and wind.

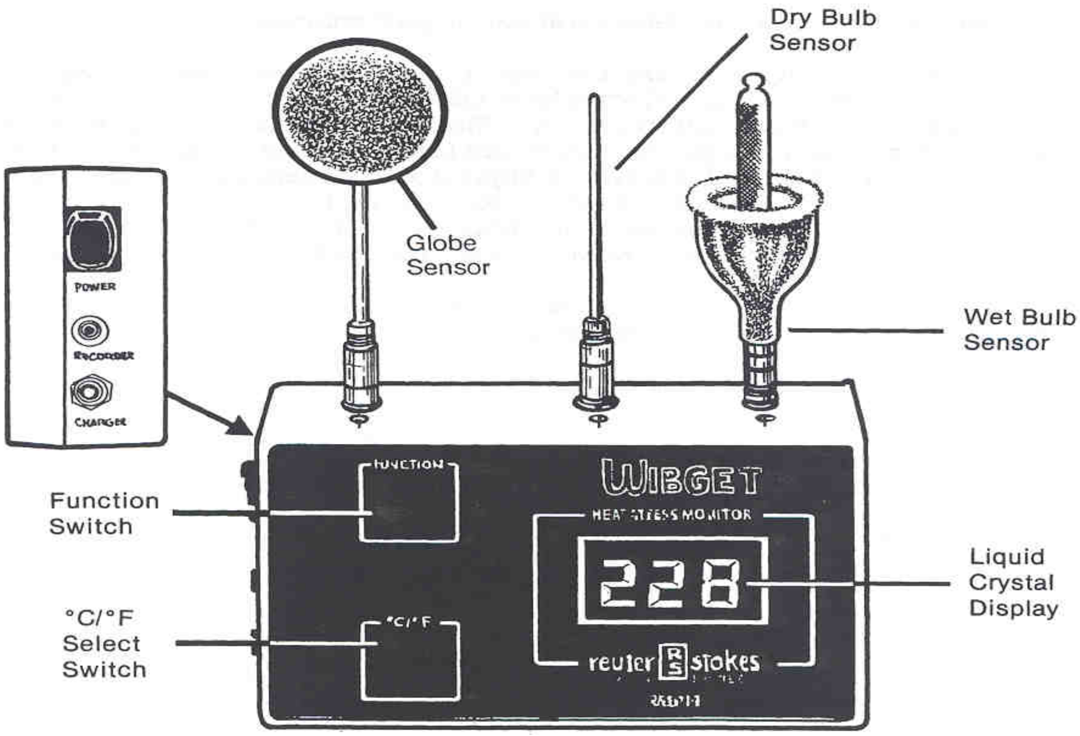


Figure 1-3. Equipment for determining the WBGT index (RSS-214 Micro-Wibget heat Stress Monitor).

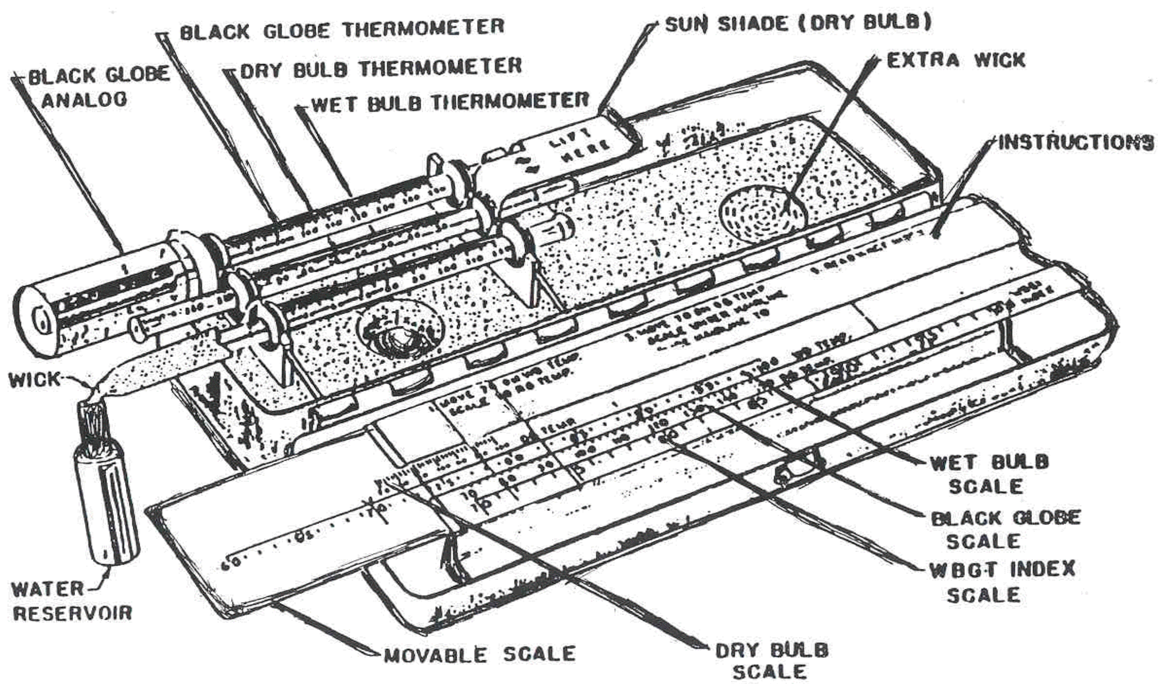


Figure 1-4. WBGT kit.

d. When using the WBGT index in control of a physical activity, the proponents of the WBGT index have proposed the following as a standard for application of the index. **IT SHOULD BE EMPHASIZED** that the measurements must be taken in a location, which is the same as, or closely approximates, the environment to which personnel are exposed.

(1) When the WBGT index reaches 78ºF or 26 ºC (Heat Category 1), (see Table 1-1) extremely intense physical exertion may precipitate heat exhaustion or heat stroke; therefore, caution should be taken.

(2) When the WBGT index reaches 82 ºF or 28 ºC (Heat Category 2), discretion should be used in planning heavy exercise for unseasoned personnel.

(3) When the WBGT index reaches 85 ºF or 29 ºC (Heat Category 3), strenuous exercise such as marching at standard cadence should be suspended in unseasoned personnel during their first three weeks of training. At this temperature, training activities may be continued on a reduced scale after the second week of training.

*Criteria		Controls	
Heat Condition/ Category	WBGT Index ºF	Water Intake Quart/Hour	**Acclimatized Work/Rest
1	78-81.9	At least ½	Continuous
2	82-84.9	At least ½	50/10 minutes
3	85-87.9	At least 1	45/15 minutes
4	88-89.9	At least 1 1/2	30/30 minutes
5	90 and up	More than 2	20/40 minutes

* MOPP gear or body armor adds 10ºF to the WBGT index.

** An acclimatized soldier is one who had worked that condition (temperature) for 14 days.

CAUTION: Due to high salt concentration in field rations, caution must be taken to maintain a high water intake.

NOTE: "Rest" means minimal physical activity. Rest should be accomplished in the shade if possible. Any activity requiring only minimal physical activity can be performed during "rest" periods. EXAMPLES: Training by lecture or demonstration, minor maintenance procedures on vehicles or weapons, personal hygiene activities, such as shin and foot care.

Table 1-1. Heat injury prevention.

(4) Outdoor classes in the sun should be avoided when the WBGT exceeds 85ºF or 29ºC (Heat Category 4).

(5) When the WBGT reaches 88ºF or 31ºC (Heat Category 4), strenuous exercise should be curtailed for all recruits and other trainees with less than 12 weeks training in hot weather. Hardened personnel, after having been acclimatized each season, can carry on limited activity at WBGT of 88ºF to 90ºF (31ºC-32ºC) for periods not exceeding six hours a day.

(6) When the WBGT index is 90ºF or 32ºC (Heat Category 5) and above, physical training and strenuous exercise should be suspended for all personnel (excluding essential operational commitments not for training purposes, where the risk of heat casualties may be warranted).

(7) Wearing of body armor or necessary warfare protective uniforms (for example mission-oriented protection posture (MOPP) clothing), in effect adds 10ºF or 6ºC to the measured WBGT. Limits should be adjusted appropriately.

(8) The optimal doctrine for preventing dehydration and heat illness during hot weather operation requires three guidelines:

(a) Command drinking of water in the absence of thirst.

(b) Adequate rest and allowing the body to cool itself.

(c) Water cooled to 60-70ºF and flavored, if necessary, to improve palatability and acceptance

e. Solar radiation injuries may occur in hot, arid climates; on high mountain slopes, where intense ultraviolet radiation may be combined with windburn; or in the Arctic, where snow blindness may result from reflected light glare. Preventive measures include the wearing of broad-brimmed hats, sunglasses, and lightweight, loose-fitting, light colored clothing. Moderate tanning is desirable to increase sunburn resistance, but the exposure time should initially be limited to 5-15 minutes per day and gradually increased. Dark, intense, long-term tanning should be avoided as a possible contributing factor to skin cancers.

f. Cold injuries are also a cause of reduced effectiveness and potentially permanent damage to health. Low temperatures are necessary for the production of cold injuries; however, freezing temperatures and temperature alone are not required, nor is a reliable guide for cold injury occurrence. Factors that, in various combinations, are involved in cold injury include temperature, humidity, wind-speed, and length of exposure, activity, type and condition of clothing, previous cold injury, race, and nutritional state. For example, the combined effect of wind and temperature has been determined and is expressed as an equivalent temperature in the wind chill chart (see Figure 1-5). This expresses the effective temperature acting upon exposed flesh.

Acclimatization to cold is difficult to measure and is relatively slight. Careful planning and adequate training of both commanders and individual soldiers are essential in the prevention of cold injuries. Specific guidelines can be found in USAEHA TG 172. Each major unit is required to publish a directive that details responsibilities for cold injury prevention and control.

g. The importance attached to the prevention and control of heat, cold, and solar injuries is illustrated by the fact that, whenever a heat injury, a cold injury, or a case of solar radiation injury occurs which requires hospitalization, the commander of the MTF is required to immediately inform the installation or organization commander of the fact. In addition, AR 40-418 requires that he also report this information by telegraph or other expeditious means to TSG, the major Army commander, and in the CONUS, the Commander, Health Services Command. In overseas areas, including Alaska and Hawaii, the report is made only to the major Army commander, who in turn notifies TSG.

h. One other environmental hazard sometimes encountered by Army personnel is the effect of high altitudes. Millions of people live and work at altitudes above 12,000 feet. However, when unacclimatized personnel are quickly moved from altitudes lower than 5,000 feet to altitudes above 10,000 feet, their combat effectiveness is reduced. This loss of effectiveness increases dramatically above 14,000 feet. Typical effects of high altitudes may include giddiness, lightheaded, insomnia, headache, and loss of appetite, elevated pulse rate, and pulmonary edema. Symptoms are usually most severe 12 to 36 hours after arrival and may be persistent and incapacitating. Although the ability to work improves rapidly after the first 2 or 3 days at high altitudes, even after months an individual's maximum work capacity is unlikely to equal that of physically fit highlanders. FM 31-71 contains detailed information on the problems encountered at high altitudes.

i. Measures to reduce non-effectiveness at high altitudes include medical screening to remove those personnel with severe obesity, sickle cell anemia, heart and/or lung disorders, or a history of spontaneous pneumothorax prior to the ascent; providing prior high altitude experience; and staging ascent with several days' stay at an intermediate altitude and drug therapy using aspirin or stronger analgesics such as codeine (when prescribed by competent medical authority).

Estimated wind speed (in mph)	Actual Thermometer Reading (° F.)											
	50	40	30	20	10	0	—10	—20	—30	—40	—50	—60
	EQUIVALENT TEMPERATURE (° F.)											
calm	50	40	30	20	10	0	—10	—20	—30	—40	—50	—60
5	48	37	27	16	6	—5	—15	—26	—36	—47	—57	—68
10	40	28	16	4	—9	—24	—33	—46	—58	—70	—83	—95
15	36	22	9	—5	—18	—32	—45	—58	—72	—85	—99	—112
20	32	18	4	—10	—25	—39	—53	—67	—82	—96	—110	—124
25	30	16	0	—15	—29	—44	—59	—74	—88	—104	—118	—133
30	28	13	—2	—18	—33	—48	—63	—79	—94	—109	—125	—140
35	27	11	—4	—21	—35	—51	—67	—82	—98	—113	—129	—145
40	26	10	—6	—21	—37	—53	—69	—85	—100	—116	—132	—148
(wind speeds greater than 40 mph have little additional effect.)	LITTLE DANGER (for properly clothed person) Maximum danger of false sense of security.				INCREASING DANGER Danger from freezing of exposed flesh				GREAT DANGER			
	Trench foot and immersion foot may occur at any point on this chart.											

Figure 1-5. Wind chill chart.

1-12. THE PHASES OF INDUSTRIAL HYGIENE

The industrial hygiene programs, with which you will come into contact, will normally consist of three phases previously mentioned: recognition, evaluation, and control. These phases will assist you to reduce those environment factors that detract from employee well being and to create a better work environment or physical and physiological work environment.

a. **Recognition**. Health hazards in the work area must first be recognized. This will usually be the result of the various surveys, inspections, and inventories, which you will make. It can also result from listening to complaints received from workers or by noting trends reflected in written reports.

b. **Evaluation**. The hazards present in the work environment must be evaluated in terms of their long term, as well as their short term, effects on employees' health. This evaluation will be based on all data available, from inspections and surveys, as well as from experience and your technical knowledge.

c. **Control**. The last phase is the development, implementation, and follow- up on corrective measures that will reduce or eliminate the existing health hazards. Control measures may include:

(1) Replacement. Replacement of toxic or harmful substances with less dangerous ones.

(2) Modification. Modification of work processes or procedures to minimize or eliminate worker exposure.

(3) Ventilation. Utilization of ventilation to reduce the concentration of harmful substances to safe levels.

(4) Distance. Increasing the distance between the worker and the source of the harmful substance or the noise.

(5) Protection. Requiring the use of personal protective equipment or clothing.

(6) Isolation. Isolation of a process of work operation to reduce the number of persons exposed.

(7) Wet methods. Using wet methods to reduce emission of dusts to the atmosphere such as in the case of abrasive blasting, lathing, and grinding operations.

(8) Housekeeping and cleanliness. Good housekeeping, including cleanliness of the work place; proper waste disposal; adequate washing, toilet, and rest room facilities; healthful drinking water and eating facilities; and control of insects and rodents.

1-13. DIRECTIVES AND REFERENCES

As a PVNTMED specialist involved in Army OH and IH programs, you will require authoritative information on a variety of technical and policy matters. These directives and publications will be useful to you.

a. **AR 11-34, The Army Respiratory Protection Program**. This regulation implements the provisions of DOD Instruction 6055.1; the legal requirements of Section 134, 29 CFR, Part 1910; and the good practice recommendations of the American National Standards Institute (ANSI) Standard 788.2. It also establishes responsibilities and outlines the essential elements for the Department of the Army Respiratory Protection Program and establishes the installation respiratory program director and the installation respiratory specialist positions.

b. **AR 40-5, Health and Environment**. This regulation describes the Army program for health and environment and assigns responsibilities for the various elements of that program. It specifically provides detailed information on the AOHP.

c. **AR 385-10, The Army Safety Program**. This regulation outlines the Army Safety Program and assigns responsibilities for carrying out the various provisions of the program. It also describes the Army protocol for record keeping and employee notification required under Public Law 91-598, the Occupational Safety and Health Act.

d. **AR 385-30, Safety Signs and Specifications**. This regulation provides detailed information on the safety signs that are to be used in areas where hazards are found.

e. **AR 385-32, Protective Clothing and Equipment**. This regulation assigns commanders of Army installations the responsibility for implementing the use of protective clothing and equipment as a means of preventing or minimizing personal hazards to workers. It also provides authority for the procurement, at no cost to the individual, of such items.

f. **TB MED 35, Health Hazards from Solvents**. This technical bulletin discusses the solvents used in certain Army industrial workplaces, guides for the proper use of the solvents, measures for the protection of workers exposed to the solvents, and less toxic substances which can be substituted.

g. **TB MED 501, Noise and Conservation of Hearing**. This technical bulletin summarizes some important facts relating to noise and its effects on the human ear and outlines the essential features of a preventive program that has as its aim the conservation of hearing.

h. **DA Pam 40-501, Hearing Conservation**. This pamphlet augments information contained in TB MED 501 and provides guidance for implementing the hearing conservation program at all facilities controlled by the DA as established in AR 40-5 and AR 385-10. It specifies audiometer testing, and so forth.

i. **TB MED 502, Respiratory Protection Program**. Although respiratory protection was addressed by AR 11-34, this technical bulletin contains information useful in the design and operation of a respiratory protection program.

j. **TB MED 503, The Army Industrial Hygiene Program**. This technical bulletin describes the responsibilities and relationships of the components of an Installation Occupational Safety and Health Program.

k. **TB MED 506, Occupational Vision**. This technical bulletin defines the occupational vision hazards and describes the components of the program designed to counter them.

l. **TB MED 507, Prevention, Treatment, and Control of Heat Injury**. Equipment and protocols needed to combat heat injuries are described in this technical bulletin.

1-14. SAFETY SIGNS AND SPECIFICATIONS

AR 385-30, Safety Signs and Specifications, provides detailed information in safety signs that are to be used in areas where hazards are found. Radiation marking signs may include a variation to the normally viewed danger and/or caution signs or labels. The categories of signs are noted below; however, not all of them are explained. The size of the panels, figures, and letters will vary with the outside dimensions of the signs. Figures 1-6 through 1-12 and Tables 1-2 through 1-6 illustrate some of the specifications for signs and labels.

Safety Color Code Markings And Signs **	
DANGER	Red
CAUTION	Yellow
RADIATION	Purple
SAFETY INSTRUCTION	Green
DIRECTIONAL	Black
INFORMATIONAL	Vary *

*A variety of colors may be used, except for red, yellow, or purple (magenta)

NOTE: There are some variances in sign colors, shapes, and markings to denote hazards. These color markings, and so forth, may be placed on danger, caution, or hazard signs.

Table 1-2. Basic required sign color markings.

a. **Danger Signs**. These signs have a red marking as the basic or highlight color for identifying such items as: fire and laser equipment and other signs or labels posted to warn of specific dangers. All personnel will be instructed that danger signs indicate immediate danger and that special precautions are necessary. Danger signs will have a white background. A black rectangular panel will be placed at the top of the sign. Within the black rectangular panel will be the word "DANGER" in white letters surrounded by a red oval. (A white line separating the outside edges of the red oval from the adjacent edge of the black panel may be used.)

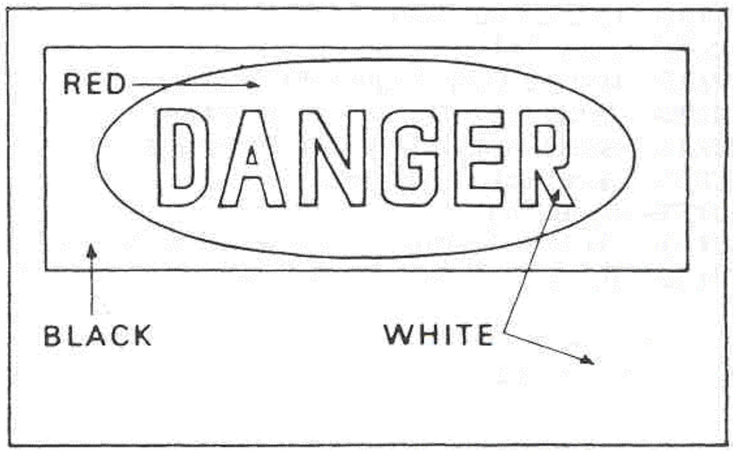


Figure 1-6. Design of danger signs.

Figure 1-7. Hearing protection decal (DA Label 172)

DANGER	High Voltage
DANGER	Keep Off, Electric Current
DANGER	No Smoking, Matches, or Open Light
DANGER	Men Working Above
DANGER	Not Room Enough Here to Clear Man on Cars
DANGER	Keep Away
DANGER	Man in Boiler
DANGER	Insufficient Clearance
DANGER	2,300 Volts
DANGER	Keep Out
DANGER	Crane Overhead
DANGER	Keep Off
DANGER	Use No Open Light Flammable
DANGER	Artillery Firing in Progress
DANGER	Small Arms Firing in Progress
DANGER	Ammunition Dud Area
DANGER	Blasting
DANGER	Do Not Operate. Man Working on Repairs
DANGER	Hands Off Switch, Man Working on Line

Table 1-3. Examples of wording for danger signs.

b. **Caution Signs**. These signs are used to warn against potential hazards or to caution against unsafe practices such as: stopping machinery to clean, oil, or repair. All personnel will be instructed that a caution sign indicates a possible hazard against which proper precautions will be taken. Caution signs will have a yellow background. A black rectangular panel will be placed at the top of the sign and within it will be the word "CAUTION" in yellow letters. Additional wording will be added below the word "CAUTION" to warn of specific possible dangers or unsafe practices.

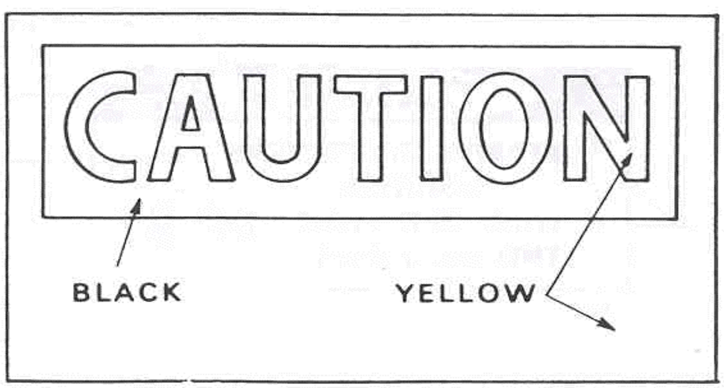


Figure 1-8. Design of caution signs.

CAUTION	Goggles Must Be Worn When Operating Machine
CAUTION	This Door Must Be Kept Closed
CAUTION	Electric Trucks, Go Slow
CAUTION	This Space Must Be Kept Clear At All Times
CAUTION	Stop Machinery to Clean, Oil, or Repair
CAUTION	Keep Aisles Clear
CAUTION	Operator of This Machine Shall Wear Snug Fitting Clothing, No Gloves
CAUTION	Close Clearance
CAUTION	Watch Your Step
CAUTION	Eye Protection Required In This Area
CAUTION	Electric Fence
CAUTION	High Intensity, Noise" Hearing Protection Required

Table 1-4. Examples of wording for caution signs.

c. **Radiation Symbols and Signs**. With the advent of modern technology, the numbers of radiation equipment and other items are increasing; therefore, safety concerns for employees are paramount.

(1) The ionizing radiation symbol sign is a three-bladed design bearing the propeller symbol in magenta (purple) with a yellow background. The wording will vary depending upon the degree of radiation, type of radiation, or area where the radiation is located. Conspicuously display the signs with the lettering mentioned below for the following areas. In addition, post or label with a sign all devices and equipment capable of producing X-rays when energized, except diagnostic and therapeutic x-ray equipment. The sign will bear the ionizing radiation symbol and the words "CAUTION-X-RAYS." Mark all diagnostic and therapeutic x-ray equipment with warning labels as required by TB MED 521.

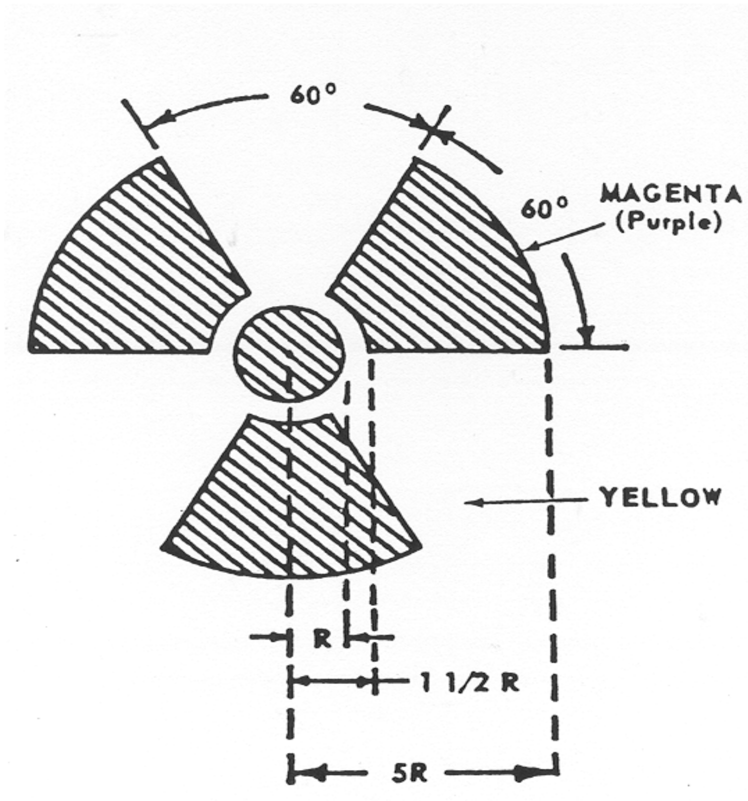


Figure 1-9. Radiation symbol.

(a) In each occupational radiation area (2mR/hr).

CAUTION
RADIATION AREA

(b) In each high-radiation area (100 mR/hr)

CAUTION
HIGH RADIATION AREA

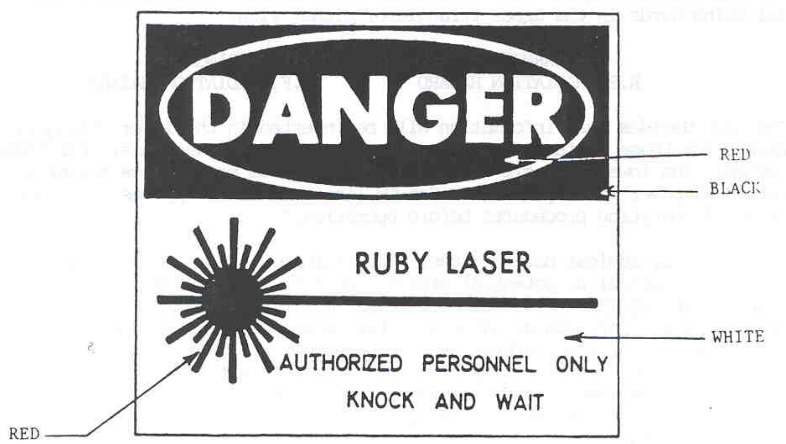
(c) In an area, room, or enclosure containing airborne radioactive material in such concentrations as to create an airborne radioactivity area.

CAUTION
AIRBORNE RADIOACTIVITY AREA

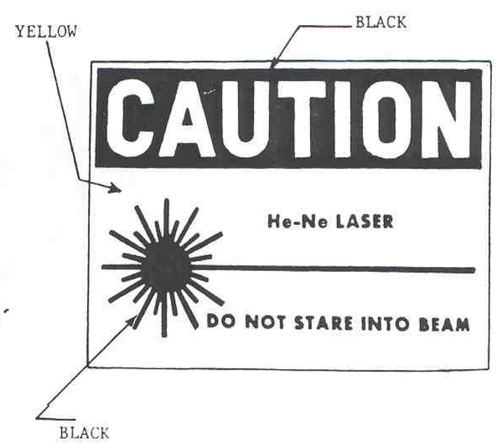
(d) In each area or room that contains radioactive materials in excess of the amount specified by 10 CFR 20.203.

CAUTION
RADIOACTIVE MATERIAL

(2) The laser radiation label and sign formats are for danger and caution data. In the white area of a danger label is to be a red sunburst for Class 3b and Class 4 lasers. In the yellow area of a caution sign and label only on Class 2 and Class 3a lasers, the sunburst is to be black. Extending from the center of the sunburst to the right is a horizontal line. Above the horizontal line of the sunburst, indicate the type of laser radiation. Below the line, indicate the action to be taken to avoid the hazard. Along the lower edge of labels, give the laser classification from TB MED 279, wavelengths, and maximum output power (or energy) of the laser.



Example of warning sign for Class 3b and Class 4.



Example of label for Class 3b and Class 4.

Example of label for Class 2 and Class 3a.

Figure 1-10. Signs and labels for laser devices.

(3) For microwave radiation warning and danger signs, use a red isosceles triangle above an inverted black isosceles triangle. Separate and outline both triangles with an aluminum color border. Always place the following words in the upper triangle of either sign:

WARNING	DANGER
R.F. RADIATION HAZARD	R.F. RADIATION HAZARD

The user decides what information will be inserted in the lower triangle, except for those systems determined to be potentially hazardous. For these systems, the lower triangle will say: "This system may produce potentially hazardous power density levels. See TM (insert TM that applies) and local standard operating procedures before operation."

d. **Biological Hazard Signs**. The biological hazard sign is used to signify the actual or potential presence of a biological hazard and to identify any equipment, containers, rooms, materials, or experimental animals that contain or are contaminated with hazardous agents. The sign may be any design in a fluorescent orange or orange-red color. The background color is optional as long as there is sufficient contrast for the symbol to be clearly defined. These labels or signs are required to be affixed as close as feasible to the container, on the equipment by string, wire, adhesive, or other method that prevents their loss or unintentional removal. The signs are to be also posted at the entrance to the work areas specified (see Figure 1-11).

Figure 1-11. Biological hazard sign.

e. **Safety Instruction Signs**. These signs are used when there is need for general instructions and suggestions pertaining to safety measures such as: reporting of all injuries or no matter how slight. Safety instruction signs will have a white background. A green panel will be placed at the top of the sign and within it will be the white letters giving the safety instructions. The sign wording in black letters, giving details of the safety instructions will be placed below the green panel.

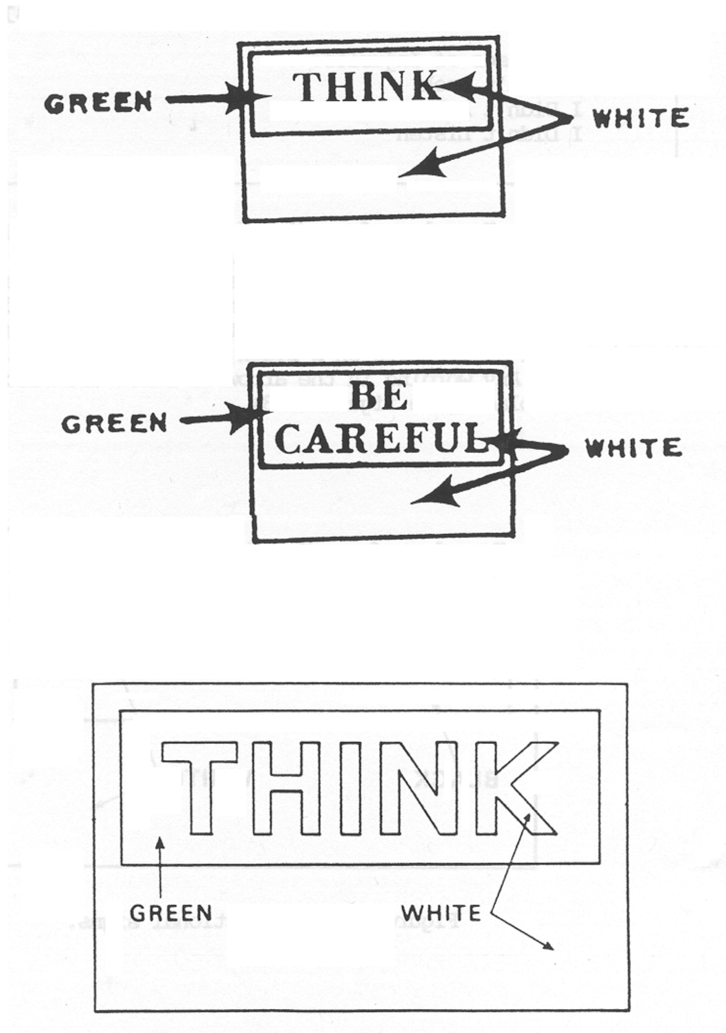


Figure 1-12. Safety instruction signs.

Report All Injuries to the First Aid Room at Once
Walk, Don't Run Avoid Injury
Report All Injuries No Matter How Slight
Make Your Workplace Safe Before Starting the Job
Report All Unsafe Conditions to Your Foreman
Help Keep This Plant Safe and Clean
Lock Out Controls Before Making Electrical Repairs
Number of Consecutive Days Without a Disabling Injury ( )

Three Causes of Injuries:
- I Didn't Look
- I Didn't Ask
- I Didn't Listen

Table 1-5. Examples of wording for safety instruction signs.

f. **Directional Signs**. These signs in sufficient numbers should be used to indicate the way to locations such as: stairways, fire escapes, and exits. Directional signs will have a white background. The arrow pointing the direction will be in white on a black rectangular panel, located at the top of the sign. Any wording in the arrow or below the black rectangular panel will be in black (see Figure 1-13).

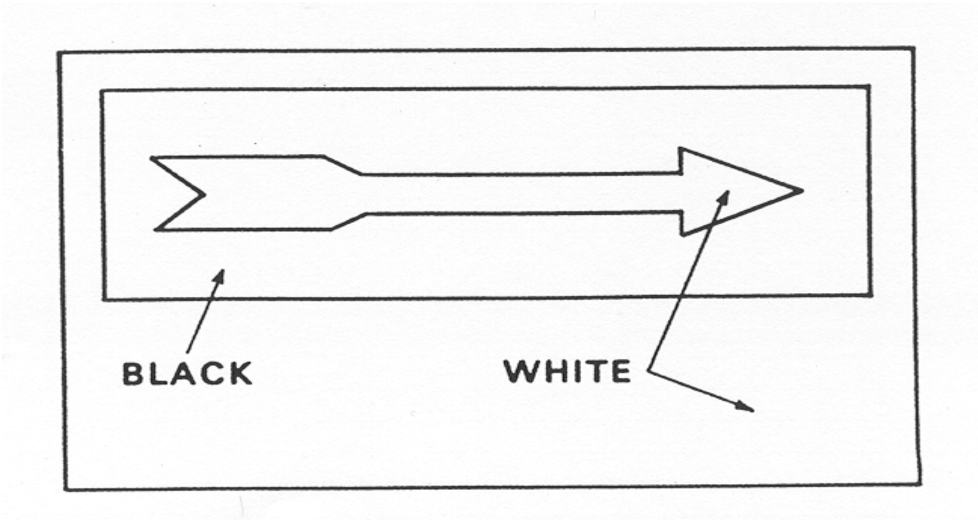


Figure 1-13. Directional signs.

This Way Out (below arrow panel) This Way (inside arrow) Out (below arrow panel). To the (inside arrow) First Aid Station (below panel). Man way (below arrow panel). This Way To (inside arrow) First Aid Room (below arrow panel).

Table 1-6. Examples of wording for directional signs.

1-15. APPENDIXES

You will carry out many of your duties as a preventive medicine specialist by serving as a member of an IH survey team. After you have completed the lessons in this subcourse, study Appendix H, Appendix I, and Appendix J. They illustrate examples of a form designed for use during a preliminary survey, a worksheet to be used during the general survey, and a report submitted following an IH survey, respectively.

Continue with Exercises

EXERCISES, LESSON 1

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Occupational health is concerned with diminishing illness and injury that results from the relationship between a (an)_____________ and his _____________.

2. In the very early days of medicine, the toxicity of _________________ had already been recognized in mining operations.

3. After adopting worker's compensation laws in the United States, it was realized that prevention of accidents was more ________________ than ________ compensation to accident victims.

4. One of the specific objectives of the Association of Occupational Health Professionals is to:

   a. Ensure that some eligible personnel are physically suited to their work.

   b. Increase economic loss caused by physical deficiency, sickness, and injury of military personnel and civilian employees.

   c. Ensure proper medical care and rehabilitation of the occupationally diseased and injured.

   d. Prevent increased combat readiness by allowing occupational illness and injury to military personnel.

5. Which person is responsible for implementing the occupational health program at the work site?

   a. The installation or activity commander.

   b. The Surgeon General.

   c. The Commander, Health Services Command.

   d. The preventive medicine officer.

6. While the emphasis of the AOHP is placed on the economic gain to the Government, it is important to note that the worker who sustains an injury or illness suffers an economic loss due to non-employment.

   a. True

   b. False

7. The elimination or reduction of job related injuries and illness is the end goal of the AOHP.

   a. True

   b. False

8. Which personnel have overall staff responsibility for OSHA compliance as stated in AR 385-10?

   a. US Public Health Service.

   b. Safety.

   c. The Surgeon General.

   d. Managers.

9. What is the basis for any occupational health program?

   a. Correcting the exposure to health hazards without inventorying the area first.

   b. Identification of personnel not at risk to health hazards.

   c. Categorizing jobs.

   d. Inventory of health hazards.

10. When performing industrial hygiene surveys, what potential health hazards will be evaluated?

    a. Chemicals, pesticides, radiation (ionizing and non-ionizing), noise, eye, and biological hazards.

    b. Pests, radiation (ionizing and non-ionizing), noise hazards, eye, and biological hazards.

    c. Chemicals, pesticides, microwaves(ionizing and non-ionizing), noise hazards, eye hazards, and biological hazards.

    d. Chemicals, pesticides, radiation, eyes, noise hazards, and biological hazards.

11. What investigations will be conducted when situations develop suggesting the possibility of an increased disease or injury rate attributable to occupational hazards?

    a. Immunization.

    b. Epidemiological.

    c. Chronic absence.

    d. Non-occupational injuries.

12. The Alcohol & Drug Abuse Prevention & Control Program was established by AR 600-85 to:

a. Evaluate, diagnosis, educate, apprehend, and refer civilian employees as per local guidelines.

b. Remediate, educate, apprehend, and refer civilian employees as per local guidelines.

c. Evaluate, diagnose, counsel, and refer civilian employees as per local guidelines.

d. Evaluate, diagnosis, educate, consider, and refer civilian employees as per local guidelines.

13. Varying electromagnetic fields in the frequency range of 10 KHz to 300,000 MHz, with corresponding wavelengths of 30 KM to 1 millimeter, are known as:

a. Occupational hygiene hazards.

b. Microwave radiation.

c. Laser radiation.

d. Pregnancy surveillance.

14. Employees exposed to laser radiation sources are identified and included in medical surveillance program as per which TB?

a. TB MED 523.

b. TB MED 501.

c. TB MED 35.

d. TB MED 279.

15. What control measure would be performed if an environmental hazard were found?

    a. Use dry methods to reduce emission of dust.

    b. Continue to use the same material.

    c. Reduce exposure to radiant energy by shielding, increasing distance, and limiting the time.

    d. Use quantitative measurement and render an opinion.

16. Industrial hygiene primarily involves all EXCEPT:

    a. The recognition of environmental factors and stresses associated with work and work operations and how it affects the well being of the work force.

    b. Evaluation of quantitative measurements and magnitude of environmental factors and stresses that impair man's health and well-being.

    c. Prescribing methods to control or reduce environmental factors and stresses when necessary to alleviate their effects.

    d. The nature of hazards found in the work environment and distinctive characteristics of the work force.

17. What are four of the required minimum essential elements that comprise an installation IH program?

    a. Implementation plan, RAC, recording contract, and design review.

    b. Occupational Service Health Act standards, implementation plan, occupational vision, and RAC.

    c. Hearing conservation, OSHA standards, RAC, and design review.

    d. Record keeping, implementation plan, hearing conservation, and design review.

18. Under the Respiratory Protection Program for IH, what requirements must supervisory, safety, and preventive medicine personnel keep in mind when jointly developing installation program?

    a. Legal.

    b. Administrative.

    c. Logistical.

    d. Training.

19. Name the most important principles for acclimatization for the prevention of heat injuries.

    a.____

    b.____

    c.____

20. Although nothing can be done to control the climate, weather, or altitude at which soldiers must function, what can the industrial hygienist do to prevent harmful effects on personnel and subsequent deterioration of performance?

    a. Little.

    b. Pay attention to heat indices and workplace accomplishments.

    c. Develop and keep current defined goals and objectives in the IH area.

    d. Give physical examinations to soldiers complaining of certain physical problems.

21. What type of injuries is the result of excessive elevation of body temperature and/or water electrolyte imbalance due to inadequate replacement of fluid lost through perspiration?

    a. Cold.

    b. Sprain.

    c. Heat.

    d. Ingrown toenail.

22. What would the WBGT index be for ºF and ºC if the air temperature is 90ºF, the air movement and relative humidity reading is 80ºF, and the radiantheat reading is 100ºF?

    a. 85ºF; 31.9ºC.

    b. 64ºF; 28.3ºC.

    c. 73ºF; 35.2ºC.

    d. 85ºF; 29.7ºC.

23. If the heat condition or category is four, then the WBGT index is_____ and the acclimatized work/rest periods would be _________________.

    a. 82.4; 50/10.

    b. 88.4; 30/30.

    c. 86.1; 45/15.

    d. 90.7; 20/40.

24. What are ALL the listed factors that cause cold injuries, in various combinations?

    a. Temperature, humidity, wind speed, length of exposure, activity, type and condition of clothing, previous cold injury, race, and nutritional state.

    b. Temperature, humidity, length of exposure, activity, type and condition of clothing, previous cold injury, race, and nutritional state.

    c. Temperature, humidity, wind speed, length of exposure, activity, clothing size and type of fabric, previous cold injury, race, and nutritional state.

    d. Temperature, humidity, wind speed and chill, length of exposure, activity, type and condition of clothing, amount of snow fallen, race, and nutritional state.

25. Which AR describes the Army program for health and environment and specifically provides detailed information on the AOHP?

    a. AR 11-34.

    b. AR 40-5.

    c. AR 385-10.

    d. AR 385-32.

26. What is the safety color code marking for a safety instruction sign?

    a. Red.

    b. Yellow.

    c. Green.

    d. Black.

27. Which hazard sign uses florescent orange or orange-red for its design with an optional color background?

   a. Laser radiation.

   b. Biological.

   c. Safety instruction.

   d. Directional.

28. Which kind of sign would normally have the wording "Electric Fence"?

   a. Caution.

   b. Danger.

   c. Directional.

   d. Safety instruction.

29. A three-bladed design bearing the propeller symbol in magenta(purple) with a yellow background would be used for what sign?

   a. Laser radiation.

   b. Biological.

   c. Ionizing radiation.

   d. Microwave radiation.

30. Which TB contains important facts relating to noise and its effects on the human ear?

   a. TB MED 35.

   b. TB MED 279.

   c. TB MED 501.

   d. TB MED 523.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 1

1. Individual, job (para. 1-1a)

2. Lead. (para 1-1b, c)

3. Profitable; paying. (para. 1-1e)

4. c (para. 1-1g(4))

5. a (para. 1-2h)

6. a (para 1-3f)

7. a (para 1-3f)

8. b (para 1-4b)

9. d (para 1-6a(1))

10. a (para 1-6b)

11. b (para 1-6i)

12. c (para 1-6j)

13. b (para 1-6l(3))

14. d (para 1-6l(2))

15. c (para 1-7d(5))

16. d (para 1-7a)

17. d (para 1-8)

18. a (para 1-8g)

19. Command drinking of water in the absence of thirst.
Adequate rest to allow the body to cool.
Maintain drinking water temperature between 60-70ºF. (par 1-11d (8))

20. c (para. 1-10a)

21. c (para 1-11b)

22. d (para 1-11c)

23. d (para 1-11d(4), Table 1-1)

24. a (para 1-11f)

25. b (para 1-13b)

26. c (para 1-14e), Table 1-2)

27. b (para 1-14d)

28. a (Table 1-4)

29. c (para 1-14c(1))

30. c (para 1-13g)

END OF LESSON 1

LESSON ASSIGNMENT

LESSON 2 Control of Toxic Substances.

TEXT ASSIGNMENT Paragraphs 2-l through 2-30.

LESSON OBJECTIVES After completing this lesson, you should be able to:

2-l. Define toxicity, micron, vapor, dust, fume, mist, ceiling value (C), and skin notation.

2-2. List and identify the routes of entry for toxic contaminants.

2-3. Select the natural body defenses against toxic contaminants.

2-4. List the five potential effects of chemical contaminants on the body.

2─5. Determine the threshold limit value (TLV) for Selected contaminants.

2─6. Identify the various types of sampling.

2─7. List examples of the various items of equipment used for sampling gaseous or particulate contaminants.

SUGGESTION Study the appendixes carefully, as they are Important in the computations. After studying the assignment, complete the exercises at the end of this lesson. These exercises will help. You to achieve the lesson objectives.

LESSON 2

CONTROL OF TOXIC SUBSTANCES

Section I. THE NATURE OF CONTAMINANTS

2-l. GENERAL

a. Hazards in the work environment can be purely mechanical in nature, or they may occur in the form of materials or substances, which are capable of causing fire or explosion, or of producing injury or illness by inhalation, by contact with the skin or eyes, or by ingestion. Physical forms of energy such as noise, ionizing and non-ionizing radiation, and heat can also be health hazards. This lesson deals specifically with the subject of toxic substances in the industrial workplace, the effects of these substances on the human body, and measures that can be employed to protect workers from them. As you read this lesson, you should periodically refer to Appendix B, which contains a list of typical operations found on Army installations, the health hazards associated with the individual operations, and the control instituted to reduce or eliminate the hazards.

b. Basic to the control of an industrial health hazard is the recognition and evaluation of the hazard. Once the hazard has been identified, and its severity determined measures for its control can be developed. Once this is done, it then becomes a matter of instituting appropriate control measures and monitoring their effectiveness.

2-2. CLASSIFICATION OF CHEMICAL HAZARDS

a. There are over l00, 000 chemicals used in industrial operations in this country today. Several of them have been identified as cancer causing agents, or carcinogens. Hundreds of them are known to destroy body organs, or to cause extreme irritation leading to reduced or total non-effectiveness of workers. Still others are in use whose effects on the body are unknown, or about which very little is known. In this lesson we will concern ourselves with known effects such as toxicity and skin contamination. Appendix C contains a partial list of potentially hazardous substances found on Army installations.

b. Chemicals that may create potential hazards may be classified according to their physical states or characteristics. Some occur as gases, vapors, mists, dusts, or fumes that may be breathed with the air. Others are solids or liquids that may be absorbed through the skin or ingested (taken in through the mouth). It is important to understand these physical states in which toxic materials may occur, since the hazard associated with their use often depends upon this factor.

(1) Gases. A gas is a fluid that has neither independent shape nor volume, but tends to expand indefinitely. Some examples are air, oxygen, chlorine, and the gas, which constitutes one of the most serious occupational hazards, carbon monoxide.

(2) Liquids (liquid itself, vapors, and mists). Liquids are fluids characterized by particles that move freely, without a tendency to separate from one another as in the case with a gas. Examples of liquids are water and most insecticide formulations.

(a) Vapors. Vapors are gaseous forms of substances that are normally liquid or solids at normal temperature and pressure. Vapors can be changed to liquids and solids by increasing the pressure or decreasing the temperature. Among the vapors, the solvents are particularly hazardous, since they tend to vaporize easily and contaminate the work atmosphere. Benzyl, carbon tetrachloride, and trichloroethylene are examples of organic solvents that vaporize readily.

(b) Mists. Mists are airborne droplets formed by the breaking up of a liquid, as by splashing, foaming, or atomizing. Mist particles can also result from vapor condensation and are generally larger than vapor particles. Mists are particularly apt to form over hot solutions and can spread throughout an area if ventilation is poor. Acid mists are primarily respiratory irritants; however, chromic acid mists are suspected of causing lung cancer.

(3) Solids

(a) Dusts are finely divided solid particles formed by the crushing, grinding, or abrading of solid materials. Dusts settle to the ground at variable rates depending on their size and mass. Dusts may cause pneumoconiosis (a chronic inflammation of the lungs after continued inhalation of dusts after a period of time). The most common reaction is fibrosis. Silicosis is the predominant form of fibrosis that is known to cause disability. Systemic poisons in the form of dusts are common, and some need not be inhaled to cause damage. Skin absorption may be the route of entry for some toxic dusts. Examples of toxic dusts are those formed from lead, antimony, manganese, and some plastics.

(b) Fumes are very small-suspended solid particles generated by condensation from the gaseous state usually evolved from heated metals or other materials to form metallic oxides. Fumes are responsible for a particular occupational illness known as "metal fume fever." "Metal fume fever" is a temporary condition resembling an acute respiratory infection and occurs most commonly in galvanizing and welding operations. Some of the metal fumes may be absorbed into the bloodstream and thereby cause toxic symptoms in other parts of the body. Examples of toxic fumes are those of lead, mercury, manganese, and cadmium.

2-3. ROUTES OF ENTRY OF TOXIC AGENTS

Toxic chemicals can enter the body by various routes and the response to any toxic agent may vary markedly depending on the specific route of entry. It is important to understand the routes of entry since protecting the individual from toxic agents depends on preventing exposure.

a. **Inhalation**. Inhalation is the most important route of entry for toxic agents. Some toxic agents may produce acute effects that will be quickly recognized by the person being exposed. Others may cause chronic effects that may take up to 25 years to recognize, such as asbestosis from asbestos exposure.

b. **Absorption**. The most common occupational disease seen in the Army and in the public sector is dermatitis. Effects on the skin and other sites of absorption are primary irritation from contact, sensitization from repeated exposure, and systemic poisoning from absorption.

c. **Ingestion**. Ingestion occurs as a result of eating or smoking with contaminated hands, contaminated utensils, or in contaminated areas. Ingestion of inhaled materials also occurs as a result of the natural cleaning action of the lungs. Material is removed from the lungs by cilia and is deposited in the throat to be swallowed.

d. **Injection**. Accidental injection occurs mainly during the administration of drugs. Other injections may occur from the use of high pressure, air or liquid, such as in spray painting, or from the rupture of high-pressure lines.

2-4. NATURAL BODY DEFENSES

a. **The Respiratory System**. The conducting portion of the respiratory system provides a low resistance pathway for uniform distribution of gases to the air sacs in the lungs, and it contains structures which "condition" the air and protect the lungs from at least the largest of infectious or toxins particles in the atmosphere. Some of these structures are:

(1) Mucosa. The mucous surfaces of the nose protect nose breathers from inhaling particles larger than 5 or 10 microns in diameter (a micron is one millionth of a meter or approximately 1/25,000 inch). Soluble gases are largely removed by absorption and the air is moistened and warmed (or cooled, in hot, dry conditions). In addition, the smell receptors in the upper reaches of the nose may serve as a protective role.

(2) Cilia. The tracheobronchial system is lined with cilia (short hairs) that constantly force mucus toward the larynx. When the mucus reaches the pharynx, it may be expectorated but is usually swallowed. These "pulmonary clearance"

mechanisms play an important role in preventing pulmonary effects from inhalation of dusts, fumes, and other forms of potentially hazardous materials.

b. **The Skin Surface**. The skin, with its thick layers of cells and its secretions, is almost impervious to chemical agents. However, certain chemicals, such as solvents and gases, can penetrate the skin's barriers.

c. **The Excretory System**. The body attempts to modify harmful substances into less harmful substances. The liver and kidneys play a major role by extracting and expelling chemicals. However, the excretory system is perhaps the least effective of the body's defenses against harmful chemicals.

2-5. EFFECTS OF CHEMICALS ON THE BODY

Many chemicals may act as toxic agents. A detailed discussion of all the biological actions of all the toxic agents a preventive medicine specialist would encounter would be an impossible undertaking. Instead, the toxic agents will be discussed according to their general biological actions.

a. **Irritants**. The basis of classifying these materials is their ability to cause inflammation of mucous membranes. Many irritants are strong acids and alkalis familiar as corrosive to nonliving things. Bear in mind that inflammation is the reaction of living tissue and is distinct from chemical corrosion.

b. **Asphyxiates**. The basis of classifying these materials is their ability to deprive the tissue of oxygen. The materials classified as asphyxiates do not damage the lungs. Simple asphyxiates are physiologically inert gases that act when they are present in sufficient quantities to exclude an adequate oxygen supply. Among these substances are nitrogen, nitrous oxide, carbon dioxide, hydrogen, helium, methane, and ethane. Some of these gases are chemically reactive and some may pose a major threat of fire. Chemical asphyxiates are materials which specifically render the body incapable of utilizing an adequate oxygen supply. Two classic examples are carbon monoxide and cyanides.

c. **Anesthetics**. The main action of these materials is their depressant effect upon the central nervous system, particularly the brain. The degree of anesthetic action depends upon the effective concentration in the brain as well as upon the specific pharmacological action. The anesthetic potency of simple alcohol rises with increasing numbers of carbon atoms up to amyl alcohol, which is the most powerful of the series.

d. **Lung Damaging Agents**. In this category are materials that produce damage of the pulmonary tissue but not by immediate irritant action. Materials such as free silica produce fibrotic changes. Asbestos also produces a typical damage to the lung tissue, and there is newly aroused interest in possible effects of low-level exposure of individuals who are not asbestos workers. Other dusts, such as coal dust, can produce pneumoconiosis. Many dusts, of organic origin such as those arising from cotton or wood can cause pathology of the lungs and/or alterations in lung function.

e. **Systemic Poisons**. In this category are materials that cause damage to internal organs such as the liver, the kidney, and the nervous system. Carbon tetrachloroethane is probably the most toxic of the chlorinated hydrocarbons and produces atrophy of the liver; that is why it is no longer used as a solvent. Other chlorinated hydrocarbons are chloroform and a certain group of pesticides. Some halogenated hydrocarbons are chloral hydrate, trichloroethane, and chloroform. Some halogenated hydrocarbons produce damage to the kidney as well as the liver if excessive, acute, or chronic exposure to these compounds occurs. Some metals such as manganese, mercury, and thallium cause damage to the nervous system. Organic phosphorus pesticides inhibit the production of cholinesterase, which is an enzyme necessary for the proper function of the nervous system. Some other examples are benzene, uranium, lead, and mercury.

f. **Carcinogens**. These materials have demonstrated that they cause cancer in humans or suspected of causing cancer based on animal studies. The classic example is cancer of the scrotum from coal tar pitch volatiles. Other substances of proven carcinogenic potential in humans are asbestos, chromium (VI), vinyl chloride, and naphthylamine. The list of substances suspected of causing cancer is lengthy and is growing nearly every day. It includes benzene, beryllium, carbon tetrachloride, chloroform, ethylene oxide, formaldehyde, and methyl iodide.

NOTE: Some substances may fit in two or more categories. Many variables determine the effect of hazardous substances with the most important consideration is the dose response relationship. Dose involves two variable concentration and duration of exposure. For certain chemicals, a high concentration for a short period of time would produce the same effects as a low concentration for a long period of time. Safe limits are set so that the combination of concentration and time are below levels, which will produce injury or illness, the "response." A sufficiently small amount of most chemicals do nothing injurious. This means that there is a threshold of effect of a "no response" level.

2-6. FACTORS AFFECTING TOXICITY

a. The toxicity (poisonous effect) of a chemical agent may be affected by a variety of factors based on the characteristics of the contaminant itself, such as:

(I) Volatility.

(2) Temperature.

(3) Solubility.

(4) Particle size.

(5) Density.

b. Physical conditions of the workers themselves can have an effect on the toxicity of agents. These factors include the worker's age, his general state of health, and his prior history of sensitivity.

c. The toxicity of chemical agents can also be affected by environmental factors such as:

(1) Concentration

(2) Control measures in effect.

(3) Duration of exposure

(4) Frequency of exposure

SECTION II. ATMOSPHERIC HAZARDS

2-7. GENERAL

The atmosphere includes toxic chemicals that are released into the air as by products of industrial activity. Examples include: carbon monoxide from tuning and testing combustion engines, welding fumes, solvent vapors from spray painting, degreasing operations, and the like.

2-8. CARBON MONOXIDE

a. **Source of Exposure**. Carbon monoxide is produced whenever fossil fuels are burned in the presence of insufficient oxygen to transform all the hydrocarbons present to carbon dioxide and water. Carbon monoxide is produced in the incomplete combustion of coal, gasoline, natural gas, and other carbon containing substances. It is produced in the explosion of dynamite and nitroglycerine and in the operation of blast furnaces and internally lubricated compressors. Automobile exhaust contains 5 to l0 percent or more carbon monoxide. Carbon monoxide occurs in small traces in natural gas, but incomplete burning of natural gas can produce greater amounts. Since gasoline, oil, coal, and gas are used in virtually all jobs and homes, the potential for exposure to carbon monoxide is widespread. Carbon monoxide is an insidious hazard, in that it is odorless, colorless, tasteless, and nonirritating, and its presence may therefore go undetected.

b. **Bodily Effects**. Carbon monoxide interferes with the supply of oxygen to the tissues of the body. Normally, inhaled oxygen is transferred in the lungs to a chemical known as hemoglobin, which is present in all red blood cells. Hemoglobin then transports oxygen, by way of the bloodstream, to the tissue cells where transfer takes place. The affinity of hemoglobin for carbon monoxide is 250 times greater than it is for oxygen. When carbon monoxide combines with hemoglobin, the transport of oxygen to the tissue cells is blocked. Without oxygen, cells cannot live, and when the concentration of carbon monoxide is great enough, death occurs through asphyxiation.

c. **Prevention**. The most common and most easily recognized potential exposure to carbon monoxide is in installation motor pool maintenance shops. Whenever "gasoline powered" (the chemical profile for diesel engine exhaust does not include much carbon monoxide) vehicle engines are operating, a method of removing the carbon monoxide-laden exhaust from the vehicle's breathing zone must be used. This is best accomplished by a combination of natural ventilation and mechanical tail pipe extension systems that carry the exhaust outside the building. A full discussion of ventilation systems is found in lesson 4 of this subcourse.

2-9. OTHER GASES

a. **Irritant Gases**. The gases that have an irritant effect on the mucous membranes of the respiratory tract and eyes are important occupational hazards. Gases in this group are chemically very different, but their bodily effects are similar. Nitrogen dioxide and phosgene will be used as examples of irritant gases.

(1) <u>Sources of exposure</u>. Nitrogen dioxide gas is produced in many processes, including welding, bleaching, and the manufacturing of explosives. Phosgene was used as a chemical warfare agent in World War I. It can be accidentally produced when chemicals called chlorinated hydrocarbons come into contact with a flame, hot metal, or any other heat source. Trichloroethylene is a chemical commonly used in vapor-degreasing operations. Contact of this vapor with a heat source can produce phosgene. Phosgene can also be produced when the vapor of a chlorinated hydrocarbon comes in contact with ultra-violet radiation such as that produced by electrical arc welding.

(2) <u>Bodily effects</u>. The body has many mechanisms for protecting its tissues from injury by harmful gases. For example, some of the irritant gases cause coughing, sneezing, narrowing of the air passages, or even temporary cessation of respiration. Also, the tears of the eye and mucus of the respiratory tract tend to dilute and wash away irritating substances. Irritation of the eyes and upper respiratory tract may in some cases be severe enough to drive a person out of an area of exposure before serious damage can occur. On the other hand, some gases damage the lungs, yet produce only slight irritation of the upper respiratory tract. This effect is characteristic of phosgene, for example. Other gases may fail to produce warning symptoms when the amount of gas in the air is increased gradually. The effects of exposure to a large amount of irritating gases for a short time are different from those

due to small amount stretched over weeks or months. Sudden, large exposure results in inflammation, swelling, and narrowing of the airway, and in some cases the lungs fill up with a fluid-a condition known as pulmonary edema. Those that primarily affect the lungs, such as phosgene, often cause few, if any, symptoms at the time of exposure. The employees may continue at their jobs, unaware that they have inhaled a dangerous gas. Only after several hours do headache, vomiting, coughing, and shortness of breath appear. In severe cases, death may occur. Prolonged exposure to small amounts of irritant gas may produce a persistent cough or repeated cold-type infections as the only symptoms.

(3) Prevention and control. The best prevention of exposure to irritant gases is to ensure that they are not present in the workers' environment. This is best accomplished by good engineering design and maintenance of the equipment on the job. If exposure to some irritant gas is unavoidable, then provisions should be made for appropriate personal protective equipment. Appendix B lists those representative control measures used to reduce or eliminate the hazard from irritant gases.

b. **Narcotizing Gases**. Narcotic substances can produce unconsciousness and many of the same symptoms that are exhibited with asphyxiates. The distinguishing feature of narcotics is the effect on the central nervous system, causing it to fail to do its normal job. Anesthetics and narcotics exert their principal action by causing simple anesthesia without serious systemic effects, unless the dose is massive. Depending on the concentration present, the depth of anesthesia will range from mild symptoms to complete loss of consciousness and death. In accidents involving very high concentrations, death may be due to asphyxiation. Substances like ether, chloroform, and other anesthetics that are very effective in producing anesthesia are selected when the intent is to make someone unconscious. In the industrial environment, there are many things that have a narcotic action. Examples of these are acetone, methyl bromide, and carbon disulfide.

c. **Toxic Gases**.

(1) Ethylene oxide, a common toxic gas, is used for sterilizing surgical supplies. The high chemical reactivity and the general exothermic nature of ethylene oxide reactions present a number of stable conditions, but the vapor in concentrations of 3 to l00 percent is highly flammable and subject to explosive decomposition. Ignition and decomposition are initiated by many common sources of heat, and the pressure rise is sufficiently rapid and extensive to cause violent rupture of containing equipment. The hazards of health associated with the handling of ethylene oxide are those of inhalation of the vapor and contact of the eyes and skin with the liquid or solutions even as dilute as one percent. Ethylene oxide may be described as a central depressant, an irritant, and a protoplasmic poison. Contact with even dilute solutions may cause irritation and necrosis of the eyes and irritation, blistering, edema, and necrosis of the skin. Excessive exposure to vapor may cause irritation of the eyes, respiratory tract, lungs, and central depression. Nausea and vomiting are usually delayed and may be

followed by convulsive seizure and profound weakness of the extremities and secondary infection of the lungs.

(2) Hydrogen sulfide, a colorless gas with the foul odor of rotten eggs that is flammable and highly toxic, is used as an industrial chemical. It is encountered in mining, especially where sulfide ores are found; in excavating in swampy or filled ground, and sometimes in wells, caissons, and tunnels; in natural gases and in sewer gases. By far the greatest danger from the inhalation of hydrogen sulfide is from its acute effects. Concentrations of 700 PPM and above may result in acute poisoning. Although the gas is an irritant, the systemic effects from the absorption of hydrogen sulfide into the blood stream exceed that which is readily oxidized. Systemic poisoning results, with a general action on the nervous system. Hyperpnea occurs shortly, and respiratory paralysis may follow immediately. This condition may be reached without warning as the originally detected odor of hydrogen sulfide may have disappeared. Unless the victim is removed to fresh air within a very few minutes and breathing is stimulated or induced by artificial respiration, death occurs.

Section III. ORGANIC SOLVENT HAZARDS

2-10. GENERAL

The most widespread, and some of the most dangerous, occupational hazards are created by liquid chemicals, such as solvents. These chemicals may present hazards from the use of the liquid itself, as a vapor of the liquid, or as a mist of the liquid. The vast majority of liquid chemicals found in the industrial workplace are organic compounds. The organic compounds are those that contain carbon. They are found in plant and animal tissues and in materials, such as petroleum and coal, which result from the breakdown of living substances. Lubricants, solvents, fuel, and many insecticides are but a few of the many hundred of different compounds in use, and new ones are constantly being produced. These chemicals are used in the course of most industrial-type jobs, as well as being commonly found in the home. Because of their widespread use and their harmful properties, the organic compounds present significant military occupational hazards.

2-11. SOURCES OF EXPOSURE

It would be virtually impossible to list all the possible occupations or industrial type operations in which exposure to liquid chemicals occur, since so many occupations or industrial processes use these chemicals in one way or another. However, a few typical military exposures will be discussed, and others are listed in Appendix B.

a. **Liquid Chemicals**. There are many military situations in which individuals are exposed to a potentially hazardous organic compound in liquid form. Many different solvents and fuels are used in military operations. Vehicle and weapons maintenance requires grease, oil, and other lubricants. Field sanitation teams, engineers, and preventive medicine personnel handle insecticide concentrates. Additional examples of operations involving the use of liquid chemicals can be found in Appendix B.

b. **Liquid Chemicals as Vapors**. Most organic compounds can be vaporized very easily; in fact, some vaporize at room temperature. A common exposure involving chemical vapor occurs in vapor degreasing of metal parts. When metal machine parts are removed for repair or cleaning, their lubricating oils and greases must be removed. This is often accomplished by immersing the parts in the vapor of solvents which, when contained in open top containers, will evolve various amounts of vapor, depending upon the type of solvent and its temperature.

c. **Liquid Chemicals as Mists**. Liquid chemicals can be changed into a fine mist by passing the compound through an appeture such as a spray-painting nozzle. A common example of this process is spray painting. Spray painting is widely used in vehicle repair shops, machinery maintenance facilities, and building construction and maintenance. Paint contains many organic compounds that make up the pigment, binders, thinners, wetting agents, and solvents.

2-12. BODILY EFFECTS

a. **General**. The bodily effects of liquid chemicals vary widely, depending on the exact chemical involved. The effects on the skin, nervous system, liver, and those leading to cancer will be discussed in this subcourse.

b. **Skin Diseases**. In terms of numbers, occupational skin diseases (dermatitis) are by far the most important of the occupational diseases. Although occupational skin conditions may cause considerable loss of time from work, they are not usually severe enough to cause permanent disability.

(1) The healthy skin has certain barriers against injury. The dead surface cells resist most chemicals, while the oily secretions of the skin form a protective covering against some chemicals. Deeper skin cells prevent the loss of water from the skin.

(2) The occurrence of occupational dermatitis depends mainly on the specific chemicals to which the skin is exposed and the length of the exposure. The presence of other skin diseases lowers resistance to exposure. Personal cleanliness is important, since failure to wash the skin or to remove dirty clothing increases the length of exposure. The type of skin is an important factor, too. People with oily skins are more likely to develop infected sweat glands; where as those with dry skins are more affected by drying agents such as detergents. Male workers have more skin disease than do female workers, possibly because females take better care of their skin. There is more skin disease in the summer than in the winter because of the fact that less clothing is worn and to the presence of sweat.

(3) The effect of chemicals on the skin may be an irritant effect, a sensitizing effect, or both. A chemical that is classified, as a skin irritant will cause irritation to any individual's skin, if left in contact with the skin longs enough. Most of the organic compounds can be considered skin irritants, although they vary greatly in strength. Chemical agents which do not cause skin disease on first contact but do so after 5 to 7 days or more of continuous or repeated contact are called sensitizing chemicals. This is a type of allergy, which develops only in a small number of people exposed, depending on the chemical involved and the individual's sensitivity to that substance. Examples of chemicals capable of sensitizing are the explosives, photographic developers, epoxy mixtures, some insecticides, and some fungicides.

c. **Nervous System Effects**. It is difficult to summarize the toxic effects of organic solvents, since they vary greatly in their effects on human tissue. There is one property, however, which is common to practically all of the organic solvents. It is their ability to produce a loss of sensation and sometimes a loss of consciousness. Sudden large exposures to concentrated vapors of certain solvents can lead to instant unconsciousness and even death. With lower levels of exposure, less severe symptoms will be experienced. Headaches, dizziness, nausea, vomiting, and convulsions may occur. Even low exposure may produce enough drowsiness to create an accident hazard under certain conditions. The insecticides are good examples of these toxic properties; for example, the chlorinated hydrocarbon insecticide like DDT acts directly on the brain and can cause tremors, dizziness, and convulsions. Organophosphorus and carbamate insecticides such as Malathion are also organic compounds, but they exert their toxic action on that part of the nervous system that controls breathing, digestion, muscle strength, vision, and sweating. Thus, excessive exposure to these chemicals results in respiratory difficulty, vomiting, muscle weakness, blurry vision, and excessive sweating, which are but a few of the many symptoms. No attempt will be made to describe the toxic effects of each specific chemical in this group.

d. **Cancer Producing Liquid Chemicals**. Brief mention should be made of the cancer producing properties of certain liquid chemicals. In lesson I, it was mentioned that as early as I775, cancer of the scrotum in chimney sweeps was recognized as a hazard of that occupation. Since that time, skin cancer as been found in many other occupations in which exposure to coal tar and pitch exists. Cancer of the urinary bladder has been reported in workers who handle certain organic dyes. Occupational Service Health Act has published a list of cancer producing chemicals (carcinogens) that can be found in 29 CFR Part 1910.1000.

2-I3. PREVENTION AND CONTROL

a. **General**. Measures for the prevention and control of illnesses arising from exposure to liquid chemicals fall into three groups: environmental control, personal control, and medical control. By far the most effective category is environmental control; this type of control involves designing the work area and associated equipment to minimize the exposure of the worker to the liquid chemical, its vapors, or its mists. Environmental control also includes one of the most basic control measures substituting less toxic substances for the more toxic substances being used. Personal protective measures are not as effective as engineering controls (like ventilation) or work practice modifications. Personal protective measures are limited to the use of protective clothing and respirators. Medical control refers to programs encompassing pre-placement physical examinations and medical surveillance of workers to detect early signs of occupational disease.

b. **Prevention of Occupational Dermatitis.** The best prevention against occupational dermatitis is to use measures that decrease, as far as possible, contact of the workers with the dermatitis causing chemicals. When complete avoidance is impossible, personal protective measures are used. These include protective clothing, protective ointments, and personal cleanliness. Protective clothing should cover every part of the body exposed to the irritating or hazardous chemical. This protective clothing, and in some cases, underclothing, must be supplied and laundered daily. Contaminated work clothing should never be worn away from the place of work. There are many types of protective ointments available; when applied to the skin they form a film that affords some protection. The main value of protective ointments comes from the subsequent washing off, since the harmful chemicals are removed at the same time. Personal cleanliness is the best protective measure against occupational dermatitis. If strong irritant chemicals come into contact with the skin, they should be removed immediately with water. Washing facilities should always be readily available. Pre-placement and periodic medical examinations are recommended, to aid in the prevention of occupational dermatitis.

c. **Welding Fumes**. Welding fumes vary in composition and quantity. They depend upon the alloy being welded and the process, and the electrodes being used. Therefore, for the analysis of these welding fumes to be accurate, consideration must be made on the type of welding process performed and the system being inspected.

(1) Aluminum and titanium (little flame but intense radiation). For example, when aluminum and titanium (a reactive metal and alloy) are welded in argon (a protective, inert atmosphere), they will produce very little flame but intense radiation. This radiation's can offspring into ozone.

(2) Steels (low-level fumes). When arc-welding steel, which is a similar process to that of aluminum and titanium, fumes, produced is low level. These fumes contain chromium and nickel compounds and the electrodes, coated and flux-cored with fluorides, produce fumes containing considerably more fluorides than oxides.

(3) Ferrous alloys (considerable fumes). When arc-welding ferrous alloys in an oxidizing atmosphere or environment, what is generated are significant amount of fumes and carbon monoxide. These fumes are composed of different particles of amorphous slag's containing silicon, iron, manganese, and other metallic components. The alloy system used will determine the make up of the constituents.

NOTE: Slag is dross or scum (mainly oxides and impurities) forming on the surface of molten metals, as they are being melted or refined.

(4) Individual constituent testing. Because of the varying factors when arc-welding and the varying fumes are produced, the fumes must be frequently tested for the presence of individual constituents to determine if specific threshold limit value has been exceeded. When arc-welding steels, for example, testing should be conducted on the fumes to determine if a hazardous form of hexavalent chrome (CrVI) (a chrome compound) is present and registering above the TLV. Some hexavalent chrome compounds are carcinogenic, especially water-insoluble ones. Because the TLVs vary with the compounds present for chrome and their chrome compounds, analysis of the fumes for hexavalent, and total chrome are needed.

NOTE: Variable concentrations of a wide variety of substances are found in the work place air. Two organizations promulgate standards for worker exposure to specific chemicals. In Title 29 Code of Federal Regulation 1910.1000, OHSA has established Permissible Exposure Limits (PEL'S) for potentially hazardous chemical substances. The American Conference of Government Industrial Hygienists (ACGIH) has recommended threshold limits (TLV) which do the same. Ordinarily, ACHGIH TLVs are more stringent (and provide greater worker protection) than OSAH PELs. It is important to understand that PELs and TLVs is not the same thing.

(5) Total fume concentration or content analysis. Analyze the total fume concentration or content as needed. This analysis will be sufficient if no other toxic elements are present in the metal, welding rods, or metal coatings and conditions are not ripe for toxic gas formation.

2-l4. STANDARDS

The U.S. Army must comply with the standards of 29 CFR l9l0.l000 for exposures to airborne contaminants. In addition, the Army has adopted the consensus standards developed by the ACGIH. We must check both sources and use the more stringent of the two standards.

a. **Standards**. The standards in 29 CFR l9l0.l000 are termed Permissible Exposure Limits (PELS) while those from ACGIH are TLVs. Whatever they are called, they represent the maximum amount of chemicals under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. The TLV booklet is a consensus standard published by a civilian organization. They are updated annually to reflect current data. The TLV booklet is the most common and current source of standards for airborne contaminants. Appendix C contains industrial hazards found in the Army.

b. **Terms**.

(1) Threshold limit value-time weighed average . The threshold limit value-time weighed average (TLV-TWA) is the time weighted average for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed day after day without adverse health effects.

(2) Threshold limit value short-term exposure limits. The threshold limit value short-term exposure limits (TLV─STEL) is the concentration to which workers can be exposed continuously for a short period of time. A STEL is defined as a l5 minute time weighted average exposure, which should not be exceeded at any time during a work day even if the 8-hour time-weighted average is within the TLV. Exposure at the STEL should not exceed l5 minutes and should not be repeated more than 4 times a day. There should be at least 60 minutes between successive exposures at the STEL.

(3) Threshold limit value-ceiling. The Threshold limit value-ceiling (TLV-C)is the concentration that should not be exceeded even instantaneously. Indicated by a "C" in the TLV listing.

(4) "Skin" notation. Listed substances followed by the designation "skin" refer to the potential contribution to overall exposure by the coetaneous route including the mucous membranes and eyes.

(5) "Ceiling" values. There are certain toxic substances for which time-weighted average concentrations are inappropriate. For example, there are substances that are predominantly fast acting, and whose threshold limit is based on this response. Substances of this type are assigned a "ceiling" limit ("C") that should not be exceeded under any circumstances. Appendix E contains examples of substances to which "C" limits have been assigned.

c. **Computation of a Time-Weighed Average**. Exposures must be averaged for the time period of the standard 8 hours or l5 minutes, and because sampling periods may differ, a simple arithmetic average will not yield the true average. The following formula is used to average results from sampling for atmospheric contaminants.

T = Time
C = Concentration
TWA = time weighed average
Hrs = hours

$$\frac{(T1 \times C1) \quad + \quad (T2 \times C2) \quad + \quad (Tn \times Cn)}{8 \text{ Hrs}} = \text{TWA}$$

d. **Working with TLV Data**. The following examples will provide practice in using TLV's and related data.

(1) Example 1. Workers in an industrial shop on an Army installation are exposed to a perchloroethylene solvent of the following concentrations, for the following periods: l hour at 50 parts per million (ppm); 2 hours at ll0-ppm; 3 hours at 30-ppm; l l/2 hours at l5-ppm; and l/2 hour at 200-ppm.

(a) Refer to preceding paragraphs and to Appendix E, then answer the following questions:

1 What is the TLV for perchloroethylene?

2 What is the TWA exposure for these workers during the 8-hour day?

3 Are the concentrations to which these workers are exposed acceptable?

(b) Solutions:

1 By referring to Appendix E, we determine that the TLV for perchloroethylene is 50-PPM.

2 The TWA exposure is determined by substituting our data in the formula:

$$\text{TWA} = \frac{(T1 \times C1) + (T2 \times C2) + \quad (Tn \times Cn)}{8 \text{ hrs}}$$

3 Substituting, we have:

$$\text{TWA} = \frac{(1 \times 50) + (2 \times 110) + (3 \times 30) + (1.5 \times 15) + (0.5 \times 200)}{1 + 2 + 3 + 1.5 + .5}$$

$$\frac{50 + 220 + 90 + 22.5 + 100}{8} = \frac{482.5 \text{ ppm}}{8} = 60.3$$

4 The TWA exposure is 60.3-ppm.

5 The exposure is out of compliance with the TLV-TWA.

(2) Example 2. Workers are engaged in a process that results in the production of ozone (03). Throughout most of the 8-hour shift, the process, the concentration reaches 0.005-ppm. However, at four steps in the process, the concentration reaches 0.5-ppm, for about l2 minutes each time. These four instances of 0.5-ppm concentrations are 90 minutes apart.

(a) Refer to preceding paragraphs and to Appendix E; then answer these questions:

1 What is the TLV for ozone?

2 What is the STEL for ozone?

3 Do the concentrations to which these workers are periodically exposed exceed standards (that is, are they unacceptable)?

(b) Solutions:

1 By referring to Appendix E, we determine that the TLV for ozone is 0.l ppm as a ceiling value.

2 There is no STEL for ozone.

3 Remember, the ceiling value is a maximum concentration to which workers may not be exposed for any time period.

4 Because the actual concentration exceeds the ceiling limit, this situation does not meet standards, that is, it is unacceptable; control measures to reduce the concentrations, or to protect the workers from the excessively high concentration, will be necessary.

(3) Example 3. A soldier working in a laboratory uses formaldehyde routinely. The exposure in his breathing zone usually is for 20 minutes. The soldier believes that he is in no danger from these short periods of 2-ppm concentration.

(a) Is he correct, or should some action be taken to control the concentration?

(b) Solution: From Appendix E, we determine that although the TLV for formaldehyde is 1.0-ppm, this substance has been assigned a STEL which means that the STEL region must not be exceeded for longer than 15 minutes. This soldier's health is in jeopardy and control measures are imperative.

2-15. SAMPLING TECHNIQUES

a. The collection and analysis of representative samples of the air in the work place is an important means of determining the nature and extent of occupational hazards or exposures associated with an operation or process. In addition, the effectiveness, or the inadequacy, or exiting control measures may be demonstrated by appropriate sampling. In this regard, the preventive medicine specialist will frequently be called upon to assist in the collection of samples of potentially contaminated air in a variety of work places on Army installations. Very often this sampling will be conducted for the purpose of determining compliance with Department of the Army and OSHA environmental standards. There are a number of important factors that must be considered during the collection of samples if reliable results are to be obtained. Disregarding any of these factors can seriously limit the accuracy of the data collected and can lead to invalid conclusions.

b. Before the sampling technique or method can be selected, some basic questions must be answered:

(l) Where should sampling be done?

(2) Whom (which workers) should be sampled?

(3) How long should each sampling period be?

(4) How many samples will be necessary?

(5) When should sampling take place?

c. The ***sampling location*** will be dictated by the kind of information needed or the type of evaluation desired. It may be one, or a combination, of the following.

(1) General room (area or background) air sample. The general room air sample provides an indication of the total concentration of a contaminant in the overall work area. Such sampling gives qualitative data on what contaminants are present in the work area and to some extent indicates if control measures are effective.

(2) Breathing zone/personal sample. The breathing zone personal sample more definitely determines the worker's exposure to a contaminant. From breathing zone samples, a daily time-weighed average can be determined. Frequently breathing zone samples are used in conjunction with biological samples such as urine and blood to assess the total effect the exposure has on the worker.

(3) Operation/process area sample. This third type of sampling is done at the operation or process area itself and will provide both qualitative and quantitative information about the influence of the operation or process on those exposed to it and the need for local control of the contaminant. It also allows the identification of the step

in the operation or process, which constitutes the greatest hazard, and the duration of the hazard.

d. Determination of ***whom to sample*** is closely related to ***where to sample***. The most effective way to determine actual worker exposure is to collect breathing zone samples from all workers. Some work areas have a large number of workers and collection of breathing zone samples from all the workers is not feasible. Samples would then be collected from the maximum risk workers. The maximum risk worker is normally the worker closest to the source of the contaminant. Other considerations are work patterns, work habits, worker mobility, and air movement patterns.

e. Depending upon the physical demands of the work, workers inhale from 5 to 20 cubic meters of air during an 8-hour day. However, the volume of the air sample (and hence, the length of the sampling period) need not approach the volume of air actually inhaled by the worker. All that is needed is a representative sample of the air, large enough to contain sufficient contaminant to be analyzed and identified. Therefore, the volume of the air sample (and the duration of the sampling period) will be dependent upon the TLV of the contaminant, sensitivity of the analytical procedure to be used, and the estimated concentration of the contaminant in the work place atmosphere. The sample volume and flow rate is determined by using the USAEHA Sampling Guide TG 141 (see Appendix D). The duration of the sampling run depends on the flow rate of the sampling pump and the volume required and can be calculated by using the formula:

$$\text{Duration} = \frac{\text{Volume}}{\text{Flow rate}}$$

f. There is no set rule for determining the ***number of samples*** needed to evaluate a worker's exposure, provided that a minimum number characterizing the exposure in time and space is taken. A single grab sample is never sufficient even if it is believed that the concentration at the time of sampling will be maintained throughout the work period. If the indicated concentration is near or above the TLV, repeated sampling should be done. Ordinarily, contaminants are not generated at uniform rates, so the concentration can vary from time to time. In addition, the type of contaminant will, to some extent, dictate the number of samples to be taken as well as the type of instrumentation to be used for sampling. The number of samples to be collected will also depend upon the type of evaluation being conducted. If the objective is merely to determine the presence of a contaminant, a few samples will suffice. On the other hand, if a comprehensive survey is being conducted, more samples will be required.

g. Before we can decide ***when*** to sample, we must consider the purpose of the evaluation (for example, what information is desired) as well as the overall nature of the particular operation or process being evaluated. Since the concentration of contaminant may vary considerably throughout a 24-hour period, it is necessary to take samples during each shift of operation. In addition, when Army installations are located in areas which experience wide seasonal variations in temperature, it may be necessary to sample during each of the seasonal extremes, since the demands on the ventilation system and hence, the ability of the system to control the contaminant, may vary considerably.

h. Closely related to the question of ***how long*** to sample, ***how many*** samples to collect, and when to collect the samples is the matter of determining ***how*** to sample, that is, the type of sample to be collected. In this regard, there are four general categories of samples: spot (grab) samples, partial period samples, full period single samples, and full period consecutive samples.

(1) Grab samples. This is a method for collecting a sample of gas or vapor. Grab samples are also called instantaneous samples, as they are collected almost instantaneously, that is, usually within a few seconds, although some grab samples may be collected over a period of up to l5 minutes. A grab sample is therefore representative of the atmospheric conditions at the sampling site at a given point in time. Normally, at least five to seven samples should be taken, at random, except for contaminants with a "ceiling" TLV. In this case, the samples must be taken at times when concentrations are expected to be maximum. Evacuated flask samples, Mylar bag samples, and detector tube samples are all examples of grab samples. Examples of grab sample collecting devices are shown in Figures 2-1 and 2-2.

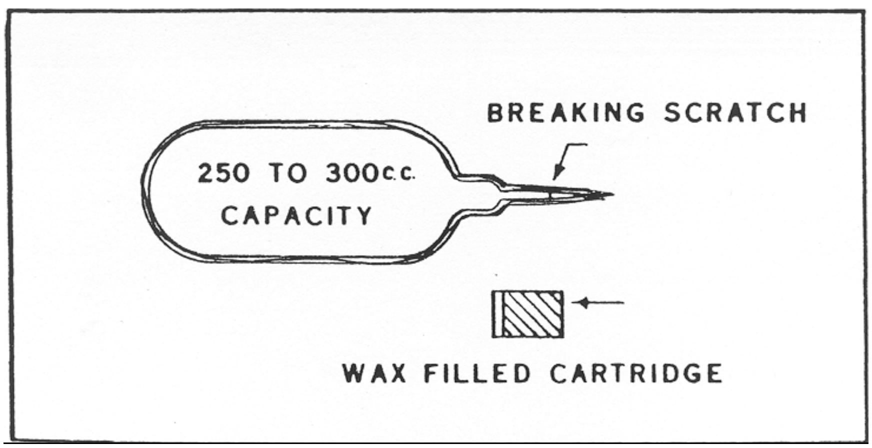


Figure 2-1. Evacuated flask for collecting grab sample.

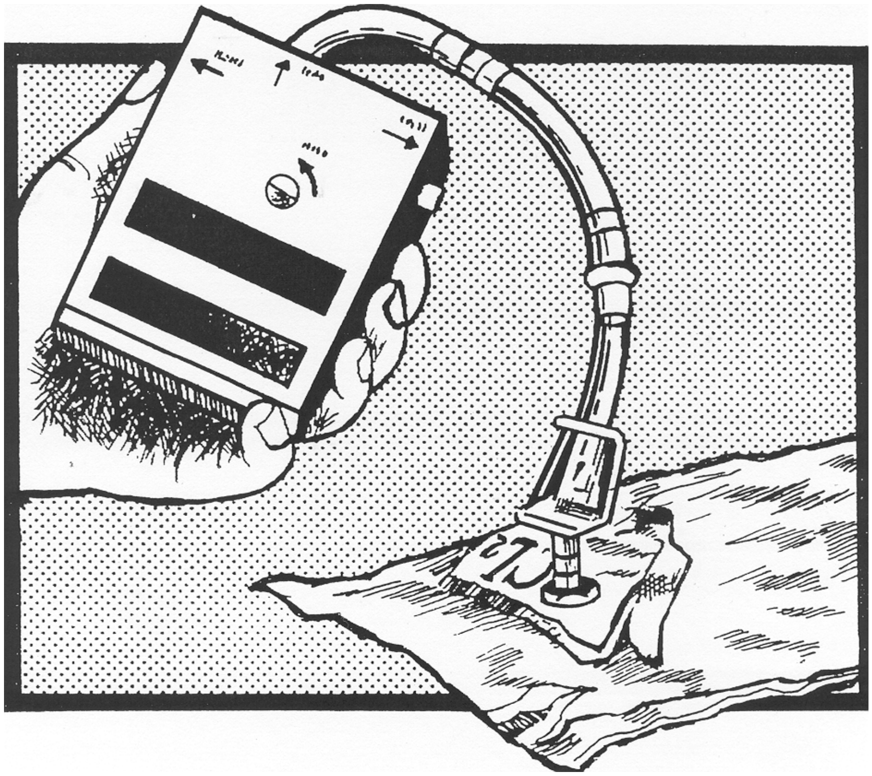


Figure 2-2. Bag for collecting grab samples

(2) Partial period samples. In this kind of sampling, the sample is collected for a portion of some standard period such as workday or shift. Partial period sampling should not be conducted for less than 70the period of the standard (for example, 5 l/2 hours of an 8-hour work period). To collect partial period samples, it is necessary to collect atmospheric air and pass it through a device or a series of devices in which the contaminant can be concentrated for later analysis.

(3) Full period single samples. A full period single sample is one sample collected continuously throughout the full period of the standard (for example, the work shift or workday). As was the case with the partial period sample, it is necessary to draw in atmospheric air and process it through some device (like a charcoal tube), which collects and/or concentrates the contaminant for later analysis.

(4) Full period consecutive samples. Several samples of equal or unequal time are taken for the full period of the standard. This sampling method yields the most dependable results because there are no unsampled periods of time throughout the workday. Furthermore, because there is more than one sample for the work period, it is easier to pick out, from the results, periods or "excursions" of chemical exposure that might exceed the STEL limits for a particular chemical. Unfortunately, because of the number of samples that must be analyzed, generally by an analytical laboratory, this method is the most expensive and labor-intensive sampling.

(5) Analysis of samples. Once air samples have been requested on charcoal tubes, filters, and so forth, the sample media is sent to USAEHA for analysis. The sampling form with instructions is at Appendix I. This information applies to each type of sampling.

i. This description of sampling techniques and strategies has of necessity been general and relatively brief. For detailed guidance on specific sampling procedures, see USAEHA Technical Guide (TG) 141. Technical Guide 141 can be obtained by sending a DA Form 17 to the Commander, USAEHA, Aberdeen Proving Grounds, and Maryland 21010.

2-l6. SAMPLING INSTRUMENTATION AND METHODS

a. **General**. In deciding upon a sampling strategy, it is important to remember that the sampling period must be statistically significant, that is, it must provide a sample of the exposure, which is truly representative of the exposure in time and space. The purpose of the evaluation will be the major consideration in determining how long the sampling period must be in order to be statistically significant. The purpose of the evaluation, as well as the general nature of the suspected contaminant (for example, probable concentration, gaseous, or particulate), will influence the choice of sampling technique and/or equipment, which will fall into one of the following categories.

b. **Gases and Vapors**.

(1) In the case of soluble contaminants, absorption devices may also collect samples. These devices concentrate the contaminant by dissolving it in some medium; bubblers and impinges (see Figure 2-3) are examples of such devices. They are used in conjunction with some form of pump or suction device, which captures the air-gas mixture and brings it into the absorption device where it is impinged on a receptive liquid. In using such a device, it is necessary to know the rate at which the air-gas mixture was collected (flow rate) and the duration of the sampling period, in order to determine the volume of air from which the contaminant was extracted.

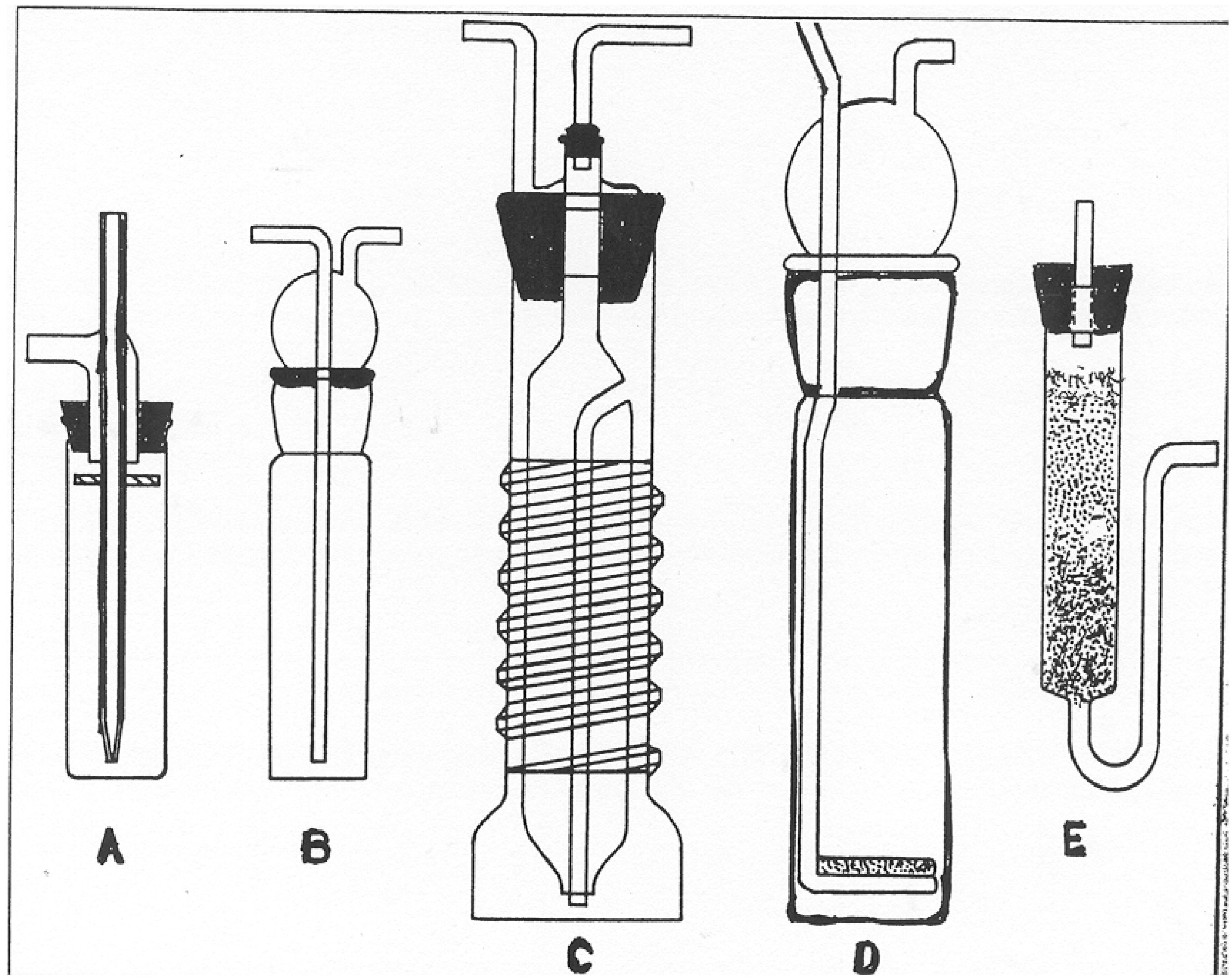


Figure 2-3. Absorption devices for collecting gaseous or vapor forms of soluble contaminants. Gas washing (A and B); helical (C); fretted bubbler (D); glass-bead contaminants (E).

(2) In the case of insoluble contaminants, adsorption devices such as charcoal tubes and silica gel tubes (see Figures 2-4 and 2-5) can be used to collect and concentrate the contaminant, for further analysis. These devices use a medium, to the surface of which the contaminant adheres. Again, it will be necessary to keep accurate data on the flow rate of the pump and the duration of the sampling period, in order to determine the volume of the sample.

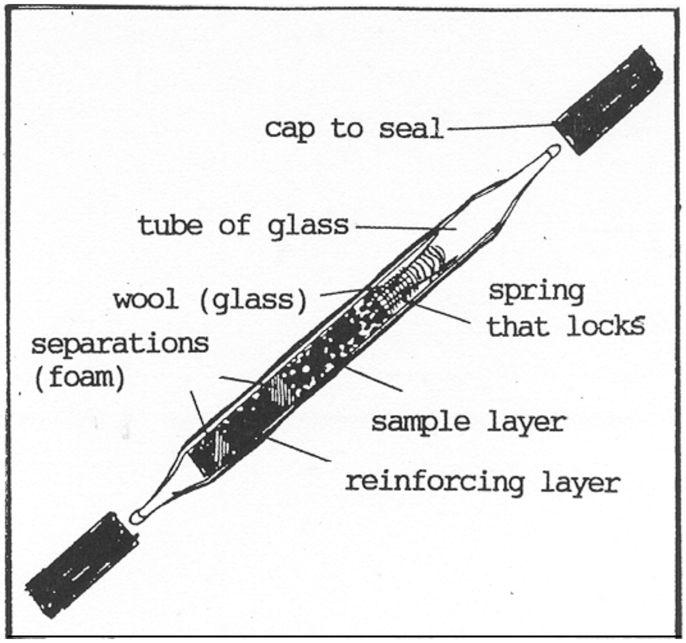


Figure 2-4. Charcoal tube for collecting insoluble contaminants.

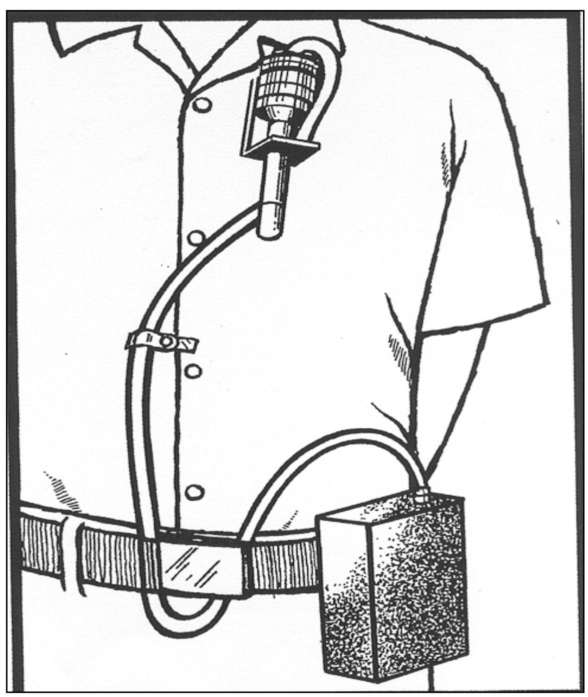


Figure 2-5. Cyclone/filter holder assembly and sampling pump.

(3) When sampling gas/vapor contaminants, it is possible to use direct reading devices that do not require subsequent laboratory analysis. One such device is the detector tube (see Figure 2-6), which is accurate to plus or minus 25 physical principles (e.g., heat of oxidation and wavelength of light) to obtain direct indications of the concentration of contaminant. These are limited to use with certain specific contaminants. Examples of this kind of instrument are carbon monoxide monitor (see Figures 2-7 and 2-8).

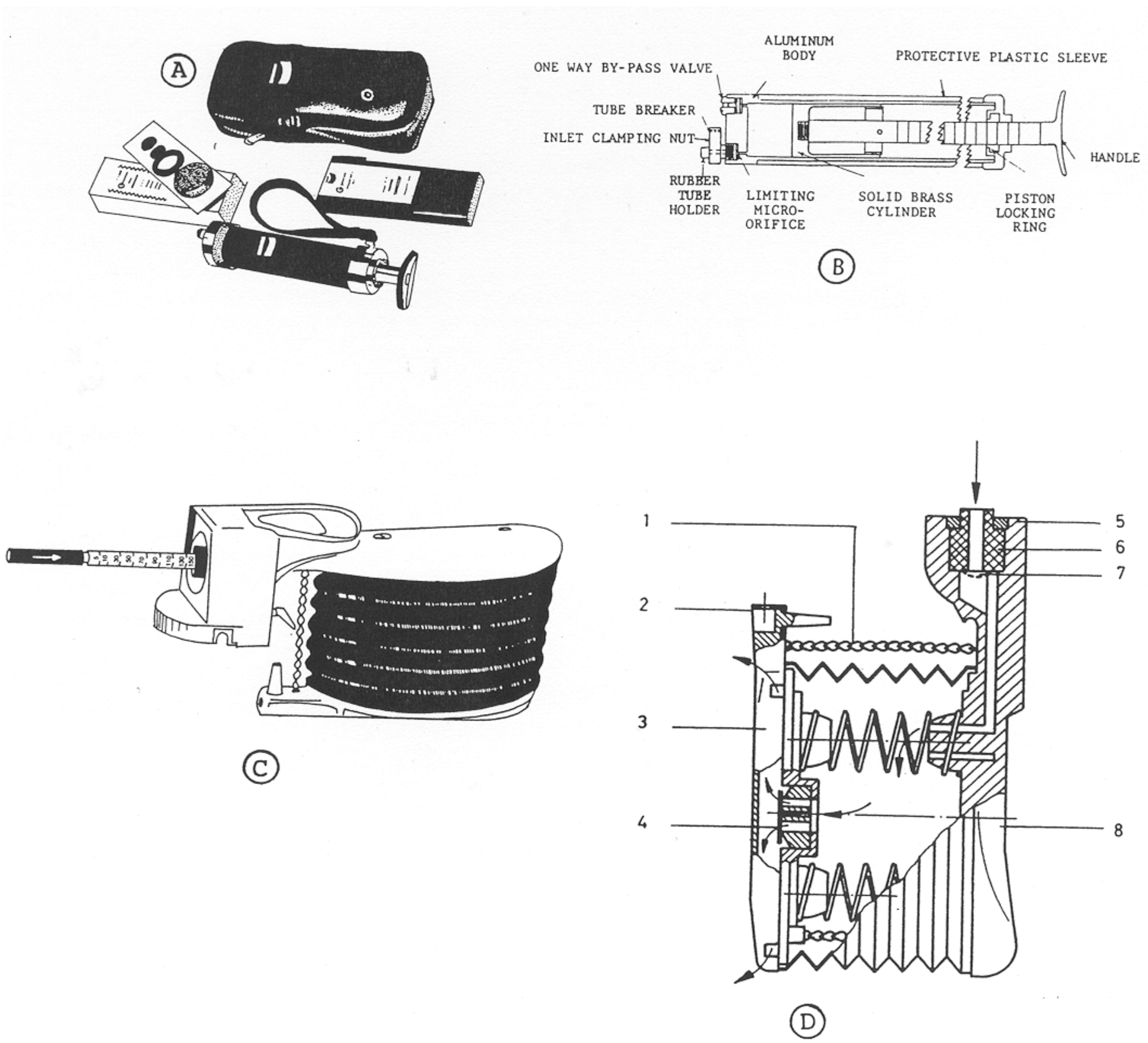


Figure 2-6. Precision piston gas detector system (A); cut away view of automatic precision hand pump (B); bellows pump with detector tube and stroke counter (C); and cut away view of bellows pump (D).

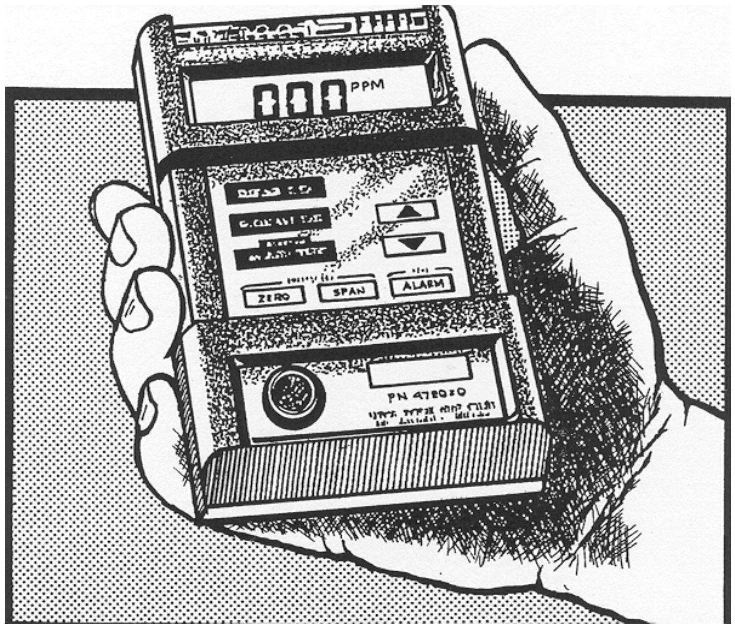


Figure 2-7. Portable carbon monoxide monitor.

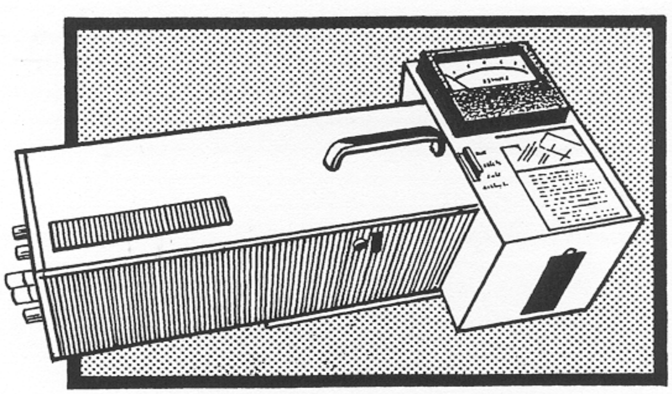


Figure 2-8. Infrared analyzer for general-purpose gas analyzer and portable gas analyzer.

c. **Particles**. Contaminants in the form of particulate may be sampled in several ways, depending on the size of the individual particles.

(1) Impingement or impactors. These devices require a means of collecting atmospheric air (such as a pump), which forces the air into the device, where the particles strike various surfaces due to inertia, and are collected on these surfaces. Such devices sometimes employ a medium, on which the particles impinge and are

collected. These devices may also be single-staged or multistage (for example, consist of two or more devices connected in tandem).

(2) Filtration. In many cases, drawing contaminated air through a filter medium and collecting the particulate contaminant is the preferred method. Filtration devices allowing a range of sampling rates (high volume or low volume) are available. A variety of filter materials are used, including polyvinylchloride (PVC), cellulose ester (CE), and glass fiber (GF). The filter medium chosen will depend to some extent on the size of the individual particles of contaminant (see Figures 2-5 and 2-9).

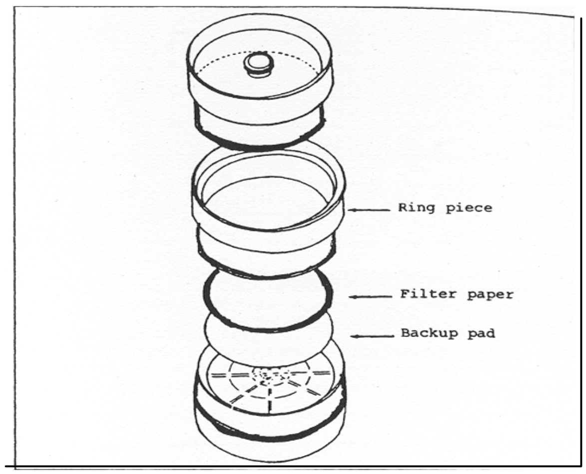


Figure 2-9. Filters.

(3) Respirable dust sampling. Some standards are based upon the dust being of respirable size, meaning the dust will not be filtered out before reaching the air sacs in the lungs. In this case, a cyclone is utilized before the filter, which slows the dust down, to enable the filter to capture it (see Figure 2-5).

(4) Precipitators. Electrostatic precipitators are frequently used to collect samples of contaminants occurring in the form of fumes. They are very efficient when collecting particles smaller than 1 micron in diameter. Electrostatic or electric precipitation differs from particle collection mechanisms in that the forces acting to separate the particles from the gas in which they are suspended are electric rather than inertial or thermal. Charged particles passing through the precipitator are attracted to oppositely charged plates or tubes. Electrostatic precipitators can be extremely hazardous in potentially explosive environments.

d. **The Sampling Train**. Discussions thus far have borne on various devices used in sampling the air in the worker's environment. In actual practice, these devices are interconnected in a certain order to obtain the desired sample; this interconnection of instruments and devices is known as a sampling train (see Figure 2-10). A sampling train for particulate would consist of these critical elements, in this order: an inlet orifice (opening); particulate separator (filter, precipitator, impinge, and so forth); air flow meter (to determine flow rate); flow rate control valve; and suction pump. The suction pumps will require some sort of power supply; some particulate separators also require an additional source of electrical power. A sampling train for gas or vapor would be similar, except that some type of absorption or adsorption device would replace the particulate separator. Refer again to Figure 2-5 for an example of a sampling train, in this instance, assembled to sample for respirable dust).

e. **Calibration**. The accurate analysis of a contaminant's concentration in the work environment is possible only if the volume of the air sample can be accurately determined and the efficiency of the collection device maintained at its maximum. For these reasons, frequent calibration of all equipment is essential. While it is important for you to be aware of this requirement, you will probably not be required to be able to actually calibrate the equipment. A detailed discussion of calibration techniques is beyond the scope of this subcourse.

Section IV. RESPIRATORY PROTECTIVE DEVICES

2-I7. GENERAL

One of the major routes of entry for toxic substances is through inhalation. Almost every industry has some form of respiratory hazard associated with it. Industrial type operations carried out on Army installations have hazards too. In the field of industrial hygiene, our primary concern is to protect the worker from exposure to hazardous situations in the work environment. One method of eliminating an inhalation exposure is to place a barrier between the worker's respiratory tract and the hazardous environment. You may recall that in lesson I we referred to Pliney the Elder, who, in 60 AD, reported that a goat's bladder placed over the face could protect workers from the hazard of working with lead (the bladder is a barrier between the worker's respiratory tract and the hazardous environment). Respirator design has come a long way since that time; however, the improper use of a respirator or the selection of the wrong one can leave a worker with a false sense of security, and possibly less protection than he might get with a goat's bladder. As a preventive medicine specialist, you may be called upon to evaluate the use of respirators and to train employees in their proper selection, use, and maintenance.

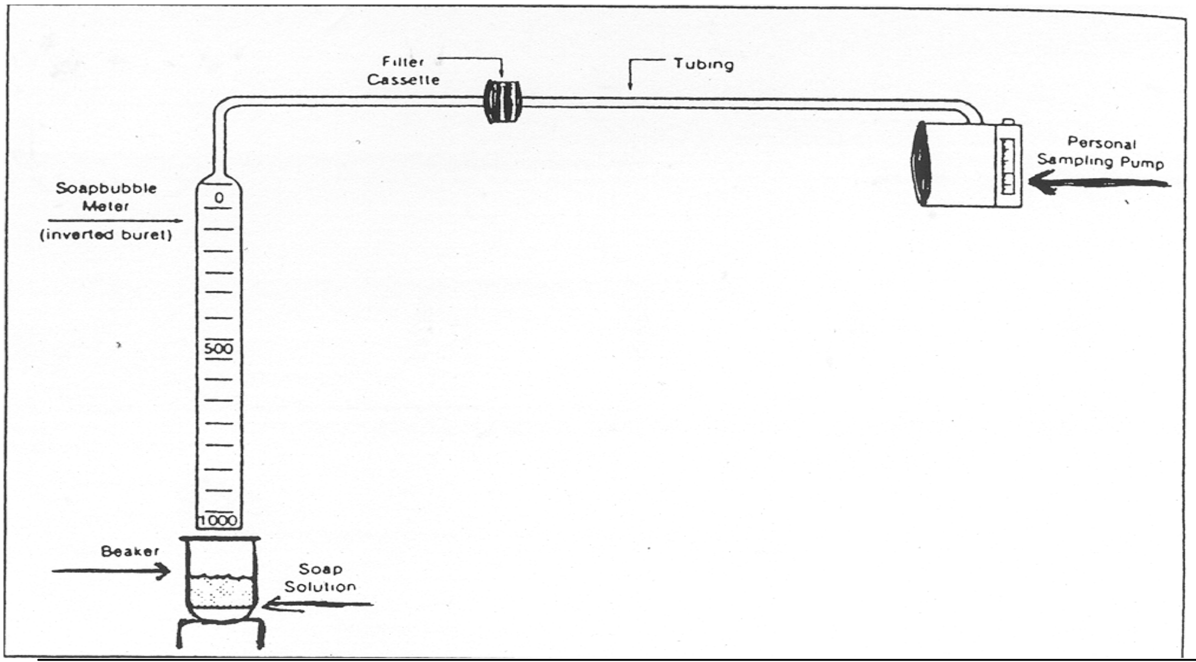


Figure 2-l0. Calibration setup of a sampling train.

2-l8. TYPE OF RESPIRATORS

Industrial respiratory protective devices have been designed, tested, and approved for protection against specific industrial exposures. These devices have been grouped for convenience into two general classifications according to mode of operation. The two basic groups are the atmospheres supplying respirators and the air purifying respirators. The choice of respirator for a given situation will depend upon a number of factors, which will be discussed in paragraph 2-22. Detailed information on these general classes of respirators is provided in succeeding paragraphs.

2-19. AIR-PURIFYING RESPIRATORS

a. **General Description**. Air-purifying respirators can be half mask, quarter mask, full-face piece, or mouthpiece styles equipped with air purifying units to remove gases, vapors, and particulate matter from the ambient air prior to its inhalation (see Figure 2-11). Some air purifying respirators are "breathing assisted" (blower operated) and provide respirable air to the face piece (or hood) under a light positive pressure. These are often referred to as "powered air-purifying respirators" or "PAPR."

b. **General Limitations**. Air-purifying respirators do not protect against oxygen deficient atmospheres or against skin irritation by, or absorption through the skin of, airborne contaminants. The designed efficiency and capacity of the cartridge, canister, or filter for the contaminant and the measured concentration of the contaminant at the work site determine the maximum contaminant concentration, against which an air-purifying respirator will protect. Since air-purifying respirators may not have an end of

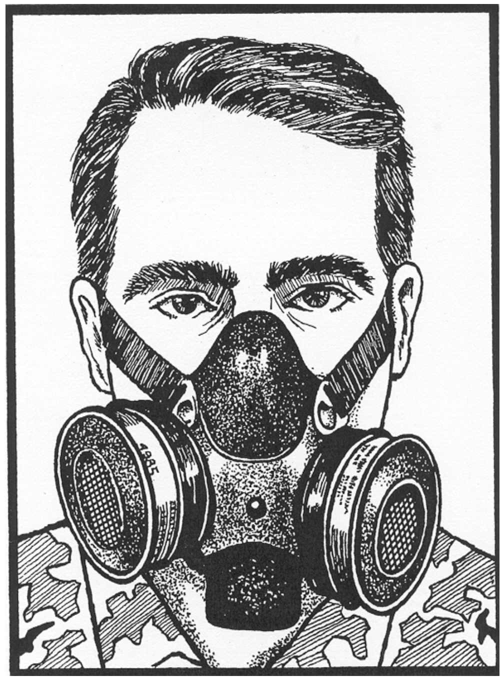


Figure 2-11 Air purifying respirator.

service indicator, they may not be used for contaminants that have poor odor warning properties. The maximum concentration for which the air-purifying unit is effective is specified by applicable Federal occupational health standards. Respirators will not provide the maximum design protection specified unless the face piece is carefully fitted to the wearer's face to prevent inward leakage. Fit testing is a requirement of Federal Law and Army regulation. The time period over which protection is provided is dependent on canister, cartridge, or filter type, concentration and physical state of contaminant, and the wearer's respiratory rate. The proper type of canister, cartridge, or filter must be selected for the particular atmosphere and condition. Air purifying respirators may cause discomfort and objectionable resistance to breathing. Respirator face pieces present special problems to individuals required to wear prescription lenses, and those individuals who have a profile on shaving. Army Regulation 11-34, The Army Respiratory Protection Program specifically prohibits unshaven personnel (especially having beards) from working in environments where wearing a respirator is required. This requirement is also an OSHA mandate.

c. **Gas and Vapor-Removing Respirators.**

(1) General description . See Figure 2-12. Packed solvent beds (cartridge or canister) remove single gases or vapors (for example, chlorine gas), a single class of gases or vapors (for example, organic vapors) or a combination of two or more classes of gases and vapors (for example, acid gases, organic vapors, ammonia, and carbon monoxide) by absorption, chemical reaction or catalysis or a combination of these methods.

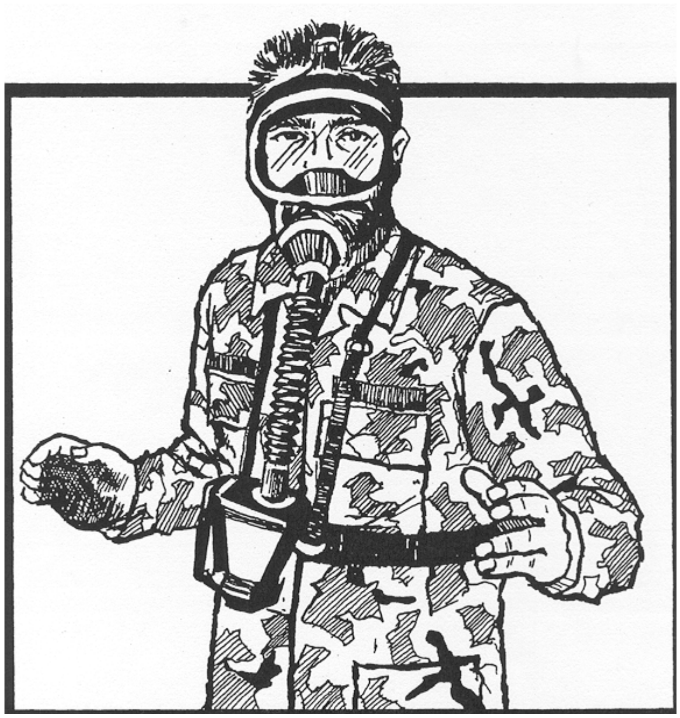


Figure 2-12. Gas mask.

(2) General limitations. No protection is provided against particulate contaminants, unless specified on canister or cartridge label. A rise in canister or cartridge temperature indicates that a gas or vapor is being removed from the inspired air. This is not a reliable indicator of canister performance. An uncomfortably high temperature indicates a high concentration of gas or vapor and signals a potentially very hazardous environment, which requires a different form of respiratory protection.

(3) Gas masks. Gas masks include all completely assembled air purifying masks that are designed for use as respiratory protection during ***entry*** into atmospheres not immediately dangerous to life or health or ***escape*** only from hazardous atmospheres. Gas masks are further described according to the types of gases or vapors they remove. They may be front mounted and back mounted (consisting of a full face piece, a canister which is usually attached to the face piece, and associated connections).

(b) Limitations. Gas masks shall be used only for escape from (not entry into) immediately dangerous to life or health (IDLH) atmospheres and shall not be used against gases or vapors with poor warning properties or which generate high heats or reaction with solvent materials in the canister. In addition, eye protection may be required when escape type gas masks are used. In general, gas masks have only been tested and approved against certain contaminants. See Table 2-1 for a description of the label that is required on the canister of all gas masks, and Table 2-2 for the color code used for gas mask canisters.

(4) Chemical cartridge respirators.

(a) Description. Chemical cartridge respirators (see Figure 2-13) include all completely assembled respirators which are designed for use as respiratory protection during entry into or escape from atmospheres not immediately dangerous to life and health, and are described according to the specific gases or vapors against which they are designed to provide respiratory protection (see Table 2-3). Each device may contain the following component parts, as appropriate: face pieces (half mask or full), mouthpiece, hood or helmet, cartridge, with filter, harness, breathing tube, and attached blower.

1. On each canister shall appear in bold letters the following on the most conspicuous surface or surfaces of the canister: **Canister for • • • • • • • • • • •** **(Name for atmospheric contaminant)** In addition, essentially the following wording shall appear beneath the appropriate phase on the canister label: "For respiratory protection in atmospheres containing not more than. percent by volume of. ” 2. Canisters having a special high-efficiency filter for protection against radio nuclides and other highly toxic particulates shall be labeled with a statement of the type and degree of protection afforded by the filter. The label shall be affixed to the neck end of, or to the gray stripe, which is around and near the top of, the canister. The degree of protection shall be marked as the percent of penetration of the canister by a 0.3-micron diameter dioctyl phthalate (DOP) smoke at a flow rate of 85 liters per minute. 3. Each canister shall have a label warning that gas masks should be used only in atmospheres that are not oxygen deficient (at least 19.5 percent oxygen by volume at sea level), since gas mask canisters are only designed to neutralize or remove contaminants from the air.

Table 2-1. Labels for gas mask canisters.

Type of Atmospheric Contaminant*	Color Code
Acid gases	White
Acid gases, ammonia, carbon monoxide, and organic vapors	Red
Acid gases, ammonia, and organic vapors	Brown
Acid gases and organic vapors	Yellow
Ammonia gas	Green
Carbon monoxide gas	Blue
Organic vapors	Black
Other vapors and gases not listed above	Olive
Radioactive materials (except tritium and noble gases)	Purple
Dusts, fumes, and mists (other than radioactive material)	Orange

* A purple or orange stripe on any cartridge or canister signifies that contaminant is contained within, regardless of percentage.

* If only the labels are color-coded as above, then the canister or cartridge body is to be gray or natural metallic color.

* Wording on the label will tell you the contaminant contained within and the degree of protection it will give you.

Table 2-2. Color-coding for cartridges and gas mask canisters.

Type of Chemical Cartridge Respirator	Maximum Use Concentration Parts Per Million (PPM)
Ammonia	600
Chlorine	10
Hydrogen Chloride	50
Methyl Amine	l00
Organic Vapor*	l,000
Sulfur Dioxide	50

*Not for use against organic vapors with poor warning properties or those which generate high heats or reaction with solvent material in the cartridge.

*Maximum use concentrations are lower for organic vapors that produce atmospheres immediately hazardous to life or health at concentrations equal to or lower than this concentration.

Table 2-3. Maximum concentration of gas and vapor for chemical cartridge respirators.

Figure 2-13. Chemical cartridge respirator.

(b) Limitations. Chemical cartridge respirators shall not be used in atmospheres immediately dangerous to life or health and will be limited to the maximum concentration of gases and vapors as specified on the cartridge (also see specific standard for exposure to chemical or chemicals in question). Some chemical cartridges are listed in Table 2-4. In addition, in the case of the half mask face piece, no protection is provided for the eyes. The nose clip on mouthpiece style respirators shall be securely in place to prevent nasal breathing. No protection is provided to the eyes.

NSN		Respirator
4240—01—259—4573	*	Respirator, air filtering, for pesticides (Respirator furnished with 50 cartridges and 100 filters
4240—01—108—4171	*	Respirator, air filtering, for dusts (Respirator furnished with 50 filters)
4240—01—259—4575	*	Respirator, air filtering, for metal fumes (Respirator furnished with I00 filters, or 50 filters depending on whether the mask is dual or single element)
4240—01—259—4577	*	Respirator, air filtering, for paint spray (Respirator furnished with I00 or 50 cartridges and filters)
4240—0I—259—4576	*	Respirator, air filtering, for organic vapors (Respirator furnished with I00 or 50 cartridges)

Table 2-4. Air purifying respirators and gas masks available in the Federal supply system.

d. **Dust, Fume, and Mist Respirators (Particulate Respirators).**

(1) Description. These respirators include all completely assembled respirators designed for use as respiratory protection during entry into and escape from hazardous particulate atmospheres that contain adequate oxygen to support life. Devices may be attached to a powered blower. Each device may contain mouthpiece with nose clip, hood, helmet, filter unit, harness, attached blower, and breathing tube. These devices are further described as follows:

(a) Respirators, either with replaceable or reusable filters, designed as respiratory protection against dusts, fumes, and mists having maximum acceptable exposure limits not less than 0.05 milligram per cubic meter (mg/m3) of air.

(b) Respirators, with replaceable filters, designed as respiratory protection against dust, fumes, and mists having maximum acceptable exposure limits less than 0.05 mg/m3.

(c) Respirators, with replaceable filters, designed as respirator protection against radon daughters, and radon daughters attached to dusts, fumes, and mists.

(d) Respirators, with replaceable filters, designed as respirator protection against asbestos containing dusts and mists. The Federal Asbestos Standard (29 CFR 1910.1000) is very specific about respirators to be used for asbestos handling.

(e) Single use dust respirators designed for protection against pneumoconiosis and fibrous producing dusts, or dusts and mists, including asbestos.

(2) Limitations.

(a) General. Protect against nonvolatile particles only. No protection against gases and vapors. The filter shall be replaced or cleaned when breathing becomes difficult due to plugging by retained particles. These respirators shall not be used during shot and sand blasting operations.

(b) Half mask face pieces. Fabric coverings are only permissible in atmospheres of coarse dust and mists of low toxicity. No protection is provided to the eyes.

(c) Mouthpiece respirator. Nose clip shall be firmly in place to prevent nasal breathing. Mouth breathing prevents the detection of any incidental vapor contaminants by odor. No protection is provided for the eyes.

e. **Combination Gas, Vapor, and Particulate Removing Respirators.**

(1) Description. These respirators include all the devices discussed having either canisters or cartridges with filters for protection against dusts, mists, fumes, gases, and vapors. These include respirators that have been tested against lacquer and enamel mists (paint spray respirators).

(2) Limitations. With the exception that these devices protect against gases, vapors, and particulates, the limitations of the other devices would also apply to the combination device.

f. **Pesticide Respirators.**

(1) Description. Pesticide respirators include all completely assembled respirators that are designed for use as respiratory protection during entry into and escape from atmospheres containing pesticide hazards. These would include the following types:

(a) Front or back mounted gas masks.

(b) Chin style gas masks.

(c) Chemical cartridge respirator.

(d) Air purifying respirator with attached blower.

(e) Combination devices.

(2) Limitations. Limitations previously discussed for each type of device will also apply, in general, to pesticide respirators.

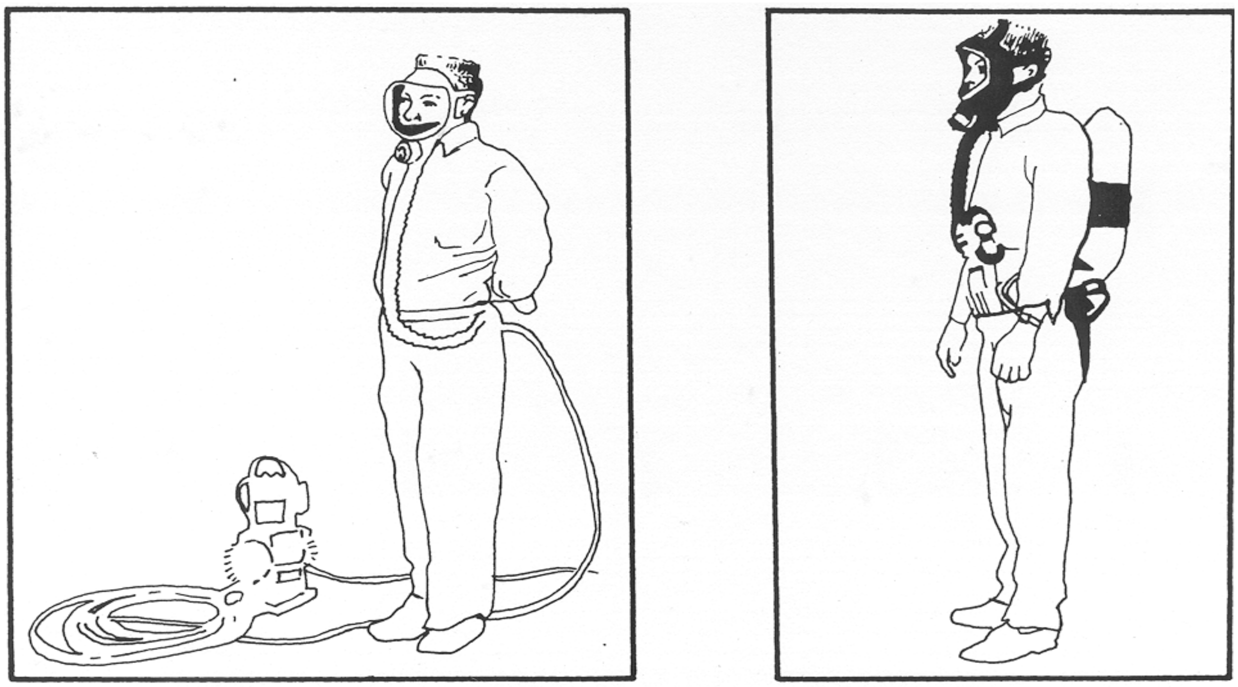
NOTE: See Table 2-4 for a list of air purifying respirators and gas masks available in the federal supply system.

2-20. ATMOSPHERE-SUPPLYING RESPIRATORS

See Figure 2-14 for air supply and self-contained respirators.

a. **General Description**. A respirable atmosphere is supplied independent of the ambient air surrounding the wearer. These devices provide protection against oxygen deficiency and most toxic atmospheres.

b. **General Limitations**. Except for the supplied air suit, no protection is provided against skin irritation by materials such as ammonia and hydrochloric acid (HCl), or against absorption of materials such as hydro cyanic acid (HCN), tritium, or organic phosphate pesticides through the skin. Face pieces present special problems to individuals required to wear prescription lenses.



A B

Figure 2—l4. Air-line respirator (A) and self-contained respirator (B).

c. **Self-Contained Breathing Apparatus**

(1) Description. The self-contained breathing apparatus (SCBA) includes all completely assembled, portable, self-contained devices designed for use as respiratory protection during entry into and escape from or escape only from hazardous atmospheres.

(a) Open circuit apparatus. An apparatus from which exhalation is vented to the atmosphere and not re-breathed. This may be demand type apparatus (in which the pressure inside the face piece in relation to the immediate environment is positive during exhalation and negative during inhalation), or it may be pressure demand type apparatus (in which the pressure inside the face piece in relation to the immediate environment is positive during both inhalation and exhalation).

(b) Closed-circuit apparatus. An apparatus of the type in which the exhalation is rebreathed by the wearer after the carbon dioxide has been effectively removed and a suitable oxygen concentration restored from sources composed of compressed, chemical, liquid oxygen, or an oxygen generation solid.

(2) Limitations.

(a) General. Use is permissible in IDLH atmospheres. The period over which the device will provide protection is limited by the amount of air or oxygen in the apparatus, the ambient atmospheric pressure (service life is cut in half by a doubling of the atmospheric pressure), and workload. A warning device shall be provided to indicate to the wearer when the service life has been reduced to a low level. Some SCBA devices have a short service life (few minutes) and are suitable only for escape (self rescue) from a non-respirable atmosphere. Chief limitations of SCBA devices are their weight or bulk or both, limited service life, and the training required for their maintenance and safe use.

(b) Closed circuit apparatus. The closed circuit operation conserves oxygen and permits longer service life.

(c) Open circuit demand and pressure demand. The demand type produces a negative pressure in the face piece on inhalation whereas the pressure demand type maintains a positive pressure in the face piece and is less apt to permit inward leakage of contaminants.

d. **Supplied-Air Respirators**.

(1) Description. Supplied-air respirators include all completely assembled respirators designed for use during entry into or escape from hazardous atmospheres. The respirable air supply in not limited to the quantity an individual can carry, thus the devices are lightweight and relatively simple.

(a) Type "A" supplied air respirator. A hose mask respirator for entry into and escape from atmospheres not immediately dangerous to life or health which consist of a motor driven or hand operated blower that permits the free entrance of air when the blower is not operating, a strong large diameter hose having a low resistance to airflow, a harness to which the hose and the lifeline are attached and a tight fitting face piece.

(b) Type "B" supplied air respirator. A hose mask respirator, for entry into and escape from atmospheres not immediately dangerous to life or health, which consists of a strong, large diameter hose with low resistance to airflow through which the user draws inspired air by means of his lungs alone, a harness to which the hose is attached, and a tight fitting face piece.

(c) Type "C" supplied air respirator. An airline respirator, for entry into and escape from atmospheres not immediately dangerous to life or health, which consists of a source of respirable breathing air, a hose, a detachable coupling, a control valve, orifice, demand valve or pressure demand valve, an arrangement for attaching the hose to the wearer, and a face piece, hood, or helmet.

(d) Types "AE," "BE," and "CE" supplied air respirators. Types "A," "B," or "C" supplied-air respirator equipped with additional devices designed to protect the wearer's head and neck against impact and abrasion, and with shielding material to protect the window(s) of face pieces, hoods, and helmets which do not unduly interfere with the wearer's vision and permit easy access to the external surface of such window(s) for cleaning.

(2) Limitations.

(a) General. The wearer is restricted in movement by the hose or air line and must return to a respirable atmosphere by retracing his route of entry. The hose or air line is subject to being severed or pinched off.

(b) Type "A" hose mask respirator with blower. If the blower fails, the units still provide an air supply and sufficient protection to permit the wearer to escape although a negative pressure exists in the face piece during inhalation. Use is not permissible in atmospheres immediately dangerous to life or health.

(c) Type "B" hose mask without blower. If the air supply fails, no protection is provided the wearer. Limited to use in atmospheres not immediately dangerous to life or health and from which the wearer can escape unharmed without aid of the respirator.

(d) Type "C" air line respirators (continuous flow, demand, and pressure demand types). The demand type produces a negative pressure in the face piece on inhalation whereas continuous flow and pressure demand types maintain a positive pressure in the face piece at all times and are less apt to permit inward leakage of contaminants. Demand flow air-line respirators are for use in atmospheres immediately dangerous to life or health, provided an auxiliary self-contained air supply is worn to permit escape if the air supply fails.

2-21. COMBINATION ATMOSPHERE-SUPPLYING AND AIR-PURIFYING RESPIRATORS

Combination respirators will usually be made up on an air line respirator with an air purifying attachment to protect the worker if the air line should fail; or, they may be air-purifying respirators with small cylinders attached in case contaminant concentrations exceed the capabilities of the air-purifying respirator. In assessing the capabilities of combination respirators, limitations of the respective individual components will determine the overall limitations of the combination. In other words, the part (component) with the greater limitation will determine the overall limitations, since the wearer may not change over, even if conditions should require it.

2-22. SELECTING THE PROPER RESPIRATORY PROTECTIVE DEVICE

Selection of the appropriate type of respiratory protective device is essential if the health of the worker is to be protected. The following criteria should be considered when making selections:

a. **Nature of Hazard**. Identify the substance or substances against which protection is required. Determine the hazards and significant properties of each substance. Determine the physical state in which the contaminant is likely to occur. Is the hazard one of oxygen deficiency, or is it dangerous to life and health? This is the first and over riding consideration.

b. **Conditions of Exposure**. Determine the conditions of exposure, the potential exposure, and the reliable exposure (determines the TWA) present. What is the location of the hazard? What will be the duration of the exposure?

c. **Safety Requirements**. What are the specific requirements for protection of the eyes, face, and so forth? Are there human capabilities that are essential to the safe use of the devices?

d. **Movement Required**. What is the range of worker movement necessary for accomplishment on the job? What are the entry and exit (egress) requirements?

e. **Decision Logic**. Appendix F contains a guide for selection of respirators.

NOTE: There is one limitation that should be kept in mind, as it affects all respiratory protective devices: Certain gases can harm the body by means other than through the respiratory tract. For example, ammonia, in a sufficiently high concentration, can cause skin burns, particularly on moist skin. As a result, suitable protective clothing would have to be worn, in addition to the proper respirator.

2-23. INSTRUCTION IN RESPIRATOR USE

If respirators are to be safely used, the workers must be thoroughly instructed and trained in their selection, use, and maintenance. Both workers and supervisor must be trained, and only persons fully competent in the use of the devices should be allowed to conduct the training. As a minimum, the training must include:

a. Instruction in the nature of the hazard, along with an honest appraisal of the consequences if the respirator is not used.

b. Explanation of why the respirator is needed and why it is not possible to employ more positive control in the work area. Worker acceptance will be enhanced if there is recognition that every reasonable effort is being made to reduce or eliminate the need for respirators.

c. Explanation of the basis for selection of the particular respirator. The training must include instructions covering the fitting of respirator on personnel with special problems, such as facial hair, eyeglasses, deep cuts, scars, or irregular facial features (for example, hollow temples, dentures, lack of teeth, and so forth.).

d. A discussion of the respirator's capabilities and limitations.

e. Instruction and training in the actual use of the respirator. This must include hands on training during which workers are provided an opportunity to handle the respirator, fit it properly, test its face piece to face seal, wear it in a test atmosphere. Training must include that required to recognize and cope with emergency situations; it must also include the requirement that respirator face piece shall be checked for fit each time they are worn.

2-24. ASSIGNMENT OF RESPIRATORS TO PERSONNEL

Each job, which requires the use of a respirator, should have the correct respirator specified for that job. Selection of the respirator should be made by the supervisory personnel, using guidance provided by the Installation Medical Authority (IMA), the Installation Respirator Program Director (IRPD), and the Installation Respirator Specialist (IRS). Care should be taken that when a worker has been fitted with a particular style and size of mask and instructed in its use and capabilities, substitutions for that particular respirator must not be made. Respirators permanently assigned to an individual worker must be durably and legibly marked with the individual's name. The date of issuance should be centrally recorded and maintained by the responsible individual for the overall respiratory protection program.

2-25. MAINTENANCE AND CLEANING

a. Routinely used respirators must be cleaned and disinfected as frequently as necessary to ensure that the workers are provided the proper protection. This is generally after the workers have been thoroughly briefed on the cleaning procedure, so that they will be confident of always receiving a clean, disinfected respirator. This is doubly important when respirators are not individually assigned. Those respirators maintained for emergency use must be cleaned and disinfected after every use.

b. The following cleaning and disinfecting procedures are recommended:

(1) Remove any filters, cartridges, or canisters.

(2) Wash face piece and breathing tube in cleaner disinfectant or detergent solution. Cleaner disinfectant solutions are available which effectively clean the respirator and also contain a bactericidal agent. As an alternative, respirators may be washed in a liquid detergent solution and then immersed either in a hypo-chloride solution for 2 minutes or an aqueous iodine solution for 2 minutes, or a quaternary ammonium solution. A hand brush may be used to facilitate the removal of dirt. Because some of these disinfecting agents may age rubber parts and corrode metal parts, immersion times should be kept to a minimum and all disinfectants thoroughly drained from the parts.

(3) Rinse completely in clean, warm water. Because some disinfectants can damage rubber, elastomer, or metal parts, and because quaternary ammonium solutions can even cause dermatitis if not rinsed completely from the respirator, the importance of through rinsing cannot be stressed too strongly.

(4) Air-dry the part in a clean area.

(5) Clean other respirator parts as recommended by the manufacturer.

(6) Inspect valves, head straps, and other parts for wear and/or damage; replace with new parts if defective.

(7) Insert new filters, cartridges, or canisters; ensure that all seals are tight.

(8) Place in plastic bag or container for storage.

c. Repairs to respirators or replacement of parts should only be done by the Installation Respirator Specialist or other experienced personnel, using parts designed for the particular respirator. Repairs, adjustments, or parts replacement beyond the manufacturer's recommendations should not be attempted. Regulators and reducing admission valves are particularly critical parts and should be returned to the manufacturer or to a trained technician for adjustments or repair.

CAUTION: Improper disposal of an oxygen generating canister from a closed circuit SCBA is dangerous. Maintenance personnel should consult manufacturer's instructions or the National Institute for Occupational Safety and Health (NIOSH) TG.

2-26. INSPECTION

a. Respirators should be inspected routinely before and after each use. Respirators that are not routinely used, such as those kept ready for emergency use, should be inspected after each use and regularly (monthly, at the minimum) to ensure that they are in proper working condition. Self-contained breathing apparatus should also be checked monthly, and air/oxygen cylinders kept fully charged in accordance with the manufacturer's specifications. Regulator and warning devices must be checked carefully to ensure that they function correctly. Complete records of inspection date and findings must be kept for respirators maintained for emergency use.

b. When inspecting respirators, be sure to check the tightness of connectors and the condition of the face piece, headbands, valves, connecting tubes, and canisters. During the inspection, respirators should also be checked for leaks. Rubber and soft-formed material (elastomer) parts must be inspected for pliability and signs of deterioration. It is helpful to stretch and manipulate rubber and elastomer parts with a massaging action. This keeps them pliable and flexible and prevents them from assuming an undesirable "set" during storage.

2-27. STORAGE

a. After respirators are inspected, cleaned, and repaired, they should be properly stored to protect them against the undesirable effect of dust, sunlight, heat, extreme cold, damaging chemicals, excessive moisture, or mechanical damage. Respirators that are routinely used, such as dust respirators, may be kept in plastic bags between uses. Respirators should not be stored in lockers or toolboxes unless they are in carrying cases or cartons designed expressly for that purpose.

b. Frequently, respirators are kept at work areas or stations for emergency use. In such cases, they should be stored in compartments built for the purpose, quickly accessible at all times, and clearly marked.

c. No matter where they may be stored, respirators should be packed so that the face piece and exhalation value will rest in a normal position, thereby preventing the softer materials used in these parts from assuming shapes or positions that might impair their functions.

2-28. PROGRAM SURVEILLANCE AND EVALUATION

If respiratory protection for workers in a hazardous environment is to be effective, there must be continuous surveillance and evaluation of the program. This surveillance and evaluation is the shared responsibility of supervisors and the IRPD with guidance from the IMA. It will entail active monitoring of the issuing, storage, maintenance, inspection, and utilization of respirators, as well as evaluation of the effectiveness of the training provided to users. Records of inspection should be checked periodically to ensure that inspections are being conducted when required and that they are achieving their purpose.

2-29. MEDICAL EXAMINATIONS

Pre-employment medical examinations are normally required for all personnel. Those workers who work in potentially hazardous environments, and especially those who work in environments which require the use of reparatory protective devices, should be given additional medical examinations, to ensure that the devices are adequately protecting the health of the workers and to determine the effects of their environment on the workers. These examinations should be given as frequently as deemed necessary by the medical authority, but should be given at least annually. During the annual examination, in addition to the pulmonary function test, blood and urine should be tested.

2-30. APPROVING AGENCIES

At one time, the US Bureau of Mines was the governmental agency responsible for approval of respirators. The NIOSH and the Mine Safety and Health Administration (MSHA) have assumed this responsibility. Manufacturers of respirators are to submit respirators to NIOSH for testing and certifying. When a respirator is found to be satisfactory for use against a specific contaminant and concentration, NIOSH issues it a "TC" number indicating that it has been "tested and certified" with Federal Law. Thereafter, it must be used as a unit as certified. If it requires any replacement parts, they must be replaced by parts identical to those being replaced.

Continue with Exercises

EXERCISES, LESSON 2

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. The gas that constitutes one of the most serious occupational hazards is ____.

2. In which state is a chemical hazard classified if it is a fluid, which has neither independent shape nor volume but tends to expand indefinitely?

   a. Liquid.

   b. Mist.

   c. Gas.

   d. Fume.

3. A metal toxic fume is:

   a. Sulfide.

   b. Iron.

   c. Lead.

   d. Iron sulfide.

4. List three examples of organic solvents that vaporize easily.

   a. _____________________________________.

   b. _____________________________________.

   c. _____________________________________.

5. Which particles are finely divided solids resulting from crushing, grinding, or abrading?

   a. Solids.

   b. Dust.

   c. Liquids.

   d. Gases.

6. Which part of the body, with its thick layers of cells and its secretions, is almost impervious to chemical agents? However, certain chemicals, such as solvents and gases, can penetrate this barrier.

   a. The skin.

   b. Excretory system.

   c. Respiratory system.

7. For all practical purposes, mists and vapors are the same.

   a. True.

   b. False.

8. Which potential chemical hazard is most likely to be formed during the heating of metals?

   a. Solid.

   b. Dust.

   c. Mist.

   d. Fume.

9. Liquids are fluids characterized by particles that move freely, without a tendency to separate from one another as in the case with a gas. What are examples of mist liquids?

   a. Benzol and carbon tetrachloride.

   b. Lead and mercury.

   c. Insecticide and water.

   d. Oil and vinegar.

10. The most common route of entry to the body for a chemical agent is through ingestion.

   a. True.

   b. False.

11. The human tracheobronchial system is lined with short hairs known as ______________________.

12. Name the two body organs that play the major role in extracting and expelling chemicals:

   a. ______________________.

   b. ______________________.

13. The skin offers virtually no resistance to the entry of harmful chemicals into the body.

   a. True.

   b. False.

14. Select the chemical asphyxiants that render the body incapable of utilizing an adequate oxygen supply (because they replace the oxygen in the air or interfere with the body's oxygen transfer mechanism).

    a. Carbon monoxide (automobile fumes) and cyanides.

    b. Nitrogen and nitrous oxide (laughing gas used by dentists).

    c. Carbon dioxide (gas produced by plants), hydrogen, and helium.

    d. Methane (gases from marshes and mines) and ethane (natural gases and fumes).

    e. All of the above.

    f. Both a and c.

15. An anesthetic may be used during surgery as a depressant to the central nervous system, particularly the brain. However, an anesthetic is a chemical that is potentially hazard in that its:

    a. Effectiveness depends upon the effective concentration in the brain.

    b. Degree of anesthetic action depends upon the effective concentration in the brain as well as upon the specific pharmacological action.

    c. Potency of simple alcohols rises with increasing number of carbon atoms up to amyl alcohol, which is the most powerful of the series.

    d. All of the above.

16. List four examples of systemic poisons.

    a. ___________________________.

    b. ___________________________.

    c. ___________________________.

    d. ___________________________.

17. The toxicity of a chemical may be affected by all of the following except:

    a. Volatility.

    b. Particle size.

    c. Color.

    d. Density.

18. The physical condition of a worker has no effect on the toxicity of a chemical agent to which he might be exposed.

    a. True.

    b. False.

19. List two environmental factors that can affect the toxicity of a chemical agent.

    a. ____________________.

    b. ____________________.

20. What gas damages the lungs but only slightly irritates the upper respiratory tract?
    _______________________________________-

21. What is the best prevention and control of irritant gases?

    a. Aerate the area.

    b. Good engineering design and strong willed employees.

    c. Protective equipment and better rooms.

    d. Protective equipment and good engineering design and maintenance of the equipment on the job.

22. Which one of the following does NOT produce carbon monoxide?

    a. Operation of internal combustion engines.

    b. Explosion of dynamite.

    c. Incomplete burning of natural gas.

    d. Photosynthesis of plants.

23. Carbon monoxide interferes with the function of ________________ which is to transport ________________________ to the body tissues.

24. What type of gas can accidentally be produced when chemicals called chlorinated hydrocarbons come into contact with a flame, hot metal, or any other heat source?

    a. Carbon monoxide.

    b. Nitroglycerine.

    c. Carbon dioxide.

    d. Nitrogen dioxide.

25. Which toxic colorless gas will quickly cause systemic poisoning, hyperpnoea on the nervous system and immediate respiratory paralysis, without warning, and unless the victim is removed to fresh air within a very few minutes and breathing stimulated or induced by artificial respiration, death will occur?

    a. Ammonia.

    b. Nitrogen dioxide.

    c. Hydrogen sulfide.

    d. Carbon dioxide.

26. Chemicals, found at most industrial type jobs and homes, contain harmful organic liquid chemical properties, which may present a ________________ military occupational hazard to soldiers.

    a. Possible.

    b. Significant.

    c. Mediocre.

    d. Remote.

27. More specifically, ____________ are good examples of the liquid chemicals which are widespread in their use and which constitute some of the most dangerous occupational hazards.

28. Most organic compounds can be vaporized very easily; in fact,

    a. Some vaporize at room temperature.

    b. When metal machine parts are removed for repair or cleaning, their lubricating oils and greases are immersed in the vapor of solvents will give off vaporous fumes.

    c. When open top containers house organic compounds, various amounts of vapor will evolve, depending upon the type of solvent and its temperature.

    d. All of the above.

    e. None of the above.

29. Dermatitis is one of the most important occupational diseases and the effect of chemicals on the skin may be caused by:

    a. A sensitizing effect.

    b. An irritant effect.

    c. Both a and b.

    d. None of the above.

30. Which is the most important of the occupational diseases for time lost from the job but usually not severe enough to warrant permanent disability?

    a. Nervous system effect.

    b. Skin diseases.

    c. Cancer-producing liquid chemical.

    d. Respiratory diseases from ingesting unsafe water.

31. The three types of measures used for the prevention and control of illnesses arising from exposure to liquid chemicals are ___________ control, ___________ control, and ______________ control.

32. Personal control measures for the prevention and control of illnesses arising from liquid chemicals are limited to the use of ________________, _________________, and _________________.

33. Which organic insecticide solvent acts directly on the brain causing tremors, dizziness, and convulsions?

    a. Methyl chloroform.

    b. Chlorinated hydrocarbons like DDT.

    c. Ammonia.

    d. Sodium carbonate.

34. When a "ceiling" limit is assigned to certain toxic substances, it should:

    a. Exceed when the threshold limit is reached.

    b. Not be exceeded under any circumstances.

    c. Change as circumstances change.

    d. Be removed for fast acting substances.

35. List three of the sample locations that may be used, depending upon the type of evaluation desired, when performing sampling techniques.

a. ____________________.

b. ____________________.

c. ____________________.

36. Which of the following sampling devices is NOT a direct readout device of gases and vapors?

a. Portable carbon monoxide monitor and dector tube.

b. Infrared analyzer and charcoal tube.

c. Charcoal tube and silica gel tube.

d. Fritted bubbler and infrared analyzer.

37. The number of air samples to be collected will depend upon the type of evaluation being conducted and what is necessary to effectively evaluate a worker's exposure.

a. True.

b. False.

38. Devices used to sample air, which are interconnected in a certain order to obtain the desired sample, are known as:

a. Impingers.

b. Flow meters.

c. Sampling trains.

d. Suction pumps.

39. Air purifying respirators do not protect against _________________ or against ___________________.

40. A sampling train for ______________ would be similar to a sampling train for particulate, except that some type of absorption or adsorption device would replace the particulate separator.

41. One limitation for a gas mask is that it may only be used for escape from:

    a. Entry.

    b. Exit.

42. Which type of chemical cartridge respirator could have a maximum use concentration of 100 ppm?

    a. Ammonia.

    b. Chlorine.

    c. Hydrogen chloride.

    d. Methyl Amine.

43. The respirator with a Federal supply system NSN of 4240-01-259-4575 indicates that this is a:

    a. Respirator, air filtering, for pesticides (respirator furnished with 50 cartridges and I00 filters).

    b. Respirator, air filtering, for dusts (respirator furnished with 50 filters).

    c. Respirator, air filtering, for metal fumes (respirator furnished with I00 filters, or 50 filters depending on whether the mask is dual or single element).

    d. Respirator, air filtering, for paint spray (respirator furnished with I00 or 50 cartridges and filters).

    e. Respirator, air filtering, for organic vapors (respirator furnished with I00 or 50 cartridges).

44. Pesticide respirators contain:

    a. Shoulder-style gas masks.

    b. Air purifying respirator with an attached blower.

    c. Individual devices.

    d. No cartridge respirators.

45. List three criteria to be considered when selecting a respirator.

    a. ________________.

    b. ________________.

    c. ________________.

46. Which is NOT a criteria for selecting the proper respiratory protective device?

    a. Movement requirements.

    b. Conditions of exposure.

    c. Atmospheric conditions downstream.

    d. Nature of hazard.

47. What do you look for when checking a respirator during an inspection?

    a. Tightness of connectors and condition of face piece, headbands, valves, connecting tubes, and canisters. Leaks in respirator; pliability and signs of deterioration in rubber and soft-formed material (elastomer) parts.

    b. Looseness of conductors.

    c. Clean parts.

    d. None of the above.

48. After the respirator has been washed and completely rinsed in clean, warm water, what are the next correct sequenced steps?

   a. Air dry the part in a clean area and clean other respirator parts. Insert new filters, cartridges, or canisters; ensure that all seals are tight. Inspect valves, head straps, and other parts for wear and/or damage; replace with new parts if defective. Place in plastic bag or container for storage.

   b. Air dry the part. Inspect valves, head straps, and other parts for wear and/or damage; replace with new parts if defective. Insert new filters, cartridges, or canisters; ensure that all seals are tight. Clean other respirator parts as recommended by the manufacturer. Place in plastic bag or container for storage.

   c. Inspect valves, head straps, and other parts for wear and/or damage; replace with new parts if defective. Air dry the part in a clean area. Clean other respirator parts as recommended by the manufacturer. Insert new filters, cartridges, or canisters; ensure that all seals are tight. Place in a plastic bag.

   d. Air dry the part in a clean area. Clean other respirator parts as recommended by the manufacturer. Inspect valves, head straps, and other parts for wear and/or damage; replace with new parts if defective. Insert new filters, cartridges, or canisters; ensure that all seals are tight. Place in plastic bag or container for storage.

49. Where should respirators always be stored?

   a. Lockers.

   b. Plastic bags.

   c. Tool boxes.

   d. Desk drawers.

50. What must be continuously checked and evaluated if respiratory protection for workers in a hazardous environment is to be effective?

a. Only the respirators.

b. The program.

c. Only the workers.

d. The oxygen-generating canister.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 2

1. Carbon monoxide. (para 2-2b(l))

2. c (para 2-2b)

3. c (para 2-2b(3)(b))

4. Benzol.
   Carbon tetrachloride.
   Trichloroethylene. (para 2-2b(2)(a))

5. b (para 2-2b(3)(a))

6. a (para 2-4b)

7. b (para 2-2b(2))

8. d (para 2-2b(3)(b))

9. c (para 2-2b(2))

10. b (para 2-3a, c)

11. Cilia. (para 2-4a(2))

12. Liver
    Kidneys. (para 2-4c)

13. b (para 2-4b)

14. e (para 2-5b)

15. d (para 2-5c)

16. (any four of the below)
    Carbon tetrachloride.
    Tetrochlorethane.
    Halogenated hydrocarbons.
    Metals such a manganese, mercury, thallium, lead, and uranium.
    Organic phosphorus pesticides.
    Benzene. (para 2-5e)

17. c (para 2-6a)

18. b (para 2-6b)

19. (any two of the below)
Concentration.
Control measures in effect.
Duration of exposure.
Frequency of exposure. (para 2-6c)

20. Phosgene. (para 2-9a(1)(2))

21. d (para 2-9a(3))

22. d (para 2-8a)

23. Hemoglobin, oxygen. (para 2-8b)

24. d (para 2-9a(1)

25. c (para 2-9c(2))

26. b (para 2-10)

27. Solvents. (para 2-10)

28. d (para 2-11b)

29. c (para 2-12b(3))

30. b (paras 2-12b, 2-13b)

31. Environmental, personal, medical. (para 2-13a)

32. Protective clothing, protective ointments, and personal cleanliness. (para 2-13b)

33. b (para 2-12c)

34. b (para 2-14b(5))

35. General room (area or background) air sample.
Breathing zone sample.
Operation or process area sample. (para 2-l5c)

36. c (para 2-l6b(2), Figure 2-5)

37. a (para 2-l5f)

38. c (para 2-16d)

39. Oxygen deficient atmospheres; skin irritation/absorption of contaminant. (para 2-19b)

40. Gas or vapor (para 2-16d)

41. b (para 2-19c(3)(b))

42. d (Table 2-3)

43. c (Table 2-4)

44. b (para 2-19f(1)(d))

45. (any three of the below)
Nature of the hazard.
Conditions of exposure.
Safety requirements.
Movement required.
Decision logic. (para 2-22)

46. c (para 2-22)

47. a (para 2-26b)

48. d (para 2-25b)

49. b (para 2-27a)

50. b (para 2-28)

END OF LESSON 2

LESSON ASSIGNMENT

LESSON 3 Noise and the Conservation of Hearing.

TEXT ASSIGNMENT Paragraph 3-1 through 3-20.

LESSON OBJECTIVES After completing this lesson you should be able to:

3-1. List and define the properties of sound.

3-2. Select the statement which best describes the factors for determining whether noise is hazardous to hearing.

3-3. Select the statement which best describes the mechanics of hearing and the effects of noise on the ear.

3-4. Select the statement which best describes management's responsibilities for providing workers with a safe noise level environment as per the Army Hearing Conservation Program.

3-5. Select the statement which best describes the essentials of a hearing conservation program for job-related noise, management and its staff's responsibilities for noise abatement, and the effects of excessive noise.

3-6. Define the purpose of a noise survey.

3-7. Select appropriate measurement noise standard criterion and ensure measuring equipment accuracy.

3-8. Select the statement that correctly describes protective and medical measures to abate noise.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 3

NOISE AND THE CONSERVATION OF HEARING

Section I. INTRODUCTION

3-1. GENERAL

We are surrounded by sound. Twenty-four hours each day, we live in a world of sound. Even while we are asleep, the ticking of the clock or the whirring of the air conditioner may be part of our environment. In our waking hours, we are immersed in sound-passing automobiles, overhead aircraft, clattering computer printers and typewriters, weapons firing, equipment operating, people talking, radios playing. A total lack of sound can in itself be disturbing; too much sound can be literally deafening. In the field of industrial hygiene, we are concerned with those sounds known as noise and the hazards that they present to workers. Exposure to certain noises can have profound physical and psychological effects on the individual. To protect Federal government personnel against these effects, hearing conservation programs must be planned and implemented at all Army installations. Management of such programs is an installation responsibility; however, the US Army Medical Department is responsible for ensuring that such programs are established and that they are effective. As a PVNTMED Specialist, you will play an active role in the installation hearing conservation program.

3-2. RESPONSIBILITIES

a. **Installation Commander**. The commander of an Army installation is responsible for providing a safe work environment, free of hazardous noise levels, and to meet the hearing conservation program requirements according to Army Regulation (AR) 40-5 and AR 385-10. Subordinate commanders, supervisors, and managers are responsible for purchasing new equipment that generates the lowest noise level feasible.

b. **Safety Director or Officer**. The safety director coordinates with the Installation Medical Authority to determine the existence of noise and performs the following functions:

(1) Conducts inspections and includes noise hazard abatement projects in the hazard abatement plan.

(2) Controls entrance to hazardous areas by posting color-coded caution and other signs designating the more hazardous areas.

c. **Installation Medical Authority (IMA).** The IMA plans and supervises the overall Occupational Health Program, including the Hearing Conservation Program in accordance with (IAW) TB MED 501 and DA Pam 40-501. The IMA ensures that a physician determines the diagnosis of noise-induced hearing loss and notifies the Civilian Personnel Office of hearing and noise hazardous problems. Specialists, who assist the IMA, include medical officers, audiologists, hearing conservation officers, and preventive medicine specialists.

d. **Preventive Medicine Specialist**. In most cases, preventive medicine specialists will wear several hats and serve as the supervisors or commander's industrial hygiene manager (TB MED 503) and/or the hearing conservation officer (TB MED 501 and USAEHA Technical Guide (TG) No. 167), especially in the field. These individuals will manage and coordinate all aspects of the hearing conservation program as outlined in AR 40-5. Responsibilities of the preventive medicine specialist will vary according to level of skill, certification needed in certain disciplines, and composition of staff at installation or regional areas. Responsibilities include:

(1) Drafting, staffing, and implementing a SOP.

(2) Ensuring that medically trained personnel fit individuals with hearing equipment.

(3) Performing announced and unannounced inspections of noise hazardous areas at installations and in the field.

(4) Using approved and calibrated equipment, and surveying all suspected noise-hazardous areas and equipment at least once and within 30 days of any change in operations.

(5) Establishing a time-weighted average for all civilians working in noise-hazardous areas and soldiers working in noise-hazardous industrial type operations.

(6) Performing audiometric testing, maintaining audiograms (IAW ARs 40-66 and 25-400 and TB MED 501) and providing audiometric test records and exposure health materials or information upon request. (Must be certified to do so.) (Usually performed by an ear, nose, and throat specialist or OH nurse).

(7) Maintaining a current inventory of all noise-hazardous areas, using DD Form 2214 (Noise Survey), until health hazard information module (HHIM) can accommodate noise information.

(8) Providing the names of noise-exposed personnel and the magnitude of their noise exposure to their commander or supervisor and the hearing officer, if one is available.

(9) Recommending job placement and job criteria, that is, wearing personal protective devices.

e. **Civilian Personnel Officer**.

(1) Ensuring that OH is included on the in processing and out processing checklists for new, transferring, or terminating personnel.

(2) Maintaining pertinent personnel records of civilian employees involved in the hearing conservation program and for notifying job supervisors of annual audiometry appointments.

(3) Ensuring that job descriptions (IAW AR 385-10) include, where applicable, the requirement to wear hearing personal protective equipment (PPE) (hearing protectors) and enforcing such use.

f. **Director of Engineering and Housing**. The Director of Engineering and Housing (DEH) engineer provides corrective actions designed to reduce or eliminate sources of hazardous noise levels, that is, installing engineering controls such as acoustical materials, when exposure to steady, loud, and so forth, noise exceeds the time weighed criteria. In addition, facility engineers are responsible for providing treated booths or rooms for audiometric testing, when the number of persons requiring such testing warrants the expense involved. Usually, the purchase of prefabricated audiometric booths is more economical than constructing a sound treated room and is also more satisfactory for testing purposes.

Section II. THE ARMY HEARING CONSERVATION PROGRAM

3-3. PURPOSE

The purpose of the Army hearing conservation program is to prevent hearing losses caused by exposure to noise in the work environment. In addition to the reduced job performance caused by hearing loss, this hearing damage costs the Army as much as $100 million a year in the form of compensation paid to individuals. Army surgeons, as well as civilian industrial physicians in the employ of the Army, must be familiar with the nature of noise, the effects of noise on human hearing, and measures for preventing hearing loss caused by noise. It is the responsibility of these medical officers not only to be familiar with the subject, but also to identify noise hazards that may exist in the work environment of the personnel for which they have health responsibility and to establish hearing conservation programs when the need is indicated. Before an effective noise abatement program can be implemented, the subject of sound must first be understood and its problems recognized.

3-4. THE MECHANICS OF HEARING

The human ear is composed of three major sections: the external ear, the middle ear, and the inner ear. Each of these has a distinct function in the hearing process.

a. The external ear or external auditory canal is a somewhat trumpets shaped structure that leads to the middle ear. It's bone and cartilage is covered with skin that is very sensitive. This canal skin is protected and kept moist by the sebaceous glands (located distally). Sound waves entering the ear travel through the external ear canal, are funneled to the middle ear, and strike the eardrum, or tympanic membrane.

b. The middle ear consists of the eardrum, the air cavity, filled with a chain of small bones called the malleus, incus, stapes or the hammer, anvil, and stirrup plus the oval window. One end of this chain rests against the eardrum, while the other end is connected to the inner ear. It is within the middle ear that the sound waves strike the tympanic membrane (eardrum), which in turn, cause vibrations. Note in Figure 3-1 that the tympanic membrane is catty-corner to the auditory canal. These vibrations are then bounced off hammer, anvil, stirrup, and oval window as they are carried or transferred to the inner ear.

c. The inner ear consists of a spiral or curved tube filled with fluid. The spiral tube contains the cochlea, organ of Corti, and semicircular canals. The cochlea, sea shell shaped, bone contains the organ of Corti, which consists of many sensory cells with delicate hairs or hair cells projecting into the fluid. The organ of Corti receives the sound waves and transfers these impulses to the eighth cranial nerve. This auditory nerve transmits the impulses to the brain for interpretation by the brain.

3-5. PROPERTIES OF SOUND

There are several definitions of the physical properties of sound, which you need to understand and that will be helpful to you in carrying out your responsibilities.

a. **Sound.** Sound is based upon the sense of hearing. Sound is the effect produced on the organ of hearing and its central connections by the vibrations of the air or other medium. The motion, energy, and frequency, of these particles (gas, liquid, or solid) passing through a medium, like a human ear or tunnel, provide a sensation. This sensation or vibration reaching the human ear is interpreted by the human brain as "sound." A frequency of between 8 and 20,000 cycles per second provides the stimulus for the subjective sensation of hearing. Although sound resembles forms of electromagnetic energy (light, x-rays, radio waves), it always requires a transport medium.

b. **Frequency.** Frequency is the rate per unit time that high and low pressure regions occur. It is measured as Hertz, where one Hertz is equivalent to one cycle per second. The range of sound frequencies, which the human ear can perceive, extends from 16 Hz up to as high as 30,000 Hz (also written as 30 KHz). The average young adult can hear sounds from 20 to 20,000 Hz, although as a practical matter, few adults can hear sounds whose frequency exceeds 11,000 Hz (11 KHz).

c. **Intensity.** Intensity is a measure of the rate of energy passing through a unit area. It is measured in decibels (dB or dbs). Loudness is the observer's impression of the sound intensity received.

d. **Tone.** A tone is an acoustic stimulus (sound), whose pressure varies in a perfectly periodic manner. If there is only one component whose pressure varies in a simple sinusoidal (like a sine wave) manner, it is called a "pure tone"; if it can be analyzed into several such components, it is termed a "complex tone."

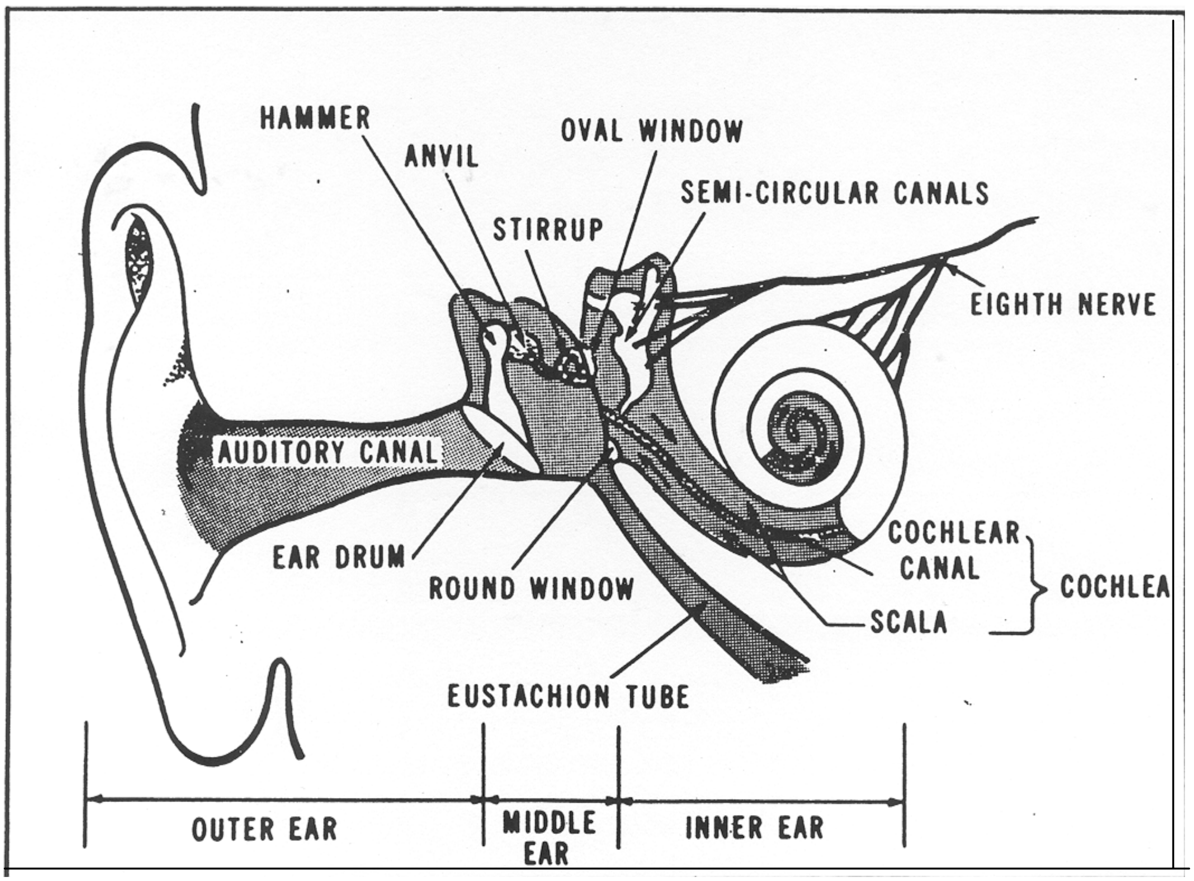


Figure 3-1. Anatomy of the human ear.

e. **Noise**. Noise, normal or abnormal, is simply defined as unwanted sound, whether it is a pure tone, a complex of tones, or unwanted speech or music. For actual complex sounds, the acoustical character is usually applied to sounds which contain a large number of separate frequency components that extend over a wide range of frequencies, coming from animate or inanimate objects, and may or may not convey meaning or information. Then again, noise may be a single sharp, squeaky, or piercing sound of short or long duration.

f. **Steady Noise**. Steady noise is a periodic or random variation in atmospheric pressure at audible frequencies. It may be continuous, intermittent, or fluctuating with the sound level varying over a wide range.

g. **Spectrum of Sound**. Decibels are measured in the A scale or dB(A). This term refers to the pattern of the distribution of energy or sound pressure present at different points or areas along the scale of audible (capable of being heard) frequencies. It is common practice to analyze a single complex sound by means of octave bands, an octave being a range of frequencies where the upper is twice the lower. This result is called an octave band analysis of the sound.

h. **Impulse or Impact Noise**. Noise characterized by a sharp rise in intensity followed by a rapid decline in intensity, such as that produced by gunfire. It cannot be measured accurately with an ordinary sound level meter.

i. **Audiogram**. It is measured as dB(P). An audiogram is a graphic record of an individual's hearing sensitivity in each ear for each of a number of pure tone or sound test frequencies. The measure of hearing sensitivity is the individual's threshold of hearing, which is the lowest intensity of a given tone that he hears. (This job function is usually performed by a different specialist).

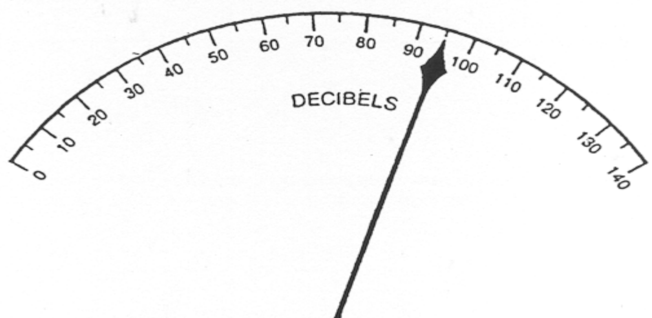
j. **Audiometer**. This is the electronic device that produces acoustic stimuli of a known frequency and the intensity for the measurement of hearing or stated another way; it is an instrument that detects response to sound stimuli by changes in the electroencephalogram. (This job function is usually performed by a different specialist).

k. **Hearing Level of an Ear at a Specified Frequency**. This is the amount, in decibels, by which the threshold of audibility for that ear exceeds, or is less than, the standard audiometric threshold. This threshold of audibility varies among individuals.

l. **Decibel**. The decibel (dB or db) is a term borrowed from electrical engineering, and represents a relative quantity. When used to express sound pressure levels, it represents a level compared to a reference level. This reference level is usually a sound pressure of 20 micropascals (uPa) and is usually referred to as "0 decibels" or "0 dB." Practically speaking, this beginning or starting point on the relative scale of noise levels is about the level of the weakest sound that can be heard by a person with very good hearing in an extremely quiet environment. To use the decibel in a familiar example, the sound pressure level in a large administrative office is usually between 40 and 60 dB. It should be no higher than 60 dB.

m. **The dB(A)**. When measuring the intensity of sound using a sound level meter, the meter is equipped with a system of "weighting networks" whose effect is to duplicate the response of the human ear. To achieve this, these weighting networks cause the sensitivity of the meter to vary with frequency and intensity of sound, as does the sensitivity of the human ear. When referring to sound levels in this subcourse, we will be referring to sound levels measured by a meter employing the "A-weighting" network and will use the term "dB(A)" rather than "dB." Table 3-1 lists some typical noise levels, given in dB(A).

n**.** **The dB(P)**. This is the unit used to express the peak sound pressure of impulse noise.



Threshold hearing-acute	0 dB (A)	Truck going by	82 dB(A)
" " -average	15 dB(A)	Heavy city traffic	90 dB(A)
Rustling leaves	20 dB(A)	Diesel truck	92 dB(A)
Broadcast studio	30 dB(A)	(at 25 ft)	
Whisper	34 dB(A)	Air compressor	94 dB(A)
Average dwelling	35 dB(A)	Noisy factory	95 dB(A)
Quiet office	40 dB(A)	Cut-off saw	97 dB(A)
House refrigerator	47 dB(A)	Lawn mower	98 dB(A)
Average office	50 dB(A)	City overhead train	99 dB(A)
Quiet automobile	53 dB(A)	Bench grinder	105 dB(A)
Window air-conditioner	55 dB(A)	Boiler factory	106 dB(A)
Average restaurant	57 dB(A)	Air chisel	106 dB(A)
Conversation	60 dB(A)	Vacuum pump	108 dB(A)
Quiet typewriter	60 dB(A)	Chain saw	115 dB(A)
Vacuum cleaner	65 dB(A)	Car horn	120 dB(A)
(at 10 ft)		Airplane motor, 20 ft	125 dB(A)
Stenographic room	67 dB(A)	Rock drill	130 dB(A)
Average factory	75 dB(A)	Motor test chamber	141 dB(A)
Printing press	79 dB(A)	M14 rifle	160 dB peak
Alarm clock	80 dB(A)		sound pressure level
(at 2 ft)		Howitzer	185 dB peak
Printing plant	86 dB(A)		sound pressure level

Table 3-1. Some typical noise levels.

3-6. THE EFFECTS OF NOISE ON THE EAR

a. Exposure to excessive noise for extended periods of time over-activates the hair and hair cells in the inner ear, causing injury or destruction. Such injury to the organ of Corti usually leads to permanent loss of hearing. There is no known treatment for such hearing loss. Depending upon the duration of the exposure to excessive noise, hearing loss may be only temporary in nature. Table 3-2 shows some common noise exposures that personnel encounter.

	Peak Sound Pressure Level dB
Rifle, 5.56-mm, automatic, M16	154-158
Machine gun, 7.62-mm, M60	149-161
Rifle, recoilless, 106-mm, M40A1	171
Howitzer, light, towed, 105-mm	185-191
TOW (tube launched, optical tracked, wire guided).	166-170
	Sound Pressure Level dB(A)
UH-1D Iroquois (Rotary Wing)	96-99
CH-47C Chinook (Rotary Wing)	110
U-6A Beaver (Fixed Wing)	99-102
U-21A Ute (Fixed Wing)	80-102
Truck, Cargo, 5-ton, 8X8, M656, M757, M759	87-101
Truck, Fork Lift, 6,000-lb, gasoline	98
Truck, Fork Lift, 6,000-lb, Diesel	102
Grinder, electric, 10-inch	92
Riveter, pneumatic	105-112
Saw, Chain, gasoline, 7-hp	125
Saw, Table, electric, 10-inch	108
Tractor, Full-tracked, D-7E	106

SOURCE: Sound Level Data of Military Noise Sources, US Army Environmental Hygiene Agency, Edgewood Arsenal, MD.

Table 3-2. Some common military exposures to noise.

b. Over exposure to high frequency noise causes more significant hearing loss than over exposure to low frequency noise of the same intensity. During initial exposure, most of the hearing impairment is in the frequency range above those important to the understanding of speech. As a result, early damage is frequently not noticed by the individual. Detection of losses in these ranges by the medical officer is important, as early losses may be regarded as danger signs of further potential hearing loss. Continued exposure will lead to progressively greater damage, including loss of the speech frequencies that, if allowed to reach an advanced stage, will cause a severe handicap.

c. Other physiological effects that can be produced by excessive exposure to noise include nausea and headaches. In many cases the reflex responses of the individual will be affected.

d. Psychological stress from noise may be manifested in the form of fatigue, inability to function, annoyance, and distraction.

3-7. FACTORS DETERMINING THE DEGREE OF NOISE HAZARD

Of the properties or characteristics of noise, there are four that determine whether a given noise is likely to be hazardous to the hearing of workers.

a**.** **Frequency**. The frequency of a noise determines its pitch, which is that attribute of an auditory sensation in terms of which sounds may be ordered on a scale extending from low to high. High frequency (high pitched) noises are more dangerous to hearing than low frequency (low pitched) noises.

b. **Intensity**. The relative loudness of the noise, expressed in decibels, will play a large part in determining the degree of hazard; the louder the noise, the greater its potential for causing hearing loss.

c. **The Nature of the Noise**. Noise may be continuous or intermittent. It may be steady or made up of a series of impact or impulse noises.

d. **The Duration of Exposure**. The longer the exposure, the greater the damage to the hearing mechanism.

3-8. ESSENTIALS OF A HEARING CONSERVATION PROGRAM

A hearing conservation program is an effective program to prevent hearing loss due to exposure to excessive job-related noise. It involves the carefully coordinated application of engineering control measures, personal protective measures, medical control measures, health education, proper supervision, and personal discipline on the part of workers. Normally, the first step in establishing a hearing conservation program will be to conduct a noise survey. However, there are occasions when a program can be initiated without such a survey. For example, a noise survey is unnecessary in the following cases:

a. When personnel have difficulty communicating by speech while they are in the noise area.

b. When personnel hear noises or ringing sounds in their ears after working in the noise area for several hours.

c. When personnel experience temporary loss of hearing, which muffles speech and certain other sounds, after several hours of exposure to the noise.

NOTE: In borderline cases, a noise survey is recommended.

3-9. THE NOISE SURVEY

The purpose of the noise survey is to evaluate the exposures to noise in the work place in relation to interference with speech, worker comfort, and hearing loss. Another important purpose served is the collection of information for use in designing controls. In making noise measurements, the following points are important.

a. At all locations where noise makes it difficult for two persons with good hearing to converse at close range, tests should be made with a sound level meter. The average, overall level is determined by taking several meter readings at each location. In general, when it is necessary to shout in order to be heard intelligibly at a distance of 1 foot, the noise level is at least 60 dB(A), and probably even higher.

b. Steady noises from several sources, varying in their composition and frequency spectra, can lead to hearing loss. It is therefore essential that such noise be broken down into its several components and analyzed. This can be done by using an octave band analyzer with the sound level meter.

c. Noise levels should be measured at the approximate position of the worker's more exposed ear. Repeated measurements should be made to take into account variations in noise levels resulting from changes in operating schedules or work procedures.

d. Repeated measurements should be taken in order to accurately determine the manner in which noise levels are distributed throughout the workday.

e. Many operations and areas that are sources of hazardous noise are common to most Army installations and should be the site of sound surveys. These include the interiors of tanks, personnel carriers, and truck cabs; the vicinity of field electrical generator sets; machine shops, carpenter shops; sheet metal shops; engine repair and testing shops; weapons ranges; areas in which air driven tools are used; aircraft in operation on the ground and in the air; and aircraft engine test facilities.

f. During noise surveys, inventories of hazardous noise areas are usually kept. Records of noise surveys are kept on DD Form 2214 (Appendix H). Risk assessment codes are assigned for all sound levels above 85 dB (A).

3-10. HAZARDOUS NOISE STANDARDS

a. **Steady Noise -- Exposure Criterion**. Levels of steady noise of 85 dB(A) or greater are considered hazardous regardless of the duration of exposure for the purpose of administering a hearing conservation program. Hearing conservation measures must be initiated when personnel are exposed to levels 85 dB(A) or greater. This criterion affords the advantage of increasing the overall efficiency of the program by simplifying its administrative aspects and eliminating the requirement for dosimetry. The dosimetry would determine a cumulative measure of varying noise levels and exposure durations. It will also better protect those individuals who are more susceptible to the effects of noise. Figures 3-2, 3-5 show examples of education posters, which should be prominently posted in noise hazardous areas.

(1) Although the requirements of the program demand the initiation of hearing conservation measures when levels are 85 dB(A) or greater, the implementation of all available measures may not be necessary in every case. For example, visitors to noise hazardous areas are required to wear hearing protective devices, but the requirement for hearing evaluations does not apply to visitors.

(2) There may also be unique situations where noise levels rise infrequently and unpredictably to 85 dB(A) or greater for short durations so that the wearing of hearing protective devices may be judged impractical or unnecessary. Decisions to waive the wearing of hearing protective devices or any other requirement of the program must not be made arbitrarily. Such judgments may be rendered by trained AMEDD personnel who will perform a thorough evaluation using approved instrumentation and who will consider all factors relative to the potential for a given exposure to cause hearing impairment.

b. **Impulse Noise--Exposure Criterion**. Levels that exceed 140 dB(P) are considered hazardous. The measurement of impulse noise requires the use of special instrumentation and must be done only by specially trained AMEDD personnel. All small arms used by the Army produce impulse noise levels above 140 dB(P). Hearing conservation measures must be instituted and enforced when firing weapons during training. Impulse noise between 120 and 140 dB(P) may be uncomfortable and the wearing of hearing protection may be advisable. Repeated exposure to levels exceeding 100 dB(A) can result in significant hearing loss.

3-11. ENGINEERING CONTROL MEASURES

The environmental control of noise exposure may involve the solution of complex noise reduction problems. Many such projects should be undertaken only with the help of acoustical engineers or consultants in noise control.

a. **Noise Control Methods**. The following general methods of noise control may be applied in certain situations.

(1) Reducing the amount of noise produced by the source.

(2) Reducing the amount of noise transmitted through air or building structures.

(3) Revising operating procedures.

b. **Examples of Noise Source Reduction**.

(1) Substituting new equipment for that now in use.

(2) Periodically repairing and maintaining equipment.

(3) Making changes in processing methods.

c. **Examples of Reducing Noise Transmissions**.

(1) Increasing the distance between work areas and noise sources.

(2) Providing acoustical barriers between work areas and sound sources.

(3) Reducing reverberation by sound treating work area room surfaces.

(4) Installing vibration mounts under equipment.

d. **Examples of Operating Procedure Changes.**

(1) Providing acoustical observation booths.

(2) Providing sound-isolated remote control positions.

(3) Changing job schedules.

(4) Rotating personnel.

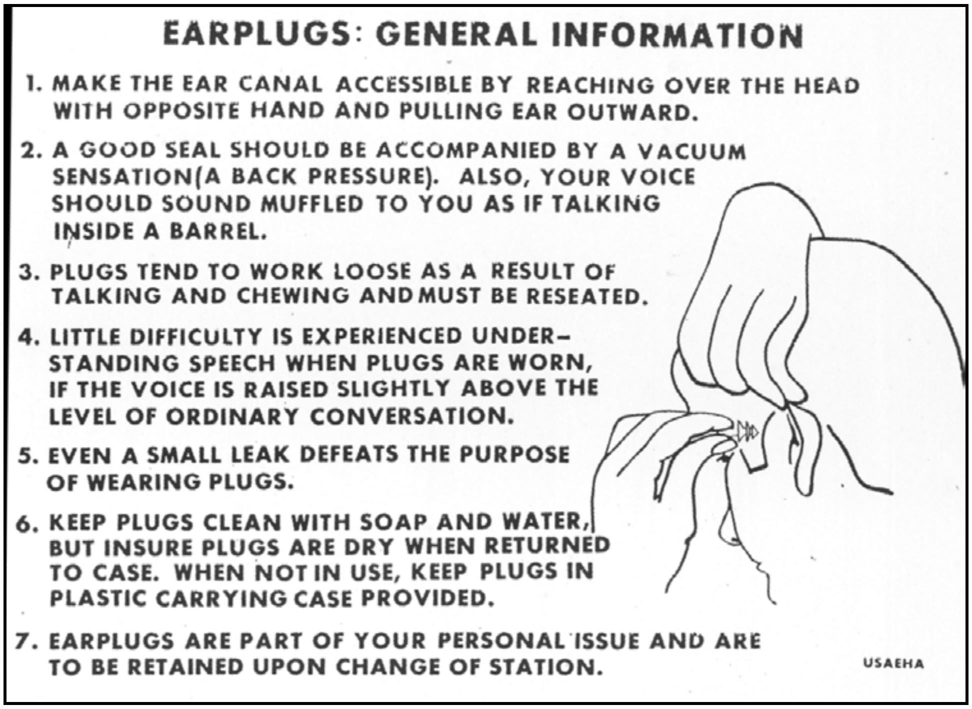


Figure 3-2. Safety poster (general information on using earplugs).

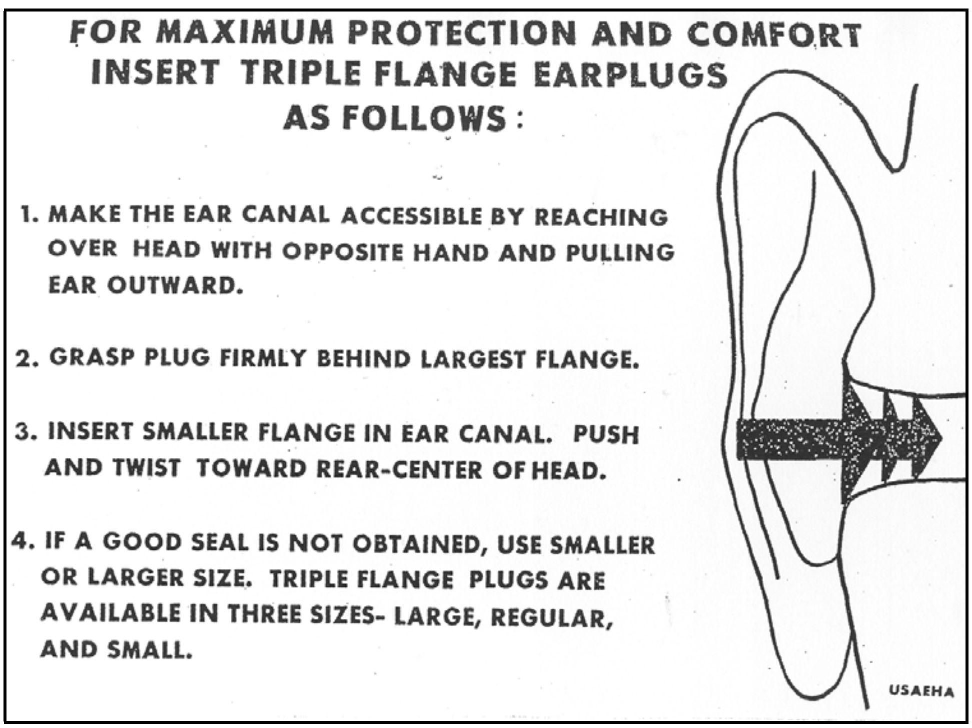


Figure 3-3. Safety poster (inserting the triple-flange earplugs).

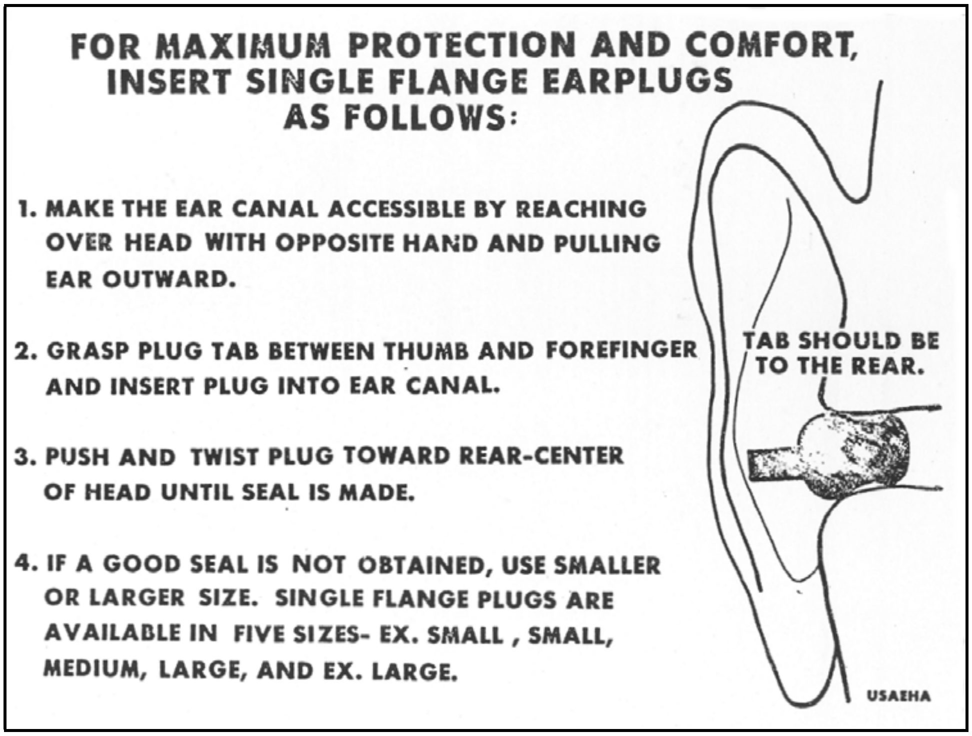


Figure 3-4. Safety poster (inserting the single-flange earplugs).

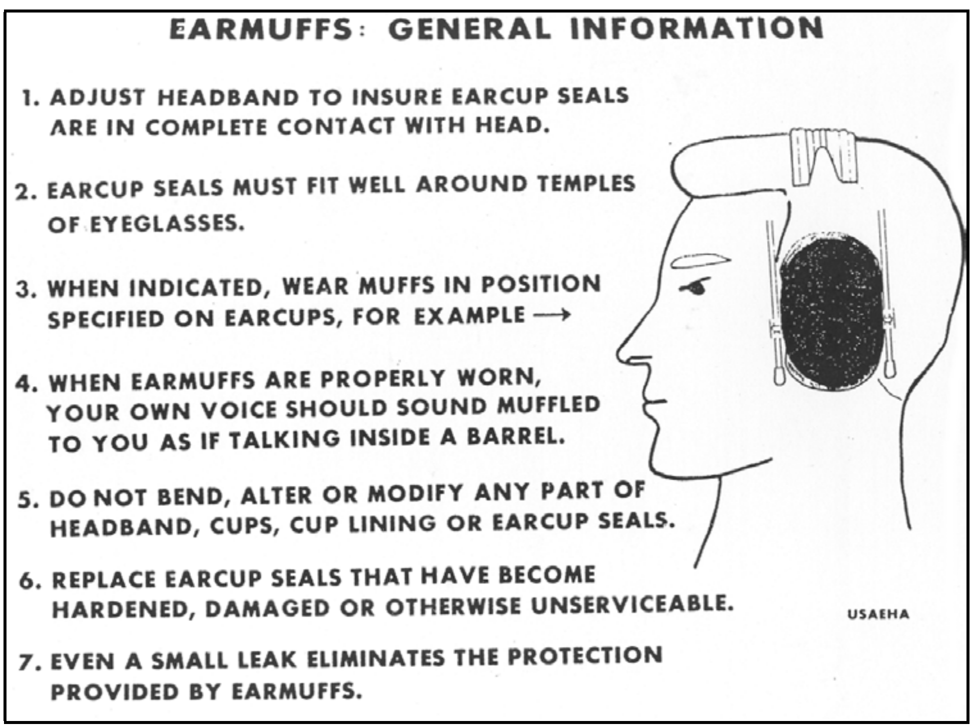


Figure 3-5. Safety poster (general information on earmuffs).

3-12. PERSONAL PROTECTIVE MEASURES

a. Personal protective devices to lessen the risk of hearing loss consist of earplugs and earmuffs (see Figures 3-6, 3-7, 3-8). Whichever device can be worn comfortable and consistently by the exposed individuals is an important element in selecting the device to be worn. In exposures to extremely high, steady state noise levels (108 dB (A) and above), earplugs and earmuffs must be worn together. Table 3-3 gives a list of earplugs and earmuffs available through medical and/or regular supply channels.

b. Well-designed and properly fitted earplugs or earmuffs will lessen the noise reaching the inner ear by 15 dB in the lower frequencies and by up to 35 dB in the higher frequencies. Wearing earplugs and earmuffs together, however, does not provide attenuation (weakening of the sound) equal to the arithmetic sum of the individual attenuation of earplugs and earmuffs worn separately. The combination of plugs and muffs provides from 35 to 40 dB noise attenuation at most frequencies. Regular use of ear protective devices is mandatory for all individuals exposed to noise in excess of 85 dB(A) or impulse noise in excess of 140 dB(P).

c. Persons with normal hearing will have little difficulty in understanding speech when earplugs or muffs are worn if the speakers will raise their voices slightly above the level of ordinary conversation. Actually it is easier for a person to hear and understand auditory signals with them. A simple demonstration will be useful in illustrating this conversation in a noisy room. You will note that the conversation can be more easily understood.

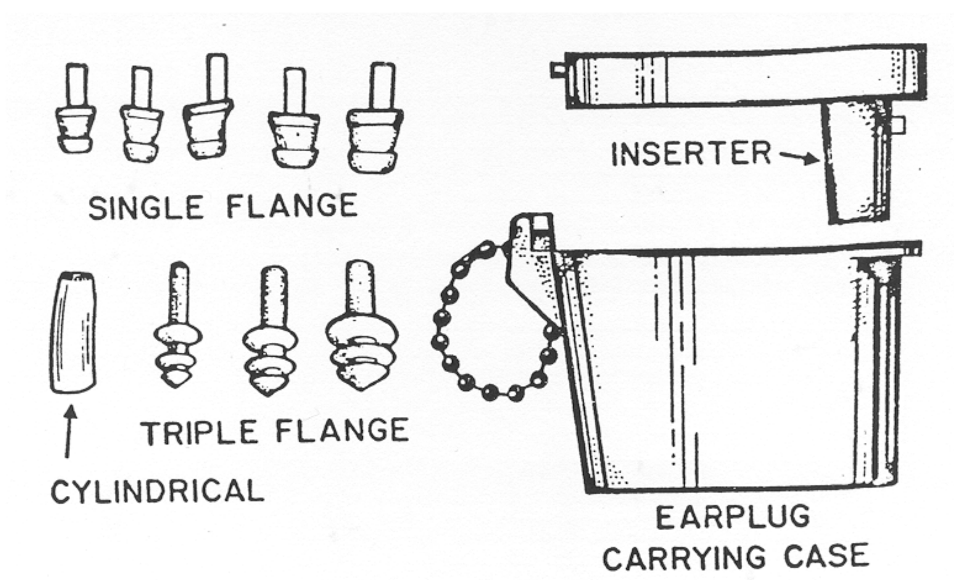


Figure 3-6. Ear plugs and carrying case approved by The Surgeon General.

d. Properly fitted earplugs will not cause damage to the normal ear canal if the earplugs are kept reasonably clean. Plugs should be fitted individually for each ear, under medical supervision (see Figure 3-9). Occasionally, an individual's two ear canals will require earplugs of different sizes. A good seal between the ear canal and the earplug is very important, so that no leak develops. A really good seal may cause some initial discomfort to the wearer. When earmuffs are chosen in preference to earplugs, the headband must be properly adjusted to ensure a snug fit. When eyeglasses are worn at the same time as earmuffs, it is important that the flange of the muff fit well around the temple of the glasses, because even a small "leak" will completely destroy the purpose of the ear protector, yet the wearer will have a false sense of security because of wearing the protector. A related problem with earplugs is that they tend to work loose as a result of talking and chewing. As a result, they must be reseated from time to time during the workday.

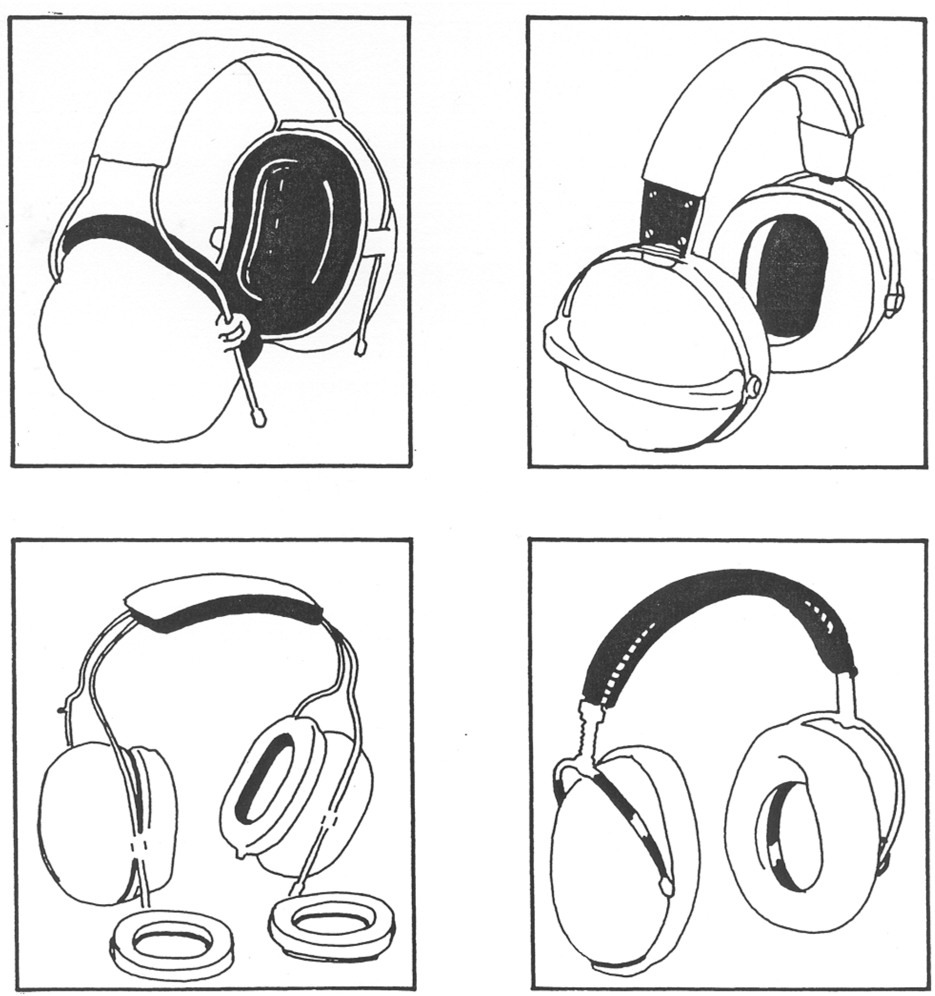


Figure 3-7. Type I earmuffs.

e. The only effective ear protector is one that is worn consistently. Hearing damage becomes progressively worse with each additional day of exposure; personnel must be convinced of the importance of wearing their ear protectors.

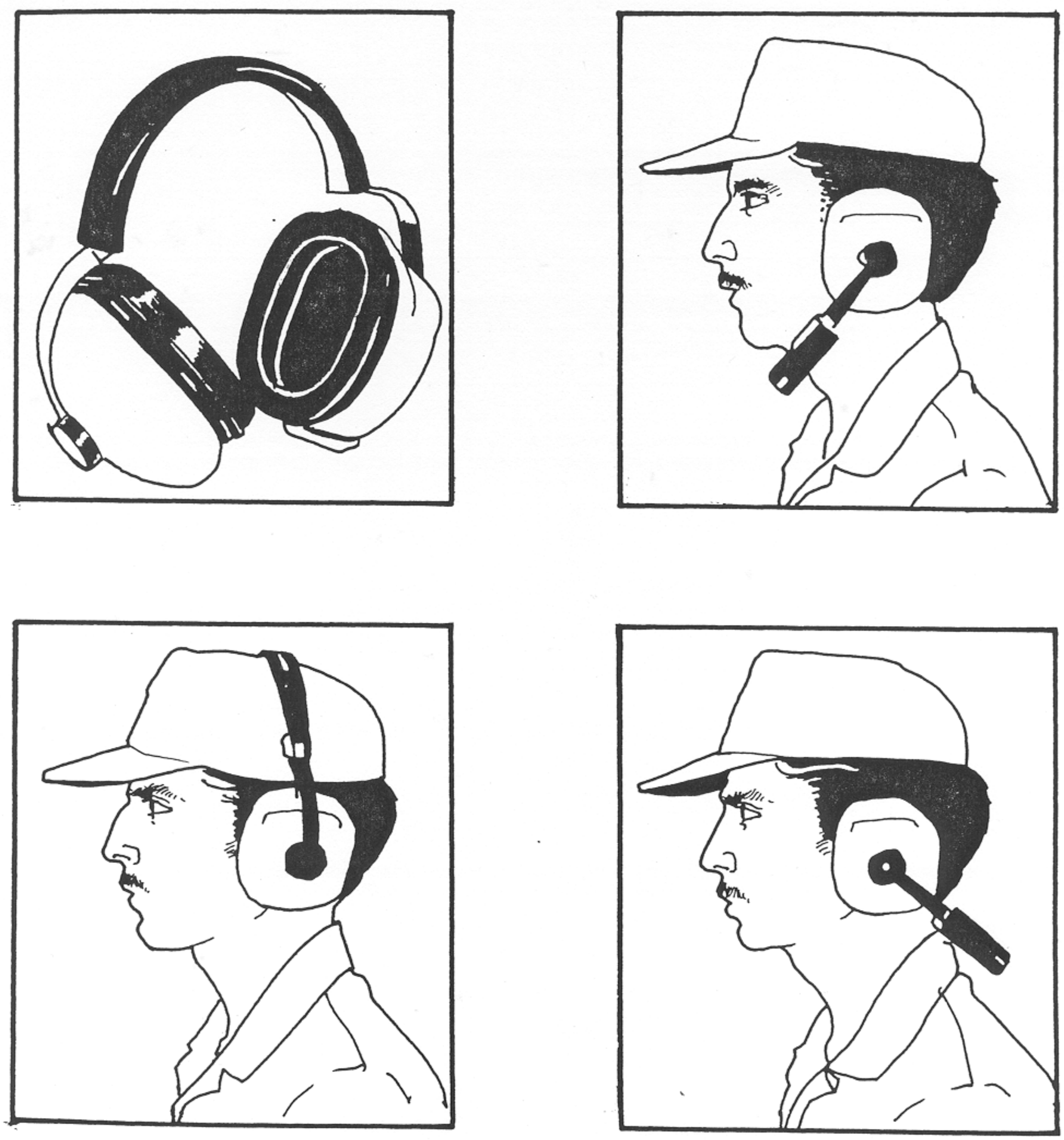


Figure 3—8. Type II earmuffs.

Ordering Earplugs

The following are the nomenclatures and National Stock Numbers (NSNs) for ordering Hearing Protection Devices from TB Med 501, as listed in Federal Supply Catalog C-6515-IL and CTA 8-100.

	Distribution of Sizes (percent/100 individuals)
Preformed Earplugs	
Plug, Ear, Hearing Protection, Single Flange, 24s	
NSN 6515-00-442-4765 (extra-small, white)	5%
NSN 6515-00-467-0085 (small, green)	15%
NSN 6515-00-467-0089 (medium, international orange)	30%
NSN 6515-00-442-4807 (large, blue)	30%
NSN 6515-00-442-4813 (extra-large, red)	15%
Plug, Ear Hearing Protection, Triple flange, 24s	
NSN 6515-00-442-4821 (small, green)	5%
NSN 6515-00-442-4818 (regular, international orange)	75%
NSN 6515-00-467-0092 (large, blue)	20%
Case and Earplug Inserter, Olive drab, translucent	
NSN 6515-01-100-1674	

Hand Formed Earplugs

Plug, Ear, Hearing Protection, Universal Size, Yellow, 400s
NSN 6515-00-137-6345

Plug, Ear, Silicone Rubber, Hearing Protection, Cylindrical, Disposable 48s and 200s
NSN 6515-00-135-2612 (48s)
NSN 6515-00-133-5416 (200s)

Plug, Ear, cotton, Impregnated, Disposable, 100s
NSN 6515-00-721-9092

Ear Canal Caps

Plug, Ear, Plastic, Hearing Protection, Universal Size, Single Flange
NSN 6515-00-392-0726

Plug, Ear, Hearing Protection, Universal Size, 12s
NSN 6515-01-059-1821

Ear Muffs

Aural Protector, Sound, Type II
NSN 4240-00-022-2946

Table 3-3. Ear plugs and earmuffs available through medical and/or regular supply channels.

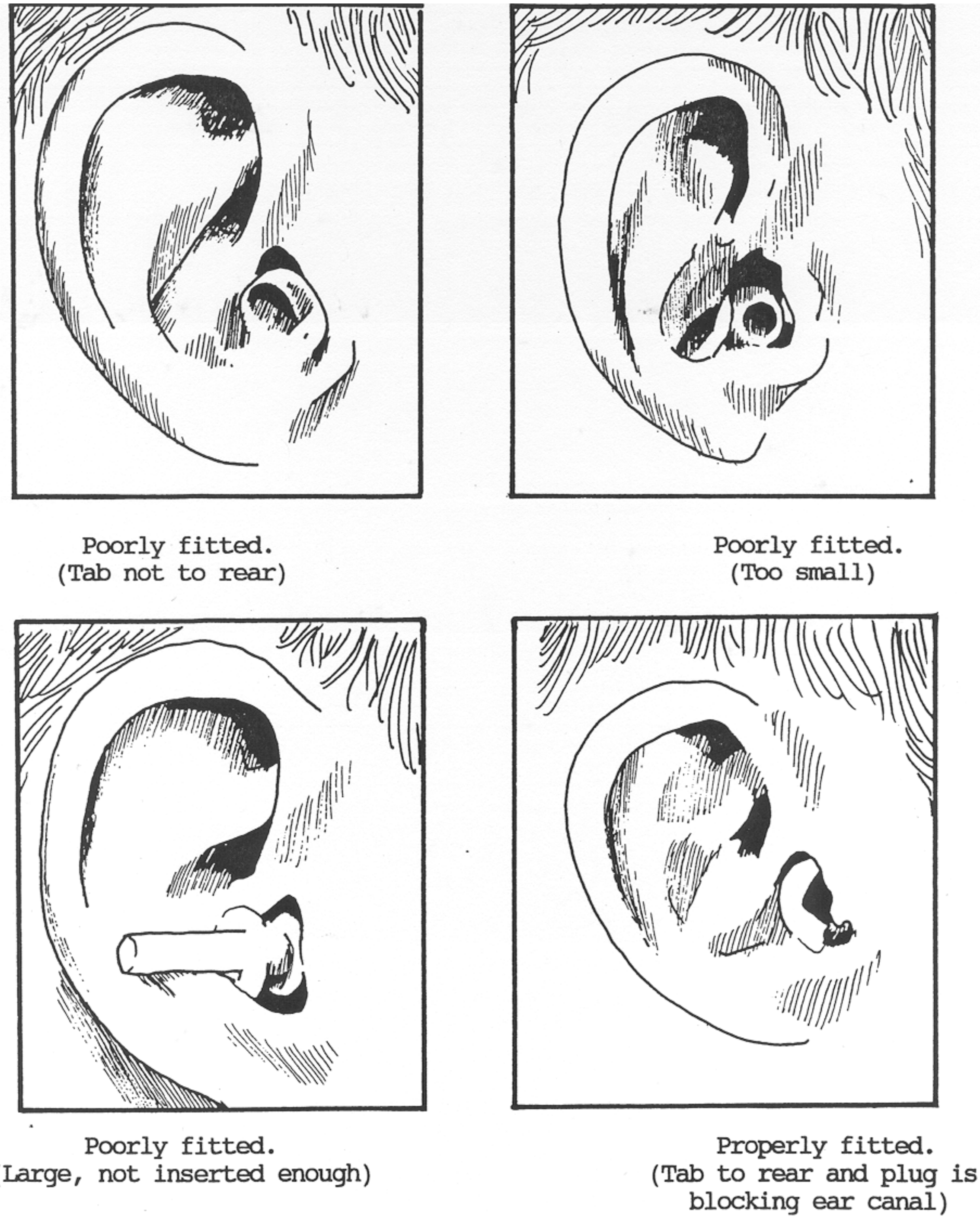
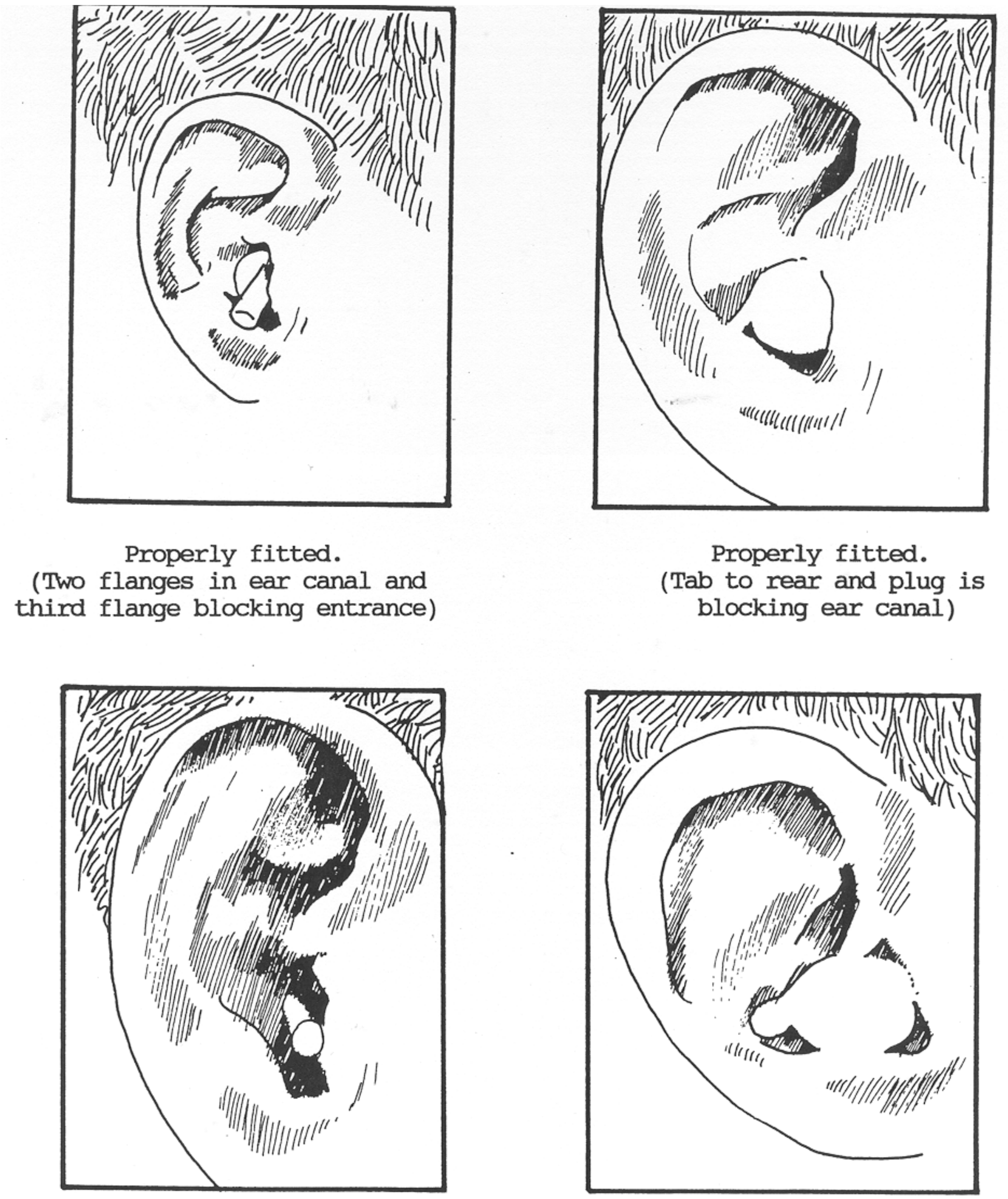


Figure 3-9. Examples of poorly fitted/poorly inserted earplugs and well-fitted/properly-seated earplugs (continued).



Properly fitted.
(Two flanges in ear canal and third flange blocking entrance)

Properly fitted.
(Tab to rear and plug is blocking ear canal)

Poorly fitted.
(Too small, inserted too far)

Poorly fitted.
(Too large, not inserted enough)

Figure 3-9. Examples of poorly fitted/poorly inserted earplugs and well-fitted/properly-seated earplugs (concluded).

3-13. HEALTH EDUCATION, SUPERVISION, AND DISCIPLINE

a. Personnel exposed to hazardous noise levels must be taught the nature of the hazard from excessive noise and the measures which they can employ to reduce the hazard. They must also be fully indoctrinated in the proper use and care of their personal protective equipment. These educational efforts must not be limited to the initial job safety orientation, but must be integrated into a continuing program of on-the-job training and supervision (see Figure 3-10). One of the goals of this continuing program should be the development of a high degree of worker safety discipline.

b. Supervisory and command personnel should be fully indoctrinated in the overall aspects of the hearing conservation program. They have a responsibility to imbue workers with a confidence that all possible engineering controls have been implemented, and with an awareness of the importance of personal protective devices. Supervisors and commanders are charged with the overall responsibility for the success of the program. They must be prepared to take disciplinary action, if required to ensure compliance with safety procedures. Imaginative use of multimedia materials such as films, video tapes, pamphlets, posters, decals, along with classes and seminars can greatly aid in the conduct of a health education program of the type required in a successful hearing conservation program.

3-14. MEDICAL CONTROL MEASURES

a. Audiograms must be a part of all replacement physical examinations. They are an absolute requirement when the individual is to be assigned duties in a noisy environment. In purely military units, the tasks and duties associated with certain military occupational specialties (MOS) will involve exposure to high noise levels; pre-assignment hearing evaluations should be made of all soldiers to be assigned in such an MOS.

b. Audio metric testing must be done only by trained personnel. The baseline or reference audiogram should be made at least 15 hours after the most recent exposure to high intensity noise. For the purposes of a hearing conservation program, only air conduction tests are required.

c. Losses in excess of 20 dB indicate the need for referral of the individual to a physician for otological study. In all cases, accurate recording of the audiometric results is vital. Results of the audiometric examination along with other pertinent hearing conservation data can be conveniently entered on DD Forms 2215 and 2216.

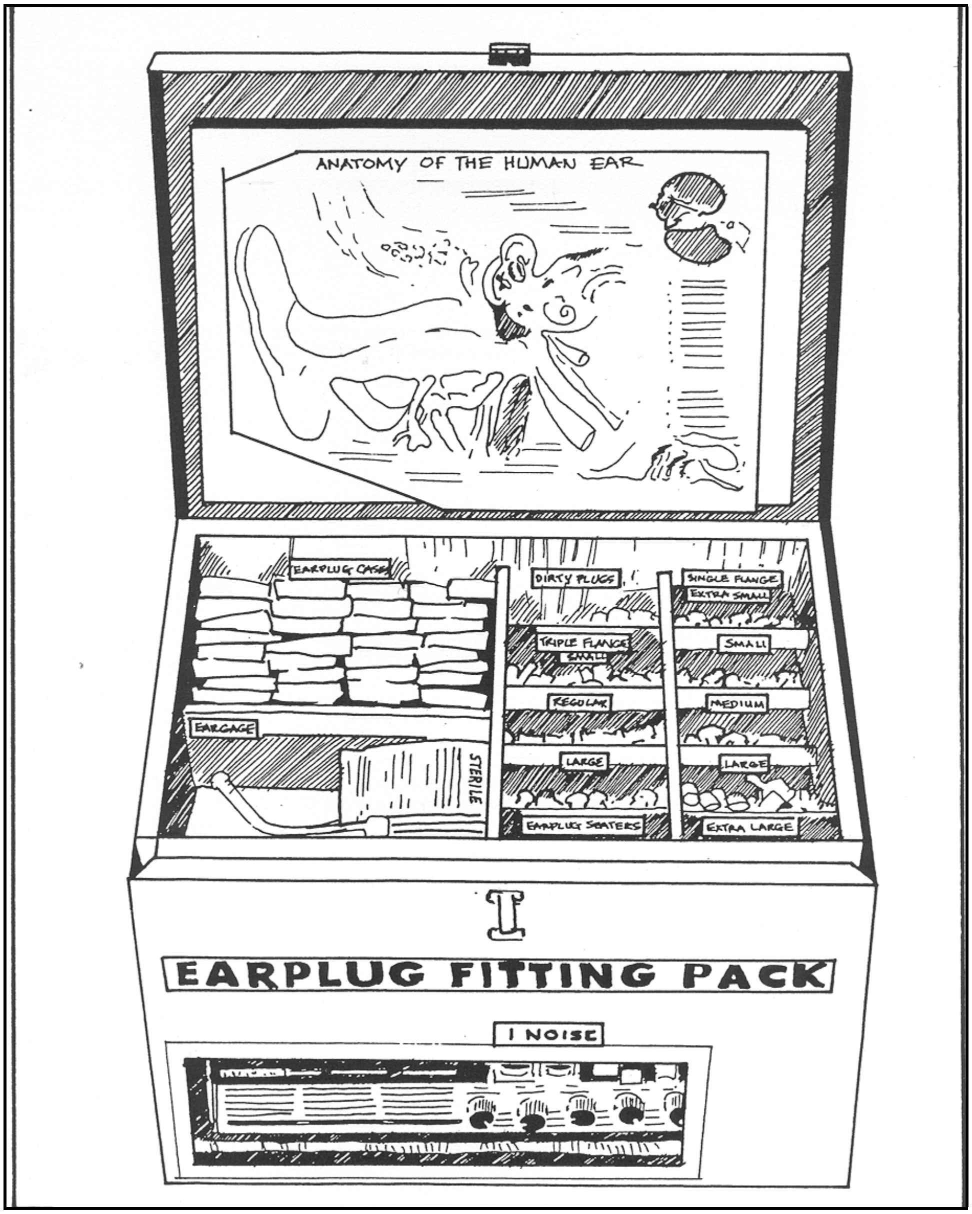


Figure 3-10. Example of an earplug fitting and educational pack.

d. The accuracy of the audiometer must be checked at least once a week; this is easily done by testing two young persons with no history of ear disease or hearing loss and a known hearing threshold level (HTL). Such a procedure checks not only the accuracy of the instrument, but also the effectiveness of sound insulation in the test room. The results should be within 5 dB of HTL level of the individual at each test frequency. Failure to obtain such results indicates either incorrect audiometer calibration or excessive room noise, or both. The audiometer should be calibrated periodically, at least semiannually for self-recording audiometers, and annually for others by a qualified medical equipment repair facility.

3-15. PERIODIC HEARING EVALUATION

a. Routine periodic audiograms made on all personnel working in areas having high intensity noise are necessary to detect beginning changes in hearing acuity, since the individual may be unaware of any hearing change. The first in this series of periodic audiograms should be made at the beginning of the workday, approximately 90 days after the beginning of the worker's exposure to high noise levels. If no significant change in hearing acuity is noted, subsequent audiograms should be made every 12 months. Personnel exposed to excessively high-noise levels (that is, weapons instructors and members of gun crews) should be tested more frequently.

b. All personnel should be encouraged to report for evaluation if symptoms of progressive hearing loss or progressive tinnitus (ringing of the ear) develop. This is imperative, since prompt action may prevent a permanent hearing loss.

3-16. DIAGNOSIS

Hearing loss caused by noise is difficult to differentiate from that resulting from such other factors as systemic disease, toxicity from infection, effect of drugs, and presbycusis. All reasonable methods of differential diagnosis should be used before establishing the diagnosis of hearing loss caused by noise. This includes a careful investigation of the worker's history with special references to any previous hearing tests, a general physical examination, accurate pure tone and air conduction audiometric tests, and complete speech and discrimination tests. Trained personnel under the supervision of a physician or a qualified audiologist may measure hearing. The physician, however, is responsible for determining and evaluating the degree of hearing loss.

Section III. SOUND MEASURING EQUIPMENT

3-17. GENERAL

In order to conduct accurate noise surveys, it is necessary to be able to operate the instruments for measuring noise. It will be your job when you get to the field to operate the equipment and take reliable readings and interpretations from them.

3-18. THE SOUND LEVEL METER

a. The standard sound level meter is the basic measuring instrument for the industrial hygienist. It consists of a microphone, an amplifier with calibrated volume control, and an indicating meter. It measures the sound pressure level in decibels, which is proportional to intensity or sound energy flow.

b. Sound level meters of the same type differ mainly in external shape, arrangement of controls, and other convenient features that frequently influence the selection made by a prospective user. A typical sound level meter is pictured in Figure 3-11.

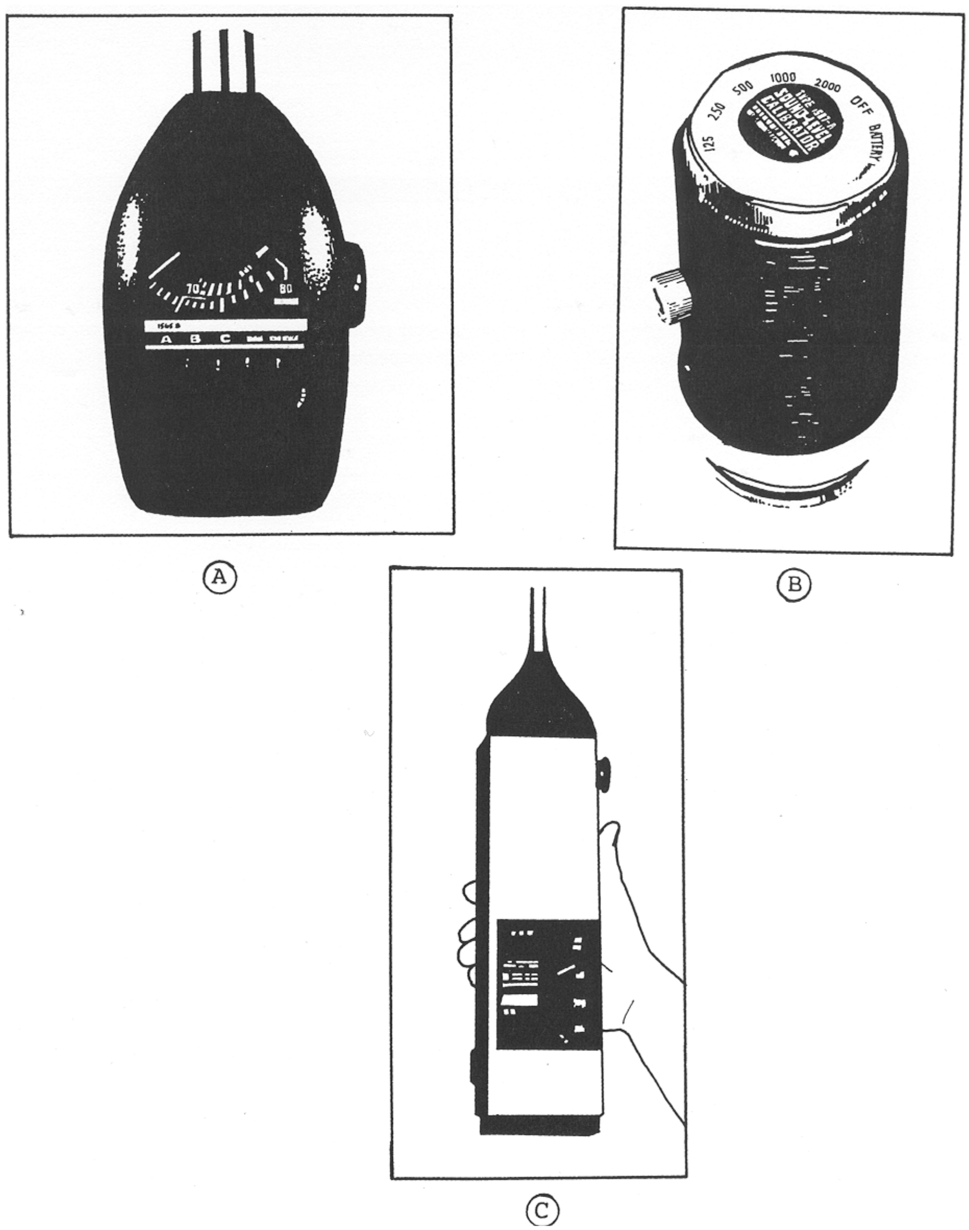


Figure 3-11. Typical sound level measuring equipment.
(A) Sound level meter. (B) Calibrators.
(C) Octave band analyzer with SLM.

c. Standards for sound level meters specify performance characteristics in order that all conforming instruments will yield consistent readings under identical circumstances. The more important characteristics specified are frequency response, signal averaging, and tolerance.

d. Three weighting networks (A, B, and C) are provided on standard sound level meters. The purpose of these is to give a number that is an approximate evaluation of the total loudness level. The (A) scale emphasizes those frequencies, which the human ear responds to. The (B) scale is an intermediate scale. The (C) scale has a flat response, which indicates the actual sound pressure level.

e. The A-weighting network is the most useful one on the sound level meter. It indicates the A-weighted sound level, often abbreviated dB(A) from which most human responses can be predicted quite adequately (see para 3-2m).

f. Action of the indicating meter may be selected as "fast" or "slow." Steady state sounds are measured with the more sluggish "slow" response to reduce meter needle swings.

g. The speed of meter response affects the readings obtained for transient sounds. For example, the level of a whistle toot lasting 1/5 second should be indicated no more than 2 dB low on the "fast" scale. On the "slow" scale, the level of a toot lasting 1/5 second would read 3 to 5 dB low. The "slow" meter response must be used for steady-state noise surveys.

h. American standard sound level meters are furnished in three types offering varying degrees of precision. Designated Types 0, 1, and 2 in order of increasing tolerances, the Type 2 generally measures within 2 or 3 dB of true levels, which is satisfactory for most purposes.

i. By combining a device known as an octave band filter with a sound level meter, it is possible to determine the pattern of the distribution of sound pressure at different points or areas along the scale of audible frequencies (see Figure 3-11). Using this equipment, it is possible to make a spectrum analysis of complex sounds or noises.

3-19. USE OF THE SOUND LEVEL METERS (SLM)

a. Since the hazardous criteria for steady state noise is 85 dB(A) s, the SLM should be set for a range of 80 to 90 dB on the weighted scale.

b. Starting at a point a distance from the noise source, the technician moves toward the noise, holding the SLM at a 70o angle to the noise source. When the SLM registers 85 dB (A), he stops recording the spot on a diagram of the area. He then repeats the procedure 3 to 5 mores times from different points, thereby making it possible to establish a noise contour.

c. All of the area inside the contour is considered noise hazardous. Hearing protection must be worn while inside the contour.

3-20. THE SOUND LEVEL CALIBRATOR

The overall accuracy of sound measuring equipment may be checked by using an acoustical calibrator such as is shown in Figure 3-11. It consists of a small, stable sound source that fits over the microphone and generates a predetermined sound level within a fraction of a decibel. If the meter reading is found to vary from the known calibration level, the meter may be adjusted to eliminate this error. The acoustical calibration procedure supplements the electrical calibration incorporated in some meters to check the gain of all electronic components following the microphone. Sound level calibrators should be used only with the microphones for which they are intended in order to avoid errors and microphone damage. Appendix G illustrates representative procedures for calibrating sound level meters.

Continue with Exercises

EXERCISES, LESSON 3

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all the exercises, turn to "Solutions to Exercise" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Exposure to certain hazardous noise in the work environment can have what type of effect on the individual?

   a. Make the individual feel the environment is ideal.

   b. Can cause profound physical and psychological effects on the individual.

   c. Cause the individual's productivity to increase.

   d. Increase the individual\s hearing range.

2. Will the total absence of all sound result in an ideal work environment?

   a. Never.

   b. Always.

   c. Sometimes.

3. To protect Federal government personnel against the effects of hazardous noise or sounds, what must all Army installations plan and implement?

   a. Better entrance tests.

   b. More elaborate health examinations.

   c. Preventive medicine programs for said specialists.

   d. Hearing conservation or noise abatement programs.

4. What type of new equipment are commanders, supervisors, and managers responsible for purchasing to maintain a safe work environment?

   a. Equipment with the lowest noise level feasible.

   b. Big heavy equipment.

   c. Equipment with matching colors.

   d. A variety of different brand name equipment.

5. Who is responsible for performing audiometric testing, maintaining audiograms, and providing audiometric test records and exposure health materials or information upon request?

   a. Safety Officer.

   b. Occupational health nurse or ears, nose, and throat specialist.

   c. Army Medical Department or IMA.

   d. Director of Engineers and Housing.

6. Which item is a function of the preventive medicine specialist?

   a. Conduct inspections and include noise hazard abatement projects in the hazard abatement plan.

   b. Ensure that OH is included on the in-processing and out-processing checklists for new, transferring, or terminating personnel.

   c. Provide for treated booths or rooms for audiometric testing, when the number of persons requiring such testing warrants the expense involved.

   d. Maintain a current inventory of all noise hazardous areas, using DD Form 2214, until HHIM can accommodate noise information.

7. What is the purpose of the Army hearing conservation program?

   a. Run tests to determine how much noise or sound individuals can sustain before it is reduced.

   b. Try out new hearing supplies and equipment on its individuals.

   c. Prevent individual hearing loss caused by exposure to noise in the work environment.

   d. Comply with Government regulations.

8. When noise or hazardous sound is not reduced or eliminated in the work environment, what does this cause?

   a. Reduced job performance caused by hearing loss.

   b. Cost to the Army of up to $100 million a year in individual compensation.

   c. Paperwork that could have been avoided.

   d. All of the above.

9. Army physicians and civilian industrial physicians in the employ of the Army, must be familiar with the:

   a. Nature of noise.

   b. Effects of noise on human hearing.

   c. Measures for preventing hearing loss due to noise and hazardous sound.

   d. All of the above.

10. As part of the mechanics of hearing, which statement is correct concerning the movement of sound waves?

    a. Sound waves are funneled to the external ear and then strike the tympanic membrane.

    b. Sound waves strike the inner ear.

    c. Sound moves in straight lines.

    d. Sound waves entering the ear travel through the external ear canal, are funneled to the middle ear, and strike the eardrum, or tympanic membrane.

11. Which small bones in the middle ear receive vibrations from the tympanic membrane and transmit them to the inner ear?

    a. Malleus, incus, stapes or the hammer, anvil, and stirrup.

    b. Oval window.

    c. a and b.

    d. Organ of Corti and semicircular canals.

12. The vibrations are transmitted to the brain by the:

    a. Sensory cells.

    b. Eighth cranial nerve.

    c. Organ of Corti.

    d. Auditory canal.

13. The sense of hearing is based upon which property?

    a. Tone.

    b. Sound.

    c. Intensity.

    d. Frequency.

14. As an age dependent and practical matter, in most cases, few adults can hear sound whose frequency exceeds:

    a. 4,000 Hz.

    b. 7,000 Hz.

    c. 11,000 Hz.

    d. None of the above.

15. What is the difference between the terms loudness and intensity?

    a. About several Hz.

    b. Loudness is the observer's impression of the sound intensity received.

    c. There is no difference.

    d. The range of sound.

16. Define noise.

    a. Noise, normal or abnormal, is simply defined as unwanted sound, whether it is a pure tone, a complex of tones, or unwanted speech or music.

    b. Noise may be a single sharp, squeaky, or piercing sound of short or long duration that is unwanted by the person receiving.

    c. a and b.

    d. A conveyer of information.

17. Which statement is correct concerning steady noise?

    a. Intermittent, continuous, or fluctuating noise with the sound level varying over a wide range.

    b. A single complex sound within octave bands.

    c. Noise we sometimes hear.

    d. Noise that does not fluctuate nor vary in sound level range.

18. When the pressure of a sound varies in a perfectly periodic manner, the sound is termed as a:

    a. Tone.

    b. Sound.

    c. Decibel.

    d. Frequency.

19. The ____________________ is a graphic record of an individual's hearing sensitivity.

    a. Audiometer.

    b. Audiogram.

    c. Impulse of noise.

    d. Level sound meter.

20. Which electronic device needs to be calibrated before use?

    a. Audiometer.

    b. dB(P).

    c. Microphone.

    d. Ear muff.

21. The beginning or starting point on the relative scale of noise levels is about the level of the weakest sound that can be heard by a person with very good hearing in an extremely quiet environment. The word for this is _____________and is expressed as ________________.

    a. Decibel (dB or db); "0 dB."

    b. DB(A); "0 dB."

    c. dB(P); "0 dB."

    d. DB; "0 dB."

22. A dB(P):

    a. Is the frequency and intensity sound level?

    b. Expresses the peak sound pressure of impulse noise.

    c. Is usually the sound pressure expressed in micropascals.

    d. Is used for sound test frequencies above 10 micropascals.

23. Which item in Table 3-1 has a peak sound pressure of impulse noise at 94 dB(A)?

    a. Whisper.

    b. Howitzer.

    c. Air compressor.

    d. Printing plant.

24. If over an extended period of time, ears are exposed to excessive noise, what happens to the individual's inner ear?

    a. The hair <u>and hair cells</u> activate, causing hearing injury or destruction.

    b. Injury to the organ of Corti usually leads to permanent loss of hearing.

    c. Depending upon the duration of the exposure to excessive noise, hearing loss may be only temporary in nature.

    d. All of the above.

25. Which statement is correct concerning overexposure of frequency noise?

    a. Overexposure to high frequency noise causes more significant hearing loss than low frequency noise of the same intensity.

    b. During initial exposure, most of the hearing impairment is in the frequency range above those important to the understanding of speech.

    c. Detection of losses in these ranges is important, and possible danger signs of further potential hearing loss.

    d. Continued exposure will lead to progressively greater damage, including loss of the speech frequencies, which if allowed to reach an advanced stage, will cause a severe handicap.

    e. All of the above.

26. What are the other physiological effects that can be produced by excessive exposure to noise?

    a. Nausea and headaches.

    b. Reflex responses will change.

    c. a and b.

    d. Pure-tone will change.

27. Psychological stress factors to noise may also be manifested in the form of:

    a. Fatigue, inability to function, and annoyance and distraction.

    b. Fatigue, acceptance of distraction, and inability to function.

    c. Annoyance and distraction, mental reservation, and fatigue.

    d. Inability to function, chemical imbalances, and irritability.

28. Early damage to hearing may not be noticed by the individual.

    a. Always.

    b. Never.

    c. Sometimes.

    d. All of the above.

29. Which are the correct factors in determining the degree of noise hazard?

    a. Intensity, frequency, tone, nature of noise, and duration of exposure.

    b. Frequency, tone, nature of noise, and duration of exposure.

    c. Sound, intensity, frequency, steady noise, nature of noise, and duration of exposure.

    d. Intensity, frequency, nature of noise, and duration of exposure.

30. If the frequency of noise determines its pitch, then which pitched noise is more likely to be dangerous to the individual?

    a. High.

    b. Medium.

    c. Low.

    d. Intermittent.

31. Based upon exercise # 30, which item would be more dangerous to the ear than a gasoline chain saw?

    a. Diesel truck.

    b. Grinder, electric.

    c. Chain saw.

    d. None of the above because their frequencies are lower.

32. Which statement is correct? Noise may be:

    a. Continuous, intermittent, steady, or a series of impact or impulse noises and the longer the exposure, the greater the damage to the hearing mechanism.

    b. Continuous, intermittent, steady, or a series of impact or impulse noises and the shorter the exposure, the greater the damage to the hearing mechanism.

    c. Of greater damage to inanimate objects.

    d. Part of overall efficiency.

33. The hearing conservation program can be an effective means to prevent hearing loss from exposure to excessive job-related noise if careful coordination involves:

    a Engineering control measures, medical control measures, and health education.

    b. Personal protective measures and personal discipline on the part of workers.

    c. Proper supervision and an effective implementation of the hearing conservation program.

    d. All of the above.

34. What is the first step in establishing a hearing conservation program?

    a. Check the noise impulse.

    b. Determine steady noise.

    c. Conduct a noise survey.

    d. Determine the standards.

35. Under what circumstances might a noise survey be conducted? When personnel:

    a. Have difficulty communicating by speech while they are in the noise area.

    b. Hear noises or ringing sounds in their ears after working in the noise area for several hours.

    c. Experience temporary loss of hearing, which muffles speech and certain other sounds, after several hours of exposure to the noise.

    d. All of the above.

36. What is the purpose of a noise survey?

a. Determine the relationship of noise to interference with speech, worker comfort, and hearing loss.

b. Determine the noise level average.

c. Find out which area configurations are the quietest.

d. Determine who may suffer from hearing loss if loud noises persist.

37. During a noise survey, which points are important when making noise measurements?

a. Check all locations where noise interferes with persons conversing at close range and can't hear each other.

b. Check steady noises from several sources, varying in composition and frequency spectra.

c. Measure noise levels at the approximate position of the worker's more exposed ear.

d. All of the above.

38. If it is necessary to shout in order to be heard at a distance of 1 foot, then the noise level is probably at or above what dB (A)?

a. 0.

b. 75.

c. 70.

d. 60.

39. If noise or sound is at 90 dB(A), how many decibels over the normal range of office administrative noise is this?

a. 30 to 50.

b. 20 to 40.

c. 10 to 30.

d. 00 to 20.

40. Why is it essential to break down the composition and frequency spectra of steady noise coming from several sources?

    a. Determine which noises have high frequency/pitch and to what degree.

    b. Find out which noises are loud, continuous or short, and low.

    c. Compile the noise information, evaluate exposures, and make sound recommendations to management.

    d. All of the above.

41. Sound or noise above 60 dB may need to be reduced depending on the working environment but noises above _______ are considered to be __________ and risk assessment codes are assigned for all sound levels above this.

    a. 80; dangerous.

    b. 85; hazardous.

    c. 90; OK.

    d. 96; moderate.

42. When measuring for noise, you check the noise level at the source and at the approximate position of the worker's:

    a. Ear.

    b. Foot.

    c. Hand.

    d. Knees.

43. Hazardous noise standards consist of what type of noise exposure?

    a. Frequency and steady.

    b. Intensity and frequency.

    c. Steady and impulse.

    d. Steady and intensity.

44. An example of engineer noise source reduction is to:

    a. Provide acoustical barriers between work areas and sound surfaces.

    b. Install vibration mounts under equipment.

    c. Move personnel closer to the noise source.

    d. a and b.

45. Generally speaking, when a worker is exposed to steady state noise levels in excess of ________________ he should wear both earplugs and earmuffs.

    a. 60 dB(A).

    b. 68 dB(A).

    c. 108 dB(A).

    d. 138 dB(A).

46. Which statement concerning ear protectors is <u>not</u> true?

    a. One size earplug will fit all individuals.

    b. It is important to keep earplugs clean.

    c. Earplugs should be fitted under medical supervision.

    d. Earplugs tend to work loose as a result of chewing and talking.

47. Which forms are used to record an audiometric examination results?

    a. DD Form 2215.

    b. DD Form 2A.

    c. DD Form 2216.

    d. a and c.

48. The three basic parts of a standard sound level meter are the:

 a. Calibrator, amplifier, and indicating meter.

 b. Microphone, amplifier, and indicating meter.

 c. Microphone, presbycusis, and indicating meter.

 d. Indicating meter, acoustical barrier, and amplifier.

49. Which weighting network sound level meter scale empathizes those frequencies, which the human ear responds?

 a. dB (A).

 b. dB (B).

 c. dB (C).

 d. a and b.

50. Which statement about the sound lever meter is correct?

 a. The American models are furnished in four types offering varying degrees of precision.

 b. The designated Types 0, 1, and 2 are in decreasing order of tolerances.

 c. By combining an octave band filter with a sound level meter, you can determine the pattern of the distribution of sound pressure at different points or areas along the scale of audible frequencies.

 d. The Type 2 generally measures within 4 to 6 dB of true levels.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 3

1. b (para 3-1)
2. c (para 3-1)
3. d (para 3-1)
4. a (para 3-2a)
5. b (para 3-2d(6))
6. d (para 3-2d(7))
7. c (para 3-3)
8. d (para 3-3)
9. d (para 3-3)
10. d (para 3-4a)
11. c (para 3-4b)
12. b (para 3-4c)
13. b (para 3-5a)
14. c (para 3-5b)
15. b (para 3-5c)
16. c (para 3-5e)
17. a (para 3-5f)
18. a (para 3-5d)
19. b (para 3-5i)
20. a (para 3-5j)
21. a (para 3-5l)

22. b (para 3-5n)

23. c (Table 3-1)

24. d (para 3-6a)

25. e (para 3-6b)

26. c (para 3-6c)

27. a (para 3-6d)

28. c (para 3-6b)

29. d (para 3-7)

30. a (para 3-7)

31. d (Tables 3-1, 3-2)

32. a (para 3-7c)

33. d (para 3-8)

34. c (para 3-8)

35. d (para 3-8)

36. a (para 3-9)

37. d (para 3-9a, b, c)

38. d (para 3-9a)

39. a (para's 3-5l, 3-9a)

40. d (para 3-9)

41. b (para 3-9f)

42. a (para 3-9c)

43. c (para 3-10)

44. d (para 3-11c)

45. c (para 3-12a)

46. a (para 3-12d)

47. d (para 3-14c)

48. b (para 3-18a)

49. a (para 3-18d, e)

50. c (para 3-18i)

END OF LESSON 3

LESSON ASSIGNMENT

LESSON 4 Ventilation.

TEXT ASSIGNMENT Paragraphs 4-1 through 4-12.

LESSON OBJECTIVES After completing this lesson, you should be able to:

4-1. Select the statement which best describes the purpose of ventilation airflow.

4-2. Identify the methods of ventilation, the selection criteria, and advantages and disadvantages of each.

4-3. Given background information on a hazardous operation, determine whether the type of ventilation is appropriate.

4-4. Identify the various instruments used to measure airflow and its velocity.

4-5. Select the statement that best describes the calibration of airflow instruments.

4-6. Compute the airflow.

4-7. Select the statement which best describes the basic principles of air flow.

4-8. Correctly survey and evaluate the performance of air flow systems.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 4

VENTILATION

Section I. VENTILATION SYSTEMS

4-1. GENERAL

a. Industrial operations of some kind will be found on virtually all Army installations. Many of these operations generate toxic substances, dust, and heat which can be harmful to the worker if they are inhaled or which can cause severe worker discomfort. To prevent this from happening, various types of ventilation systems have been designed and are used to protect the worker and to create a safe, comfortable working environment. An understanding of ventilation systems will help you to evaluate their effectiveness in eliminating the health hazards associated with industrial operations.

b. Ventilation is probably one of the most important control techniques, which can be employed to improve or maintain the quality of the air in the work area for administrative or industrial operations. Generally speaking, ventilation is a way of controlling the environment with airflow. In industrial work areas, the purpose of airflow is to achieve one or more of these aims:

(1) Heating or cooling,

(2) Removing a contaminant,

(3) Diluting the concentration of a contaminant, or

(4) Supplying makeup air.

c. All applications of ventilation usually fall into one of these three areas:

(1) Prevention of fire and explosions,

(2) Control of atmospheric contaminants to healthful limits, or

(3) Control of heat and humidity for comfort.

4-2. METHODS OF VENTILATION

a. **Two Methods**. Two different methods of ventilation can be employed to control potentially hazardous airborne contaminants.

(1) General (dilution) ventilation. The first method involves diluting the concentration of the contaminant before it reaches the worker's breathing zone. This method is referred to as "general ventilation" or "dilution ventilation."

(2) Local exhaust ventilation. The second method involves capturing and removing the contaminant near its source or point of generation, thus preventing the release of the contaminant into the work pace. This method is called "local exhaust ventilation."

b. **Comparison of Methods**. Dilution ventilation does not actually reduce or eliminate the total amount of hazardous material released into the workspace. On the other hand, local exhaust ventilation prevents the release of the contaminants into the workspace. Normally, local exhaust ventilation is the preferred, more effective, and more economical method for contaminant control compared to dilution ventilation.

Section II. VENTILATION SELECTION CRITERIA

4-3. GENERAL (DILUTION) VENTILATIONS

General ventilation describes a system in which a workspace, a room, or an entire building is flushed by supplying and exhausting a large volume of air throughout the area. General ventilation can be quite effective in removing large volumes of heated air or in reducing the concentration of certain atmospheric contaminants. General or dilution ventilation can be achieved by either natural or artificial means. In actual practice, best results are often achieved through a combination of natural and mechanical air supply coupled with a system of natural and mechanical exhaust.

a. **Natural General Ventilation**. Natural means by which workspaces or buildings may be ventilated include wind and thermal convection. These effects result from natural pressure differences and air density differences, respectively; they each cause natural displacement and infiltration of air through windows, doors, walls, and other openings. (The amount of air that enters a building under a natural ventilation scheme depends upon the wind and upon thermal effects occurring within the building. Warmer air inside a building rises and leaks out of openings, cracks, and vents in the upper areas; colder air leaks into the building by the same process in the lower areas.) If it were adequate, natural ventilation would be more economical then mechanical ventilation, but wind currents and thermal convections are erratic and not always predictable. As a result, natural ventilation is unreliable as a primary control method.

b. **Mechanical General Ventilation**. Modern buildings in which industrial operations are conducted are usually of large area, low height design, or, if they are of multi-story design, are of masonry and glass construction. In either case, natural ventilation forces are virtually nonexistent and mechanical ventilation must be relied upon completely. Mechanical air supply must be provided all year round to reach interior areas, provide adequate air distribution, and prevent the creation of negative air pressures in the building. In large, open industrial buildings, general ventilation can be achieved by roof fans used with or without gravity ventilators. The best method of providing general ventilation in a closed building is to supply air through ductwork and distribute it into the work areas in a manner that will provide both humidity and temperature control.

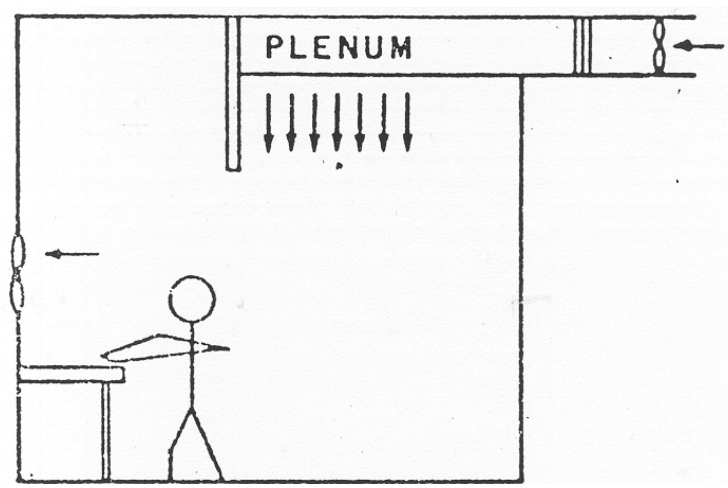


Figure 4-1. Simplified schematic of a general ventilation system.

c. **Dilution Selection Criteria**.

(1) When considering whether dilution (general) ventilation would be preferable to a local exhaustion system, there are limiting factors, which must be kept in mind.

(a) The quantity of contaminant generated must not be excessive; if it is, the volume of air required for dilution will be impracticality high.

(b) The toxicity of the contaminant must be low.

(c) Workers must be located far enough away from the point of contaminant evolution, or the contaminant must be in low enough concentrations, so that workers will not have an exposure that is above acceptable limits.

(d) The evolution or generation of contaminants must be reasonably uniform.

(2) Considering these factors, dilution ventilation would usually not be recommended for control of fumes and dust, because the high toxicities often encountered require excessively large quantities of air and because the velocity and rate of contaminant evolution are usually quite high, resulting in unacceptably high local concentrations.

d. **Advantages of a Dilution Ventilation System.**

(1) General ventilation systems have several advantages over local exhaust systems. Perhaps the most obvious of these are simplicity of design and low initial cost. However, it would not be wise to choose a general ventilation system solely because of its low initial cost; because these systems invariably exhaust large volumes of heated air from a building, their use can result in high operating costs in the form of conditioned make-up air. Over a long period of time, this would tend to make the general ventilation system much more expensive.

(2) Use of general ventilation systems does result in great flexibility in the layout of the work area. In addition, it does provide a certain amount of comfort ventilation.

e. **Disadvantages of Dilution Ventilation System**. Generally speaking, the velocity of the air circulating in a general ventilation system is too low to effectively remove high concentrations of contaminants. In addition, general ventilation is inadequate for removing contaminants of high toxicity, that is, contaminants whose TLV is less than 100 ppm.

4-4. LOCAL EXHAUST VENTILATION

A local exhaust system is one in which the contaminant being controlled is captured at or near the point at which it is created or dispersed. In contrast to general or dilution ventilation, local exhaust ventilation places total reliance on mechanical means of controlling airflow. A typical local exhaust system usually includes the use of hoods or enclosures, ductwork leading to an exhaust fan, an air cleaning device for abatement of air pollution, and finally, discharge to the outside air (see Figures 4-2 and 4-3). Local exhaust systems usually contain more mechanical components than general ventilation systems, require more precise control of their operation, and, as a result, require more maintenance.

a. **Basic Principles**. When applying local exhaust ventilation to a specific problem, there are several basic principles that should be kept in mind.

(1) The source of contaminants should be enclosed as completely as practicable.

(2) The contaminant should be captured with adequate air velocity.

(3) The contaminant should be kept out of the worker's breathing zone.

(4) Adequate make-up air must be provided.

(5) The exhaust air must be discharged away from air inlet systems.

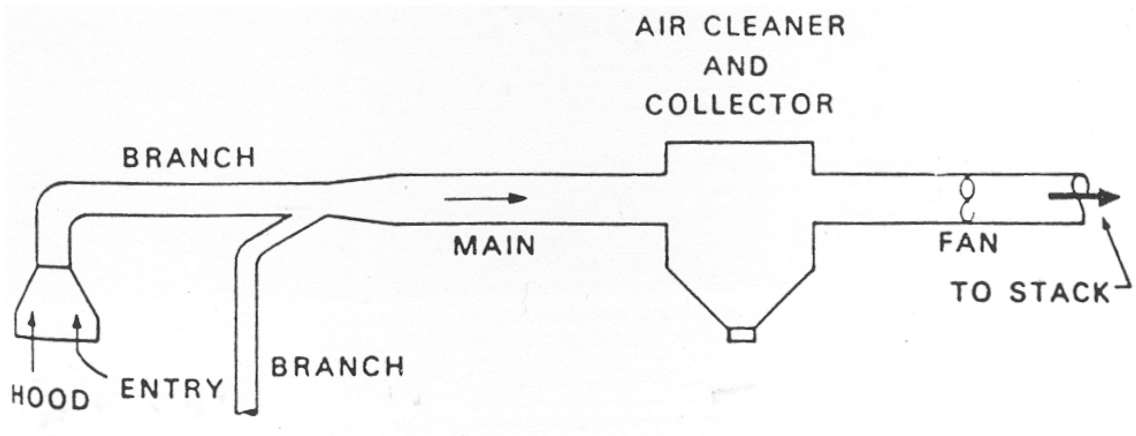


Figure 4-2. Schematic of a local exhaust system.

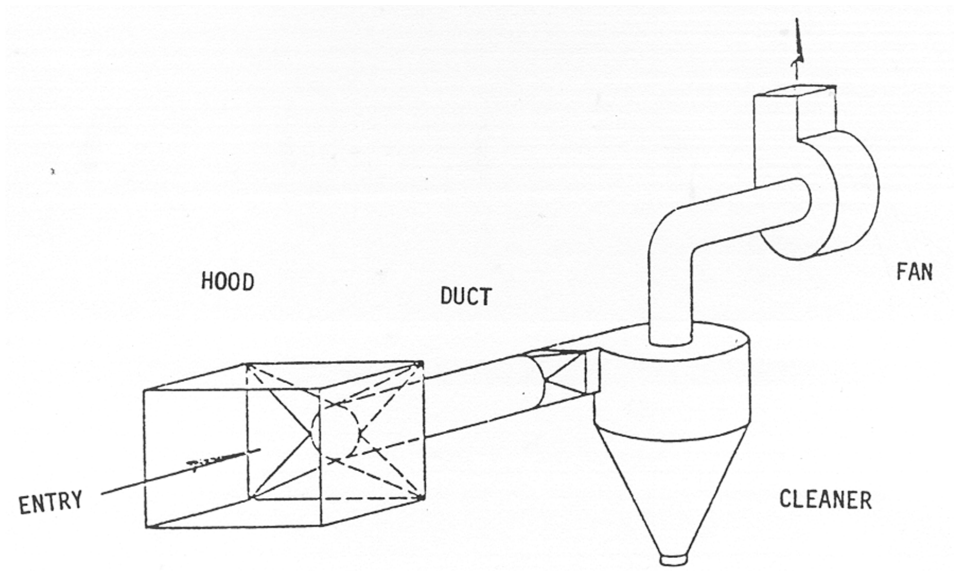


Figure 4-3. Elements of a local exhaust system.

b. **Selection Criteria**. Local exhaust ventilation systems are usually specified when the following conditions exist in the work environment:

(1) The concentration of contaminant is high.

(2) The toxicity of the contaminant is high.

(3) The worker's position is close to the point of the contaminant's evolution or dispersion.

(4) The generation of the contaminant is non-uniform.

c. **Advantages of Local Exhaust Systems**. Local exhaust systems are usually preferred over general ventilation systems for these reasons:

(1) Control of the contaminant can be complete; therefore, the exposure of the worker to the contaminant can be prevented, which results in a much more healthful work environment.

(2) A local exhaust system can handle more highly toxic contaminants.

(3) A local exhaust system can handle higher concentrations of contaminants.

(4) The velocity of the air in the system is high; as a result, performance of the exhaust fan system is not likely to be affected by cross drafts.

d. **Disadvantages of Local Exhaust Ventilation Systems**.

(1) Local exhaust systems are, as a rule, mechanically complex. This fact results in high initial costs and a greater requirement for maintenance.

(2) Installation of the enclosures and ductwork associated with local exhaust systems results in an inflexible work area.

4-5. GUIDELINES FOR AIR-FLOW IN VENTILATION SYSTEMS

a. **Basic Laws**. The basic laws governing the complete motion of a fluid such as air are complex. In the simple case of moving a layer, or layers of air (laminar flow), the motion of the air can be computed analytically. However, in most ventilation systems (and especially in local exhaust systems) the air-flow is usually turbulent to some degree. As a result, the analytical solution to the motion of air in exhaust systems depends largely on experimental data.

b. **Basic Principles**. A basic consideration in the principles of airflow is conservation of mass, or put another way, the continuity equation. This equation states that the mass rate of flow remains constant along the path taken by a fluid such as air. Therefore, at any two points in the stream of air:

$$Q_1 = Q_2 \qquad \text{and} \qquad A_1V_1 = A_2V_2$$

Where $Q = AV$ is the volumetric rate of air-flow in cubic feet per minute (cfm);
A = cross sectional area in square feet (ft^2);
V = velocity in feet per minute (ft/min).

There is a very definite relationship between velocity and rate of flow, which can be expressed by the equation:

$Q = AV$

Where Q = rate of flow in cfm.
V = average linear velocity in ft/min.
A = cross-sectional area of the duct or hood in ft^2.

From this equation, it is possible to calculate airflow rate (Q) if the velocity (V) and the cross-sectional area (A) are known.

For example: If a duct is 12" by 36," and the velocity of the air has been measured four times, with readings of 170, 185, 210, and 195 ft/min, what is the rate of flow?

First, determine the average velocity:

$$V = \frac{170 + 185 + 210 + 195}{4}$$

$$V = \frac{760}{4} = 190.0 \text{ feet per minute (fpm)}$$

Then, determine cross-sectional area:

$A = 1' \times 3' = 3\ ft^2$ (Change inches to feet before computing A.)

Finally, substitute values in the formula:

$Q = AV$
$Q = 3 \times 190.0 = 570.0$
$Q = 570.0$ cubic feet per minute (cfm)

NOTE: For circular ducts, cross-sectional area is determined using the formula for area of a circle: $A = \pi r^2$, where $\pi = 3.1416$ and r = radius of the circle (r = 1/2 x diameter).

c. **Air Velocity**. The purpose of the exhaust system in an industrial work area is to remove the contaminant from the environment. To do this effectively, the air must have sufficient velocity to overcome opposing air currents and particle inertia causing the contaminated air to flow into the enclosure (usually a hood) and there must be sufficient velocity to keep the contaminant from settling out in the duct.

(1) Capture velocity. To effectively remove the contaminant from the environment, the air must have sufficient velocity to overcome opposing air currents and particle inertia causing the contaminated air to flow into the enclosure (usually a hood). This minimum air velocity is called the capture velocity and is an important consideration in designing a local exhaust ventilation system or in evaluating the operating effectiveness of an existing system. The minimum air velocity at a point within or in front of an exhaust hood necessary to overcome opposing air currents and

particle inertia, causing the contaminated air to flow into the hood. The capture velocity can be calculated for a distance (x) from the hood, using Figure 4-4.

(2) Duct velocity. The air velocity found within the duct.

(3) Face velocity. The air velocity is at a point parallel with the face of the hood.

(4) Transport velocity. That velocity required to prevent the settling of a contaminant within the duct.

4-6. TYPES OF PRESSURES

a. **Velocity Pressure**. Air in motion exerts a pressure called velocity pressure, which maintains air velocity and which may be thought of as kinetic energy. This pressure exists only when air is in motion, and it acts in the direction of air-flow. It is always a positive pressure.

b. **Static Pressure**. Another important aspect of airflow principles is static pressure. Static pressure actually produces initial air velocity; it also overcomes the resistance in a system caused by friction of the air against the duct walls and overcomes turbulence and shock caused by a change in direction or velocity of air movement. Static pressure may be thought of as potential energy; it exists even when there is no air motion and acts equally in all directions.

c. **Total Pressure**. The driving force for airflow is actually a pressure difference. Pressure is required to start and maintain flow. This pressure is called total pressure and has two components: velocity pressure and static pressure. Static pressure, velocity pressure, and total pressure are all interrelated, as shown by the formula:

$$SP + VP = TP$$

HOOD EXHAUST VS. CAPTURE VELOCITY

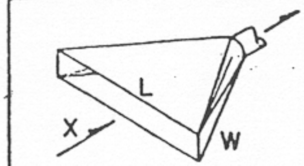
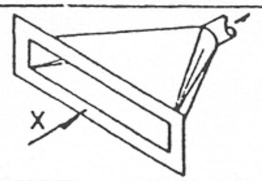
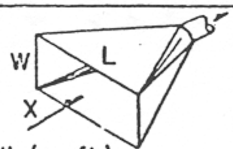
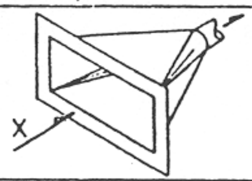
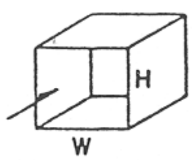
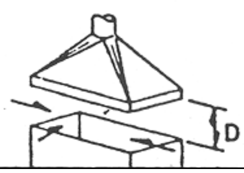
HOOD TYPE	DESCRIPTION	ASPECT RATIO $\frac{W}{L}$	AIR VOLUME
	SLOT	0.2 OR LESS	$Q = 3.7\ LVX$
	FLANGED SLOT	0.2 OR LESS	$Q = 2.8\ LVX$
 A=WL (sq.ft.)	PLAIN OPENING	0.2 OR GREATER AND ROUND	$Q = V(10X^2 + A)$
	FLANGED OPENING	0.2 OR GREATER AND ROUND	$Q = 0.75V(10X^2 + A)$
	BOOTH	TO SUIT WORK	$Q = VA = VWH$
	CANOPY	TO SUIT WORK	$Q = 1.4\ PVD$ P = PERIMETER D = HEIGHT

Figure 4-4. Capture velocity of some representative hood types.

4-7. TYPES OF PRESSURE LOSSES

Pressure losses in airflow systems are caused by a variety of factors.

a. **Friction Losses**. Friction losses result from the fact that air in motion encounters resistance along any surface confining the flowing volume. Some of the energy of the air is given up in overcoming this friction and is transformed into heat. The rougher the surface confining the flow or the higher the flow rate, the higher the frictional losses will be.

b. **Dynamic Losses**. Dynamic losses are those energy losses encountered in airflow that result from turbulence caused by a change in direction or velocity within a duct. The pressure drop in a duct system due to dynamic losses increases with the number of elbows or angles and the number of velocity changes within the system.

4-8. MEASURING INSTRUMENTATION FOR AIR- FLOW AND VELOCITY

a. **Rate of Air-Flow**. The purpose of a local exhaust system is to capture and transport airborne contaminants from the source through an air cleaner to the atmosphere. Precise measurements of capture velocities as well as estimates of exhaust or supply volumes can be made at the point where the airflow system interacts with the work environment.

b. **Anemometers (Air-Flow Measuring Instruments)**. In using any of the various airflow instruments, which are known as anemometers, the need to take multiple measurements of a given slot, hood, or diffuser must be kept in mind. Only by making a uniform traverse of the opening being evaluated will you be able to arrive at a satisfactory average velocity to use in the calculation of airflow.

(1) <u>Rotating vane anemometer</u>. The rotating vane anemometer is comprised of a vane or propeller on a shaft connected to gears. The air movement causes the vane to rotate, turning gears that register the revolutions on the dial of the instrument as linear feet. Readings are usually taken for one-minute periods, thus giving air velocity in linear fpm. These instruments are best suited for determining air velocities and estimating air flow through large openings such as mine shafts and air supply and discharge grilles. It will be necessary to consult the instrument operating instructions for correction factors to be used in calculating actual airflow rates. In addition, these instruments must be handled with extreme care; they require the use of a timing device and must be frequently calibrated. They should be used in relatively clean air.

(2) <u>Swinging vane anemometer</u>. The swinging vane anemometer indicates air velocity as a function of the pressure exerted by the air stream on a spring-loaded swinging vane. They are quite portable and used extensively by industrial hygienists and ventilation engineers in the field. They are used primarily for measuring velocities of exhaust or supply openings. By using the fittings available for some brands of swinging anemometers, they can be used to measure static pressures. It is important to follow the instructions carefully, using the recommended correction factors and calibrating the instrument periodically. Figure 4-5 illustrates several possible applications of a swinging vane anemometer.

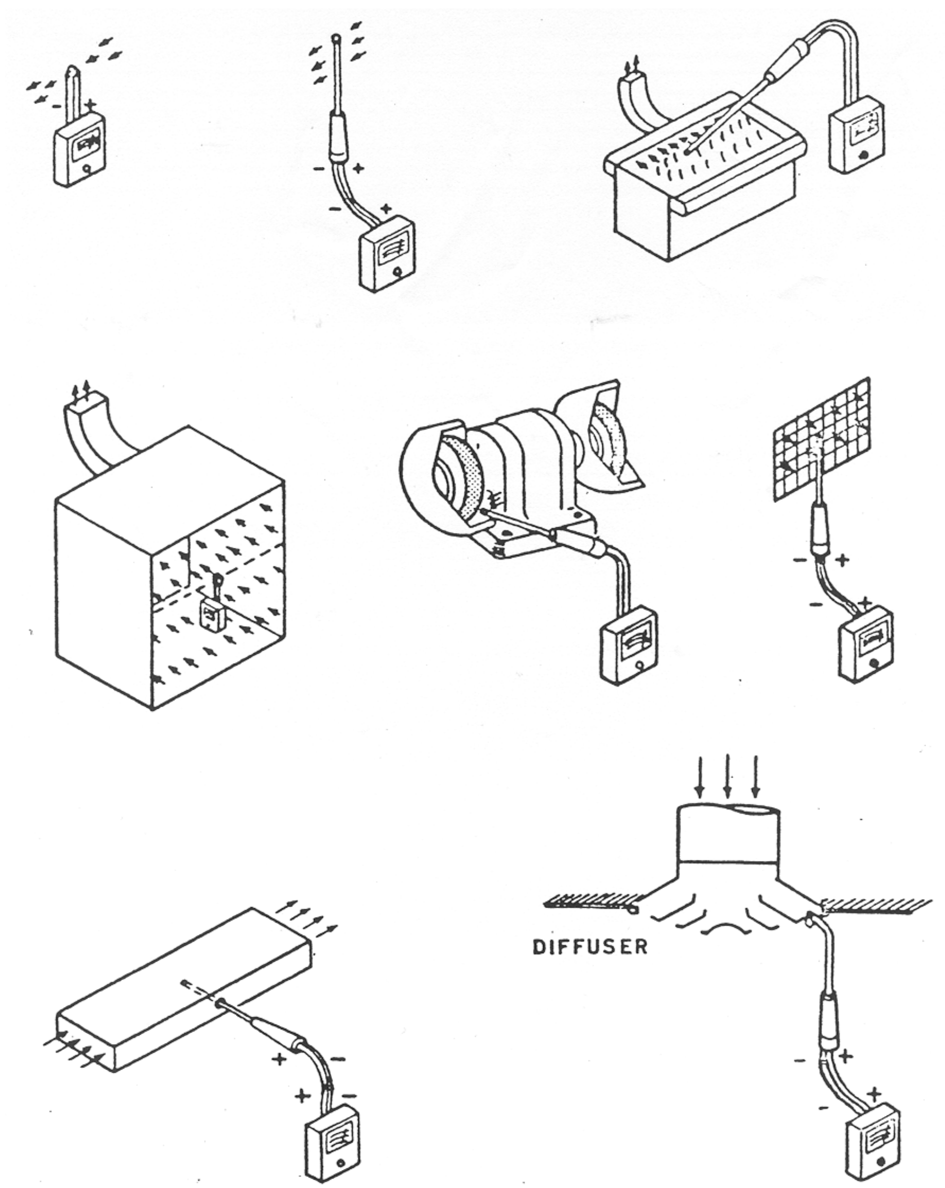


Figure 4-5. Applications of a commercially available swinging vane anemometer.

(3) Heated thermocouple anemometer. The heated thermocouple anemometer operates on the principle that air moving past a heated object will remove heat. The amount of heat removed is proportional to the quantity of air passing, which is a function of velocity. These instruments have one or more thermocouples as sensing elements that are heated by either alternating or direct current. A change in airflow causes a change in temperature of the thermocouples, resulting in a change of direct current output. Another unheated thermocouple is in the direct current circuit to a meter. As a result of the changes in temperature, a change in voltage is developed which is read as air velocity. These instruments are usually comprised of a single probe

connected to an operating unit housing circuitry, meter, batteries, and so forth, and are about the size of a cigar box. They are quite portable and commercially available. Problems with these instruments are related primarily to maintaining the integrity of the probe. Heavy dust loadings or corrosive materials, as well as mechanical shock, can damage the delicate wires in the probe. These instruments also require periodic calibration.

(4) Heated wire anemometer. Heated wire anemometers depend upon the change in resistance of a wire with a change in temperature. The degree of temperature change is proportional to the velocity of air passing the wire. Velocity is read directly on a meter that is actuated by a change in voltage, resulting from the temperature change. Generally, the advantages and limitations of these instruments are the same as those described for heated thermocouple anemometers.

4-9. CALIBRATION OF INSTRUMENTATION

All too often the need for calibration is not applied to devices for measuring airflow and velocity, yet, as a group (with the exception of the Pitot tube), such devices require periodic calibration. Calibration needs to be executed before measurements are performed. Generally, airflow-measuring instruments are based on electrical or mechanical systems, which are sensitive to shock. In addition, use of these instruments in corrosive or dusty atmospheres affects their reliability.

4-10. MEASURING AIR FLOW WITHIN THE SYSTEM

a. It is frequently necessary to determine precise measurements that characterize the performance of an air flow system within the system. Instead of measuring the velocity of air going into exhaust hoods or coming from air outlets, measurements are made inside the ductwork leading to the point of entry of discharge. Such measurements are usually made to determine static pressure drops associated with hood entries, ducts, and across air cleaners, as well as velocity pressures.

b. The Pitot tube is the standard instrument for measuring the velocity of air in ducts. The Pitot tube consists of two concentric tubes. The opening of the inner tube is axial to the flow of air and measures total pressure, while the large tube with circumferential openings measures static pressure. The difference between the total pressure and the static pressure is the velocity pressure. Figure 4-6 shows the relationships between the various pressures in an exhausting system, while Figure 4-7 illustrates the construction of a standard Pitot tube. The major disadvantage of the Pitot tube is that it is not direct reading. The Pitot tube measures velocity pressure in inches of water.

NOTE: An inch of water is a unit of pressure equal to the pressure exerted by a column of liquid one inch high at a standard temperature.

To calculate the rate of air flow use:

$$V = 4005 \sqrt{VP(d)}$$

Where V = rate of flow in fpm.
VP = velocity pressure; measured with Pitot tube.
d = air density factor; at standard temperature and pressure = 1.0.

c. Some of the anemometers that have previously been discussed, for example, those with relatively narrow probes and fittings, can also be used to measure air velocities within the system. No matter which device is used, however, the accuracy in determining duct velocities or flow rates will be dependent upon proper locations and number of measurements taken in traversing the duct.

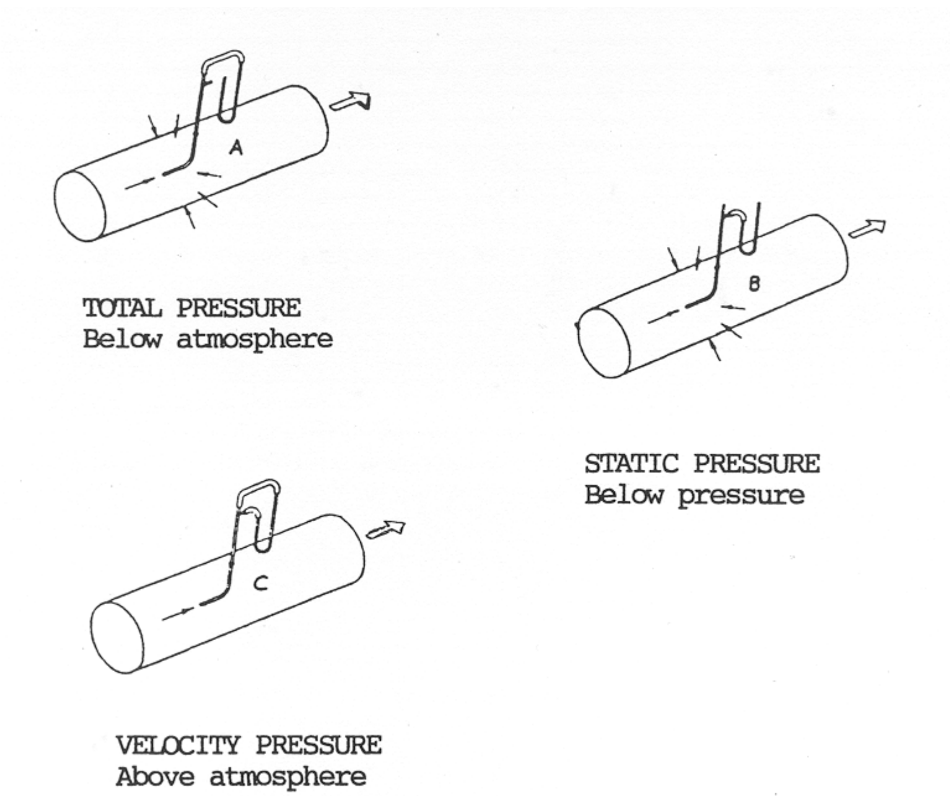


Figure 4-6. Relationships between pressures in an exhausting system.

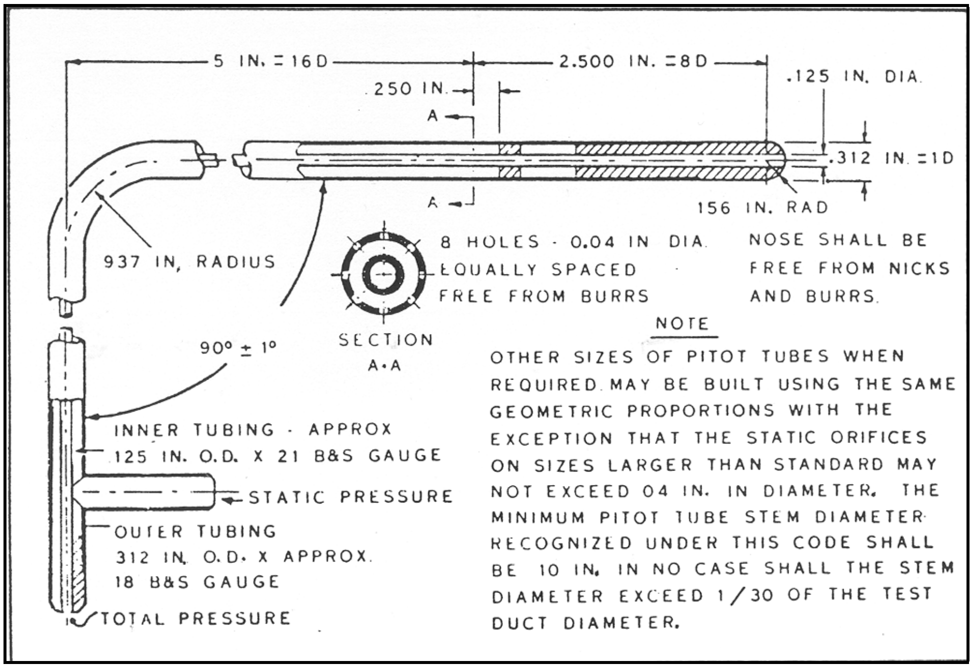


Figure 4-7. Construction of the standard Pitot tube.

d. Pitot tubes are used to determine the velocity pressure contours inside ducts. These measurements are obtained by connecting the static and total pressure taps of the Pitot tubes to a manometer, which is an instrument for measuring gas (air) pressure (see Figure 4-8). Inclined manometers are normally used since they increase the accuracy and precision, especially for air velocities below 2,000 feet per minute.

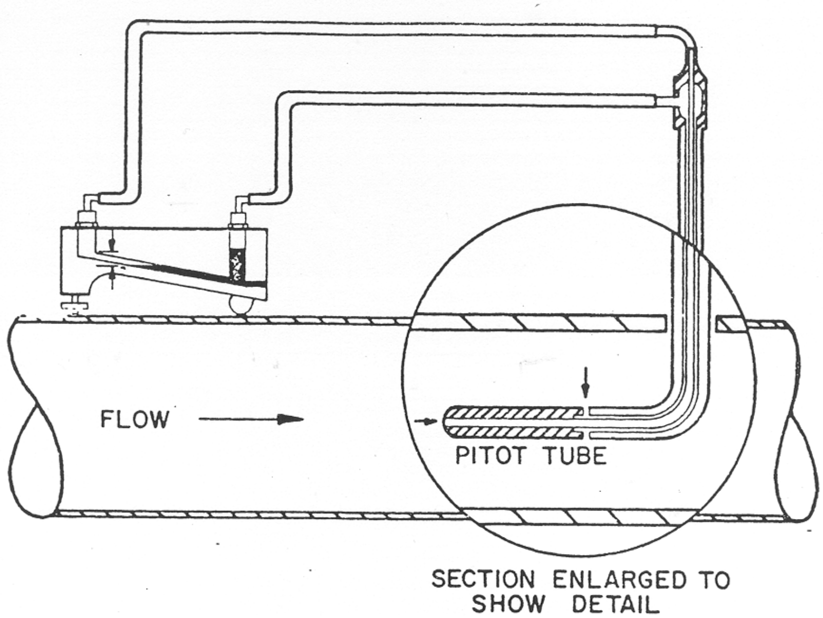


Figure 4-8. Pitot tube connected to an inclined manometer.

e. Aside from avoiding instrument error, the most significant requirement in making valid velocity or air flow measurements is the location selected for the measurements and the traverse of that location. The reason for these requirements is that airflow is not uniform in the cross section of a duct. This is especially true near such interferences as elbows, entries, and so forth. Therefore, for greater accuracy, measurements should be taken at least 7.5 diameters of straight run downstream or 1.5 diameters upstream from any interference. Once a location is selected, a Pitot traverse can be conducted. Figure 4-10 shows a cutaway drawing of both a round and a rectangular duct, illustrating the principle of measuring the velocity pressure of equal areas. Note that for round ducts it is advisable to traverse in two planes perpendicular to each other. The suggested optimum number of measurements per plane for ducts of stated dimensions is given below.

Duct Diameters (Inches)	Number of Measurements
3-6	6
5-48	10
48 and greater	20

Like round ducts, rectangular ducts are traversed in terms of equal area segments. Rectangular ducts should be divided into a minimum of 16 to a maximum of 64 equal area rectangles with readings taken in the center of each rectangle, as shown in Figure 4-9.

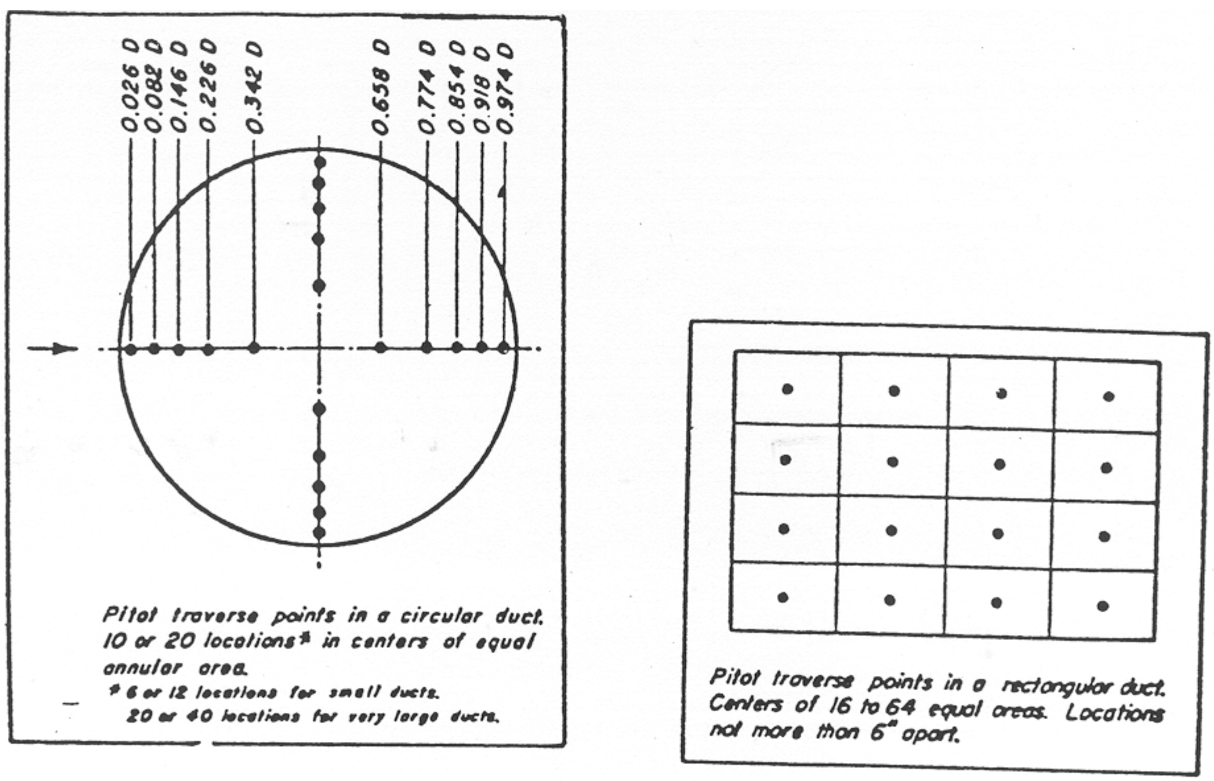


Figure 4-9. Traverse of a round and a rectangular duct.

f. There are fewer limitations for Pitot tubes than for other air velocity measuring devices. Although they can be used in corrosive or variable temperature conditions, the impact and static openings can become clogged with particulate matter. Also, as with other instruments, corrections will have to be made if the temperature is plus or minus 30°F from standard; if the altitude is greater than 10,000 feet, or if the moisture content is 0.02 pound per pound or higher. They cannot be used to measure low velocities (less than 600-fpm) and require an inclined manometer that must be level and free of vibration. They are not applicable for use in small diameter ducts (less than 3 inches) or in orifice type openings.

g. In addition to inclined manometer, there are other instruments available for pressure measurements within an exhaust system.

(1) Aneroid gauges. The most common and best known of the aneroid gauges is the Magnehelic gauge. Aneroid gauges can be used for total, static, and, in conjunction with a Pitot tube, velocity pressure measurements. They are small, extremely portable, and not as sensitive to vibration and leveling as liquid filled manometers. Since the inches of water pressure is a function of the location of an indicating needle on a dial, they are extremely easy to read. The principal limitations are accuracy and calibration. Accuracy is usually below plus or minus two is a need to calibrate these devices periodically.

(2) Manometers. Manometers range from the simple U-tube to the inclined manometers mentioned earlier. A range of sizes and varieties of U-tube manometers is available and they may be filled with a variety of media ranging from alcohol to mercury. Readings can be converted to inches of water simply by correcting for differences in density (that is, 1 inch of mercury is equal to 13.61 inches of water). When extreme accuracy is not essential or in high-pressure systems, U-tube manometers will suffice. However, for greater accuracy and in low-pressure systems, inclined manometers are required. Figure 4-8 illustrates an inclined manometer used with a Pitot tube.

h. It is frequently necessary to make static pressure measurements within a ventilation system. Instruments used in making static pressure measurements include the static leg of the Pitot tube as well as any pressure-measuring device connected to a hole in the side of a duct. U-tube manometers and Magnehelic gauges are quite acceptable. Whereas the exact location of the hole is not extremely critical, the type of hole is. Generally, the holes should not be located in points where there is some basis for turbulency or nonlinear flow such as the heel of an elbow. Holes should be flush with the inside of the duct, with no projections or burrs. Thus, holes should be drilled and not punched. The location of holes 90 degrees apart will allow for the averaging of multiple readings to provide an improved estimate of static pressure. Taps can vary in complexity from a simple soft rubber hose held tightly against a 1/16th-inch hole, to soldered petcocks for use in high-pressure systems. Figure 4-9 illustrates the traverse of a round and a rectangular duct.

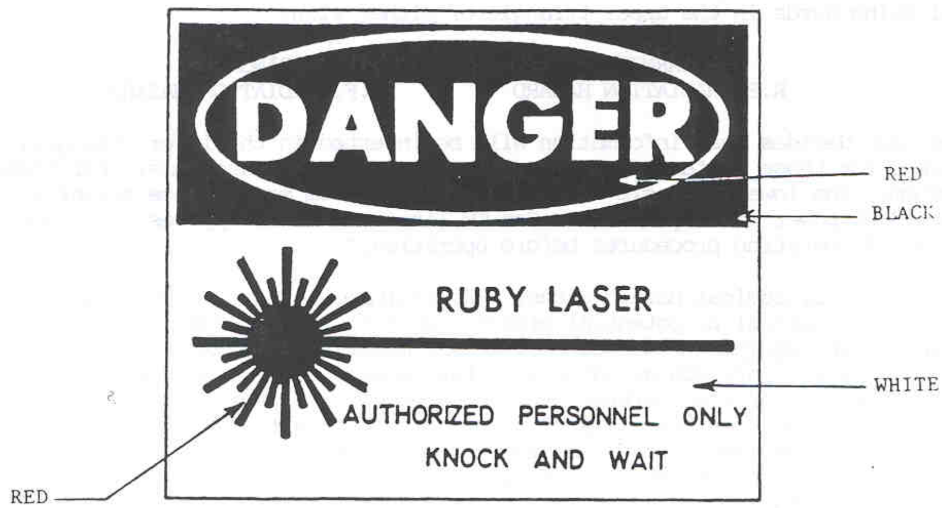
i. Static pressure measurements at strategic points in a system provide invaluable information on the performance of the system. These measurements are neither difficult to obtain nor do they require expensive or delicate instrumentation.

(1) Coefficient of entry. Estimation of airflow, using static pressure, provides a fairly accurate estimation of flow rate of an exhaust opening if the coefficient of entry can be determined. (The coefficient of entry is the ratio of actual flow and theoretical flow.) Coefficients of entry for various hoods are given in Figure 4-10. Measurements are made between one and three diameters of straight duct from the throat of the exhaust inlet (point where the hood is connected to the branch duct). It is advisable to take multiple readings 90 degrees apart. The flow rate in cfm can then be calculated using this formula:

$$Q = 4005\, C_e\, A \sqrt{SP_h}$$

Where: Q = Rate of flow in cfm (see Figure 4-11)
C_e = Coefficient of entry
A = Cross-sectional area of duct in square feet
SP_h = Average static pressure reading in inches of water (in the hood).

(2) Static pressure. Static pressure comparisons provide a means of either continuously or periodically monitoring the performance of a system. It is true that additional information may be required, but strategically located static pressure measurements can detect dirty filters, dented exhaust hoods, and changes in fan static pressure. The placement of such devices across a filter can determine the need for shaking, cleaning, or maintenance.



Example of warning sign for Class 3b and Class 4.

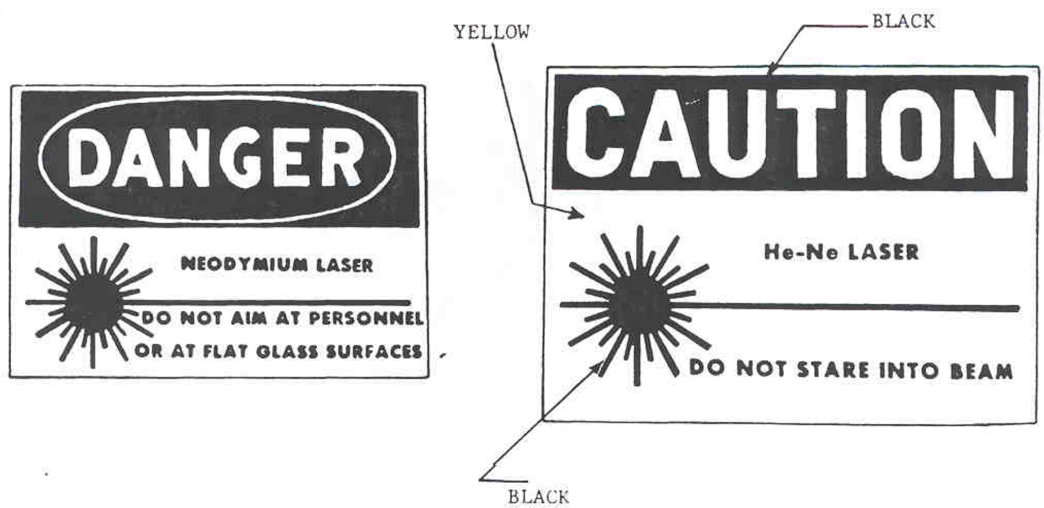


Figure 4-10. Coefficient of entry for a variety of hood and duct shapes.

4-11. AIR FLOW SYSTEM SURVEYS

a. **System Start-Up vs System Design Basis**. Any ventilation system, be it local exhaust for contaminant control or general ventilation for comfort, is designed in terms of removing or redistributing a specified quantity of air at a specific velocity at a total system pressure. An initial survey is the only time a valid comparison can be made between the design basis and the optimum system performance.

(1) <u>Sketch of the system.</u> A sketch not necessarily to scale but representative of dimensions should be drawn noting such items as hoods, elbows, branchings, air cleaner, fan, and stack. Supply ducts, plenums, and diffusers should be

shown for general ventilation systems. Figures 4-1 through 4-3 represent a simplification of this concept. Sketches of systems should be considered as part of the permanent record on which future changes in the system may be recorded.

(2) Specific air-flow measurements. Measurements in terms of airflow, velocity, and static pressure must be made to determine that the system is adequately balanced and performing to the design basis. These measurements include:

(a) Air flow in cfm at hoods (throat suction method), branches and mains (Pitot tube), and up and downstream of fan (Pitot tube).

(b) Static pressure measurements at hoods, up and downstream of the air cleaner, and up and downstream of the fan.

(c) Supply, capture, face, and transport velocities at diffuser outlets (supply velocity), face or opening of hood (face velocity), velocity at point of contaminant release (capture velocity), branches, and mains (conveying velocity).

(d) Fan performance in terms of fan speed in rpm and horsepower (BHP) is calculated using cfm (Q), total pressure (TP), and mechanical efficiency (ME) of fan. This operation is occasionally performed by a preventive medicine specialist.

NOTE: The measurements obtained should agree within 10. If they do not, the system will have to be modified until it meets design criteria.

(3) Records. The locations of the measurements must be identified on the sketch and a record kept for future comparisons.

(4) Other checks. Local exhaust systems are installed for the singular purpose of removing some contaminant from the work environment. Visualization techniques using smoke tubes or candles can be most helpful in verifying that the system exerts a sphere of control over a sufficient area to prevent excessive exposures to operating personnel. Air examination for specific contaminants is also recommended to verify that the system will control contaminants to levels known to be safe. Air samples taken in the breathing zones of operating personnel will be most helpful in assessing the adequacy of contaminant control. Photographic records of smoke tests and the results of evaluation tests should be maintained for future reference.

b. **System Operation vs System Start-Up**. Once systems are started up and determined to perform satisfactorily, the degree of evaluation can be reduced as long as good records of start-up or initial conditions have been made. Experience with airflow systems clearly indicates that periodic surveys are required to assure that system performance is adequate. Operating personnel cannot be relied upon as an "indicator" of system performance. Also, ventilation systems are rarely an integral part of the operation in terms of quality and production, and all too often receive inadequate maintenance. For most systems, simple velocity measurements at exhaust hoods and supply ducts will provide a crude indication of system performance when compared with start up evaluations. For local exhaust systems, the throat suction method applied to exhaust hoods or face velocity and the static pressure differentials for air cleaners and fans will suffice in confirming that the system is performing satisfactorily.

(1) The throat suction method will provide valid information, unless:

(a) The hood entry has been modified or damaged,

(b) There are obstructions ahead of the point of measurement, or

(c) The system has been modified.

(2) A reduction in throat suction or face velocity can provide valuable information, such as an indication that there has been:

(a) An accumulation of material in an elbow, branch, or main, thus clogging or restricting airflow. Build-up in elbows results from impaction, while build-up in straight runs results from insufficient conveying velocity or from overloading the system.

(b) A change in blast gate settings, if the system is balanced using blast gates.

(c) Additional branches and hoods added to the system. "Adding on" to a system is always a real temptation; however, it is not sound economics when it renders the whole system deficient.

(d) Excessive build-up on the filter. It is best to monitor filter build-up by attaching a static pressure measuring device across the filter.

(e) Reduced fan output resulting from belt slippage, damaged, or worn rotor, or build-up on the fan blades.

c. **Data Handling and Recording**. The sketch of the system made at start-up or for the initial evaluations survey must be recorded and filed in such a manner that future air-flow surveys can be conducted in a similar manner. The frequency of airflow surveys can be determined only by such conditions as:

(1) Nature of the materials being controlled. The more hazardous the materials, the more frequently the system should be checked.

(2) Nature of the system. A blast gate system will require more frequent checks than other systems.

(3) The level of maintenance. Airflow systems can be used to indicate the need for more frequent and improved maintenance.

4-12. EVALUATING THE PERFORMANCE OF AIRFLOW SYSTEMS

a. There are several reasons for evaluating the performance of air-flow systems.

(1) To assure adequacy of design and performance.

(2) To assure system performance is maintained.

(3) To determine the feasibility of expanding (adding to) the system.

(4) To establish improved design parameters for new systems.

(5) To assure compliance with Federal, state, or other regulations.

b. Just as there is numerous reasons for evaluating air flow systems, there are differing degrees to which they may need to be evaluated. Instruments and techniques are available which may provide only a cursory evaluation of a part of the system or an in-depth survey of the total system.

c. Visualization is a technique that can be employed to make a cursory estimate of the performance of a local exhaust system. It employs various methods of generating visual "clouds" which can then be observed to evaluate airflow patterns and air velocities at exhaust entries and supply outlets. There are several chemical devices available for use in visualization of a system.

(1) Smoke tubes is a descriptive term applied to glass tubes containing titanium tetrachloride absorbed on a granular medium. When the ends of the glass tube are broken and air passes through the tube, the moisture in the air reacts with the chemical to generate hydrochloric acid "smoke."

CAUTION: Direct inhalation of the "smoke" should be avoided, as it is extremely irritating to the respiratory system. The same effect can be obtained by using glass ampules of liquid titanium tetrachloride, available through standard chemical supply companies.

CAUTION: These fumes and the liquid are corrosive to the skin, and irritating to the eyes and respiratory system.

(2) Smoke candles are available in a range of sizes and a few colors. They are sized on the basis of volume (cubic feet) of smoke produced or the duration of smoke evolution.

(3) There are other means of generating visible clouds to follow airflow. A "heavier-than-air" cloud can be generated by placing dry ice in an alcohol bath. A "lighter-than-air" cloud can be generated by blowing air through a smoldering mixture of sawdust and oil.

d. Visualization devices are best suited for the evaluation of air-flow patterns and velocities at exhaust entries and supply outlets.

(1) The industrial hygienist can carry smoke tubes with him as he conducts surveys or inspections of industrial work areas. The tubes can be used best as an immediate survey type tool in assessing the ability of a local exhaust system to capture airborne contaminants. Smoke should be administered close to the hood entry initially, and gradually the smoke source moved away from the entry to observe the sphere of containment the exhaust system produces. Larger quantities of smoke can be generated inside the hood or enclosure to estimate rate of clearance as well as to check for eddy currents, reverse airflows, and escaping contaminants. Small amounts of smoke can be used to estimate the force and direction of air from outlets as well as a qualitative check of the performance of return air outlets.

(2) Titanium tetrachloride is best used by swabbing it along the periphery of hoods as a check for eddy currents, reverse airflow, and lack of control. Once swabbed inside a hood, the smoke will persist for several seconds, providing an opportunity for prolonged observation or photographs.

(3) Smoke candles can be used to estimate clearance rates and containment of large hoods such as paint spray booths, laboratory hoods, or other high volume exhaust systems. The hygienist must ensure that the system is operating at minimal performance levels before igniting a smoke candle to ensure reasonable removal of the smoke. Smoke candles can be held by forceps and moved across hood face openings to estimate the air distribution at the face. Colored smoke can be introduced in ventilation systems to check for leaks.

(4) The fire department should be informed of the use of excessive amounts of smoke to prevent false alarms.

e. There are two distinct limitations on the use of visualization techniques.

(1) Visualization is strictly qualitative and does not provide any information in terms of design or performance specifications.

(2) The materials used can be hazardous or at the very least a nuisance, thus their use in occupied work areas should be somewhat restricted.

Continue with Exercises

EXERCISES, LESSON 4

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, matching, or by writing the answer in the space provided at the end of the exercise.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. For industrial operations, what type of system has been designed to protect workers and create a safe, comfortable working environment?

    a. Ventilation.

    b. Sewer.

    c. Dilution.

    d. Exhaust.

2. Generally speaking, why is ventilation probably one of the most important control techniques for workers? It:

    a. Provides for fire protection.

    b. Is a way of controlling the environment with air=flow.

    c. Creates negative air.

    d. Is used in its natural form.

3. The purpose of air-flow in an industrial operations environment is to reach which aim?

    a. Adding contaminants.

    b. Increasing concentrations of contaminants.

    c. Providing for proper heating and cooling.

    d. Deleting make-up air.

4. The three applications of ventilation usually concern:

____

____

____

5. What are the different methods of ventilation used to control potentially hazardous airborne contaminants?

   a. General ventilation.

   b. Dilution ventilation.

   c. Local exhaust ventilation.

   d. All of the above.

6. Which method of ventilation actually reduces the concentration of the contaminant or hazardous material before it reaches the worker's breathing zone?

   a. Local exhaust.

   b. Dilution.

   c. General.

   d. b and c.

7. Local exhaust ventilation is best defined as:

   a. Capturing and removing the contaminant near its source or point of generation.

   b. Preventing the release of the contaminant into the workspace.

   c. a and b

   d. Partially removing the total amount of hazardous material released in the work place.

8. Which method of ventilation is preferred and more economical?

   a. Dilution.

   b. Local exhaust.

9. Which is correct?

   a. General ventilation is a system to flush a workspace, a room, or an entire building by supplying and exhausting a large volume of air throughout the area.

   b. General ventilation can only be achieved by artificial means.

   c. a and b.

   d. General ventilation is quite effective in removing large volumes of heated air or in removing low decentralized sources.

10. Which type of general ventilation provides the best results in most modern buildings in which industrial operations are conducted?

   a. Natural.

   b. Mechanical.

   c. Combination of natural and mechanical.

   d. None of the above.

11. Natural general ventilation means that workspaces or buildings may be ventilated by:

   a. Wind.

   b. Sun.

   c. Thermal convection.

   d. a and b.

12. If wind and thermal convection are natural general ventilation, how do they work?

    a. Their effects result from natural pressure and air density differences.

    b. Each causes natural displacement and infiltration of air through windows, doors, walls, and other openings.

    c. Warmer air inside a building rises, leaks out of openings in the upper areas as colder air leaks into the building from lower areas, warms up and rises.

    d. All of the above.

13. Which words describe wind currents and thermal convections for mechanical ventilation on a hot and sticky day outside?

    a. Constant and smooth.

    b. Erratic and unreliable.

    c. Pleasant and clear.

    d. Natural and cold.

14. If only mechanical general ventilation is used in an industrial operation building, what must be relied upon completely?

    a. The air supply must reach interior areas to provide adequate air distribution and prevent the creation of negative air pressures in the building.

    b. Continuous fresh supply of oxygenated air.

    c. Removal of stagnant and contaminant air.

    d. All of the above.

15. In using mechanical general ventilation, which is the best method of providing general ventilation in a closed building? Supply air:

    a. Via ductwork.

    b. By using roof fans.

    c. Through holes in walls.

    d. With a center atrium filled with plants.

16. What will a good mechanical general ventilation system do for the workers? It will keep:

    a. Humidity high and temperature down.

    b. Humidity low and temperature comfortable.

    c. Temperature hot and humidity high.

    d. Humidity low and temperature cold.

17. Which is a limiting factor when considering the dilution ventilation system for purchase?

    a. Toxicity of the contaminant must be low.

    b. Quantity of contaminant generated must be excessive.

    c. Workers must be located close to contaminant evolution.

    d. Evolution of contaminants must be reasonably erratic.

18. Because high toxicities encountered require excessively high quantities of air, __________________ would usually not be recommended for control of fumes and dusts.

    a. Dilution or general ventilation.

    b. Local exhaust ventilation.

19. What are two obvious advantages of general (dilution) ventilation systems?

   a. Simplicity of design and high initial cost.

   b. Low cost and exhaust of small volumes of heated air.

   c. Simplicity of design and low initial cost.

   d. Complex design that results in low running cost.

20. What do local exhaust systems usually contain or need?

   a. More mechanical components than general ventilation systems.

   b. More precise control of their operation.

   c. More maintenance.

   d. All of the above.

21. List four basic considerations that should be kept in mind when applying local exhaust ventilation to a specific problem.

   ____

   ____

   ____

   ____

22. What is/are the advantages of the local exhaust system?

   a. Control of the contaminant is complete.

   b. The worker is exposed to the contaminant.

   c. It can handle more highly toxic contaminants.

   d. a and c.

23. What is the disadvantage of the local exhaust ventilation system?

    a. It is not efficient.

    b. It weighs less.

    c. Installation of ductwork causes an inflexible work area.

    d. The cost is initially high but it is more efficient to operate.

24. The basic laws governing the complete motion of a fluid, such as air, are widely known and relatively simple.

    a. True.

    b. False.

25. What is the air-flow rate if the velocity was measured at 210, 320, 195, and 305 ft/min for a duct that is 12" by 36"?

    a. 257.5 cmf.

    b. 386.25 cfm.

    c. 772.5 cfm.

    d. 1030 cfm.

26. What consideration is needed for circular ducts when determining the rate of air-flow? Use the:

    a. Radius of a circle.

    b. Area of a circle.

    c. Area of a square.

    d. Diameter of a circle.

27. What term represents the minimum air velocity required to cause the contaminated air to flow into an enclosure?

    a. Capture velocity.

    b. Static pressure.

    c. Duct velocity

    d. Face velocity.

28. When using the local exhaust system, this term maintains air velocity, exists only when air is in motion, acts in the direction of the flow, and is always positive. What is this term?

    a. Capture velocity.

    b. Velocity pressure.

    c. Static pressure.

    d. Total pressure.

29. When using the local exhaust system, this pressure term is required to start and maintain air flow. What is the term?

    a. Velocity pressure.

    b. Static pressure.

    c. Inner pressure.

    d. Total pressure.

In exercises 30 through 32, write the letter of the term in the right-hand column with the appropriate equation definition in the left-hand column.

30. ____	SP + VP = TP	a. Relationship between velocity and rate of flow.
31. ____	Q = AV	b. The continuity equation.
32. ____	$A_1V_1 = A_2V_2$	c. Relationship difference of pressure components.

33. Friction loss is caused by:

    a. The rough surface confining the flow of air.

    b. Turbulence.

    c. A change in direction or velocity within a duct.

    d. A pressure drop in a duct caused by elbows or angles.

34. Which anemometer is best suited for determining air velocities and estimating air flow through large openings such as mine shafts, air supply, and discharge grilles?

    a. Rotating vane.

    b. Swinging vane.

    c. Heating thermocouple.

    d. Heated wire.

35. Which anemometer is quite portable and used extensively by industrial hygienists and ventilation engineers in the field?

    a. Heated wire.

    b. Rotating vane.

    c. Swinging vane.

    d. Heating thermocouple.

36. A heated wire anemometer:

    a. Requires the use of a timing device and must be frequently calibrated.

    b. Usually has readings taken for one-minute periods, thus giving air velocity in linear fpm.

    c. Usually is comprised of a single probe connected to an operating unit housing circuitry, meter, batteries, and so forth, and are about the size of a cigar box.

    d. Depends upon the change in resistance of a wire with a change in temperature.

37. Which anemometer can have its delicate wires damaged in the probe if heavy loadings or corrosive materials come in contact with it?

    a. Heated wire.

    b. Rotating vane.

    c. Swinging vane.

    d. Heating thermocouple.

38. What basic instrument is used to measure air velocity?

    a. Anemometer.

    b. Rotating vane.

    c. Swinging vane.

    d. Heating thermocouple.

39. Generally, the electrical or mechanical systems on which air flow measuring instruments are based are quite sensitive to _________; this is one reason that such instruments require periodic_______________ .

a. Touch; watering.

b. Shock; calibration.

c. Noise; static pressure.

d. Pressure; pitot tube cleaning.

40. An <u>inch of water</u> is:

a. A unit of pressure equal to the pressure exerted by a column of liquid one inch high at a standard temperature.

b. A unit of pressure more than the pressure exerted by a column of liquid one inch high at a standard temperature.

c. A formula used to help calibrate instruments.

d. Read directly on a meter, which is actuated by a change in voltage.

41. Which statement is correct concerning anemometer accuracy?

a. Relatively wide probes and fittings can also be used to measure air velocities within the system.

b. The accuracy in determining duct velocities or flow rates will be dependent upon proper locations and number of measurements taken in traversing the duct.

c. The difference between the velocity pressure and the static pressure is the total pressure.

d. All of the above.

42. The major disadvantage of the Pitot tube is that it is:

a. Not the standard instrument for measuring the velocity of air in ducts.

b. Used to measure the velocity pressure contours inside the ducts.

c. Not used with the inclined mamometers.

d. Not direct reading.

43. Because the air flow is not uniform in the cross section of a duct, how many diameters should be measured straight run downstream or upstream of any interference for greater accuracy?

a. At least 7.5 diameters of straight run downstream or 1.5 diameters upstream from any interference.

b. At least 7.0 diameters of straight run downstream or 1.0 diameters upstream from any interference.

c. Not more than 7.5 diameters down run or 1.5 diameters upstream.

d. Two thousand feet either way.

44. Which is true about Pitot tubes?

a. These tubes are to be used during corrosive or variable temperature conditions.

b. Corrections do not have to be made if the temperature is plus or minus 30°F from standard.

c. They are not used in small diameter ducts less than 3 inches or in orifice type openings.

d. They are used to measure velocities less than 600 fpm.

45. The aneroid gauge:

a. Is small, extremely portable, and not as sensitive to vibration and level as gas liquid filled manometers.

b. May be filled with a variety of media ranging from alcohol to mercury.

c. Is used when great accuracy and in low pressure systems are needed.

d. Is used when extreme accuracy is essential as well as sensitivity to vibration.

46. The manometers:

a. May be filled with a variety of media ranging from alcohol to mercury.

b. Are used when great accuracy in low pressure systems are needed.

c. Are used when extreme accuracy is not essential or in high pressure systems will suffice.

d. All of the above.

47. What is/are the principle limitations of the aneroid gauge?

a. Reading them.

b. Accuracy and calibration.

c. Turbulence.

d. The nonlinear flow.

48. What is a critical point on any pressure-measuring device?

a. Location of the hole.

b. Type of hole.

c. Taps.

d. Static leg.

49. Which statement is correct concerning fan performance with respect to fan speed, horsepower, total pressure, and mechanical efficiency?

    a. Measurements should agree within 10 percent of the design basis. If not, modify the fan until it meets design uncriteria.

    b. Measurements should agree within 15 percent of the design basis.

    c. Prevent excessive exposure to operating personnel.

    d. All of the above.

50. Which statement is correct concerning visualization when evaluating the performance of air flow systems?

    a. By generating visual "clouds," they can be observed to evaluate airflow patterns and air velocities at exhaust entries and supply outlets.

    b. It is a technique which can be employed to make a cursory estimate of the performance of a local exhaust system.

    c. Visualization devices are best suited for the evaluation of airflow patterns and velocities at exhaust entries and supply outlets.

    d. All of the above.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 4

1. a (para 4-1a)

2. b (para 4-1b)

3. c (para 4-1b)

4. Preventing fire and explosions, controlling atmospheric contaminants to healthful limits, controlling heat and humidity for comfort. (para 4-1c)

5. d (para 4-2)

6. d (para 4-2a(1))

7. c (para 4-2a(2))

8. b (para 4-2b)

9. a (para 4-3)

10. c (para 4-3)

11. d (para 4-3a)

12. d (para 4-3a)

13. b (para 4-3a)

14. d (para 4-3b)

15. a (para 4-3b)

16. b (para 4-3b)

17. a (para 4-3c(b))

18. a (para 4-3c(2))

19. c (para 4-3d(1))

20. d (para 4-4)

21. The source of contamination should be enclosed as completely as possible.
The contaminant should be captured with adequate air velocity.
The contaminant should be kept out of the worker's breathing zone.
Adequate make-up air must be provided, or, exhaust air must be discharged away from air inlet systems. (para 4-4a)

22. d (para 4-4c)

23. c (para 4-4d(2))

24. b (para 4-5a)

25. c (para 4-5b)

26. b (para 4-5b NOTE)

27. a (para 4-5c(1))

28. b (para 4-6a)

29. d (para 4-6c)

30. c (para 4-6c)

31. a (para 4-5b)

32. b (para 4-5b)

33. a (para 4-7a)

34. a (para 4-8b(1))

35. c (para 4-8b(2))

36. d (para 4-8b(4))

37. d (para 4-8b(3))

38. a (para 4-8b)

39. b (para 4-9)

40. a (para 4-10b, NOTE)

41. b (para 4-10c)

42. d (para 4-10b)

43. a (para 4-10e)

44. c (para 4-10f)

45. a (para 4-10g(1))

46. d (para 4-10g(2))

47. b (para 4-10g(1))

48. b (para 4-10h)

49. a (para 4-11a(2)(d)NOTE)

50. a (para 4-12c)

END OF LESSON 4

APPENDIX A

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8. DODI 1000.3, Safety and Occupational Health Policy for the Department of Defense, 29 March 1979.

9. DODI 6055.1, Department of Defense Occupational Safety and Health (OSH) Program, 26 October 1984.

10. DODI 6055.1, Industrial Hygiene and Occupational Health, 30 April 1980.

11. DHEW Publication No. (NIOSH) 76-189, A Guide to Industrial Respiratory Protection.

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13. Title 29, Code of Federal Regulations (CFR), 1980 ed., Part 1910, Occupational Safety and Health Standards.

14. Executive Order 12196, Occupational Safety and Health Programs for Federal Employees, 26 February 1980.

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16. TB MED 501, Hearing Conservation, 15 March 1980.

17. TB MED 502, Respiratory Protection Program, 15 February 1982.

18. TB MED 503, The Army Industrial Hygiene Program, February 1985.

19. TB MED 506, Occupational and Environmental Health Occupational Vision, 15 December 1981.

20. TG 141, USAEHA Industrial Hygiene Air Sampling and Bulk Sampling Instructions, December 1990.

21. TG 172, USAEHA Cold Injury, December 1989.

22. HSC Pam 40-2, Occupational Health Program.

END OF APPENDIX A

APPENDIX B

TYPICAL OPERATIONS FOUND AT MILITARY INSTALLATION: THEIR EXPOSURES AND CONTROLS

Operation	Exposures	Controls Needed to Control Exposure*
Acetylene-welding	Infrared and intense visible radiation; oxides of nitrogen; metal and flux fumes	Mechanical general ventilation, goggles, gloves
Arc welding and inert gas arc inert gas arc welding	Ultraviolet, infrared and intense visible radiation nitrogen; metal and flux fumes; ozone	Local exhausts ventilation (100 feet per-minute (fpm) at welding site), helmets, gloves, aprons, screens (at least 7" high)
Metalizing	Infrared and intense visible radiation; oxides of nitrogen; metal and flux fumes, noise	Exhaust-ventilated booth for routine work (face velocity of 200 fpm) goggles, gloves, hearing conservation program, washing facilities
Testing, tuning, and repairing vehicle engines	Carbon monoxide other products of combustion, oils, greases	Powered flexible tailpipe exhaust extensions (dimensions and exhaust capacities are found in the (USAEHA Ventilation Standards), washing facilities
Charging lead-acid Batteries	Sulfuric acid and its mist	Mechanical general ventilation (2 cfm/sq ft of floor space), impervious gloves, aprons, chemical splash goggles, or face shield, deluge shower, eyewash fountain
Steaming cleaning	Steam, alkaline Mists	Outdoor operation usually (if performed indoors, mechanical general ventilation is necessary), rubber gloves, rubber boots, aprons, face shield, washing facilities

** The number and type of controls will depend on character and length of exposure. Controls presented here are considered the optimum.*

TYPICAL OPERATIONS FOUND AT MILITARY INSTALLATION: THEIR EXPOSURES AND CONTROLS (continued)

Operation	Exposures	Controls Needed to Control Exposure*
Parts cleaning	Various solvents and their vapors including Stoddard solvent and its vapor	Mechanical general ventilation, washing facilities, minimize skin contact with solvent, splash goggles
Vapor-degreasing	Trichloroethylene or Perchloroethylene and vapor	Degreasing machine, with vapor zone thermostat, adequate freeboard, properly isolated or baffled to prevent cross-drafts, mechanical general ventilation, washing facilities, splash goggles
Leading in vehicle body surfaces	Lead fume	Mechanical general ventilation, a temperature flame should be used in lead, NIOSH approved fume respirators, medical surveillance for lead absorption
Power-sanding painted and/or leaded surfaces	Metal and abrasive	Exhaust-ventilated booth having a velocity of 150-fpm, equipped with a collector, NIOSH approved toxic-dust or all-dust respirators, washing facilities, medical surveillance for lead absorption goggles
Abrasive cleaning (small parts and equipment)	Metal and siliceous dust	Enclosed exhaust ventilated abrasive blasting cabinet with dust collector, NIOSH approved abrasive blasting helmet, protective clothing, washing facilities, hearing conservation program
Abrasive cleaning (vehicles and large equipment)	Metal and siliceous dust	Enclosed exhaust ventilated blasting room with dust collector NIOSH approved abrasive blasting helmet, protective clothing, washing facilities, hearing conservation program
Machining and grinding metals	Metal and abrasive dusts, cutting and coolant oils, greases	Natural ventilation, goggles, washing facilities
Forging steel	Carbon monoxide Smoke	Exhaust-ventilated enclosing hood forge, washing facilities, tinted goggles.

TYPICAL OPERATIONS FOUND AT MILITARY INSTALLATION: THEIR EXPOSURES AND CONTROLS (continued)

Operation	Exposures	Controls Needed to Control Exposure*
Heat-treating Metal	Heat, sodium carbonate, oxides of nitrogen, carbon monoxide, smoke	Exhaust-ventilated enclosing hood(ventilating rate of 200 cubic feet per minute (cfm)/sq ft of opening area), washing facilities, tinted goggles
Soldering	Metal and flux fumes including lead fume	Mechanical general ventilation, washing facilities, tinted goggles
Cutting and threading pipe	Cutting and coolant oils	Natural ventilation, washing facilities, goggles
Developing and processing still and motion picture film	Standard photographic chemicals and reagents	Mechanical general ventilation of air conditioning (10 air changes per hour), splash goggles, washing facilities, eye wash
Mixing photographic chemicals and reagents	Standard photographic chemicals and reagents	Mechanical general ventilation of air conditioning (10 air changes per hour), goggles, gloves, aprons, washing facilities, eye wash
Cleaning film	Various solvents and their vapors including trichloroethylene and methyl chloroform	Mechanical general ventilation and/or enclosed exhaust ventilated film cleaning machine, washing facilities
Arc-light reproduction	Ultraviolet, infrared, and intense visible radiations oxides of nitrogen ozone	Mechanical general ventilation, screens (at least 7' high) or isolation of the operation, tinted glasses or goggles
Multilith reproduction off-set printing, other printing operations	Inks, various cleaning solutions and their mists and vapors, including trichloroethylene, Stoddard solvent and its vapor, methyl chloroform, acidic chromate solutions	Mechanical general ventilation washing facilities, minimize skin contact with solutions
"Ozalid" reproduction	Ammonia	Enclosed exhaust ventilated machine, washing facilities

TYPICAL OPERATIONS FOUND AT MILITARY INSTALLATION: THEIR EXPOSURES AND CONTROLS (continued)

Operation	Exposures	Controls Needed to Control Exposure*
Powered wood working	Noise, wood dusts	Hearing conservation program, locally exhaust ventilated machines, washing facilities
Stripping paint from furniture	Paint-stripping compounds usually containing methylene chloride	Mechanical general ventilation, washing facilities (if material is sprayed onto the equipment, an exhaust-ventilated booth having a face velocity of 150-fpm should be used) splash goggles
Spray-painting	Paint mists, thinner vapors	Exhaust ventilated spray-paint booth (150 -fpm through the cross section of the booth), NIOSH approved spray paint respirators (NIOSH-approved airline respirator for work in confined spaces), washing facilities, splash goggles
Brush painting	Paint pigments thinner vapor	Mechanical general ventilation, washing facilities, splash goggles
Dry painted equipment	Thinner vapors	Exhaust-ventilated drying booth
Mixing and dispersing insecticides	DDT, chlordane lindane, malathion, herbicides, warafarin	Mechanical general ventilation in mixing area, gloves, splash goggles, washing facilities, respirators
Filling fire extinguishers	Sulfuric acid and its mist, carbon tetrachloride	Mechanical general ventilation, aprons, gloves, face shields, washing facilities, dyed carbon tetrachloride solution
Proof-testing small arms and ammunition in indoor range	Lead fume, combustion products, noise	Local-exhaust ventilation (300-fpm at firing area and 200 fpm at target end of range), hearing conservation program, medical surveillance for lead absorption
Chemical analyses in laboratory	Standard laboratory reagents and chemical	Laboratory fume hood (100-fpm face velocity with hood door fully open), washing facilities, splash goggles

END OF APPENDIX B

APPENDIX C

COMMON INDUSTRIAL HAZARDS FOUND IN THE ARMY

Gases	TLV (ppm)	STEL	Typical Operations
Carbon monoxide	50	400	Engine operations Welding and cutting Combustion
Nitrogen dioxide	3	5	Metalizing Carbon arc reproduction
Aldehydes (Formaldehyde)	(1, A2)*	(2, A2)	Diesel engines Map sorting and storage
Sulfur dioxide	2	5	Diesel engines Heating plants
Thinner vapors Toluene Xylene	100 100	150 150	Painting
Ozone	C 0.1	C 0.2	Inert gas welding Carbon arc reproduction Metalizing
Ammonia	25	35	Ozalid reproduction
Chlorine	0.5	11	Chlorinating water and sewage
Methyl bromide	5 (skin)	--	Fumigation work
Methyl ethyl ketone (MEK)	200	300	Spraying strippable coating, paint removing
Mercury	0.05 mg/M^3 (skin)	--	Filling mercury gauges and instruments Calibration of mercury instruments
Trichloroethylene	50	200	Vapor degreasing Cleaning metal parts by hand with cold solution

* A2 indicates suspected carcinogen.

COMMON INDUSTRIAL HAZARDS FOUND IN THE ARMY (continued)

Solvents	TLV (ppm)	STEL	Typical Operations
Perchloroethylene	50	200	Vapor degreasing Multilith reproduction
Benzene	10 (suspected carcinogen)	--	Cleaning metal parts Inner tube repair
Methylene chloride	50	--	Cleaning metal parts
Stoddard solvent	100	--	Cleaning metal parts
Chloroform	10 (suspected carcinogen)	--	Cleaning metal parts Laboratory work
Cresylic acid (Cresol)	5 (skin)	--	Carburetor cleaning
Methyl chloroform	350	450	Cleaning typewriters and office equipment
Formaldehyde	(1,A2)	(2,A2)	Tissue processing Map storage
Acetone	750	1000	Cleaning optics, silk screening
Ethyl alcohol	1000	--	Cleaning optics, silk screening

COMMON INDUSTRIAL HAZARDS FOUND IN THE ARMY (continued)

Mists	**TLV in mg/m^3**	**STEL**	**Typical Operations**
Paint mists (solvent mists or vapors and pigment particles)	dependent on solvent and pigments	--	Paint spraying
Phosphoric acid	1.0	3.0	Aluminum bright dip De-rusting
Chromic acid	(Recognized carcinogen)	--	Chrome plating Anodizing aluminum Acid dipping zinc and magnesium
Sulfuric acid	1	3.0	Surface treatment of metals Charging lead batteries
Sodium hydroxide	2C	--	Alkaline cleaning of metals. Some paint removers
Cyanides (as CN)	5 (skin)	--	Electroplating and stripping
Oil mists	5	10	Coolant for machining

COMMON INDUSTRIAL HAZARDS FOUND IN THE ARMY (continued)

Fumes	TLV in mg/m^3	STEL	Typical Operations
Iron oxide fume	5	10	Arc and acetylene welding
Cadmium oxide fume	0.05C	--	Silver brazing Welding and cutting on cadmium plated surfaces
Copper fume	0.2	--	Silver brazing Welding or cutting on brass or bronze
Silver (soluble)	0.1	--	Silver brazing
Lead	0.15	--	Leading-in work on vehicle bodies, communications equipment, battery terminals, and pipes. Welding and cutting on leaded steel.. Welding and cutting on lead painted surfaces.. Weapons firing Ammunition popping Lead melting and casting
Zinc oxide fume	5.0	10	Silver brazing Welding and cutting on galvanized metals
Chromium and chromium oxides	05 to .5 (many recognized as carcinogens)	--	Welding and cutting on stainless steel

COMMON INDUSTRIAL HAZARDS FOUND IN THE ARMY (continued)

Dusts	TLV in mg/m^3	STEL	Typical Operations
Iron oxide	5	10	Power sanding or grinding on oxidized iron or steel
Lead	0.15	--	Power sanding or grinding lead base painted surfaces. Power sanding on leaded-in vehicle body work
Various insecticide dusts such as:			Mixing and dispersing
Chlordane,	0.5 skin	--	
Lindane,	0.5 skin	--	
Dieldrin,	0.25 skin	--	
DDT,	1.0	3	
Malathion	10 skin	--	
Silicon dioxide (free silica)	consult TLV Table	--	Sandblasting Foundry operations
Fluoride dusts	2.5	--	Fluoridation of water supplies

END OF APPENDIX C

APPENDIX D

INDUSTRIAL HYGIENE SAMPLING GUIDE INSTRUCTION FOR SUBMISSION OF INDUSTRIAL HYGIENE AIR SAMPLES

1. Fill out the Sample Data Sheet <u>completely.</u>

2. Requestor is to fill in columns b, c, d (optional), e or f, g, h, and i.

3. Number all samples and blanks using consecutive numbers.

4. A "blank" MUST accompany ALL air samples. The "blank" is to be numbered and the word "BLANK" written on the tube, filter, bottle, passive monitor or impinger. Indicate on the form the "blank" sample number.

5. All samples are to be forwarded to:

   Commander
   U.S. Army Environmental Hygiene Agency
   ATTN: HSHB–ML-A, Bldg E-2100
   Aberdeen Proving Ground, MD 21010-5422

NOTE: Bulk Sample Data (AEHA Form 8) or Air Sample Data (AEHA Form 9) is to accompany <u>all</u> industrial hygiene samples submitted for analysis.

NOTE: Request for additional forms should be submitted to:

   Commander
   U.S. Army Environmental Hygiene Agency
   ATTN: HSHB–ML-A
   Aberdeen Proving Ground, MD 21010-5422

   or

   Locally reproduce

6. Refer to the following table for specific sampling instructions.

Air Sampling Procedures For Chemicals Contaminants

Chemical Contaminant	Sampling Method and Collecting Medium	Sampling Rate* Per Minute	Sample Volume in Liters** Minimum	Maximum
Acetic acid	Chromosorb[R]*** tube for acids (see page D-9)	100–500 ml	15	60
Acetone	200/400 mg charcoal tube or passive monitor	20–100 ml	1	6
Acid mists	See Specific Acid			
Alkali mists (such as NaOH,KOH)	See Specific Compound			
Ammonia	Preferred: 100/200-mg ammonia adsorption tube (ORBOR-77) [R] (see page D-9)	100-500 ml	3	24
	Alternate: Midget impinger (15 ml of 0.5% sulfuric acid)	1-2 liters	10	40
Asbestos	25 um filter cassette, open face shrouded (CE 0.8 um filter) w/50 mm extension cowl	0.5-2.5 liters	400	--

*Use the flow rate that will give the recommended air volume. Minimum liters generally refer to the least number of liters that are required to see 0.1 to 0.2 TLV (TWA). Maximum liters refer to largest number of liters, which may be collected without significant breakthrough for a compound if present at approximately two times TLV (TWA) levels. The recommended volumes should be collected even if very low or very high levels are suspected.

**Contact USAEHA for information regarding temporary loan of equipment.

Air Sampling Procedures For Chemicals Contaminants (continued)

Chemical Contaminant	Sampling Method and Collecting Medium	Sampling Rate* Per Minute	Sample Volume in Liters** Minimum	Maximum
Benzene	200/400 mg charcoal tube	50-500 ml	25	40
	or passive monitor	2-8 hr	--	--
Beryllium	Filter cassette, closed face with spacer (CE 0.8 micrometer (um) filter)	1-4 liters	250	1000
Cadmium	Filter cassette, closed face with spacer (CE 0.8 um filter	1-3 liters	100	1500
Carbon tetra-chloride	200/400 mg charcoal tube	50-500 ml	25	40
Chlordane	33/66 mg Chromosorb 102 tube	1-2 liters	300	500
Chlorpyrifos (Dursban^R)	Specially constructed glass sampling tube containing a glass fiber filter and 2 sections of XAD-2^R resin	1 liter	480 only	--
Chlorine	Midget fritted glass bubbler (100 ml of methyl orange reagent)	1.5 liters	20	30

Air Sampling Procedures For Chemicals Contaminants (continued)

Chemical Contaminant	Sampling Method and Collecting Medium	Sampling Rate* Per Minute	Sample Volume in Liters** Minimum	Maximum
Chloroform	200/400-mg charcoal tube	50-500 ml	25	40
Chromic acid mist	Filter cassette, closed face with spacer (PVC 5.0 um filter) submit three blank filters	1-4 liters	--	500
Chromium (as dust or fume)	Filter cassette, closed face with spacer (CE 0.8 um filter)	1-3 liters	100	1000
Copper	Filter cassette, closed face with spacer (CE 0.8 um filter)	1-3 liters	60	1500
Cresols (cresylic acid)	260/250 mg Silica Gel	50–500 ml	25	40
Cyanide (dust or fume)	Midget impinger (10 ml of 0.2N sodium hydroxide (Transfer to a plastic bottle after collection)	1.5 liters	20	90
Diazinon	Specially constructed glass sampling tubes containing a glass fiber filter and 2 sections of XAD-2 resin	1 liter	480	--
Dieldrin	Filter cassette, closed face (GF 37 mm)	1.5 liters	160	200
Dioxane	200/400 mg charcoal tube OR passive monitor	50-500 ml or 90 min-8 hr	7.5	40

Air Sampling Procedures For Chemicals Contaminants (continued)

Chemical Contaminant	Sampling Method and Collecting Medium	Sampling Rate* Per Minute	Sample Volume in Liters** Minimum	Maximum
Dust (total)	Filter cassette, pre-weighed, closed (PVC 5.0 um filter)	1-2 liters	400	1000
Dust (Respirable)	Filter cassette, pre–weighed, with spacer and cyclone (PVC 5.0 um filter)	1.7 liters only	500	816
Ethyl alcohol	200/400 mg charcoal tube OR passive monitor	20-50 ml 15 min-1.0 hr	0.5	2
Ethylene oxide	ORBO-78 ETD tube OR passive monitor	20-200 ml 8 hrs	9.6	20
Ethyl ether	200/400 mg charcoal tube	50-100 ml	1	6
Fluorides (dust)	Filter, closed face with spacer (PVC 5.0 um filter)	1-2 liters	20	800
Fluorides (fume)	CE 0.8 um filter same as fluorides dust	1-2 liters	20	800
Formaldehyde	ORBO-23 formaldehyde tube	100 ml	24	--
Hydrochloric acid	Silica gel tube OR ORBO-70 acid tube	200 ml only (ceiling) 500 ml only (ceiling)	3.0 only 7.5 only	 --
Iron	Filter, closed face with spacer (CE 0.8 um filter)	1-2 liters	15	500

Air Sampling Procedures For Chemicals Contaminants (continued)

Chemical Contaminant	Sampling Method and Collecting Medium	Sampling Rate* Per Minute	Sample Volume in Liters** Minimum	Maximum
Fluorides (fume)	CE 0.8 um filter same as fluorides dust	1-2 liters	20	800
Formaldehyde	ORBO-23 formaldehyde tube	100 ml	24	--
Hydrochloric acid	Silica gel tube OR ORBO-70 acid tube	200-ml only (ceiling) 500-ml only (ceiling)	3.0 only 7.5 only	 --
Iron	Filter, closed face with spacer (CE 0.8 um filter)	1-2 liters	15	500
Lead, inorganic (fumes and dust)	Filter cassette, closed face with spacer (CE 0.8 um filter)	1-4 liters	200	1200
Lead Chromate	See lead, inorganic			
Manganese	Filter cassette, closed face with spacer (CE 0.8 um filter)	1-2 liters	50	1000
Mercury vapor	Mercury vapor detector			
Methyl alcohol	260/520-mg Silica gel tube	20-200 ml	1	5
Methyl bromide	200/400-mg charcoal tube two tubes in series OR passive monitor	50-200 ml 4 hr	9 --	20 --
Methyl chloro-form (1, 1, 1-Trichloroe-thane)	200/400-mg charcoal tube OR passive monitor	20-500 ml or 1-4 hr	1 --	20 --

Air Sampling Procedures For Chemicals Contaminants (continued)

Chemical Contaminant	Sampling Method and Collecting Medium	Sampling Rate* Per Minute	Sample Volume in Liters** Minimum	Maximum
Methylene chloride	200/400 mg charcoal tube OR passive monitor	20-200 ml or 30 min-1 hr	1 —	12 —
Nitrogen dioxide	Preferred: Direct reading NO^2 meter OR 400/600/400 nitrogen dioxide tube (ORBO-76)	-- 20-50 ml	-- 2 (TWA)	-- 4
	Alternate: Fritted glass bubbler (10 ml of Saltzman Reagent) Either way, immediate analysis is preferred. Color fades approximately 3 percent each day	0.4 liter	Sample until a medium shade of purple develops but not to exceed 10 minutes.	
Nitroglycerin	50/100 mg Tenax^R tube	0.2-1 liter	15	50
Nitrous oxide	Portable infrared analyzer (that is, MIRAN^R)			
Nuisance Particulates	Filter cassette, closed face with spacer, (PVC, micrometer filter pre-weighed)	1-2 liters	400	1000
Oil mist	Filter cassette, closed face with spacer, pre-weighed (PVC 5.0 um filter)	1-2 liters	400	1000

Air Sampling Procedures For Chemicals Contaminants (continued)

Chemical Contaminant	Sampling Method and Collecting Medium	Sampling Rate* Per Minute	Sample Volume in Liters** Minimum	Sample Volume in Liters** Maximum
Ozone	Preferred: Ozone meter (direct reading)	--	--	--
	Alternate: All glass midget impinger (10 ml of alkaline KI)	1-2 liters	60	120
Pentachlor-phenol	Filter, closed face with spacer glass fiber filter	1-2 liters	50	--
	Midget impinger (15 ml of ethylene glycol***)	1.5 liter	90	120
Petroleum solvent vapors	200/400 mg charcoal tube	50-500 ml	5	40
Phenol	260/520 Silica gel tube	50 ml	3	20
Phosphoric acid	200/400 mg high purity Silica gel tube	200-500 ml	30	120
Polychlorinated biphenyls (PCBs)	50/100 mg Florisil^{R} tube preceded by 13 um glass fiber filter	50-200 ml	12	48
Potassium hydroxide	Filter cassette, closed face with spacer (CE 0.8 um filter) submitt three blank filters	1-2 liters	60	960

*** Do not use antifreeze in place of ethylene glycol.

Air Sampling Procedures For Chemicals Contaminants (continued)

Chemical Contaminant	Sampling Method and Collecting Medium	Sampling Rate* Per Minute	Sample Volume in Liters** Minimum	Maximum
Quartz (crystalline silica)				
a. Total****	Filter cassette, closed face with spacer pre-weighed (PVC, 5.0 um filter)	1-4 liters	250	1000
b. Respirable	Filter, closed face with spacer, pre-weighed and10 mm cyclone (PVC, 5.0 um filter, 37 mn diameter)*****	1.7 liters only	500	816
Sodium hydroxide	Filter cassette, closed face with spacer (CE 0.8 um filter) submit three blank filters	1-2 liters	60	960
Stoddard solvent	200/400 mg charcoal tube	50-500 ml	5	40
Styrene	200/400 mg charcoal tube OR passive monitor	50-500 ml or 1-8 hr	5 --	40 --
Sulfur dioxide	200/400 mg high purity Silica gel tube	200-500 ml	24	48
Sulfuric acid	200/400 mg high purity Silica gel tube	200-500 ml	24	48
Toluene	200/400 charcoal tube	50-500 ml	5	40

****Total quartz sampling not generally recommended. Sample for respirable dust.

*****A bulk air sample should be submitted for determination of percent respirable quartz.

Air Sampling Procedures For Chemicals Contaminants (continued)

Chemical Contaminant	**Sampling Method and Collecting Medium**	**Sampling Rate* Per Minute**	**Sample Volume in Liters**** Minimum	Maximum
Toluene disocyanate (TDI)	ORBO-80 tube	1 liter	15	
Trichloroe-ethylene	200/400-mg charcoal tube OR passive monitor	50-500 ml or 1-8 hr	5 --	40 --
Trinitrotoluene (TNT)	50/100 mg Tenax[R] ****** tube (For extremely dusty operations use a 37 mm glass fiber prefilter)	1 liter	15	50
Welding Fumes (total fume)	Filter, closed face with spacer, pre-weighed (PVC 5.0 um filter)	1-2 liters	400	1000
Welding fumes (metals)	For metal analysis see specific metal			
Xylene	200/400 mg charcoal tube OR passive monitor	50-500 ml or 1-8 hr	5 --	40 --
Zinc Compounds	Filter cassette, closed face with spacer (CE 0.8 um filter) submit three blank filters	1-3 liters	15	400

******Chromos orb is a registered trademark of Johns-Manville Products Corp., Denver, CO.
Dursban is a registered trademark of Dow Chemical Co, Midland, MI.
ORBOR is a registered trademark of Sup Alco, Inc., Supelco Park, Bellefole, PA.
XAD-2 is a registered trademark of Rohn & Haas, Philadelphia, PA.
MIRAN is a registered trademark of Foxboro Analytical, South Norwalk, CT.
Tenax is a registered trademark of Gic-Enka N.V., The Netherlands.

END OF APPENDIX D

APPENDIX E

THRESHOLD LIMIT VALUES FOR SELECTED SUBSTANCES, 1990-1991

	TWA		STEL	
Substance	**ppm**	**mg/m^3**	**ppm**	**mg/m^3**
Acetic acid	10	25	15	37
Ammonia	25	18	35	27
Cadmium oxide fume (as Cd)	--	(C 0.05)	--	--
Carbon disulfide (Skin)	10	31	--	--
Carbon monoxide	50	55	400	440
Chlorine	0.5	1.5	1	2.9
Copper fume	--	0.2	--	--
Diazinon (Skin)	--	0.1	--	--
Diethyl ether	400	1200	500	1500
Formaldehyde	(1,A2)	(1.2A2)	(2,A2)	(2.5,A2)
Nitrogen dioxide	3	5.6	5	9.4
Ozone	C 0.l	C 0.2	0.3	0.6
Phosgene	0.10	0.4	--	--
Perchloroethylene	50	339	200	1357
Stoddard solvent	100	525	--	--
Trichloroethylene	50	269	200	1070

NOTE: Threshold limit values (TLVs) are subject to change annually. Check latest edition of TLV booklet. Time weighted average (TWA).

END OF APPENDIX E

APPENDIX F

GUIDE FOR SELECTION OF RESPIRATORS

Hazard	Respirator
Oxygen deficiency.	Self-contained breathing apparatus. Hose mask with blower (Type A). Combination airline respirator (Type C) with auxiliary self-contained air supply or an air storage receiver with alarm.
Gas and vapor contaminants immediately dangerous to life or health.	Self-contained breathing apparatus. Hose mask with blower (Type A). Air-purifying, full face-piece respirator with chemical canister (gas mask for escape only).* Self rescue mouthpiece respirator (for escape only).* Combination air line respirator (Type C) with auxiliary self contained air supply or an air storage receiver with alarm.
Not immediately dangerous to life or health.	Air-line respirator (Type C). Hose mask without blower (Type B). Air purifying, gas mask or chemical cartridge respirator with appropriate canister or cartridge.

*Not for use against gases or vapors with poor warning properties or that generate high heat or reaction with sorbent materials in the canister or cartridge.

GUIDE FOR SELECTION OF RESPIRATORS (continued)

Hazard	Respirator
Particulate contaminants immediately dangerous to life or health.	Self-contained breathing apparatus. Hose mask with blower (Type A). Air-purifying, full-face piece respirator (gas mask) with appropriate filter (for escape only).* Self-rescue mouthpiece respirator (for escape only).* Combination air-line respirator (Type C) with auxiliary self-contained air supply or air storage receiver with alarm.
Not immediately dangerous to life or health.	Air purifying, half-mask or mouthpiece respirator with filter pad or cartridge. Air-line respirator (Type C). Air-line abrasive blasting respirator (Type CE). Hose mask without blower (Type B or BE).
Combination gas, vapor, and particulate contaminants immediately dangerous to life or health.	Self-contained breathing apparatus. Hose mask with blower (Type A or AE). Air purifying, full-face piece respirator with chemical canister and appropriate filter (gas mask with filter). Self-rescue mouthpiece respirator (for escape only). Combination air-line respirator (Type C or CE) with auxiliary self contained air supply or an air storage receiver with alarm.

* Not for use against gases or vapors with poor warning properties or that generate high heats or reaction with sorbent materials in the canister or cartridge.

END OF APPENDIX F

APPENDIX G

USE OF GR 1565, SOUND LEVEL METERS

1. Activation of instrument.

   a. Slide power switch to "on" position.

   b. Check batteries by depressing "BAT Check" button.

   c. Replace batteries if needle does not go past the "BAT" mark on the meter scale.

2. Calibration.

   a. GR 1562 calibrator.

      (1) Set the GR 1565 sound level meter to the 110-120 dB scale using the range selector knob on the right side of the meter.

      (2) Depress the A-weighting button.

      (3) Insert the microphone adaptor into the calibrator.

      (4) Check the calibrator battery.

         (a) Turn the dial face counterclockwise to the start position and hold in place.

         (b) The light indicates the battery is good.

      (5) Set the calibrator to 1000 Hz.

         (a) Dial must be held in start position for at least 3 seconds prior to turning to the desired frequency.

         (b) Do not stop at the off position.

      (6) Place the calibrator onto the sound level meter.

      (7) Adjust the sound level meter to 114 dB(A) $\pm$ 0.5.

         (a) Use a jeweler's screwdriver to make adjustments.

         (b) Adjust screw to the left of the weighting selector buttons, inside a small hole.

b. GR 1987 calibrator.

(1) Set the GR 1565 sound lever meter to the desired range.

(a) 90-100 dB or 110-120 dB.

(b) Use the range that is closest to the expected readings.

(2) Depress the A weighting button.

(3) Turn the calibrator onto either 94 or 114 dB.

(4) Place the calibrator onto the sound level meter.

(5) Adjust sound level meter to the appropriate dB level.

3. Measurement.

a. Set the sound level meter to the highest dB range using the selector knob on the right side of the instrument.

b. Depress the A weighting bottom (should already be depressed).

c. Depress the SLOW button.

d. Stand with the instrument extended in front of you with the sound coming from the side.

e. Turn the range selector knob until the needle registers on the scale.

f. Record the reading.

(1) If the reading is steady, record as ________dB(A).

(2) If the reading is not steady, record as _____/_____dB(A).

END OF APPENDIX G

APPENDIX H

COMPLETION OF DD FORM 2214, NOISE SURVEY

1. Enter date of survey (A preliminary survey form is at page H-3).

2. Type of survey initial, resurvey, or other (special requests, and so forth).

3. Sound level meter, microphone, and calibrator date manufacturer, model, serial number (if unable to get serial number from microphone, omit) calibration date (from sticker).

4. Windscreen-used or not used-if measurements are taken both ways; place an asterisk (*) in front of the "used" block and in the appropriate dB (A) or dB(C) block of "sound level data."

5. Measurements obtained indoors or outdoors if both, place a cross (+) after outdoors and in the appropriate location block of "sound level data."

6. Description of areas/duties.

    a. Building number.

    b. Map of area/building.

        (1) ID location of measurements.

        (2) 85 DB(A) or 140 dB(P) contours, if appropriate.

        (3) ID location of sound sources.

        (4) Location of warning signs.

    c. Performance conditions of equipment.

        (1) RPM.

        (2) Load.

7. Primary noise source--loudest.

8. Secondary noise source--any other source of noise, hazardous or not.

9. Sound level data.

   a. Location--specific equipment and/or worker location relative to the sound source, you may reference the map.

   b. Meter action--"S" slow, "F" fast.

   c. DB(C)--optional.

   d. dB(A)--required except for impulse noise.

   e. Risk assessment code--as appropriate.

10. Protection required--place a check mark in column that corresponds to appropriate dB(A) level.

11. Remarks.

    a. Type(s) of ear protection in use.

    b. Posting of signs, decals.

    c. Other deficiencies noted at time of survey.

12. More detailed evaluation requires yes or no. If yes, identify type required.

13. Persons identified for audiometric monitoring.

    a. List by name all those persons exposed to sound levels above the standards.

    b. Identify those persons not previously given audiometric testing.

14. Name, phone, and organization of supervisor of noise hazardous area--first line supervisor.

15. Survey performed by--name and signature.

16. Hearing conservation monitor--usually Pvnt Med officer of audiologist, name and signature.

Page___of___

PRELIMINARY INDUSTRIAL HYGIENE SURVEY FORM

Date _________ Installation/Directorate____________________Surveyed by______

Location Bldg/Rm	Operation/Exposure	# Exp	# Hrs	Controls/ Comments	OK

END OF APPENDIX H

APPENDIX I

INDUSTRIAL HYGIENE FIELD NOTES

LOCATION: Directorate, Branch, Building Number, Bay, Room, and so forth.

OPERATION IDENTITY

TYPE OF OPERATION:
SPACE: Describe room, Size in 3D, Operations isolated or not, and so forth.

PROCEDURES: How done, Continuous, Intermittent, Permanent, Temporary, and so forth

---

PERSONNEL: No. of operators, helpers, others, male-female, and so forth.

EXPOSURE AGENTS: Identify, explain source, no. of units, physical form, how produced, at what temp, and so forth.

PERSONNEL: Who, where, when, how many, how long.

MODE: Explain how exposure occurs, atmospheric contamination, direct contact, ingestion, and so forth.

SAMPLING: What test made or samples collected, how many, where taken, when, how long, conditions, instruments used, results, TLV or OSHA standard.

REMARKS: Trade name data, if no sample-why, adverse health effect experienced or reported, by whom.

ENGINEERING CONTROLS: Ventilation natural, mechanical, general, local exhaust and supply-rates, enclosed, remote control, and so forth.

PERSONAL PROTECTION: Measures and equipment-effectiveness, maintenance, supervision, and so forth.

OTHER: Wet method for dust, limited quantities, medical control, and so forth.

INADEQUACY: ____

RECOMMENDATION:____

END OF APPENDIX I

APPENDIX J

EXAMPLE OF AN EVALUATION OF POTENTIAL HEALTH HAZARDS

Industrial Hygiene Survey--Motor Pool

AFZZ-DEH-T 14 July 200X

MEMORANDUM TO: C, Transportation Division.

1. References: AR 40-5; TB MED 251; Title 29 Code of Federal Regulations Part 1910; DF, AFZZ-DEH-T, Directorate of Industrial Operations, dated 30 June 1992, subject: Request for Survey.

2. Purpose: The purpose of this survey was to evaluate the transportation motor pool for the presence of actual or potential health hazards, and provide recommendation for their control or elimination.

3. General: This survey was performed by SP5 Ernie Staph, of the Preventive Medicine Division on 2 July 1992. He contacted Mr. Mack Truck, C, Transportation Div, and briefed him on findings and recommendations. Equipment used during the survey was a General Radio Sound Level Meter,
SN: 4732, calibrated 2 Apr 1992 and an Anemotherm air velocity meter, SN: 21, calibrated 1 Feb 92.

4. Findings and Discussion: Areas surveyed and comments are listed below:

a. Grinding--five grinders are used in the shops, but protective goggles were available on only three.

b. Engine tuning.

(1) In Building 743, no powered exhaust ventilation was present, but tight fitting flexible tubing was being used and vented outside. This is adequate.

(2) In Building744, a powered exhaust system was present, but exhaust volume was only 100-cfm (cubic feet per minute) per outlet. Since M-35A2 multi-fuel trucks were the largest vehicles maintained, at least 168 cfm is required to control exhaust emissions.

c. Solvent and carburetor cleaning--covered solvent tanks were used for solvent cleaning and Stoddard Solvent was used as a solvent. Speedclene was the carburetor cleaner and it was also in a covered tank. Gloves and washing facilities were available.

d. Spray painting--Touch-up painting was done in Building 742 by one man, about 2 hours per day. He had three spray paint respirators, BM 23B-19, and all were coated with paint on the inside and had missing or hardened seals. The paint booth was not operating due to a broken fan. This poses a significant hazard to the health of the painter. Unless 75 fpm (feet per minute) of airflow is maintained in the booth, an airline respirator with suitable air supply is required. Even with the airflow, a new respirator with suitable air supply is required. Even with the airflow, new respirators must be procured.

e. Welding--Arc an oxyacetylene welding was performed in the motor pool and necessary protective equipment was present.

f. Noise--Several exposures to excessive noise (90 dB(A) during engine tuning) were observed. No protection was used and no hearing tests were being done on the personnel.

5. Recommendations: The following recommendations are made to eliminate hazards found during this survey:

a. Provide goggles for the two grinders in Building 743.

b. Increase airflow in the powered exhaust system for Building 744 to the required 168 cfm at each outlet.

c. Repair the paint booth fan to provide 75 fpm of airflow through the booth. Procure new paint spray respirators, NSN 4240-00-022-2524, and maintain them properly. In the interim, spray outside or with the painter wearing an approved air line respirator.

d. Enroll personnel in the post hearing conservation program and require the use of either earplugs or earmuffs while tuning M 35-A2 trucks.

6. Any further assistance may be obtained by contacting this office at 221-2646.

FOR THE CHIEF, PREVENTIVE MEDICINE DIVISION:

JOHN SNIFFER
2LT, MSC
SANITARY ENGINEER

END OF APPENDIX J

APPENDIX K

INSTRUCTIONS FOR COMPLETING AEHA FORM 8-R, BULK SAMPLE DATA

1. Return address. Self-explanatory.

2. Point of contact. Name and telephone number/DSN of person in charge of sampling/project.

3. Sampled installation. Self-explanatory.

4. Project number. For USAEHA and DSA use only.

5. ARLOC. Army location code - reference DA Pams 525-12 (CONUS) and 525-13 (Foreign).

6. Samples collected by. Self-explanatory.

7. Data collected. Self-explanatory.

8. Date shipped. Date samples sent for analysis.

9. Description of operation. Brief description of the industrial operation (for example: degreasing metal parts, spray painting vehicles, and so forth).

10. Location (building/area). Self-explanatory.

11. Associated complaints. Worker complaints about exposure problems arising from operation (for example: dizziness, nausea, skin irritation, and so forth).

12. Associated air samples. If air samples corresponding to these bulks are submitted for analysis, indicate and list the sample numbers that identify these air samples. Ship air samples separately from bulk samples.

13. Label information.

    a. Trade name. Self-explanatory; if unknown, so indicate.

    b. NSN. If available, so indicate.

    c. Manufacturer. Self-explanatory; if unknown, so indicate.

    d. Address. Self-explanatory; if unknown, so indicate.

    e. MSDS. Attach the MSDS, whenever possible, and so indicate.

14. Analysis desired. List specific parameters when they are known or suspected to be present otherwise, indicate general type of analysis desired (for example: unknown solvents, and so forth).

15. Lab use only. Leave blank.

16. Sample number. Number that field personnel assigns to the sample number. Use a consecutive numbering system so there is no duplication of numbers from batch-to batch of samples.

17. Constituents. Leave blank.

18. Results. Leave blank.

19. Remarks. Leave blank.

20. Comments to lab. Use for any general information or remarks you wish to include.

21. Lab use only. Leave blank.

BULK SAMPLE DATA

For use of this form see USAEHA TG 141; the proponent is ESHB-LO.

Return Address *(complete address including Zip Code)*	Point of Contact *(name/AUTOVON)*

Sampled Installation	Project Number	ARLOC
Samples Collected By	Date Collected	Date Shipped

Description of Operation	Location *(BLDG/AREA)*

Associated Complaints *(be specific)*

Associated Air Samples ☐ Yes ☐ No — If yes, list sample numbers

Label Information

Trade Name	NSN	Manufacturer

Address	MSDS Attached ☐ Yes ☐ No

Analysis Desired

Lab Use Only	Sample No.	Constituents	Results	Remarks

Comments to Lab:

Lab Use Only

Analyst *(initials)*	Reviewed By *(initials)*	Date Received	Date Reported

Procedures Performed	Comments:

AEHA Form 8-R, 1 Oct 84

Replaces AEHA Form 8, 1 Oct 80 which is obsolete

Return Address *(complete address including Zip Code)*			Point of Contact *(name/AUTOVON)*
			Associated Bulk Samples ☐ Yes ☐ No Bulk Sample No(s):
Samples Collected By	Date Collected	Date Shipped	
Project Number	Sampled Installation		ARLOC
Location *(BLDG/AREA)*	Description of Operation *(details on reverse)*		
☐ Persons Exposed ☐ Hrs/Day	Method of Collection		
Associated Complaints *(be specific) (state NONE if applicable)*			
Analysis Desired			

Sampling Data

Sample No.								
Pump No.								B
Time On								
Time Off								L
Total Time (min)								
Flow Rate (LPM)								A
Volume (Liters)								N
GA/BZ								
Employee Name/ID								K
Laboratory No.								

Results

Comments to Lab:

Lab Use Only

Analyst *(initials)*	Reviewed By *(initials)*	Date Received	Date Dispatched

AEHA Form 9-R, 1 Oct 84

Replaces AEHA Form 9, 1 Oct 80 which is obsolete.

Calibration information				
Pump No.	Calibration (L/min) Pre-Use	Calibration (L/min) Post-Use	Rotometer Setting	Date
			Name of Calibrator	

Operation

Source of Contaminant:

Operation Employee(s) Perform:

Ventilation: ☐ Local Exhaust ☐ General Area ☐ None

Personal Protective Equipment *(check if worn)*

☐ Respiratory Protective Equipment Type: ____________________

☐ Protective Clothing Type: ____________________

☐ Gloves Type: ____________________

☐ Goggles/Face Shield

☐ Ear Protection

☐ Other: ____________________

Field Notes/Additional Comments

END OF APPENDIX K

COMMENT SHEET

SUBCOURSE MD0165 Occupational Health And Industrial Hygiene EDITION 100

Your comments about this subcourse are valuable and aid the writers in refining the subcourse and making it more usable. Please enter your comments in the space provided. ENCLOSE THIS FORM (OR A COPY) WITH YOUR ANSWER SHEET **ONLY** IF YOU HAVE COMMENTS ABOUT THIS SUBCOURSE..

FOR A WRITTEN REPLY, WRITE A SEPARATE LETTER AND INCLUDE SOCIAL SECURITY NUMBER, RETURN ADDRESS (and e-mail address, if possible), SUBCOURSE NUMBER AND EDITION, AND PARAGRAPH/EXERCISE/EXAMINATION ITEM NUMBER.

PLEASE COMPLETE THE FOLLOWING ITEMS:

(Use the reverse side of this sheet, if necessary.)

1. List any terms that were not defined properly.

2. List any errors.

   paragraph error correction

3. List any suggestions you have to improve this subcourse.

4. Student Information (optional)

Name/Rank
SSN
Address

E-mail Address
Telephone number (DSN)
MOS/AOC

PRIVACY ACT STATEMENT (AUTHORITY: 10USC3012(B) AND (G))

PURPOSE: To provide Army Correspondence Course Program students a means to submit inquiries and comments.

USES: To locate and make necessary change to student records.

DISCLOSURE: **VOLUNTARY.** Failure to submit SSN will prevent subcourse authors at service school from accessing student records and responding to inquiries requiring such follow-ups.