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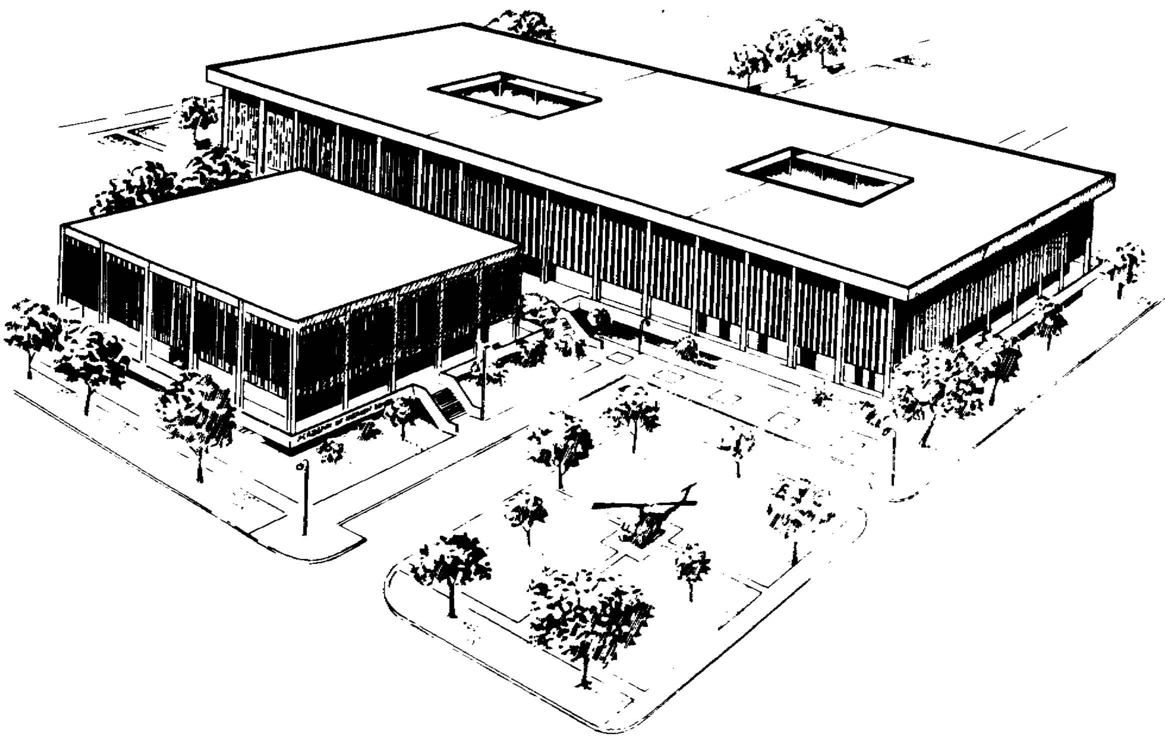

PESTICIDES IN THE MILITARY

SUBCOURSE MD0173 EDITION 100

DEVELOPMENT

This subcourse is approved for resident and correspondence course instruction. It reflects the current thought of the Academy of Health Sciences and conforms to printed Department of the Army doctrine as closely as currently possible. Development and progress render such doctrine continuously subject to change.

When used in this publication, words such as "he," "him," "his," and "men" 'are intended to include both the masculine and feminine genders, unless specifically stated otherwise or when obvious in context.

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ADMINISTRATION

Students who desire credit hours for this correspondence subcourse must meet eligibility requirements and must enroll through the Nonresident Instruction Branch of the U.S. Army Medical Department Center and School (AMEDDC&S).

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

SUBCOURSE MD0173

PESTICIDES IN THE MILITARY

INTRODUCTION

Pesticides are nothing new. Various pesticides, such as lead arsenate, nicotine compounds, and others, have been in use for years. It is even thought that Marco Polo brought pyrethrum, the active ingredient in most aerosol insecticides, back to Europe after his trip to the Orient. The widespread use of synthetic pesticides, however, did not occur until after World War II. DDT, whose insecticidal properties were first recognized in 1939, was used by U.S. military forces during the war with great success. For the first time in our military history, the individual carried an effective delousing agent with him as a normal part of his paraphernalia. DDT also played an important role in the postwar civil affairs program, as our occupation forces assisted in the rehabilitation of devastated areas.

Today the Army possesses a formidable array of pesticides, most of which are synthetic (man-made). The pesticides available for use by the environmental health technician include compounds having a wide range of toxicity, some being lethal to man in milligram dosages while others may be tolerated in moderate amounts without fatal results. The wide variety of toxic agents available offers considerable selectivity in choosing a pesticide which will achieve the desired result against a target pest while having only limited effects against beneficial insects or other animal life.

In order to intelligently and effectively employ the pesticides available, environmental health technicians and engineer personnel must understand the principles of toxicology and know the toxicity of the various pesticides. They must also know the classes of pesticides and the proper use of each. In addition, they should know how to calculate and mix pesticide formulations and be familiar with the various means of dispersal. Finally, they should be aware of the necessary safety precautions in the use of military pesticides. It is the objective of this subcourse to provide the necessary competence in these areas.

Subcourse Components:

This subcourse consists of four lessons and an examination. The lessons are:

Lesson 1, Introduction to Pesticides.

Lesson 2, Pesticide Mixing and Calculations.

Lesson 3, Pesticide Safety.

Lesson 4, Hazard Communication Program.

Credit Awarded:

Upon successful completion of this subcourse, you will be awarded 8 credit hours.

Materials Furnished:

Materials provided include this booklet, an examination answer sheet, and an envelope. Answer sheets are not provided for individual lessons in this subcourse because you are to grade your own lessons. Exercises and solutions for all lessons are contained in this booklet. *You must furnish a #2 pencil*.

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 AMEDDC&S, along with the Student Comment Sheet, in the envelope provided. *Be sure that your social security number is on all correspondence sent to the AMEDDC&S*. 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, which 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 and mail it to the AMEDDC&S for grading.

Student Comment Sheet:

Be sure to provide us with your suggestions and criticisms by filling out the Student Comment Sheet (found at the back of this booklet) and returning it to us with your examination answer sheet. Please review this comment sheet before studying this subcourse. In this way, you will help us to improve the quality of this subcourse.

LESSON ASSIGNMENT

LESSON 1 Introduction to Pesticides.

LESSON ASSIGNMENT Paragraphs 1-1--1-15.

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

1-1. Identify the categories of pesticides used by the Army.

1-2. Identify the means by which insecticides enter the bodies and act upon arthropods.

1-3. Classify pesticides according to their chemical composition and approved usage.

1-4. Apply the terms LD_{50} and LC_{50} in determining relative pesticide toxicity.

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

Section I. GENERAL

1-1. CATEGORIES OF PESTICIDES

Pesticides are chemicals that are used to kill unwanted insects, animals, or plants. Categories of pesticides used in the Army include the following.

a. **Insecticides.** Insecticides are chemicals used to kill insects or other closely related arthropods, such as spiders, ticks, mites, and scorpions.

b. **Rodenticides.** Rodenticides are used primarily against rats and mice, but their intended targets may also include such animals as gophers, rabbits, squirrels, and other small rodents.

c. **Fungicides.** Fungicides are chemicals used to kill or prevent the growth of fungi.

d. **Herbicides.** Herbicides are chemicals used in controlling weeds or unwanted vegetation.

1-2. STANDARD MILITARY PESTICIDES

a. The pesticides standardized for military issue have been carefully selected to provide a minimum number of items with maximum military application and safety. These items, if used as recommended, should provide satisfactory control of pests of military importance. Standard pesticides are reviewed, updated, and approved periodically by the Armed Forces Pest Management Board.

b. Pesticides are considered controlled items. Approval from higher headquarters is required for their procurement. Because of their toxicity and/or concentration, they may be applied only by, or under the direct supervision of, trained and certified personnel. Such personnel are normally assigned to an installation directorate of facilities engineering, a regional division of the U.S. Center for Health Promotion and Preventive Medicine (USACHPPM), or a preventive medicine detachment.

1-3. NONSTANDARD PESTICIDES

Situations may arise in which the staff pest management professional determines that a nonstandard pesticide is required for a special program. When a nonstandard time is required, the using unit must submit a request for local purchase to its approving headquarters. The request will provide full justification of the need for the nonstandard item. Pesticides discussed in this text that are nonstandard will be so identified.

1-4. TOXICITY

All pesticides must be considered potentially toxic (poisonous) to man and animals. However, the degree of toxicity is only one of several factors in the use of pesticides that determine the hazard to man. The primary hazard lies in failure to follow the precautions and directions for use indicated on the pesticide label. Safe handling of pesticides is discussed in Lesson 3; however, measurement of toxicity will be explained at this point since these terms will be used throughout the discussion of pesticides.

a. **LD_{50} Value.**

(1) The LD_{50} (lethal dosage) value of a pesticide -- or any other toxic substance -- is a statistical estimate of the dosage necessary to kill 50 percent of a population of test animals (usually white rats) with a single exposure under standardized conditions in the laboratory. It is expressed in milligrams of poison per kilogram of body weight (mg/kg) for rodents or micrograms per gram (mg/gm) for insects. The LD_{50} values do not take into account the physical condition of laboratory animals, nor do they provide data on the cumulative effects of repeated dosages; however, they do enable us to compare the relative acute toxicities of various pesticides. The higher the LD_{50} value, the lower the toxicity since more poison is required to affect a death. Thus, a pesticide with an LD_{50} value of 500 mg/kg is more toxic than one with an LD_{50} value of 1,000 mg/kg.

(2) Toxicity is expressed as an oral or dermal LD_{50} value, which varies depending on whether the poison is taken orally (by mouth) or dermally (absorbed through the skin). Most pesticides have a considerably higher dermal than oral LD_{50}. Unless otherwise specified, LD_{50} values quoted in this subcourse are oral values. In considering LD_{50} values, it must be remembered that these values have been determined from experimental data on laboratory animals; therefore, they cannot be considered exact values nor can they be directly transferred as effects on man.

(3) Various toxicologists have devised tables of relative toxicities based upon the LD_{50} derived from test animals and extrapolated (estimated corresponding effect) to humans. These tables usually begin with an LD_{50} of more than 5000 mg/kg (over a quart for a 150-pound man) as relatively harmless or practically nontoxic. Most tables rate a chemical having an LD_{50} of less than 50 mg/kg as highly toxic, 50 to 500 mg/kg as moderately toxic, 500 to 5000 mg/kg as slightly toxic, and greater than 5000 mg/kg as practically nontoxic.

b. **LC_{50} Value.** The LC_{50} (lethal concentration) value of a poison is the concentration in parts per million (ppm) of the poison applied to the environment required to kill 50 percent of a test population (fish, mosquito larvae, etc.) from a single exposure under standardized conditions. Like the LD_{50} value, a high LC_{50} value indicates low toxicity and vice versa. It should be emphasized here that LD_{50} and LC_{50} values cannot be compared to one another since they are derived from two different sets of test conditions. Like LD_{50} values, LC_{50} values are approximate values obtained on the basis of laboratory tests.

Section II. INSECTICIDES

1-5. CLASSIFICATION ACCORDING TO MODE OF ENTRY

There are three types of insecticides when classified according to the mode of entry into the insect's (arthropod's) body.

a. **Oral.** Oral poisons must be swallowed in order to kill the insect. They are used against insects with chewing, sponging, or lapping mouthparts. These insecticides are usually applied in the form of dusts or sprays to vegetation or other natural foods eaten by the target insect. The insect consumes the insecticide when it eats the foliage or when it cleans appendages to which the insecticide has adhered through contact with treated surfaces. Stomach poisons may also be mixed with baits that are more attractive to the insects than natural foods. A satisfactory stomach poison must be quick acting, inexpensive, and available in large quantities. It must be palatable to the target insects, or they will avoid it. The insecticides used as stomach poisons are chiefly the inorganic chemicals (para 1-6a) and some of the chlorinated hydrocarbons (para 1-6c(1)).

b. **Dermal.** Dermal poisons kill insects by contacting and entering the body either directly through the body wall and into the blood, through the mouthparts and into the digestive system, or through the respiratory system. These insecticides are used primarily against insects with sucking mouthparts, which would not eat normally applied stomach poisons. However, they are also effective as stomach poisons if eaten by insects with chewing mouthparts. Contact poisons may be applied directly to insects' bodies as sprays or dusts, or they may be applied for residual action on surfaces with which the target insects will come in contact. Contact insecticides in common use include the natural organic (para 1-6b) as well as the synthetic organic (para 1-6c) compounds.

c. **Respiratory.** Respiratory chemicals are volatile chemicals that kill by entering a pest through the respiratory system. They are used in gaseous form or as solids or liquids which rapidly vaporize forming poisonous gases. They are particularly appropriate for killing insects in stored products where the gas will penetrate cracks, crevices, and tightly packed material. They are extremely toxic to all animal life; therefore, they are also effective as rodenticides. Their extreme toxicity makes fumigants particularly hazardous to use; accordingly, their use is restricted to trained and certified personnel. They are discussed in Section IV.

1-6. CLASSIFICATION ACCORDING TO CHEMICAL COMPOSITION

Because some insecticides may fall into several categories when classified according to mode of entry (many, for example, are both stomach poisons and contact poisons), it is more convenient to classify them according to their chemical composition. While differences exist between insecticides within a category, each category has characteristics that are applicable, in general terms, to the insecticides in that group.

a. **Inorganic Insecticides.** Inorganics do not contain carbon, and they often contain metals or other chemical elements. Most are stomach poisons. Examples include boric acid, borate, silica aerogel, and sulfur. Others no longer used include copper acetoarcinate, lead arsenate, mercury, and zinc phosphide.

b. **Natural Organic Insecticides.** Natural organic insecticides are derivatives or refined forms of organic compounds occurring naturally. They may be botanicals (from plants) or products from petroleum and coal tar.

(1) Botanicals.

(a) Pyrethrum. Pyrethrum is the term applied to the insecticidal compounds of the flower heads of Chrysanthemum (Pyrethrum) cinerariaefolium. Four separate compounds are included, of which Pyrethrum I is the most active. Commercial pyrethrum extract is a yellow, oily liquid insoluble in water but soluble in a number of common organic solvents. Pyrethrum is a powerful contact insecticide causing a rapid paralysis or "knockdown" of the treated insects. Its efficiency is increased by the use of a synergist such as piperonyl butoxide. Pyrethrum is effective as a direct contact spray against adult flies, mosquitoes, and other flying household insect. It lacks persistence, having virtually no residual action. Many insects recover after an initial attack. Pyrethrum is one of the least toxic insecticides to mammals, having an LD_{50} value on the order of 1,500 mg/kg. It breaks down rapidly, posing no environmental hazard.

NOTE: A synergist is a compound which, when added to an insecticide, will increase the insecticidal toxicity so that the amount of insecticide needed can be decreased. Many synergists, such as piperonyl butoxide, MGK 264, sulfoxide, and sesamin are used in fly and mosquito control, particularly in aerosol bombs and space sprays.

(b) Nicotine. Nicotine, an alkaloid contained in the tobacco plant, is obtained from the wastes of the cigar and cigarette manufacturing industries. It is a dark, viscous liquid that has been used for years as a contact insecticide against soft-bodied sucking insects. It is highly toxic to most insects, but it is volatile and, therefore, nonpersistent. It is used as contact spray against sucking insects such as thrips, aphids, mealy bugs, and scale on vegetation. It is one of the most deadly and rapidly acting poisons known for higher animals by inhalation or dermal application, especially through the tongue or eye. Nicotine sulfate, one of the most common formulations, has an LD_{50} value of 83 mg/kg. Nicotine is not a standard military item.

(2) Petroleum and coal tar derivatives.

(a) Kerosene. Kerosene is used primarily as a solvent for insecticides, but kerosene itself has considerable insecticidal effect. A refined, odorless form is normally used as the carrier in household sprays. It has been used as a mosquito larvacide. Kerosene is generally quite toxic to plants and can be dangerous to man if not properly handled. Ordinary and deodorized kerosene are available from military standard stock.

(b) Fuel oils. Fuel oils (diesel oils) have been used extensively as mosquito larvicides. No. 2 diesel is the material generally used, often mixed with a spreading agent. The unmixed oil is a standard solvent for outdoor space sprays. It is available from military standard stocks.

(c) Summer oils. Summer oils are distillation fractions higher than kerosene which are employed in water emulsion on orchards and shade trees for control of mites and scale insects. The summer oils are employed against these pests when the plants are in foliage.

(d) Dormant oils. Dormant oils are more highly sulfonated petroleum oils than are summer oils and are used against the same pests, but they can only be used safely when trees are dormant. They affect primarily the egg stage and also work well on the crawler stage of scale insects. Neither summer nor dormant oils are standard stock items.

c. **Synthetic Organic Insecticides.** The synthetic organic insecticides are relatively new compounds. The first synthetic organic insecticide -- DDT -- was synthesized in 1874, and its insecticidal properties were first recognized in 1939. During World War II, research in nerve gases led to the discovery of additional compounds that are effective insecticides.

(1) Chlorinated hydrocarbons. The chlorinated hydrocarbons are characterized by having a long residual of toxic material in the environment. They vary widely in their toxicity -- from aldrin and dieldrin, which are highly toxic, to methoxychlor, which has relatively low toxicity. The chlorinated hydrocarbons act upon the central nervous system, causing death through respiratory failure. Changes in recent years pertaining to pesticide legislation and registration have resulted in the cancellation or suspension of use for all of the chlorinated hydrocarbons.

(2) Organophosphates. The organophosphates insecticides are generally more toxic to animals than are the chlorinated hydrocarbons. However, the organophosphates do not leave highly persistent residues on the treated plants and animals and are less likely to accumulate in animal tissues. The physiological action of the organophosphates is the inhibition of the production of cholinesterase, an enzyme essential to the proper functioning of the central nervous system. Cholinesterase

insufficiency causes spasm of the involuntary muscles, resulting in respiratory failure and death.

(a) Malathion. Malathion is a yellow to dark-brown liquid that is only slightly soluble in water and of limited solubility in petroleum solvents, but which can be readily mixed with most organic solvents. It is a broad-spectrum insecticide, being effective against a wide range of pests including houseflies, cockroaches, and mosquitoes, many of which are resistant to chlorinated hydrocarbons. It has also been recommended for control of vegetation pests, sand flies, bedbugs, fleas, ticks, and stored product pests. Malathion is not as long lasting as the chlorinated hydrocarbons, but it is used as a residual insecticide. It is not toxic to plants at concentrations normally used on vegetation, but it will damage ornamentals at concentrations used to control flies. Because of its low toxicity to mammals (LD_{50} 1,000-1,375 mg/kg), malathion has become one of the most commonly used insecticides. An objection to malathion for household use is its disagreeable odor.

(b) Diazinon. Diazinon is a pale to dark brown liquid that is readily soluble or miscible in most organic solvents. It is much more toxic to both insects and animals (LD_{50} 76-108 mg/kg) than is malathion, but it is diluted to much lower concentrations. Diazinon is the insecticide of choice for controlling many household insects, particularly German cockroaches. It is also used extensively for fly control as a residual spray, in sugar-bait formulations, and for impregnating fly cords. Diazinon has a somewhat longer residual effect than malathion, but at strengths of equal effectiveness, malathion is preferred for routine military use because of its lower mammalian toxicity. Diazinon is preferred over malathion in areas frequented by people, because of the offensive odor of malathion.

(c) Dichlorvos. Dichlorvos (also known commercially as DDVP or Vapona) is a relatively new insecticide that has a short residual life, but is remarkable because of its high volatility. It gives off vapors slowly from impregnated resin strips and is effective as a space insecticide. It is also added to dry and liquid fly baits to add quick knockdown and its toxic vapor aids in "clean out" applications on hard-to-reach infestations of cockroaches and dog ticks. It is more toxic than diazinon, having an oral LD_{50} value of 56-80 mg/kg and a dermal LD_{50} value of 75-107 mg/kg.

(d) Naled. Naled (Dibrom) is an organophosphate insecticide that is closely related chemically to dichlorvos. It is a contact and stomach poison with a limited amount of vapor toxicity. The principle military use of naled is as a fog for adult mosquitoes and flies. It is also effective, in a commercial form, as a bait or spot treatment for flies. The LD_{50} value of naled is 250 mg/kg.

(e) Chlorpyrifos. Chlorpyrifos (Dursban) is used in the military primarily for control of mosquito larvae and cockroaches. It also offers good control of turf pests such as chinch bugs and sod webworms. It has an LD_{50} value of 135-163 mg/kg and may be irritating to the eyes.

(3) Carbamates. The carbamates are organic sulfur compounds. They are esters of carbamic acid. They are similar to the organophosphate insecticides in their physiological action, being inhibitors of the enzyme cholinesterase. In general, they have a shorter residual effect than the organophosphates. As insects continue to develop resistance to the chlorinated hydrocarbons and the organophosphates, this group of chemicals will play a role of ever-increasing importance in chemical pest control.

(a) Carbaryl. Carbaryl (Sevin) is a moderately toxic (LD_{50} 500-850 mg/kg) insecticide which offers good control of mites, ticks, and fleas. It is highly toxic to bees and should be used with care if they might come in contact with it.

(b) Propoxur. Propoxur (Baygon) is considerably more toxic than carbaryl; therefore, most military formulations contain only 1 or 2 percent. It is particularly effective against German cockroaches resistant to diazinon. It is also effective against ants, spiders, and many other household pests.

(c) Bendiocarb. Bendiocarb (Ficam) is a moderately toxic (LD_{50} 143 mg/kg) insecticide which is effective against cockroaches, crickets, fleas, ticks, ants, bedbugs, and other pests. This product is odorless and is registered for use in hospitals.

d. **Toxicities of Insecticides.** Table 1-1 summarizes the toxicities of the most common insecticides. In interpreting this table, the following must be kept in mind.

(1) The data are not the result of laboratory tests and are subject to wide variations. They cannot be considered exact figures, but only relative values for purposes of comparison.

(2) The test data were obtained from small animals (chiefly white rats) and cannot, therefore, be directly applied to humans.

1-7. REPELLENTS

a. **General.** Repellents are chemical compounds used as liquids, creams, aerosols, or solids to prevent biting or other annoyance by insects or other animal life. Personal protection from the bites of mosquitoes, biting flies, fleas, ticks, chiggers, leeches, and other pests may be obtained by the application of repellents to the skin and/or the clothing.

b. **Use of Repellents.** As one of several ways the individual may protect himself in the absence of other pest control operations, the timely use of insect repellents is extremely important. Frequently, when the threat of disease transmission is the greatest, only individual protective measures are available.

INSECTICIDE	ORAL LD_{50} (mg/kg)	DERMAL LD_{50} (mg/kg)
<u>Inorganics</u>		
Lead Arsenic (N/S)	1,050	2,400
<u>Botanicals</u>		
Nicotine Sulfate (N/S)	83	285
Pyrethrum	1,500	1,880
Rotenone (N/S)	50 -- 75	940
<u>Chlorinated Hydrocarbons</u>		
Chlordane	335 -- 430	840 -- 690
Lindane	88 -- 91	1,000 -- 900
<u>Organophosphates</u>		
Chlorpyrifos	150	N/A
Diazinon	108 -- 76	900 -- 455
Dichlorvos	80 -- 56	107 -- 75
Malathion	1,375 -- 1,000	4,444
Naled	250	800
<u>Carbamates</u>		
Carbaryl	100	N/A
Propoxur	850 -- 500	4,000
Bendiocarb	143	N/A
<u>Other Synthetics</u>		
Allethrin (N/S)	680	N/A

NOTES: Where two values are given, the first is for males and the second is for females (test animals).
N/A denotes test data not available.
N/S denotes nonstandard.

Table 1-1. Toxicities of common insecticides.

c. **Types of Repellents.** Some repellents are more effective for some uses than are others. There are several formulations in the military supply system.

(1) <u>Personal use or skin application</u>. Repellents for personal use are applied directly to the skin. Usually, 2.5 ml of the cream rubbed between the hands and spread evenly over the face, neck, hands, and other exposed skin areas offers protection for up to 12 hours, depending upon the pest species concerned. Additional repellent may be spread on the clothing at the shoulders and other areas where the cloth fits tightly against the body. Be careful to keep the chemical out of the eyes. The chemical is lost from the skin by abrasion, absorption, and evaporation. The effectiveness of the material is lost more rapidly (6 hours) in hot, humid climates where profuse sweating occurs. Repellents that are recommended for application on the skin may also be applied by hand or by sprayer to the outside of the clothing, if desired. However, several special items have been developed for impregnation of clothing to either repel or kill mites, insects, and other pests. The repellent for personal use is DEET (30% N, N-diethyl-m-toluamide), which provides protection against all types of mosquitoes, other biting flies, and fleas. It is relatively effective against ticks and chiggers.

(2) <u>Clothing application</u>. Permethrin formulations are designed so that clothing, bednets, tents, and tent liners can be dipped or sprayed with a solution of the repellent chemical. A desired quality of these formulations is that treated materials be able to withstand laundering or wetting without losing its repellent properties. The principal requirement for a clothing treatment chemical for military use is the protection of troops against chiggers, ticks, and leeches in many areas of the world. Detailed directions for use of these materials vary with the specific item and with the type of clothing being treated. Instructions issued by the local command surgeon should be followed.

Section III. RODENTICIDES

1-8. GENERAL

Poisoning of rodents at military installations is normally undertaken with anticoagulants or zinc phosphides, both of which are standard rodenticides. Sodium monofluoroacetate, a restricted use rodenticide that requires approval of the Surgeon General for procurement and use, is a nonstandard item for emergency use. The standard rodenticides provide adequate rodent control under a wide range of conditions. Nonstandard items should be used only when standard items fail or are not available.

1-9. ANTICOAGULANTS

These rodenticides are chemicals that cause internal bleeding by reducing the clotting ability of the blood. Since all warm-blooded animals are affected in this manner, precautions should be taken to prevent humans, domestic animals, and pets from eating baits containing anticoagulants. These chemicals are stable and are odorless and tasteless to rodents in the concentrations used. A single feeding on bait containing an anticoagulant at the recommended concentration is not sufficient to cause death. Food baits or water solutions must be consumed over a period of several days before they become effective. Even when weakened, rats and mice do not associate their loss of strength with their food supply. This means that the problem of bait shyness commonly associated with "one-shot" poisons is largely overcome. Maximum kill is generally achieved between the fourth and ninth nights that poisoned bait is consumed by the rodent. Continuous baiting for two weeks (or longer) is often required to obtain satisfactory control. To control house mouse populations, continuous baiting for a month or more may be necessary because of the nibbling habits of mice. Bait should be placed in a bait station or in a place that offers the rodent a protected feeding place and protects the bait from domestic animals and the weather. Spoiling of the bait material will, of course, depend on the type of food used and on climatic conditions. Dry cereal baits remain in good condition much longer than meat or vegetable baits and are, therefore, the foods of choice for use with anticoagulants. Baits should be replenished before they are completely eaten to prevent the rodents from abandoning the feeding stations and to prevent infestation by stored products pests. Anticoagulants are provided in two formulations -- a prepared material, ready for use, and concentrated for use in the preparation of food baits or water solutions. The active ingredient may be one of the following chemicals: Diphacinone, Warfarin, Fumarin, Pival, or PMP.

a. **Rodenticide, Anticoagulant, Ready Mixed.** This formulation is a ready-to-use bait containing an anticoagulant chemical, rolled oats, sugar, and mineral oil (to increase its acceptability). A red dye has been added to distinguish it from ordinary rolled oats. The item is used directly from its container without further mixing.

b. **Rodenticide, Anticoagulant, Universal Concentrate.** This item is a concentrate that can be mixed with food, bait, or water. It consists of a warm soluble anticoagulant chemical, sugar (to make water solutions more palatable), sodium benzoate (a preservative), and a complexing agent to hold the anticoagulant in solution. Glass, plastic, or paper water-holding containers may be used for dispensing. Poisoned water is especially effective where water is scarce. The use of poisoned water and poisoned baits simultaneously will increase the effectiveness of the control program.

1-10. ZINC PHOSPHIDE

Zinc phosphide is a highly poisonous black powder consisting of about 75 percent zinc phosphide and 25 percent antimony-potassium tartrate. The latter compound is an emetic that has been added to prevent accidental poisoning of humans and domestic animals. One feeding of poisoned bait containing 0.1 percent zinc phosphide is sufficient to kill a rodent. A single sublethal dose can cause bait shyness for baits containing this poison. Therefore, an acceptable food must be used as bait to achieve successful control. Although zinc phosphide has a disagreeable odor to humans, it is not repellent to rats and may even attract them.

Section IV. FUMIGANTS AND FUNGICIDES

1-11. GENERAL

Fumigants are poisons that are used in gaseous form to kill insects, rodents, and other pests via the respiratory tract. The use of fumigants is generally limited to enclosed spaces or tightly sealed containers. The gases used as fumigants penetrate cracks, crevices, and tightly packed materials, providing a fast, direct, and effective way of killing most stages of animal life. Because of their highly toxic nature, fumigants may be applied only by trained and certified personnel. Standard fumigants may be further classified according to their use as stored product fumigants, structural fumigants, and soil fumigants.

1-12. STORED PRODUCT FUMIGANTS

Aluminum phosphide (Phostoxin), upon exposure to atmospheric moisture, releases a gas known as hydrogen phosphide (PH_3) or phosphine. It has an odor like garlic and can penetrate even closely packed commodities. It is used for fumigation of stored products indoors or outdoors under polyethylene or vinyl-coated tarpaulins, which must be sealed to the floor or ground. It cannot be used with cloth or canvas tarpaulins. It is also effective for the treatment of stored products in sealed boxcars or hopper cars, whether static or rolling. Other military uses include the fumigation of raw agricultural commodities, with or without tarpaulins, and structural or space fumigation for pests of stored products and dry wood. Hydrogen phosphide gas can explode if under vacuum and must be used only under atmospheric conditions. It will leave treated material and the fumigated stack within one hour with normal ventilation procedures. Under specific atmospheric conditions involving moisture condensation on the item being fumigated, phosphine will corrode copper or products containing copper. For this reason, such items must <u>not</u> be placed in an area or covered in a manner that may induce condensation. In accordance with EPA label instructions, aluminum phosphide must not be used in such a manner as to allow the pellets, tablets, or unreacted residues (ash) to come in contact with any processed food. With this exception, PH_3 will not combine in any form to produce a food residue. Phosphine is highly toxic to all forms of human, insect, and other animal life. For this reason, application should be closely supervised by the engineer or medical entomologist. Personnel engaged in the application of this fumigant must be certified and specially trained. Aluminum phosphide is available in tablet or pellet form.

Section V. HERBICIDES

1-13. GENERAL

Herbicides are chemicals used to kill or control the growth of weeds. A weed may be defined as any noxious plant, that is, one whose presence is unwanted and which interferes with the growth of desirable plants. Therefore, the term is a relative one. Some plants that may be desirable in one place may be very noxious in others. Examples are Bermuda grass, Johnson grass, oak trees, persimmon trees, and many kinds of vines. Weed control is an Army Engineer Corps, rather than an Army Medical Corps, responsibility. Therefore, Army Medical Department interest in herbicides is confined primarily to the areas of toxicity and environmental impact.

1-14. CLASSIFICATION OF HERBICIDES

Herbicides may be classified as to their selectivity (principal use) or to their biological action.

a. **Classification According to Selectivity.**

(1) Selective herbicides. Selective herbicides kill certain weed species without seriously injuring the desirable plants among which they are growing. The reasons for selectivity in some combinations of weeds and desirable plants are known. Annuals (seed-bearing plants which mature in one season) growing among perennials (plants that live more than 2 years) can be killed by sprays from which the perennials can recover. The reasons for selectivity in other situations are not known. Certain herbicides kill broad-leaved weeds, others kill grasses, and some kill both.

(2) Nonselective herbicides. Nonselective herbicides kill vegetation with little discrimination. Some species of plants, however, escape. Some are resistant; some have roots that extend below the depth of chemical penetration; and some shallow-rooted plants reinfest after the chemical has leached below the surface layer.

b. **Classification According to Biological Action.**

(1) Contact herbicides. Contact herbicides kill tissues that are wetted with spray. Whether the plant dies or recovers depends upon whether it has a protected growing point. Perennials usually have underground buds that will regrow.

(2) Growth regulator herbicides. Growth regulator herbicides act like plant hormones. They are absorbed through the leaves, stems, or roots and are translocated through the vascular system to other parts of the plant. They accumulate mostly in areas of rapidly dividing cells, upsetting the normal metabolism of the plant and causing death of the cells.

(3) Soil herbicides. Soil herbicides are those that are applied to the soil, absorbed by the roots, and translocated to other parts of the plant.

(4) Soil-sterilant herbicides. Soil-sterilant herbicides make the soil incapable of supporting higher plant life; however, they do not necessarily kill all life, such as fungi, bacteria, and other microorganisms. Toxic effects may persist for only a short time or for years, depending upon the chemical, the soil, and the rate of application.

(5) Pre-emergence herbicides. Pre-emergence herbicides are those applied to the soil before the foliage of the weed appears above the soil surface. They may kill by contact or they may be translocated from the point of entry into roots, stems, or leaves. Some inhibit photosynthesis, while others effect growth processes such as cell division and elongation.

1-15. STANDARD MILITARY HERBICIDES

The standard herbicides on the military stock list are shown in Table 1-2. It should be noted that, although these pesticides are standard items, they may be procured and used only by trained, certified personnel. They are of concern to AMEDD agencies primarily from the standpoint of toxicity. Table 1-2 lists the standard herbicides on which data are available, showing the name, the type of growth for which used, principal mode of action, and toxicity of each chemical. Additional information on herbicides is contained in TM 5-629, Weed Control and Plant Growth Regulation. Although the dermal toxicities of the herbicides are low in general, many of them are irritating to the eyes, nose, throat, and skin. Herbicide labels, required on all herbicide containers, list the hazards of each chemical and warn operators or consumers to protect themselves from such hazards. Any person having occasion to handle a herbicide should, as with any other pesticide, carefully read the information on the label.

Continue with Exercises

Name	Used to Control	Use or Action[1]	LD_{50} (Mg/Kg)	Rating	Dermal Toxicity
Bromacil	Noncropland grass and broadleaf weeds	SS	5,200	Low	Moderate
Cacodylic Acid	General control of established weeds	C	830 -- 1,350	Moderate	Low
Dalapon	Annual grasses; cattail and rushes, pine and cedar	GR; S	3,860 -- 9,330	Low	Low
Dicamba	Noncropland grasses and broadleaf weeds; trees; some brush species	GR	1,040 -- 2,900	Moderate	
Diquat	Aquatic weeds	C; Aq	400 -- 500	High	500
Diuron	General vegetation	SS; P	3,400 -- 7,500	Moderate to low	Low
DSMA	Noncropland Johnson grass cocklebur; many annual grasses	C	1,800-- 2,800	Moderate	None
Monuron	General vegetation; oak	SS	3,600	Moderate	Low
Picloram	Noncropland annual, perennial broadleaf weeds; trees; woody plants	GR; SS	8,200	Low	4,000
Silvex	Annual and perennial broadleaf weeds, woody plants; some aquatics	GR	375 -- 1,200	Moderate	Low
Simazine	General nonselective weed control	P; S	5,000	Moderate	None
2,4-D	Annual and deep-rooted weeds; trees	GR	300 1,000	High to Moderate	Low
2,4,5-T	Annual and deep-rooted weeds; brush	GR	300 -- 500	High	Low

[1]Legend: C = contact; S = soil; GR = growth regulator; P = preemergence; S = soil
SS = soil sterilant

Table 1-2. Standard military herbicides and their characteristics.

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 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. Match the following:

a. Pesticide ____________	(1) Anticoagulant.
b. Insecticide __________	(2) Methyl alcohol.
c. Rodenticide _________	(3) Used to kill any undesirable organism.
d. Fumigant ___________	(4) Used to kill various arthropods.
e. Herbicide ___________	(5) Always found in gaseous form.
	(6) Used to kill unwanted plants.
	(7) Enters the pest through the respiratory system.
	(8) Only one in standard inventory.

2. Standard military pesticides are chemicals that may be:

   a. Procured and used by all military personnel.

   b. Procured through military supply channels.

   c. Purchased locally.

3. Controlled pesticides may be used only:

   a. In restricted areas.

   b. Against restricted types of pests.

   c. By or under the supervision of trained and certified personnel.

   d. Overseas, during emergency situations.

4. Which of the following pesticides is more toxic from the standpoint of absorption through the skin?

   a. Pyrethrum.

   b. Nicotine.

   c. Dichlorvos.

   d. Propoxur.

5. A pesticide having an LD_{50} of 300 mg per kg of body weight is considered to have _______________ toxicity.

   a. High.

   b. Low.

   c. Moderate.

6. Match the following:

a. Stomach poison __________	(1) Causes internal bleeding of target pests.
b. Contact poison __________	(2) Can enter through the body wall.
	(3) Must have a low LC_{50} value.
c. Anticoagulant ___________	
	(4) Must be eaten to be effective.

7. Classify the following standard insecticides by indicating in the space beside each the letter from the right hand column corresponding to the chemical type.

a.	Pyrethrum __________	(1)	Inorganic.
b.	Sulfur ___________	(2)	Natural organic.
c.	Naled ___________	(3)	Chlorinated hydrocarbon.
d.	Dichlorvos __________	(4)	Organophosphate.
e.	Boric acid ________	(5)	Carbamate.
f.	Nicotine __________		
g.	Dursban _____________		
h.	Baygon ______________		
i.	Carbaryl ______________		
j.	Malathion _____________		
k.	Chlordane _____________		
l.	Diazinon _______________		

8. The standard insect repellent for skin application is:

   a. BHC.

   b. DEET.

   c. DDT.

   d. None of the above.

9. Which fumigant is currently used for the control of pests of stored food products?

    a. Diethyl toluamide.

    b. Aluminum phosphide.

    c. Aluminum chlorhydrate.

    d. None of the above.

10. Chemicals which kill certain kinds of plants while not seriously injuring others are known as ______________________ herbicides.

    a. Choosy.

    b. Discriminating.

    c. Selective.

    d. Picky.

11. Match the following:

Types of Herbicides:		Characteristics:
a. Preemergence	______	(1) Act like hormones.
b. Growth regulator	______	(2) Enter through respiratory system.
c. Soil sterilant	______	(3) Make soil unable to support life.
d. Contact	______	(4) Require repeated treatment.
		(5) Kill tissues wetted with spray.
		(6) Applied before foliage appears.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 1

1. a(3) (para 1-1)
   b(4) (para 1-1a)
   c(1) (para 1-9)
   d(7) (para 1-11)
   e(6) (para 1-1d)

2. b (para 1-2b)

3. c (para 1-2b)

4. c (para 1-4a; Table 1-1)

5. c (para 1-4a(3))

6. a(4) (para 1-5a)
   b(2) (para 1-5b)
   c(1) (para 1-9)

7. a(2) (para 1-6b(1)(a), Table 1-1)
   b(1) (para 1-6a)
   c(4) (Table 1-1)
   d(4) (Table 1-1)
   e(1) (para 1-6a)
   f(2) (para 1-6b(1)(b))
   g(4) (para 1-6c(2)(e))
   h(5) (para 1-6c(3)b)
   i(5) (Table 1-1)
   j(4) (Table 1-1)
   k(3) (Table 1-1)
   l(4) (Table 1-1)

8. b (para 1-7c(1))

9. b (para 1-12)

10. c (para 1-14a(1))

11. a(6) (para 1-14b(5))
    b(1) (para 1-14b(2))
    c(3) (para 1-14b(4))
    d(5) (para 1-14b(1))

End of Lesson 1

LESSON ASSIGNMENT

LESSON 2 Pesticide Mixing and Calculations.

LESSON ASSIGNMENT Paragraphs 2-1--2-14.

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

2-1. Identify the reasons for concentrated and diluted forms of pesticides.

2-2. Identify the four usable pesticide formulations and their components.

2-3. Determine the amount of pesticide of a given concentration required to prepare a usable formulation of a desired concentration.

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

Section I. PESTICIDE FORMULATIONS

2-1. TECHNICAL GRADE PESTICIDES

A technical grade pesticide is the basic toxic ingredient in its purest commercially available form. This material is rarely chemically pure. Technical grade diazinon, for example, contains only about 94 to 97 percent of the active chemical. However, technical grade pesticides are, in general, much too toxic for safe handling in the field. Standard military pesticides are generally technical grade pesticides that have been diluted with appropriate carriers or diluents.

2-2. REASONS FOR PESTICIDE MIXING

The concentrated forms of pesticides (restricted use) included on the military stock list, while generally less toxic than technical grade materials, are nevertheless highly concentrated in many cases. Examples are carbaryl, 80% powder; naled, 85% solution concentrate; and malathion, 95% solution concentrate. Some of these chemicals must be diluted before application, for obvious reasons. Such strong formulations would pose a severe hazard, not only to man, but also to nontarget organisms such as fish and other wildlife, domestic animals, beneficial insects (honeybees, predators, etc.), agricultural crops, ornamental plants, and other desirable forms of life. If safety were the only consideration, it would be desirable to issue every pesticide in a ready-mixed, ready-to-use formulation. For those pesticides that are considered general use items, this is the case. These items are prepared for individual and small-unit use and are in formulations of very low concentrations, very small quantities, or both. However, there are valid reasons for issuing pesticides in concentrated form for further dilution in the field.

a. **Economy in Shipping.** Requirements for shipping and storing pesticides are more stringent than are those for storing and shipping the diluents that are used to dilute them to a strength that is safe for application. Moreover, the diluent is often available from local sources and need not be shipped. For example, a 55-gallon drum of 95% malathion solution concentrate, when mixed with No. 2 fuel oil, will provide enough active material for approximately 870 gallons of 6% malathion spray for outdoor space treatment against mosquitoes. If this amount of spray were mixed prior to shipping, it would require 16 times as much shipping space and weight.

b. **Flexibility in Application.** Using concentrated pesticides to prepare diluted mixtures enables the pest control operator to vary the strength according to the target pest, the type of equipment used, and the rate of application.

2-3. DUSTS

A dust is a dry mixture that usually consists of an active pesticide mixed with talc, clay, or some other inert powder used as a diluent, or carrier. Dusts are usually the lowest in cost, easy to apply, nonstaining, nontoxic to plant life, and generally not readily absorbed through the skin. They may be dangerous if inhaled into respiratory passages. Since they are dry, they are the preferred formulation for use around electrical connections. Due to their small particle size, they can be used to penetrate small cracks and crevices. Two disadvantages of dusts are that they do not adhere well to vertical surfaces and they are easily removed by wind and rain.

2-4. GRANULES

Granules are pellets varying from 16 to 30 mesh in size. The granules are usually impregnated with 5 to 50 percent of the toxicant. The carrier is generally bentonite, although vermiculite has been used. The granular form of insecticide is particularly desirable in mosquito breeding areas covered by heavy vegetation, which is not easily penetrated by liquid sprays. In mosquito control work, the granules may be applied to large breeding sites by aircraft using special dispersing equipment. Backpack sprayers may be used for treating smaller breeding sites.

2-5. SUSPENSIONS

Suspensions are liquid formulations. They are prepared by diluting water wettable powders with water and thoroughly mixing. A water wettable powder is a toxic ingredient blended with an inert dust to which a wetting agent -- usually a soap or detergent -- is added to facilitate mixing the powder with the water. This forms a suspension in which the fine particles are suspended -- not dissolved -- in the water. Suspensions require constant agitation during application to prevent solid particles from settling to the bottom of the sprayer. They are also more prone to clog the nozzles of sprayers. These characteristics are the principal disadvantages of suspensions. The major advantage of the suspension is the low-cost and easily obtainable diluent -- water. Suspensions are also relatively safe to apply since they are generally not easily absorbed through the skin and will not cause burning of plant foliage. Suspensions usually have less odor than solutions or emulsions because of the water diluent, as opposed to an organic solvent. They are especially valuable for treating outbuildings, adobe, concrete, and thatch structures because the active material is deposited on the surface. Solutions and emulsions, on the other hand, tend to penetrate such materials and lose much of their residual effectiveness.

2-6. SOLUTIONS

A solution is a liquid formulation consisting of a solution concentrate dissolved in a diluent or solvent. The ideal solution would be one using water as the solvent, for reasons of economy as well as convenience. However, most of the synthetic pesticides relatively insoluble in water. Therefore, the solvents most commonly used are No. 2 fuel oil (used in domestic heating), diesel oil, or kerosene. Other organic solvents may also be used. The solvent selected must be one in which the concentrate is soluble. An advantage of the solution is that constant agitation is not necessary, which facilitates the use of spraying equipment. It is effective as a contact insecticide, as the oil base easily wets and penetrates the insect cuticle (outer covering). In residual spraying, the solvent evaporates from treated surfaces, leaving a deposit of the insecticide in relatively pure form. Disadvantages of solutions are that they are readily absorbed through the skin; the solvents are flammable and relatively expensive; they stain; and they are, in general, toxic to vegetation.

2-7. EMULSIONS

Emulsions are prepared by diluting emulsifiable concentrates with water and thoroughly mixing. The emulsifiable concentrate is a concentrated solution of the toxic agent in a solvent to which an emulsifying agent (wetting agent, such as soap or a detergent) has been added. The emulsifying agent enables the small droplets of solvent carrying the toxicant to remain dispersed through the water, much like the fat globules in homogenized milk. The emulsion, like the solution, need not be constantly agitated. This advantage, combined with that of a cheap, readily available diluent (water), makes the emulsion a commonly used pesticide formulation in the Army. Emulsions are similar to solutions in their effects on insects and they can be used for most residual spraying. They do not usually stain surfaces. Their principal disadvantages are that they are readily absorbed through the skin and that they may be toxic to plants.

2-8. SUMMARY

a. Figure 2-1 summarizes the basic constituents which combine to form a dust or suspension.

(1) Dust -- a technical grade insecticide plus an inert carrier.

(2) Suspension -- an insecticidal dust plus a wetting agent plus water.

b. Figure 2-2 summarizes the basic constituents that combine to form a solution or emulsion.

(1) Solution -- a solution concentrate consisting of a technical grade insecticide and a solvent, plus a diluent.

(2) Emulsion -- an emulsifiable concentrate consisting of a solution concentrate and an emulsifying agent, plus water).

c. The preparation of wettable powders and emulsifiable concentrates is accomplished by the manufacturer before the pesticides are procured by the Defense Supply Agency. Mixing by using personnel is normally limited to mixing an appropriate diluent with standard pesticides, issued through military supply channels, in one of the following forms:

(1) Powders.

(2) Wettable powders.

(3) Solutions.

(4) Solution concentrates.

(5) Emulsifiable concentrates.

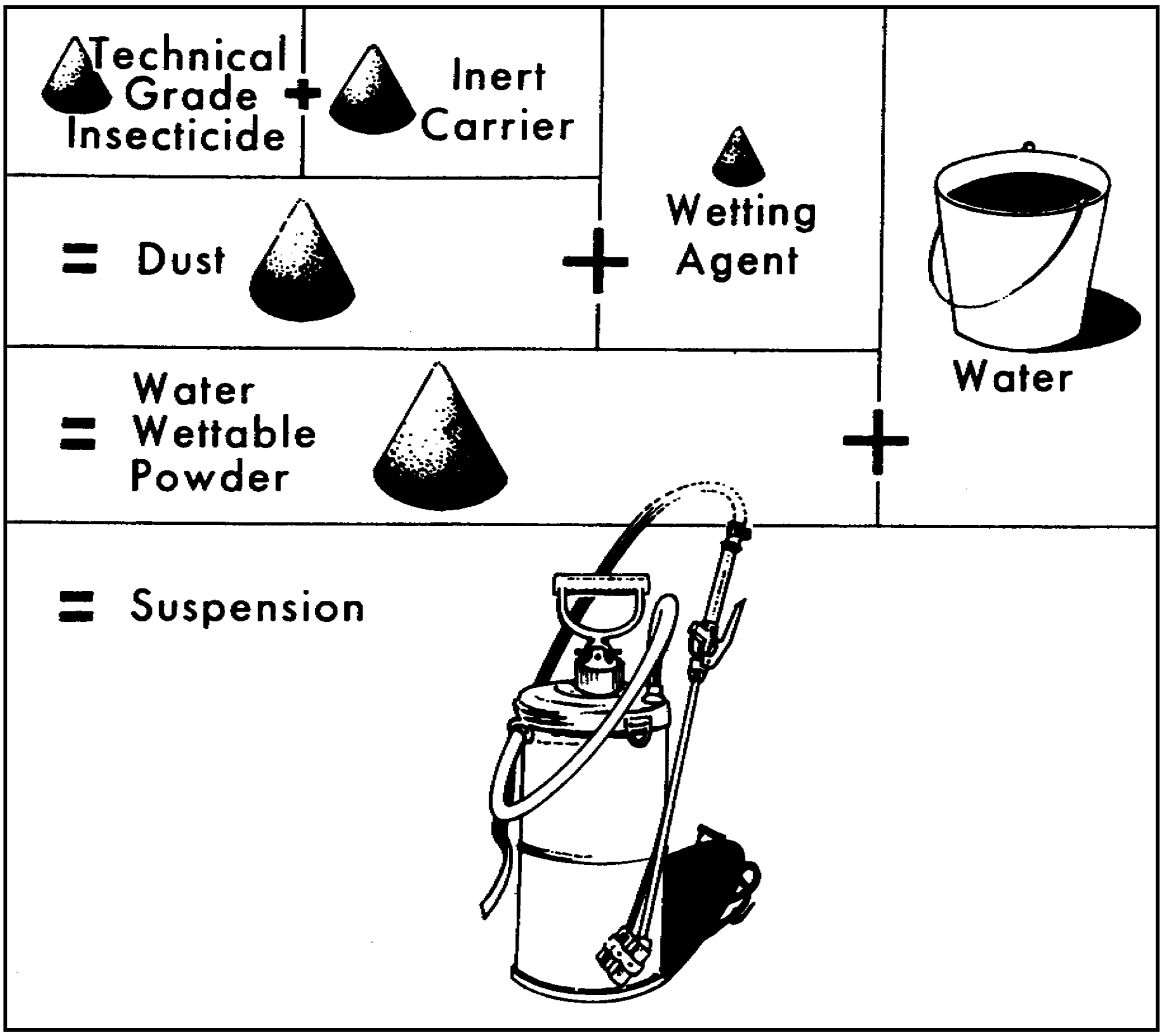


Figure 2-1. Formulation of dusts and suspensions.

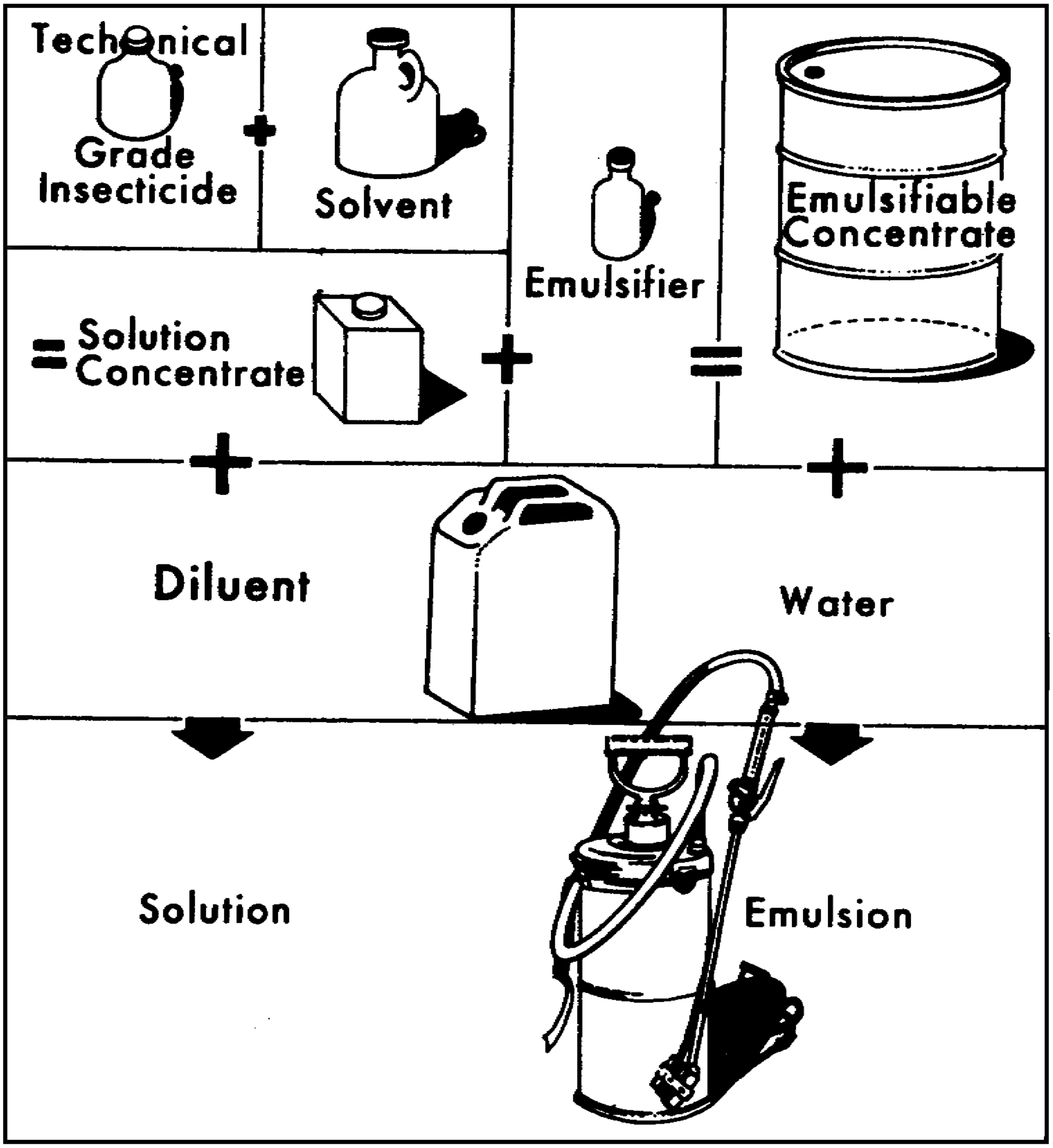


Figure 2-2. Formulation of solutions and emulsions.

Section II. PESTICIDE MIXING CALCULATIONS

2-9. IMPORTANCE OF ACCURATE CALCULATIONS

It is difficult to overemphasize the importance of making accurate calculations each time a pesticide is mixed. There are several reasons for emphasizing this importance.

a. **Safety**. If a formulation is prepared with too high a working concentration, human lives and other nontarget organisms may be endangered.

b. **Effectiveness.** If a formulation has too low a working concentration, the control program may be a failure and insects may develop resistance to the pesticide. In addition, a repeat application may be necessary, thereby increasing the total exposure to humans and other nontarget animals.

c. **Economy.** Pesticide concentrates are expensive. If calculations in mixing are not precise, not only do we run the risks cited in paragraphs a and b above, but we also may needlessly waste toxic materials. Although the cost may not be great for any one given error, the cumulative expense due to error may be enormous on an Army-wide basis.

2-10. WEIGHT/WEIGHT OR VOLUME/VOLUME CALCULATIONS

a. **General.** If we were mixing pure technical grade toxicants with diluents, mixing problems would be simple. We would merely have to mix, for example, 2 pounds of toxicant with 98 pounds of diluent (or 2 gallons with 98 gallons) to obtain a 2 percent mixture. In practice, however, our calculations are never quite so simple. We are not necessarily mixing 100 pound or 100-gallon quantities, and our concentrates are never 100 percent pure. Therefore, we use formulas that simplify our work as much as possible. In order to use the formula, there are certain basic elements of information we must have. The following must be obtained from the pesticide label:

(1) The name of the active ingredient (toxicant), its concentration, and its form (carbaryl, 80% powder; malathion, 95% solution concentrate; etc.).

(2) The type formulation to be prepared (dust solution, emulsion, etc.) and the diluent to be used.

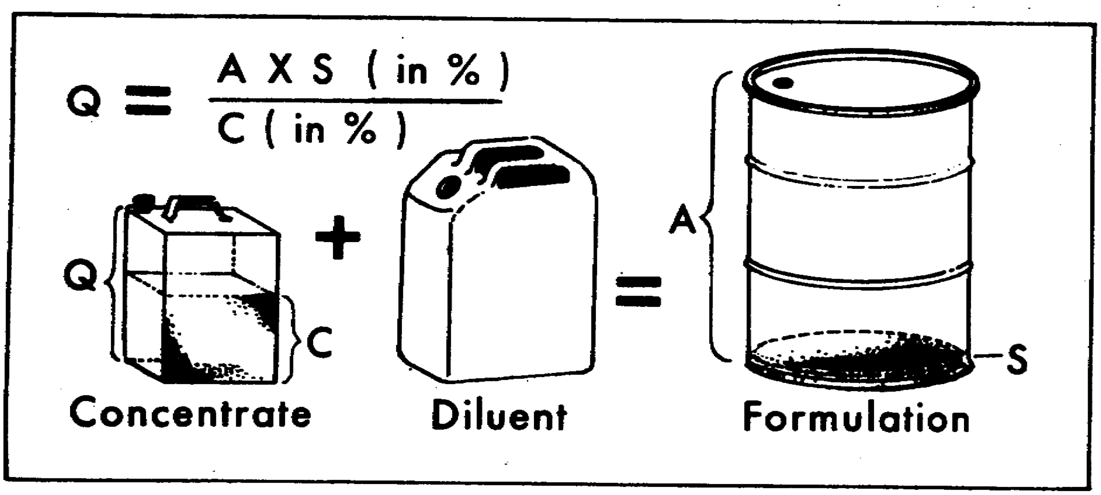
(3) The concentration of toxicant desired in the final formulation (1%, 2%, 05%, etc.).

(4) The quantity of final formulation required (5 gallons, 100 pounds, etc.).

b. **Calculation.** The following sample problems will illustrate the derivation and use of the formula for mixing liquid concentrates with liquid diluents or solid (powder) concentrates with solid (powder) diluents:

(1) Problem #1. 55 gallons of 1% diazinon emulsion are to be prepared using diazinon, 48% emulsifiable concentrate and water. How many gallons of the concentrate are required?

(a) Figure 2-3 illustrates the problem graphically.



Notation:

Q = **Quantity** of concentrate in gallons or pounds (must be same units as A).
C = **Concentration** of toxicant in the concentrate in percent.
A = **Amount** of final formulation desired in gallons or pounds (must be same units as Q).
S = **Strength** of final formulation in percent of active ingredient.

Figure 2-3. Volumetric calculations.

(b) Computation. The one element that will remain constant throughout the problem is the actual amount of toxicant involved. When we dilute a pesticide, we do not change the amount of toxicant. We merely add enough diluent so that the final formulation will consist of the desired percentage of toxicant. The amount of toxicant in either the concentrate or the final solution is determined by multiplying the amount of concentrated or formulation by the percentage of toxicant. Thus:

Amount of toxicant in concentrate = Q X C (Q X 48%)

Amount of toxicant in formulation = A X S (55 gal X 1%)

The amount of toxicant is constant; therefore,

$$Q \times C = A \times S, \text{ or } Q = \frac{A \times S}{C}.$$

Substituting the known values for the letters, we can solve for Q as follows:

$$Q = \frac{55 \text{ gal} \times 0.01}{0.48} = 1.146 \text{ gal concentrate}$$

(c) To the 1.1 (1.146 rounded) gallons of 48% diazinon emulsifiable concentrate, we must add 53.9 gallons of water to prepare the desired 55 gallons of 1% emulsion.

(2) Problem #2. In preparing dusts by diluting concentrated powders with inert talc, the procedure is identical, but we are dealing with weight instead of volume. Thus, to determine the amount of 80% carbaryl powder required to prepare 10 pounds of 5% dust.

(a) C = 80% (.80)
A = 10 lb
S = 5% (.05)

(b) $$Q = \frac{A \times S}{C} = \frac{10 \times 0.05}{0.80} = 0.625 \text{ lb (10 oz)}$$

(c) To the 10 ounces of 80% carbaryl powder, we must add 9 pounds, 6 ounces of inert talc or other carrier to prepare the desired 10 pounds of 5% dust.

2-11. WEIGHT/VOLUME CALCULATIONS

a. **General.** From time to time the pest control operator will be required to prepare suspensions, by mixing wettable powders with water. Because a given volume of powder is considerably lighter than an equal of liquid, calculation by the volume/volume method is not accurate. Therefore, we use the weight/weight calculation, converting the volume of liquid to weight so that both values are expressed in units of weight. A weight/volume calculation, then, is a calculation using a constant or conversion factor to convert the volume of the liquid to weight. The formula for a weight/volume calculation is:

$$Q = \frac{A \times S \times D}{C}, \quad \text{where D = Density of the diluent .}$$

If the dilutent is water, the density is 8.34 pounds per gallon. If a diluent other than water is used, the density of that particular diluent should be determined for most accurate results. A few common diluents and their densities are the following:

(1) Acetone (6.5 lb/gal).

(2) Fuel oil No. 2 (7 lb/gal).

(3) Kerosene (6.4 to 6.6 lb/gal).

b. **Calculation.** The following sample problem will illustrate the use of the formula for mixing solid (powder) concentrates with liquid diluents.

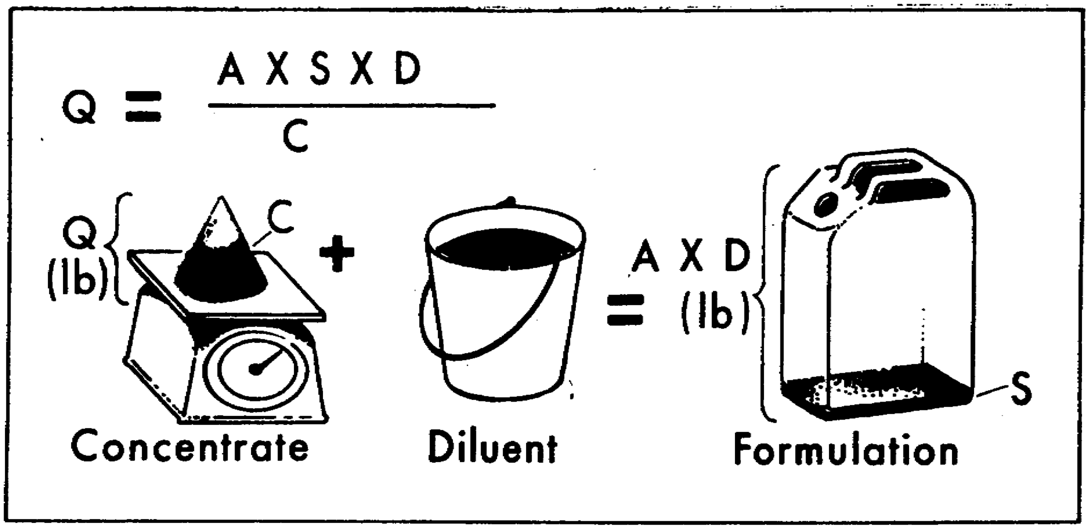
(1) Problem. 5 gallons of 2% carbaryl suspension are to be prepared using carbaryl 80% wettable powder and water. How many pounds of concentrate are required?

(2) Figure 2-4 illustrates the problem graphically.

(3) Computation.

$$Q = \frac{A \times S \times D}{C} = \frac{5 \text{ gal} \times .02 \times 8.34 \text{ lb/gal}}{0.80} = 1.04 \text{ pounds concentrate}$$

This amount (1 pound) of concentrate is placed in a 5-gallon container and enough water is added to fill the container (total mixture = 5 gallons).



Q = **Quantity** of concentrate in **pounds**.
C = **Concentration** of Q in percent.
A = **Amount** of final formulation in **gallons**.
S = **Strength** of final formulation in percent.
D = **Density** of diluent in **pounds per gallon**.

Figure 2-4. Weight/volume calculations.

c. **Uniformity of Procedure.** For the sake of uniformity, it is most convenient to use one formula for all calculations -- weight/weight, volume/volume, and weight/volume. The formula is:

$$Q = \frac{A \times S \times D}{C}$$

If Q and A are expressed in the same units (either pounds or gallons), D = 1. If Q is expressed in pounds and A in gallons, D = the density of the diluent (8.34 lb/gal if the diluent is water).

Section III. PESTICIDE APPLICATION CALCULATIONS

2-12. DETERMINING REQUIREMENTS

a. **General.** Mixing and diluting pesticides to required strengths and quantities is only one step in pest control operations. Before preparing the formulations, we must determine the quantities and strengths that are required for our particular task. Pest control operations do not fall within the scope of this subcourse; however, determining requirements for pesticides will be discussed in this section.

b. **Recommendations.** Technical Information Memorandum (TIM) 24, Contingency Pest Management Pocket Guide, has a comprehensive list of recommended pesticides, strengths, and rates of application for attacking various insects and other pests. However, the pesticide label itself is the ultimate source of guidance on pesticide application rates. Depending upon the type of application (agricultural use; household use; outdoor control of flies, mosquitoes, mites; etc.) the units of measure may vary.

c. **Requirements.** The amount of final formulation depends upon two factors:

(1) The area to be treated.

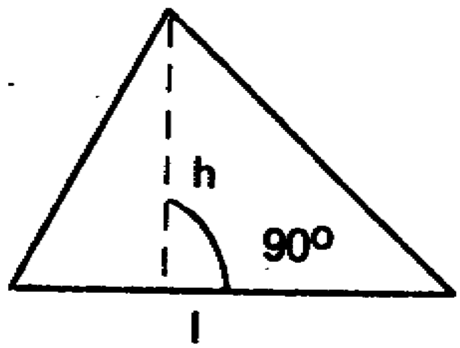
(2) The rate of application.

d. **Computaton.** The amount of formulation required is determined by multiplying the area in acres or square feet (usually in thousands) by the number of gallons or pounds of final formulation per acre or square feet (1,000 square feet).

2-13. CALCULATING AREAS

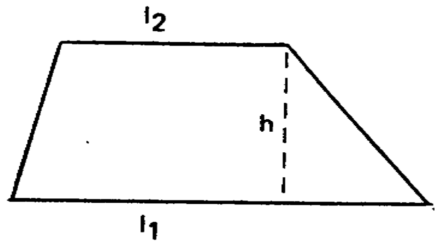
a. **Area in Square Feet.** The area of a given tract of land, household space, or storage space is determined by multiplying the length by the width. For example, a field 300 feet long and 150 feet wide contains 45,000 square feet (300 X 150 = 45,000). If a given pesticide should be applied at the rate of 1 gallon per 1,000 square feet, the total amount required for this field would be 45 gallons (45,000/1,000 = 45). Obviously, the above calculation applies only to a rectangle. Other simple formulas for calculating the areas of common figures follow.

(1) Triangle.



$$\text{Area} = \frac{l \times h}{2}$$

(2) Trapezoid.



$$\text{Area} = \frac{l_1 + l_2}{2} = h$$

(l_1 and l_2 must be parallel)

(3) Areas more complicated than previously shown can be broken down into smaller areas (see below) or, if they are quite complex, it may be necessary to have their areas computed by a professional surveyor.

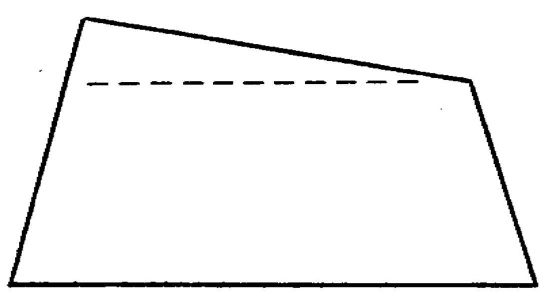


Figure broken into a triangle and a trapezoid.

b. **Areas in Acres.** An acre contains 43,560 square feet. Therefore, once an area is determined in square feet, it may be divided by 43,560 to obtain its area in acres. For example, a field 400 feet long and 400 feet wide contains 160,000 square feet (400 X 400 = 160,000). 160,000 square feet divided by 43,560 square feet per acre is equal to about 3.67 acres.

2-14. DETERMINING AMOUNT OF FORMULATION PER UNIT AREA

a. **Recommendations of TIM or Pesticide Label.** Many of the recommended rates of application of pesticides in TIM 24, and most of those on pesticide labels, are expressed directly in terms of gallons of prepared formulation per acre or per square foot. In this case, the determination of the amount formulation required is fairly simple. For example, the instructions on the label of diazinon, 48% emulsifiable concentrate (Figure 2-5), prescribe the exact proportions for mixing and the rate of application for various common household arthropod pests as follows: ROACHES AND ANTS: Prepare a 1/2 percent emulsion by slowly adding 1-1/4 fluid ounces (2-1/2 tablespoons of concentrate to a gallon of water with constant stirring. Apply until surface is wet to point of run-off (approximately 1 gallon per 1,000 square feet).

6840-00-782-3925

INSECTICIDE DIAZINON
EMULSIFIABLE CONCENTRATE

0-1-520A
1 GAL A-10/73
DSA-400-73-D-0144

OCTAGON PROCESS INC.
Edgewater, New Jersey 07020
LOT C-2796

INSECTICIDE, DIAZINON, EMULSIFIABLE CONCENTRATE
(CONTAINS 4 POUNDS DIAZINON PER GALLON)

FOR USE AGAINST INSECTS RESISTANT TO CHLORINATED HYDROCARBONS

ACTIVE INGREDIENTS :	
0,0-diethyl 0-(2-isopropyl-4- methyl-6-pyrimidinyl)-phosphorothioate*	47.5%
Aromatic petroleum derivative solvent	26.2%
INERT INGREDIENTS :	26.3%
* Diazinon TOTAL	100.00%

WARNING - KEEP OUT OF REACH OF CHILDREN

MAY BE FATAL IF SWALLOWED! MAY BE ABSORBED THRU SKIN! DO NOT BREATHE SPRAY MIST. DO NOT GET IN EYES, ON SKIN OR ON CLOTHING. WASH THOROUGHLY AFTER HANDLING. AVOID CONTAMINATION OF FEED OR FOODSTUFFS. DO NOT USE OR STORE NEAR HEAT OR OPEN FLAME. USE SUITABLE PROTECTIVE CLOTHING AND DEVICES WHEN HANDLING CONCENTRATE OR WHEN SPRAYING EXTENSIVELY. DO NOT USE ON LIVESTOCK, HOUSEHOLD PETS OR HUMANS. DO NOT ALLOW CHILDREN OR PETS IN TREATED AREAS UNTIL THE SURFACES ARE DRY.

DO NOT USE IN EDIBLE PRODUCTS AREAS OF FOOD PROCESSING PLANTS, RESTAURANTS OR OTHER AREAS WHERE FOOD IS COMMERCIALLY PROCESSED. DO NOT USE IN SERVICE AREAS WHERE FOOD IS EXPOSED.

DO NOT REUSE EMPTY CONTAINER. DESTROY IT BY PERFORATING OR CRUSHING. BURY OR DISCARD IN A SAFE PLACE.

THIS PRODUCT IS TOXIC TO FISH, WILDLIFE, AND BIRDS. DO NOT CONTAMINATE WATER BY CLEANING OF EQUIPMENT, OR DISPOSAL OF WASTES. APPLY THIS PRODUCT ONLY AS SPECIFIED ON THIS LABEL.

FOR PEST CONTROL OPERATORS USE ONLY

DIRECTIONS FOR USE

ROACHES AND ANTS : Prepare a ½ percent emulsion by slowly adding 1¼ fluid ounces (2½ tablespoons) of concentrate to 1 gallon of water with constant stirring. Apply as a coarse spray or apply with a paint brush to baseboards, areas around water pipes, cracks and crevices, surfaces behind and beneath cabinets and similar areas where these insects hide, and to ant runways. Use coarse, wet spray and apply until surface is wet to point of run-off (approximately 1 gallon per 1000 square feet). Reapply only when reinfestation is noted. Do not use for space spray or for residual treatment covering extensive indoor surfaces such as entire bulkheads and overheads.

FLY CONTROL (NOT INTENDED FOR LIVING QUARTERS) :
"Spot" bait sprays. Apply on exterior surfaces around doorways and window sills of garages, warehouses, garbage cans, outside of kennels. Apply a spray containing ¼ pint of the concentrate and 1 pound of sugar in 3 gallons of water with a knapsack or similar type sprayer to areas frequented by flies, such as doorways, around windows, and other areas where flies congregate. Repeat applications every 2 to 3 weeks as fly population warrants.

Liquid bait for sprinkling can application. Use 2 fluid ounces of the concentrate and 1 pound of sugar (or 2 cups of syrup or molasses), in 5 gallons of water and sprinkle lightly over the floor in areas frequented by flies in warehouses and outbuildings. Burlap bags may be laid out in these areas frequented by flies and sprinkle with this mixture. Do not treat areas of walkways or where contact would be made by people or animals. Application every day or two will generally be required.

BROWN DOG TICKS IN HOUSEHOLDS : Prepare a ½ percent emulsion as for roaches and ants above. Thoroughly spray infested areas around baseboards, windows and door frames, wall cracks, sleeping quarters of household pets and localized areas of floors and floor coverings. Applications should be repeated as infestations warrant and as reinfestations occur. Fresh bedding should be placed in animal quarters following treatment. Do not treat animals with this formulation.

When used in dwellings, care should be taken to avoid deposits which could be frequently contacted by children. Care should also be taken to avoid spotting of wallpaper and fabrics. DO NOT CONTAMINATE FOOD, FOOD CONTAINERS, OR COOKING UTENSILS.

NOTE: The solvent in this formulation is a petroleum distillate which may stain certain plastic, rubber and asphalt materials such as tiles and floor coverings. Do not treat such materials.

EPA REG. NO. 6830-27

Figure 2-5. Standard pesticide label.

b. **Pounds of Toxicant per Acre and Pounds of Diluted Dust Per Acre Computation.** If the recommendations for applying a pesticide in dust form specify the number of pounds of toxicant per unit area (per acre or per 1,000 square feet), the amount of diluted dust to be applied per unit area (in the same units) may be determined as follows.

(1) Pounds of toxicant per unit area = pounds of diluted dust per unit area X percent toxicant in diluted dust.

$$\text{Therefore: lb diluted dust/acre} = \frac{\text{Lb toxicant/acre}}{\text{\% toxicant}}.$$

(2) Example: How many pounds of 5 percent dust are required per acre if the recommended rate of application is 10 pounds of toxicant per acre?

$$\frac{\text{10 lb toxicant/A}}{0.05} = \text{200 lb diluted dust/A}$$

c. **Pounds of Toxicant per Acre and Gallons of Diluted Spray per Acre Computation.** If the recommendations for applying a pesticide in diluted spray form specify the number of pounds of toxicant per unit area, the amount of diluted spray in gallons may be determined as follows.

(1) Pounds of toxicant per unit area = pounds of diluted spray (gal X 8.34 lb/gal) per unit area X percent toxicant in diluted spray.

$$\text{Then: gal diluted spray/A X 8.34 lb/gal} = \frac{\text{lb toxicant/A}}{\text{\% toxicant}}$$

$$\text{Therefore: gal diluted spray/A} = \frac{\text{lb toxicant/A}}{\text{\% toxicant X 8.34 lb/gal}}.$$

(2) Example: How many gallons of 6 percent emulsion are required per acre if the recommended rate of application is 0.3 pounds of toxicant per acre?

$$\frac{\text{0.3 lb toxicant/A}}{\text{0.06 X 8.34 lb/gal}} = \text{0.6 gal diluted spray/A}$$

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. A pesticide in its purest commercially available form is known as:

   a. Pure grade.

   b. Technical grade.

   c. Commercial grade.

   d. None of the above.

2. Select the reason(s) for mixing pesticides in the field? (You may select more than one answer).

   a. To economize in shipping.

   b. Because it is more hazardous to ship ready-mixed formulations.

   c. Because mixing facilities are better in the field than in garrison.

   d. To give the operator flexibility in preparing strengths to meet specific requirements.

3. Which of the following are advantages of dusts? (You may select more than one answer)?

   a. They adhere well to vertical surfaces.

   b. They are not readily absorbed through the skin.

   c. They can be used around electrical connections.

   d. They are weather resistant.

   e. They can penetrate small cracks and crevices.

4. Suspensions are made by mixing which of the following?

   a. A water wettable powder and an organic solvent.

   b. A dust and a wetting agent.

   c. A dust and water.

   d. A wettable powder and water.

   e. A suspendable concentrate and water.

5. A disadvantage of the suspension is that it:

   a. Is easily absorbed through the skin.

   b. Is expensive.

   c. Must be constantly agitated.

   d. Penetrates building materials, losing much of its residual effect.

6. A solution consists of:

   a. A solution concentrate mixed with water.

   b. An emulsifiable concentrate mixed with oil.

   c. A solution concentrate and diluent in which the concentrate is soluble.

   d. A wettable powder and an organic solvent.

7. Which of the following are disadvantages of the solution?

   a. It usually requires an expensive solvent.

   b. It is usually flammable.

   c. It requires constant agitation.

   d. It has little effect as a contact spray or residual spray.

   e. It is easily absorbed through the skin.

8. An emulsion consists of:

   a. An emulsifying agent and water.

   b. Technical grade pesticide and an emulsifying agent.

   c. An emulsifiable concentrate and a petroleum solvent.

   d. An emulsifiable concentrate and water.

9. Which of the following are advantages of the emulsion?

   a. It uses an inexpensive diluent.

   b. It need not be constantly agitated.

   c. It is not readily absorbed through the skin.

   d. It has both contact and residual effect.

   e. It is nontoxic to plants.

10. Is the following statement true or false? "It is better to mix pesticides too weak than too strong in order to prevent a hazard to human lives and other nontarget organisms."

    a. True.

    b. False.

11. How much 80% carbaryl powder is required to prepare 16 pounds of 5% dust?

a. 10 lbs.

b. 5 lbs.

c. 1 lb.

d. None of the above.

12. How much toxic material is present in the above formulation?

a. 8 lbs.

b. 0.8 lbs.

c. 6.4 lbs.

d. None of the above.

13. How much chlopyrifos 72% emulsifiable concentrate is required to make 100 gallons of 2% emulsion?

a. 2.8 gal.

b. 5.6 gal.

c. 3600 gal.

d. None of the above.

14. How much toxicant is present in the above formulation?

a. 3.6 gal.

b. 5.6 gal.

c. 2 gal.

d. None of the above.

15. How much carbaryl 80% wettable powder is required to prepare 100 gallons of 2% suspension?

   a. 20.8 lbs.

   b. 10.4 lbs.

   c. 41.6 lbs.

   d. None of the above.

16. How many square feet are there in a room 50 feet long and 35 feet wide?

   a. 175.

   b. 1750.

   c. 85.

   d. None of the above.

17. If a pesticide label recommends application at the rate of 1 gallon per 1,000 square feet, how many gallons are required for the room in item 16 above?

   a. 0.18 gal.

   b. 1.75 gal.

   c. 0.85 gal.

   d. None of the above.

18. What is the area, in acres, of a field 385 feet long and 170 feet wide?

   a. 4.5 acres.

   b. 15 acres.

   c. 1.5 acres.

   d. None of the above.

19. If the recommended rate of application of a 5% dust is 1.5 pounds of toxicant per acre, how many pounds of diluted dust are required to treat the field in item 18?

a. 45 lbs.

b. 30 lbs.

c. 3.0 lbs.

d. None of the above.

20. If the recommended rate of application of a 2% spray is 10 pounds of toxicant per acre, how many gallons of spray are required to treat the field in item 18?

a. 60 gal.

b. 90 gal.

c. 105 gal.

d. None of the above.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 2

1. b (para 2-1)

2. a (para 2-2a)
   d (para 2-2b)

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

4. d (para 2-5)

5. c (para 2-5)

6. c (para 2-6)

7. a, b, e (para 2-6)

8. d (para 2-7)

9. a, b, d (para 2-7)

10. b (para 2-9) (Mixing a formulation too weak is equally, if not more, undesirable. If a formulation is too weak, the program may be a failure and require a repeat application and thereby increase the exposure to nontarget species.)

11. c (paras 2-10b(2), 2-11c)

$$Q = \frac{A \times S \times D}{C} = \frac{16 \text{ lb} \times 0.05 \times 1}{0.80} = 1 \text{ lb}$$

12. b (para 2-10b(1)(b))
    Amt toxicant = A X S = 16 lb X 5% = 0.8 lb, or
    Amt toxicant = Q X C = 1 lb X 80% = 0.8 lb

13. a (paras 2-10b(1), 2-11c)

$$Q = \frac{A \times S \times D}{C} = \frac{100 \text{ gal} \times 0.02 \times 1}{0.72} = 2.778 \text{ gallons (rounds to 2.8)}$$

14. c (para 2-10b(1)(b))
    Amt toxicant = A X S = 100 gal X 2% = 2 gallons, or
    Amt toxicant = Q X S = 2.8 gal X 72% = 2.016 gallons (rounds to 2)

15. a (para 2-11b)

$$Q = \frac{A \times S \times D}{C} = \frac{100 \text{ gal} \times 0.02 \times 8.34 \text{ lb/gal}}{0.80} = 20.8 \text{ lb}$$

16. b (para 2-13a) 50 ft X 35 ft = 1,750 ft^2

17. b (para 2-13a)

$$\frac{1 \text{ gal/ft}^2 \times 1{,}750 \text{ ft}^2}{1{,}000} = 1.75 \text{ gal}$$

18. c (para 2-13b)

$$385 \text{ ft} \times 170 \text{ ft} = \frac{65{,}450 \text{ ft}^2}{43{,}560 \text{ ft}^2 \text{ A}} = 1.50 \text{ A}$$

19. a (para 2-14b)

$$\frac{1.5 \text{ lb toxicant/A}}{0.05 \text{ toxicant in diluted dust}} = 30 \text{ pounds diluted dust/A}$$

30 lb/A X 1.5A = 45 lb diluted dust

20. b (para 2-14c)

$$\frac{10 \text{ lb/A}}{(0.02 \times 8.34 \text{ lb/gal})} = 60 \text{ gal/A}$$

60 gal/A X 1.5A = 90 gal

End of Lesson 2

LESSON ASSIGNMENT

LESSON 3	Pesticide Safety.
LESSON ASSIGNMENT	3-1--3-17.
LESSON OBJECTIVES	After completing this lesson, you should be able to:
	3-1. Identify the general precautions for safe handling and storage of pesticides.
	3-2. Select the proper protective clothing and equipment to use when handling pesticides.
	3-3. Identify criteria for proper pesticide mixing and storage facilities.
	3-4. Identify the environmental hazards and restrictions on the use of pesticides.
SUGGESTION	After completing the assignment, complete the exercises of this lesson. These exercises will help you to achieve the lesson objectives.

Section I. PERSONNEL AND TRAINING

3-1. GENERAL

a. Department of Defense standards for insect and rodent control require that most pesticide dispersal and other insect and rodent control operations be accomplished by trained and certified personnel. The basis for this requirement is overwhelming. Within the past few years, hundreds of new pesticides have been developed and still newer pesticides are being tested. These new chemicals permit new approaches to pest control through their residual and other actions. To obtain maximum effectiveness from these newer pesticides, it is necessary to know the biology of the pests encountered so pesticides can be applied at the right time and at the right place. These newer pesticides present a wide range of hazard in their use. If correctly used, they may be quite safe. If they are mishandled, they may present a considerable danger to the user, to the recipient of pest control service, or to the material being treated.

b. Specialized equipment has been and is being developed to disperse these newer materials in a more effective and economical manner. New control techniques have been and are being devised. Because of these complexities, only persons with capabilities for and a genuine interest in pest control should be assigned to pest control programs. Pest control personnel must be able to demonstrate their capabilities by qualifying for certification in order to comply with the certification requirements of the Federal Environmental Pesticide Control Act of 1972. Because of the rapidity of developments in chemicals, equipment, and techniques, they must be periodically reexamined and recertified.

3-2. PERSONNEL

a. **Selection Criteria.** Personnel should be carefully selected for pest control positions. Candidates must have the mental capacity to learn and an aptitude for biological sciences and chemistry. Preferably, the candidate should be a high school graduate with course work in biology and chemistry. It may be desirable to test the potential of a candidate even before placing him in training status. Experience, by itself, should never be the criterion for employing pest control personnel. In addition to having an adequate background and potential, the candidate must be genuinely interested in pest control work.

b. **Training.** Newly recruited personnel rarely will have the extensive knowledge and experience necessary to properly perform their routine pest control functions. These persons must be provided with on-the-job training. In addition, they should participate in correspondence-type instruction when it is sponsored periodically by the entomologists on the staffs of the major commands. The training courses should include responsibilities for insect and rodent control; insects and rodents as reservoirs and vectors of disease and as destroyers of property; identification, life history, habits;

and control of important pests; pesticides resistance; uses and characteristics of insecticides, rodenticides, fumigants, fungicides, herbicides, and equipment; administrative procedures; and safety precautions in handling, mixing, storing, transporting, and applying pesticides. Once the recruit has obtained a working knowledge in the field of pest control, he should complete his training by attending the Army, Navy, and Air Force Pest Management Certification Courses.

c. **Recertification.** The field of pest control is ever changing, with development of new materials, new equipment, and new research results ready to be translated into operational usage. These developments make it necessary for pest control personnel to receive periodic training. Recertification must be accomplished every 3 years and should consist of the following.

(1) A series of classes conducted by command pest management professionals and augmented by instructors at a pest management training center designed to refresh the knowledge of pest control personnel.

(2) A centrally held workshop or training conference at which installation or activity pest control personnel are brought up-to-date with recent developments and are instructed on the application of new developments to their programs.

(3) On-the-job instruction at their installation or activity.

d. **Certification.** All pest control personnel must be certified. It is through certification that commanding officers can be assured that personnel are qualified to conduct pest control operations in a safe, effective, and economical manner. To obtain certification, a candidate must demonstrate to the satisfaction of the command entomologist that he is qualified. Qualifications may be shown by passing a written examination and by demonstrating on-the-job competency. As recertification is required every 3 years, the centralized workshop or training conference offers a convenient time and location for the certification examination. Observation of on-the-job competence must be held at the activity or installation. Certificates can be withdrawn for incompetence, for negligence in safety precautions, for failure on written examination, or upon transfer to other duties.

Section II. SAFE HANDLING AND STORAGE

3-3. TOXICITY AND HAZARD

It is most important to distinguish between toxicity and hazard. Toxicity is the potential of any chemical to produce damage. Toxicity was discussed in paragraph 1-4. Hazard is the probability that any given chemical will cause damage when used in a particular way or place and, therefore, will vary greatly with local conditions and application methods. Frequently, a highly toxic chemical is less hazardous for a certain use than one of a much lower basic toxicity. For example, parathion, a nonstandard organophosphate which is extremely toxic (LD_{50} 13 mg/kg or less), often present less hazard than DDT from the standpoint of residues in food crops. Dieldrin is extremely hazardous when the skin is contaminated with dusts or sprays, although its oral toxicity is similar to that of lindane, which is used next to the skin as a delousing powder. The most toxic pesticide in a secured storeroom is less hazardous than the least toxic pesticide on a kitchen shelf. The type of formulation used also may have a considerable effect on the degree of hazard for the same chemical applied at the same dosage. Oil solutions and emulsions, for example, are absorbed more readily by the skin than are dusts and water suspensions.

3-4. HAZARDS IN THE USE OF PESTICIDES

a. **Carelessness.** Most of the accidents resulting from the use of pesticides have been caused by a careless disregard of precautions printed on the label. Pesticide manufacturers, to comply with Federal pesticide laws, are required to include warning statements on the label concerning the precautions that should be taken when using the pesticide, antidotes known to counteract the poison, first aid recommendations, and a statement concerning the hazardous nature of the material. When current recommendations of the manufacturer are followed, even the most hazardous pesticide can be used with relative safety. When recommendations are not followed, the safety hazard is increased even when using the least toxic materials.

b. **Factors in Assessing Hazard.** The most important factors to be considered in estimating the hazard from a given pesticide are:

(1) Acute oral and inhalation toxicity.

(2) Degree of skin absorption and dermal toxicity.

(3) Cumulative effect on the body.

(4) Concentration of toxicant handled in mixing or applying the chemical.

(5) Amount of toxicant that must be applied to achieve control.

(6) Frequency of application.

(7) Conditions under which the chemical is applied and the degree of exposure to the residues.

(8) Physical and chemical properties of the toxicant.

3-5. TOXICITY OF PESTICIDES

a. **Insecticides**. Toxicities of the insecticides discussed in this subcourse for which data are available are presented in Table 1-1. In reading this table, it must be recognized that the data are based on laboratory experiments with small animals. Unfortunately, humans do not always react in the same way as small animals; therefore, the lethality of these chemicals to man may vary considerably from the test data. General statements on the toxicities of various insecticides are included in succeeding subparagraphs.

(1) Inorganic insecticides. Most of the inorganic insecticides are formulated from the heavy metals and are extremely toxic to warm-blooded animals. Arsenic poisoning, for example, produces symptoms of severe irritation of the gastrointestinal tract accomplished by vomiting and albuminuria. Chronic arsenic poisoning may result from prolonged exposure to small amounts because of absorption through the lungs, skin, or alimentary tract. An apparent tolerance to ingestion of arsenic may appear, though this is not a systemic tolerance, but is based on diminished absorption from the alimentary tract. Normally, workers with this pesticide are simultaneously exposed to inhalation and skin absorption. Symptoms of chronic poisoning may go unnoticed at first. Bronchial irritation may be attributed to infection or to smoking. Loss of appetite, nausea, vomiting, and diarrhea may be attributed to some other pesticide. Prolonged chronic exposure eventually leads to anemia and multiple neuritis of the extremities; skin changes and even loss of hair and fingernails may occur. Paralysis and liver damage are late manifestations. In 1956, the latest year for which detailed records are available, 55 percent of all fatal accidents caused by pesticides in the United States involved inorganic ones, especially arsenic and phosphorous.

(2) Botanicals. Nicotine pesticides, used chiefly in the control of plant pests, are highly toxic to mammals. The poison is readily absorbed through the skin. Depending upon the concentration and duration of contact, symptoms of poisoning may appear. Rotenone is another botanical pesticide that is frequently used for a variety of pest problems and as a deliberate fish poison. The mammalion toxicity of rotenone varies considerably among animal species, though normal precautions in its use are adequate to protect humans. Pyrethrum is one of the least toxic of all pesticides to mammals.

(3) Synthetic organic insecticides.

(a) Chlorinated hydrocarbons. Many of the items used in military pest control programs belong to this group of chemicals. Some of them are quite hazardous as concentrates and a single exposure is capable of causing illness and death. There is a wide range of toxicity and hazard. Repeated exposure to dilute solutions also may be hazardous; therefore, maximum use of protective measures should be employed. Pesticides in this group of chemicals usually affect the nervous system. The result is spastic inability to coordinate muscular activity, which progress to convulsions. If death occurs, respiratory failure is usually the immediate cause.

(b) Organophosphates. This group of pesticides has a wide range of mammalion toxicity from a very low order, as in malathion; through a moderate order, as in diazinon; to a high order, as in parathion. This group of chemicals inhibits cholinesterase, an enzyme essential to the proper functioning of the nervous system. Mammalion poisoning from organophosphates pesticides, therefore, involves the central nervous system. Symptoms of poisoning may include gastrointestinal discomfort, salivation, profuse sweating, and difficulty breathing. As with poisoning due to chlorinated hydrocarbons, the immediate cause of death is usually respiratory failure.

(c) Carbamates. The insecticides in this group also inhibit the action of the cholinesterase and, like the organophosphates, exhibit a wide range of toxicity and hazard. Baygon, for example, has 5 to 8 times the toxicity of carbaryl.

b. **Rodenticides.** The materials in this group are inorganic and organic chemicals, but the uses and modes of action are sufficient to justify consideration of rodenticides as a separate group. Those formulated from heavy metals and plant products have been mentioned above. These have been the cause of most human poisoning associated with rodenticides. Another group of chemicals used widely in rodent-control programs today comprises the anticoagulants, derivatives of coumarin orindiandione. One of the early members of this group is known as "Warfarin," which is being supplemented in the military supply system by other anticoagulants in water-soluble formulations. In addition to causing capillary damage, these chemicals interfere with the formation of prothrombin, resulting in extensive internal hemorrhages. These chemicals do, however, have the advantage of low acute toxicity; consequently, in the concentrations recommended, repeated ingestion over a period of several days is required to produce lethal poisoning in mammals, including man. Accidental or deliberate ingestion of these anticoagulants, particularly of the concentrates, may lead to death. Depending on systemic levels reached, repeated prolonged exposure may result in disease conditions ranging from prolonged bleeding from minor cuts to serious hemorrhage.

c. **Fumigants.** These chemicals are used for specialized problems in rodent control as well as for insect control in selected situations.

d. **Herbicides and Fungicides.** Herbicides and fungicides fall into the same general chemical classifications as insecticides. They exhibit similar characteristics, having a wide range of toxicities (Table 1-2). The hazards are similar to those of other pesticides and are included in the information on the container label.

3-6. STORAGE AND DISPOSAL OF PESTICIDES

a. **Storage Requirements.** All pesticides must be stored in a secure space that can be locked, in order to prevent access by untrained and unauthorized persons. In addition to security, the following criteria are important in storing pesticides.

(1) Climatic conditions. Storage facilities for pesticides should be cool, dry, and well ventilated. The reasons for maintaining such conditions are preservation of materials and safety. Chemicals deteriorate more rapidly under conditions of warmth, humidity, and exposure to sunlight. Adequate lighting should be provided to prevent errors in reading labels, but materials should be protected from continuous exposure to sunlight. Ventilation is important in the interest of safety. The collection of fumes from a leaky container could present a hazard both from the standpoint of inhalation and from the possibility of explosion.

(2) No smoking. "No Smoking" signs should be posted at prominent points in the storage area, and compliance should be vigorously enforced. Many pesticides are highly flammable.

(3) Containers. Pesticide containers should be segregated according to their containers, stored away from other chemicals, and stored under a sign indicating the name of the formulation. This precaution is not only to preclude the possibility of a reaction should two chemically reactive agents come in contact with one another, but also to prevent errors in selecting or issuing pesticides. Most of the original containers designed for insecticides are adequate for prolonged storage. However, stocks should be inspected frequently for detection of any leaks or unsafe storage conditions. Glass containers are excellent substitutes for faulty metal containers. Metal containers not specially treated may be unsuitable for prolonged storage of some pesticides. Lindane, which has a corrosive action on some metals, is an example. Many of the emulsion concentrates and dilute oil-based insecticides are flammable. Spark-proof lighting fixtures must be installed and ignition hazards must be eliminated in closed storage areas.

(4) Labels. All containers must be plainly labeled and kept closed. Never use empty food or drink containers to mix, pour, measure, or store any pesticide.

b. **Disposal.** Disposal of unwanted pesticides is one of the most difficult problems facing pest control personnel today. Because of the strict environmental controls established by the Environmental Protection Agency, previously authorized methods of disposal are no longer permitted. All methods of destruction are closely controlled because of environmental considerations -- air, water, and soil pollution. Until current Army regulations and Government directives (which are under revision at the time of this writing) have been revised, the following guidelines apply.

(1) In every possible instance, use the pesticide for its intended use. Dispose of the container in accordance with instructions obtained through command channels. Never use empty pesticide containers for any other purpose.

(2) Excess pesticides that are still in serviceable condition and in serviceable containers should be turned in through normal supply channels. If they are not acceptable and cannot be used, they must be disposed of as directed through command channels.

(3) Any pesticide that has become obsolete, has deteriorated, or whose container has corroded to the extent that continued storage is hazardous should be removed from stocks and disposed of in accordance with instructions from the major command concerned.

3-7. PRECAUTIONS IN HANDLING PESTICIDES

The handling of concentrates in the preparation of more dilute solutions is one of the most hazardous operations. Contamination of the skin with high concentrate material can result in rapid poisoning and death. Maximum precautions must be observed in handling concentrates.

a. **Safety Precautions.** Operators who are exposed to fumes, vapors, dusts, or mists of pesticides may suffer illness as a result of prolonged contact. It is equally as important to protect the operator continually exposed to dilute pesticides as it is to protect the operator occasionally exposed to concentrated pesticides. The following are some of the primary precautions that must be observed in handling pesticides.

(1) The first, and most important, step in mixing or handling a pesticide is to read and follow the instructions on the label. This point cannot be overemphasized. Never use a pesticide that does not have a label. Figure 2-5 illustrates a typical standard military pesticide label and the information included on it.

(2) No smoking or eating should be permitted while insecticides are being handled. This precaution is necessary to prevent both fire and hand-to-mouth contamination.

(3) All pesticides should be handled in well-ventilated areas or outdoors to minimize inhalation.

(4) Shower and washing facilities must be available near pesticide-mixing areas.

(5) Any contamination of the skin, particularly with liquid concentrates or solutions, must be immediately washed off with detergent and water. The protection provided by frequent rinsing of the skin during pesticide application is even more effective than the use of protective clothing, and both are at least as important as the use of respirators.

(6) Clothing contaminated by spillage should be immediately removed and thoroughly laundered before wearing. Special care is required to prevent contamination of the inside of gloves.

(7) Clothing of operators should not be worn during other than duty performance and should be laundered frequently to limit contamination.

(8) Use protective clothing and/or equipment when dictated by the situation (see paragraph b, below).

(9) Each installation should develop a standing operating procedure (SOP) for safe handling of pesticides and for clean-up of pesticide spills.

b. **Protective Clothing and Devices.** Whether or not protective clothing and equipment are required depends upon several factors -- the toxicity of the chemical (particularly the dermal toxicity), its concentration, and its volatility. The precautionary statement on the pesticide label must be consulted concerning specific requirements for protective clothing and devices. TB MED223, Respiratory Protective Devices, lists respiratory which are approved for use with pesticides. There are currently no approved respirators in the military supply system; they must be purchased from commercial sources. Common Table of Allowances (CTA) 50-914 lists the standard items of protective clothing and equipment in the military supply system. AR 385-32, Protective Clothing and Equipment, fixes the responsibility on commanders for procuring (from commercial sources, if unavailable within the Army supply system) the necessary protective clothing and equipment to safeguard the health of all personnel engaged in hazardous occupations or working with hazardous materials. For advice concerning protective clothing, equipment, and devices, users may consult the U.S. Army Environmental Hygiene Agency. The Armed Forces Pest Management Board has an excellent technical information manual (TIM 14) available on protective equipment for pest control personnel. A copy may be obtained by calling DSN 291-5365 (Test Management Information Analysis Center, Wash., D.C.).

3-8. THE CHOLINESTERASE TEST

a. **General.** The principal physiological effect of organophosphates and, to a lesser degree, the carbamates on the human body is the inhibition of cholinesterase. Cholinesterase is an enzyme which is synthesized in the tissues and which works with other enzymes to control the action of the central nervous system. When cholinesterase is inactivated by chemicals such as organophosphates, carbamates, or nerve type war gases, the enzyme balance is disturbed and the nervous system does not function properly. The result are (in increasing order of severity) gastrointestinal discomfort, salivation, and profuse sweating; muscular weakness; paralysis of the legs, then arms and back; and, finally, paralysis of the diaphragm with breathing difficulty and respiratory failure.

b. **Reasons for Testing.** The action of cholinesterase inhibitors is insidious. By the time symptoms appear, irreparable damage already may have been done. It is possible, by means of laboratory analysis of body fluids, to determine the level of cholinesterase activity in the body. By detecting a drop in cholinesterase activity, we may spot danger signs in a person who has been exposed before symptoms appear. We can then take positive steps to prevent further exposure.

c. **Application of the Test.** There is no requirement for administering the cholinesterase test; however, the U.S. Army Environmental Hygiene Agency recommends that it be administered monthly, during the spraying season, to all pest control personnel who work with organophosphates and carbamates. Since cholinesterase activity is not necessarily the same in all normal persons, a baseline must first be established for each individual. Once a baseline, or level of normal cholinesterase activity for that person is established, the monthly test will show any significant decrease. Such a decrease, in the absence of other contributing factors, should be considered an indication of excessive exposure and result in an individual's assignment to other duties.

3-9. FIRST AID AND ANTIDOTES

a. **First Aid.** Procedures for first aid vary according to the type of exposure. In all cases, a person with knowledge of the incident should accompany the victim to the medical facility to inform qualified medical personnel about the nature of the accident, the material being used, the first aid given, and the victim's symptoms following exposure up to the time of his arrival at the medical facility. The pesticide container or a label from it should be delivered with the patient to the medical facility. First aid measures according to the type of exposure are given below.

(1) <u>Pesticide on the skin</u>. Remove contaminated clothing and shoes. Wash skin and hair with soap and plenty of water. Call a physician.

(2) <u>Pesticide in the eyes</u>. Flush the eyes with running water for 15 minutes. Use a low-pressure water source. Call a physician.

(3) <u>Pesticide inhaled</u>. Remove victim to fresh air and have him lie down. Loosen his clothing and keep him warm and quiet. Apply mouth-to-mouth resuscitation if breathing stops. Apply cardiopulmonary resuscitation if breathing and heart beat stops. Get medical assistance immediately.

(4) <u>Pesticide swallowed</u>. Induce vomiting only if specified on the pesticide label. Use emetics only as recommended. Apply cardiopulmonary resuscitation if breathing and heart beat stops. Get medical assistance immediately.

b. **Antidotes.** The responsible supervisor at each military installation where pesticides are used must ensure that the nearest medical facility is informed of the chemicals being used so that antidotes can be made available and medical officers will be aware of toxic symptoms. Information regarding appropriate treatment may be obtained from the nearest poison control center. No matter what the nature of the poison, it is important to reduce the exposure. In the case of exposure, decontamination should be carried out as soon as the condition of the patient permits. If poison has been taken internally, a saline laxative may be used to speed evacuation of the gut; oil laxatives and emetics (vomiting agents) should be avoided where it is possible that an organic solvent or a chlorinated hydrocarbon insecticide is involved.

Some of the more common pesticides and the appropriate antidotes are listed in Table3-1.

Group	Pesticide	Antidote or Treatment
Organophosphates	Diazinon Dichlorvos Chlorpyrifos (Dursban) Fenthion Malathion Naled	Atropine with 2-PAM in symptomatic dosage to counteract to counter-act excessive acetylcholine. Artificial respiration may be required.
Carbamates	Propoxur (Baygon) Carbaryl (Sevin) Bendiocarb (Ficam)	Atropine. Artificial respiration may be necessary.
Chlorinated Hydrocarbons	Aldrin Chlordane DDT Dieldrin Lindane (BHC) Methxychlor	Barbiturates if convulsions occur.
Arsenicals	Lead arsenate Paris green	Dimercaprol.
Phenols	Pentachlorophenol	Oxygen and circulatory stimulants.
Botanicals	Nicotine Pyrethrum	Removal of poison and promotion of respiration.
Fumigants	Cyanide	Intravenous sodium nitrite followed by sodium thiosulfate.
	Methyl bromide	Supportive; oxygen resuscitation.
Rodenticides	Sodium fluoro-acetate (1080)	Intravenous barbiturates and procaine amide.
	Anticoagulants	Soluble vitamin K and whole blood transfusion if bleeding is actually present.
	Zinc phosphide	Symptomatic treatment.

Table 3-1. Pesticides and antidotes.

Section III. PESTICIDES AND THE ENVIRONMENT

3-10. BACKGROUND

Pesticides were used for many years, with varying degrees of success, prior to the development of the synthetic organic pesticide. The widespread use of the synthetic pesticides began immediately following World War II. DDT was the forerunner and was accepted by the general public as a panacea to the problem of unwanted insects. It had been used quite effectively by the military services during the war and in the subsequent rehabilitation of devastated areas. DDT became a household word -- particularly on the farm. Soon afterward, other synthetic pesticides began appearing on the market. The new pesticides enjoyed unprecedented popularity until about 1962, when the pendulum of public opinion began to swing in the other direction. It became apparent that residues of DDT and other chlorinated hydrocarbons were present not only in soil treated some years before, but also in various foods, including milk, meat, fowl, and fish. Traces of pesticides -- principally DDT -- were even being detected in human tissue. Following 10 years of controversy and investigation, the Federal Environmental Pesticide Control Act of 1972 virtually ended the use of DDT and sharply curtailed the use of certain other highly persistant pesticides.

3-11. PESTICIDE PERSISTENCE

When we think of the environmental impact of pesticides, one of our first considerations is that of pesticide persistence. Persistence is the ability of a pesticide to retain its toxic properties over an extended period of time in the environment. Although persistence is a desirable characteristic in the sense that a residual effect is desired to kill pests over a period of time, this same characteristic can be a serious liability in terms of accumulations of the pesticide. Although wide variations occur within classes of pesticides, we can state in very general terms the degree of persistence associated with a chemical class of pesticides.

a. **Chlorinated Hydrocarbons.** The chlorinated hydrocarbons, as a group, are considered highly persistent chemicals. Although they are biodegradable to a degree, their persistence in the environment is measured in years. Some of them have shown persistence up to 15 years (massive soil treatment, as in termite control). Lindane, DDT, and its derivatives are the most persistent. The chlorinated hydrocarbons are considered our worst polluters.

b. **Organophosphates.** The organophosphate compounds are considered nonpersistent. Most of them decompose within about two weeks, although diazinon, the most persistent of the organophosphates, remains in the soil for about three months.

c. **Carbamates.** The carbamates are similar to the organophosphates in their residual effects. Carbaryl (Sevin), the best known and most extensively used of the carbamates, has a half-life of about eight days in the soil. This means that every eight days, the residual decreases by about 50 percent. After two months, only about 1/190th of the original toxicant is present.

d. **Inorganic Pesticides.** The inorganic pesticides, principally arsenic compounds and the heavy metals, may be considered permanent rather than persistent in that they combine chemically with the soil and actually become part of the soil. Of these, mercury has caused the greatest concern; it is no longer used in pesticide formulations.

e. **Natural Organics.** The natural organic pesticides, of which pyrethrum is the only one the military stock list, are rapidly biodegradable and thus have virtually no adverse effect on the environment.

f. **Herbicides.** Herbicides do not constitute a separate chemical classification, but rather fall into a number of different chemical groups including, but not limited to, the classes into which we group insecticides. Accordingly, the degree of persistence may vary from a few weeks (as with dalapon, a carbamate) to one or two months (as with 2, 4-D and dicamba) to periods of 8 to 18 months (as with diuron, monuron, simazine, and picloram). Picloram has been known to last up to three years, with very heavy applications.

3-12. HAZARDS TO MAN

a. **Acute Poisoning.** Acute poisoning occurs from improper handling and use of pesticides and the unwise practice of storing them in food or beverage containers. Within the various groups, there is a wide range of acute toxicity. For example, DDT is relatively safe in terms of acute intoxication, whereas other chlorinated hydrocarbons have produced many cases of acute poisoning. A characteristic of organochlorine poisoning is difficulty in establishing the correct diagnosis. The symptoms are nonspecific and therapeutic measures do not exist. The organophosphate pesticides include some of the most toxic materials used by man. However, their effect -- cholinesterase inhibition -- results in a well-defined clinical pattern of intoxication that can be readily diagnosed. Specific therapeutic measures are available and, if applied with speed and vigor, are highly effective. Carbamate pesticides are also cholinesterase inhibitors, but the measurement of cholinesterase activity is not a reliable guide to exposure. As with organophosphates, the toxic potential of some members of the carbamate group is very great.

b. **Chronic Poisoning.** Studies of the effects on humans of prolonged low-level exposure to pesticides have been inconclusive thus far. The chief area of concern today is the accumulation of pesticide residues in foods, particularly in animal tissues. Chlorinated hydrocarbons, when ingested by warm-blooded animals, are deposited in the fat of body tissues. Although a number of pesticide residues have been identified in animal tissues, DDT is by far the most prevalent. DDT residues in humans tend to achieve an equilibrium between absorption, storage, and excretion. Storage levels reach a plateau after relatively long periods and are little disturbed by additional intake.

Human volunteers fed 35 mg of DDT per day over a period of 21 months reached a steady storage level of residual material after about one year. When dosages were discontinued, the residual deposits were rapidly depleted and storage levels decreased until a lower level was reached. Surveys have shown that the fatty tissue of U.S. inhabitants contains an average of 4 to 7 parts per million (ppm) DDT or its derivatives. Fat storage of the chlorinated hydrocarbons has been a source of anxiety to many people. However, despite numerous careful and detailed studies, no positive causal relationship has been established between the presence of pesticide residues and human disease. Still, authorities agree that active measures must be taken to prevent the accumulation of pesticide residues. Both the Department of Health and Human Services and the World Health Organization are trying to establish valid threshold levels for the accumulation of pesticide residues in humans.

3-13. HAZARDS TO OTHER NONTARGET ORGANISMS

The hazards of pesticide employment are not limited to the toxicity to man. Man is the only one of thousands of species in the living system of the earth. Most of these organisms are considered to be essential to man's well being. When a pesticide is applied to control specific pests, organisms other than those intended for eradication are also killed. The "innocent bystanders" are referred to as nontarget organisms.

a. **Phytoplankton.** Drifting plant cells in natural waters carry on a large portion of the photosynthesis on the earth's surface. These plant cells, or phytoplankton, synthesize most of the earth's organic material, produce most of the oxygen of the atmosphere, and participate in other essential ways in the chemical cycles of the biosphere. Evidence indicates that pesticides may significantly reduce such processes.

b. **Beneficial Insects.** Not all insects are harmful or undesirable. Naturally occurring parasitic and predacious insects control many insect pests. Some of these parasitic and predaceous species are more susceptible to certain pesticides than are the pest species. For example, when parathion was applied to a cole crop, the number of predaceous and parasitic species was reduced by 95 percent, whereas the number of plant-feeding species was reduced by only 8 percent. Following such a disruption, population outbreaks of the plant-feeders occur explosively. Similar results were observed in apple orchards where DDT applied against red mites kill predacious lady beetles, but hardly affected the mite population. Subsequently, mite damage was quite severe. Honey bee and wild bee pollinators have been found to be more susceptible to carbaryl than many other species of insects. Therefore, the widespread use of this chemical may reduce the pollination of both cultivated and wild plants.

c. **Marine Invertebrates.** In the coastal environment, several kinds of organisms are unusually susceptible to chemicals contained in waters flowing from land. Shellfish and other relatively immobile forms of life living on the bottom of bodies of water must tolerate whatever reaches them since they cannot escape. Arthropods such as shrimp and crabs are biologically similar to insects and mites, and highly sensitive to some of the arthropod poisons. Oysters and mussels have notable capacities for biological concentration of pesticides, and oysters have been noted to accumulate DDT to 70,000 times the concentration in ambient water. These levels of residue not only pose a threat to the arthropods themselves, but also to the higher forms of life who feed upon them.

d. **Fish.** Various species of fish have varying degrees of susceptibility to pesticide intoxication, but concentrations of 5 ppm of DDT in trout eggs have caused 100 percent mortality in a fry. A few species of fish have developed resistance to specific pesticides, but the resistant fish apparently have higher concentrations of pesticide; therefore, they pose an increased threat to consumers, including man.

e. **Birds.** Birds have provided much of the significant evidence on the worldwide effects of insecticides. Public and scientific concerns were alerted by early reports of heavy mortalities among robins which had fed upon earthworms contaminated during insect control programs. This concern was heightened by later evidence on eagles and falcons and their failure to produce young. Significant is the fact that the best-known cases of drastic population declines are among the carnivorous eagles and hawks, which are at the end of the food chain. Concentrations of DDT as high as 75.5 ppm in body weight have been found in the tissues of seagulls, who feed on sea life which build up added residues with each link in the food chain. This buildup is known as "ecological magnification."

f. **Mammals.** Insecticide damage in mammals apparently has not been as frequent or as serious as in birds and fish, although the available data are scarce. Field sampling has shown that DDT and its derivatives are present in the fat of many species of wild mammals. Only a few wild mammals have been sampled, but it is probable that many or all have now been exposed to the persistent pesticides, that many have accumulated measurable quantities, and that some have been adversely affected.

3-14. ROUTES OF CONTAMINATION

Contamination of the environment by pesticides occurs primarily through the following routes of dissemination.

a. **Air.** One of the most common routes of contamination by pesticides is through the air, either by aerial or surface application. Aerial dispersal is the distribution of pesticides from aircraft in the form of sprays, dusts, mists, fogs, and granules. It is designed to obtain maximum efficiency at minimum cost. Aerial dispersal provides rapid coverage of large areas and breeding sources that are inaccessible by other means. In 1963, the state of California used about 20 percent of the U.S. pesticide production, 80 percent of which was applied by aerial treatment. In military use, however, aerial application of pesticides is much more limited because of the inherent hazards associated with this method of distribution. Factors that influence aerial application are wind, temperature, rainfall, turbulence, terrain, vegetation, condition of equipment, type of aircraft, and the ability of the pilot. Hazards include the inadvertent poisoning of nontarget organisms as well as the danger involved in low-level flying. Aerial dispersal of pesticides in CONUS by military agencies must be justified in terms of necessity on an epidemiological basis, clearly demonstrated economy over other measures, and impracticability of other methods. In making a decision on whether to employ aerial dispersal and, if so, how to employ it, the following factors should be considered.

(1) Wind. Aerial dispersal is most accurately controlled when there is no wind. For practical considerations, any wind greater than 7 to 8 miles per hour should be considered excessive.

(2) Temperature. The most favorable condition of temperature for aerial dispersal is what is commonly referred to as a lapse condition. This is a normal condition in which the air at ground level is warmer than the air at higher altitudes. Under a lapse condition, particles in the atmosphere tend to fall vertically with a minimum amount of dispersion. The reverse of this condition is known as a temperature inversion. In an inversion condition, the air at the earth's surface is colder than the air above it. The result is that the cool air is trapped under the warmer air and air movement is lateral rather than vertical. Aerial distribution should be avoided under an inversion condition as the pesticide particles may fall laterally far from the point of dispersal.

(3) Formulation. Dusts, being lighter than liquids, carry further and are thus harder to control -- particularly under turbulent weather conditions.

(4) Droplet/particle size. The size of the spray droplet or dust particle will also affect the distance that a pesticide will travel before reaching the ground. Unfortunately, this characteristic is often a function of equipment design and not under the control of the operator.

(5) Dust in the atmosphere. Liquid chemical droplets adhere to dust particles in the atmosphere and may be carried for great distances. Therefore, aerial dispersal should be avoided under dusty conditions.

b. **Water.** The major pathway of pesticides into the water environment occurs through direct application to surface waters and surface runoff. The major recipients of surface water are streams, lakes, and coastal waters. Some pesticides find their way into ground waters, but the contribution of pesticides to a ground water source from a surface water source or from raindrops through the air is minute. There is little danger of contamination of a public well water supply by pesticides, but a number of instances of contamination of private wells have been reported -- usually by carelessness in handling the chemicals near the wells. On the other hand, public water supplies obtained from surface waters have frequently been found to be contaminated. The removal of pesticides by water treatment processes varies with individual pesticides and concentrations thereof. In general, however, it is more difficult to remove the low levels that occur through runoff than to reduce the high levels that result from direct application and accidents.

c. **Soil.** The fallout of pesticides following sprayed applications in the direct treatment of soil has led to a buildup in the soil of various amounts of pesticides. Soil residues may, therefore, be a cause for concern since they reach man by a number of routes -- uptake from soil by consumable crops, leaching into water supplies, volatilization into the air, and by direct contact with the soil. The magnitude of the problem is directly related to the amount supplied to the soil and the rates of pesticide degradation in the soil. Other related factors include the type and formulation of the pesticide, the soil type, the soil moisture and temperature, the leaching of pesticides from the soil by water, and wind erosion. It is necessary to understand these factors to properly evaluate the contamination hazard in applying a given pesticide to a given soil.

d. **Food.** In addition to air and water, food offers a medium or route for pesticide contamination. Crops of all kinds are particularly vulnerable to pesticide contamination, for it is upon the crops that the target insects feed. Forage and cereal crops, fruits, and vegetables become contaminated not only through direct application, but also systemically through the roots of the plant. The degree of contamination depends upon several variables -- the type of plant, the type of pesticide, the degree of soil contamination, and the time lapse between application of the pesticide and harvesting of the crop. As would be expected, residues from the chlorinated hydrocarbons exceed those of other types of pesticides. This is partly because of their wider usage, but it is also because plants have the ability to metabolize the organophosphates in their cells. The problem in animal food supplies is essentially that of the food chain discussed in paragraph 3-13. Most of our meat animals are grain and forage eaters. Concentrations of highly residual pesticides present in grain and forage feeds build up in the tissues -- particularly in fat -- of these animals. Such residues are also found in animal products such as milk and eggs. Pesticide residues in milk have been traced to the absorption of chemicals through the skin by cows that had been sprayed for the control of flies, screwworms, and other pests.

3-15. PESTICIDE RESISTANCE

A major concern in the employment of pesticides is that of the development in some species of pests of resistance to certain pesticides. Cockroaches, mosquitoes, and houseflies, for example, have developed a resistance to chlordane. The problem in pesticide-resistant insects is similar to that of antibiotic-resistant strains of microorganisms. The resistance often becomes genetic, resulting in successive generations of resistant organisms. This resistance frequently leads to the use of more toxic materials or of increased concentrations of the same material. In either case, the result is an added environmental hazard.

3-16. IMPLICATIONS FOR PEST CONTROL PERSONNEL

The implications to be drawn from the available data on pesticides in the environment are fairly clear. Pesticides play an extremely important role in our constant struggle against the pests which attack our food supplies, our clothing, our homes -- even ourselves. However, we cannot use these chemicals indiscriminately and expect to maintain a wholesome environment. All persons involved in pest control operations -- from the installation engineer or entomologist down to the operator -- must:

a. First, and most important, determine whether the application of pesticides is really the best solution to the problem.

b. Determine the weather conditions before undertaking any spraying, fogging, or dusting operations.

c. Use ultra low volume (ULV) equipment whenever possible. ULV equipment is designed to disseminate a smaller volume of pesticide per unit area by delivering a spray of extremely fine droplets over a wide area.

d. Whenever possible, use nonpersistent, rather than persistent, chemicals.

e. Use the recommended pesticide dosage. Excessive dosages violate the law, increase the hazard, and waste materials. Insufficient dosages will not accomplish the mission, will necessitate repeating the operation (thereby adding to both the exposure and the expenditure of materials), and may accelerate development of a pest's resistance to a pesticide.

3-17. PESTICIDE INFORMATION

Information in concerning the use, storage, and handling of pesticides can be obtained by contacting the U.S. Army Environmental Hygiene Agency Pesticide Hotline (DSN) 584-3773. This is a 24-hour service available to all military installations worldwide.

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 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 potential of a chemical to cause damage to an organism when ingested, inhaled, or absorbed is known as:

    a. Hazard.

    b. Toxicity.

    c. Lethal potential.

2. The probability that a chemical will cause damage when used in a particular way is known as:

    a. Hazard.

    b. Toxicity.

    c. Destructive potential.

3. The most common hazard in the use of pesticides is:

    a. Ingestion.

    b. Flammability.

    c. Carelessness.

    d. None of the above.

4. Match the following terms with their appropriate definitions by writing the letter of the definition in the blank following the term. Definitions may be used more than once.

a. Inorganic insecticides ___	(1) Extremely toxic; formulated from heavy metals.
b. Botanicals ___	(2) Inhibit cholinesterase.
c. Chlorinated hydrocarbons ____	(3) Worst environmental polluters.
d. Organophosphates ____	(4) Break down rapidly; virtually no residual effect.
e. Carbamates ____	(5) Those in current use have extremely low acute toxicity.
f. Anticoagulants ____	

5. Check the conditions listed below that are favorable for the storage of pesticides:

a. _________ Cool.

b. _________ Warm.

c. _________ Light.

d. _________ Dark.

e. _________ Humid.

f. _________ Dry.

6. Which of the following activities should not be permitted in the vicinity of pesticide storage and mixing operations? (More than one answer may be correct.)

a. Smoking.

b. Eating.

c. Working.

d. Reading.

e. Playing cards.

7. What is the preferred method of disposing of a pesticide?

   a. Burning.

   b. Burial at sea.

   c. Burial in a sanitary landfill.

   d. Using it for its intended purpose.

8. What is the most important safety precaution in the use of pesticides?

   a. Read and follow label instructions.

   b. Ensure you are properly trained.

   c. Wear protective clothing.

   d. None of the above.

9. To minimize the possibility of pesticide inhalation, all mixing operations should be conducted in _________________areas.

   a. Cool, dry.

   b. Sealed.

   c. Calm.

   d. Well-ventilated.

10. The requirement to wear protective clothing and equipment when applying pesticides is dependent upon which of the following factors? (More than one answer may be correct.)

    a. Toxicity.

    b. Amount.

    c. Concentration.

    d. Volatility.

11. The cholinesterase test is recommended for personnel who periodically handle: (more than one answer may be correct)

    a. Chlorinated hydrocarbons.

    b. Organophosphates.

    c. Carbamates.

    d. Anticoagulants.

12. What does a cholinesterase test indicate?

    a. When one's cholinesterase is all used up.

    b. When one's cholinesterase level is near the bursting point.

    c. Whether one does or does not have cholinesterase in his system.

    d. A deviation in cholinesterase level from a previously established baseline.

13. First aid treatment for pesticide poisoning is not dependent on the type of exposure.

    a. True.

    b. False.

14. Vomiting should <u>not</u> be induced if a person has been poisoned with:

   a. Chlorinated hydrocarbons.

   b. Organophosphates.

   c. Botanicals.

15. The Federal Environmental Pesticide Control Act of 1972 virtually ended the use of:

   a. BHC.

   b. DDT.

   c. DEET.

16. The ability of a chemical to retain its toxic properties over a long period of time in the natural environment is known as:

   a. Longevity.

   b. Staying power.

   c. Persistence.

   d. None of the above.

17. Which of the following is most persistent?

   a. Natural organics.

   b. Chlorinated hydrocarbons.

   c. Carbamates.

   d. Organophosphates.

18. What are the two types of poisoning that can occur from overexposure to pesticides?

    a. Oral and dermal.

    b. Acute and chronic.

    c. Persistent and residual.

    d. None of the above.

19. Victims of pesticide poisoning for whom the toxicant was not intended are referred to as:

    a. Nontarget organisms.

    b. Victims of circumstance.

    c. Endangered species.

20. Select the four media (routes) by which pesticides contaminate the environment.

    a. Animal, mineral, vegetable, and ethereal.

    b. Air, water, soil, and food.

    c. Rivers, streams, springs, and lakes.

    d. Rain, snow, fog, and hail.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 3

1. b (para 3-3)

2. a (para 3-3)

3. c (para 3-4)

4. a 1 (para 3-5a(1))
   b 4 (para 3-11e)
   c 3 (para 3-11a)
   d 2 (para 3-5a(3)(b))
   e 2 (para 3-5a(3)(c))
   f 5 (para 3-5b)

5. a, d, and f (para 3-6a(1))

6. a, b (paras 3-6a(2); 3-7a(2))

7. d (para 3-6b(1))

8. a (para 3-7a(1))

9. d (para 3-7a(3))

10. a, c, d (para 3-7b)

11. b, c (para 3-8a)

12. d (para 3-8c)

13. b (para 3-9a)

14. a (para 3-9b)

15. b (para 3-10)

16. c (para 3-11)

17. b (para 3-11a)

18. b (paras 3-12a, b)

19. a (para 3-13)

20. b (paras 3-14a, b, c, d)

End of Lesson 3

LESSON ASSIGNMENT

LESSON 4 Hazard Communication Program.

TEXT ASSIGNMENT Paragraphs 4-1--4-26.

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

4-1. Identify the goals of the Hazard Communication Standard.

4-2. Define physical and health hazards.

4-3. Identify the basic types of physical and health hazards.

4-4. Define the methods of controlling chemical hazards.

4-5. Identify general information that must be contained on a Material Safety Data Sheet.

4-6. Identify health and physical hazard information that must be contained on a Material Safety Data Sheet.

4-7. Identify information that must be on all warning labels.

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

Section I. THE FEDERAL HAZARD COMMUNICATION STANDARD

4-1. INTRODUCTION

a. The Federal government is working to reduce the risk of injury or illness caused by hazardous chemicals in the workplace. Accomplishing this goal requires information and communication. Everyone needs to know about the hazardous chemicals they work with -- whether the material poses a risk to safety or health,and how to minimize or eliminate any such risks.

b. The Hazard Communication Standard was issued by the Occupational Safety and Health Administration (OSHA) in 1983 and revised in 1987. Executive Order 12196 of 1980 and 29 CFR Part 1960 provided the authority for implementing the Standard within the Federal sector. It requires that you be:

(1) Informed about hazardous chemicals in your workplace.

(2) Trained to work safely with these materials.

c. Working safely with chemical materials is a team effort. You and your co-workers that use the material must know about these chemical materials, how they can enter the body, and how they affect people's health. They must also know how to recognize hazards and how to control these hazards. Your safety and health, as well as that of your co-workers, depends on your active participation in this program.

d. This lesson is not intended to teach you everything you need to know about the program, but to make you aware of the Standard and some of the requirements. A comprehensive training program is available that includes a trainer's guide, a student workbook, and the associated 90-minute videotape. DOD activities can obtain copies of the program through their own publications channels by ordering publication DOD 6050.5-W and DOD 6050.5-G-1.

4-2. THE HAZARD COMMUNICATION STANDARD GOALS

a. This Standard strives to achieve the following goals:

(1) Reduce the incidence of injury and illness by hazardous chemicals in the workplace.

(2) Identify and evaluate chemical hazards.

(3) Establish uniform requirements for communicating information about chemical hazards to both management and workers.

b. To achieve these goals, the Standard requires certain actions. First, chemical manufacturers and importers must:

(1) Conduct hazard determinations to identify the hazards of, and appropriate control measures for the chemicals they produce or import.

(2) Label all containers of hazardous chemicals leaving the workplace to communicate the identity of the material, all appropriate hazard warnings, and the name and address of the responsible party.

(3) Obtain or prepare an accurate and up-to-date Material Safety Data Sheet (MSDS) for each hazardous chemical material sold and provide a copy to every person, agency, or company that purchases the chemical.

(4) Add new information to the MSDS on the hazards of a chemical and/or appropriate control measures within three months after becoming aware of such information.

c. The Standard also requires companies/agencies to do the following:

(1) Maintain a MSDS for every hazardous chemical used and/or stored and make these MSDSs readily available to workers on every shift and in every location where used or stored.

(2) Make sure that containers of hazardous chemicals are labeled, tagged, or otherwise marked to identify the chemical and warn workers of the hazards it presents.

(3) Maintain an up-to-date list of hazardous chemical materials known to be present in the workplace and make this list readily available to workers at all times.

(4) Inform and train workers.

(5) Maintain a written local Hazard Communication Program that describes how the organization complies with the above actions and make this written program available to employees upon request.

Section II. CHEMICAL FORMS AND EXPOSURE HAZARDS

4-3. INTRODUCTION

Many work processes require the contact with hazardous chemicals. Having a safe and healthful work environment means you must recognize potential chemical hazards and protect yourself from them.

4-4. HAZARDS

a. **Categories.** The Hazard Communication Standard defines two main categories of chemical hazards:

(1) Physical hazards. Physical hazards are chemicals that cause explosion, fires, violent chemical reactions, or other hazardous situations.

(2) Health hazards. Health hazards are chemicals that can cause illness or injury when inhaled or swallowed, or through contact with the skin or eyes.

b. **Basic Forms.** All chemicals exist in one of three basic forms:

(1) Solids. Solids have a definite shape and can become airborne s dust or fume particles.

(2) Liquids. Liquids take the shape of their container and can become airborne as mists or vapors.

(3) Gasses. Gasses are easily compressed, expand to fill a container, and become airborne when not contained.

c. **Dust and Fumes.** Both dusts and fumes are made up of tiny solid particles. Mechanical operations like grinding and crushing produce dust. So does transfer of powdered or fibrous solids and abrasive cleaning. Fumes form by vapor condensation when solids are melted in operations like welding and metal casting.

d. **Vapors**. Vapors are formed above any exposed liquid surface. Heating a liquid makes it vaporize more quickly. Mist is made up of tiny droplets that become airborne when liquids are sprayed, agitated, or applied to a hot surface. Mists also form when hot vapors cool in air and condense.

4-5. EXPOSURE ROUTES

Exposure routes are ways that chemicals enter the body. There are four main routes of exposure.

a. Breathing/inhalation takes a chemical from the nose or mouth, down the windpipe, and into the lungs. Some chemicals get trapped in the lungs. Others leave when you breathe out. But many pass from the lungs into the bloodstream.

b. Skin/eye contact can cause anything from reddening or itching to severe rashes, burns, loss of eyesight, or even death.

c. Skin absorption hazards pass through the skin on contact and enter the bloodstream. Once in the bloodstream, chemicals can spread throughout the body and cause injury or disease far away from the original site of contact. Chemicals can also be absorbed through the mucous membranes of the eye.

d. Swallowing/ingestion takes a chemical from the mouth, down the esophagus, and into the stomach. From the stomach, many chemicals enter the intestines where they can be absorbed into the bloodstream and spread throughout the body. Damage can be done at any point along the way.

4-6. DEGREE OF HAZARD

The degree of hazard associated with exposure to health hazards depends on the following:

a. **Toxicity of the Chemical.** See Table 4-1.

TOXICITY	EFFECTS OF EXPOSURE
Low	Minor symptoms that go away when exposure stops.
Medium	Require medical attention, may be permanent.
High	Can cause death or severely disabling conditions.

Table 4-1. Toxicity and its effects.

b. **Exposure Route.** Some chemicals are more toxic by one exposure route than by another. For example, onion juice vapor irritates the eyes, but skin contact with onion juice produces little or no effect.

c. **Dosage.** Dosage depends on:

(1) How <u>much</u> you were exposed to each time.

(2) How <u>long</u> each exposure lasts.

(3) How <u>often</u> you are exposed.

d. **Individual Differences.** Individual differences include the following:

(1) Work practices.

(2) Age and size.

(3) General, physical, and emotional health.

(4) Allergies and sensitivities.

(5) Levels of exertion.

(6) Combination of chemicals in the body, which depends on what medications you are taking and whether or not you smoke tobacco or drink alcoholic beverages.

Section III. TYPES OF PHYSICAL AND HEALTH HAZARDS

4-7. INTRODUCTION

Section II above stated that The Hazard Communication Standard covers both physical hazards and health hazards. This section introduces you to the different types of hazards in each of these two main categories. It will help you understand how each type of hazard can affect your health and safety.

4-8. TYPES OF PHYSICAL HAZARDS

a. Physical hazards are chemicals that can cause explosions, fires, violent chemical reactions, or other hazardous situations.

b. Physical hazards include:

(1) Compressed gases. Compressed gases contain a great deal of stored energy. They are physical hazards because the sudden release of this energy is dangerous.

(2) Explosives. Explosives cause a sudden release of pressure and heat.

(3) Fire hazards. Fire hazards ignite and burn easily or cause/support fire in other materials.

(4) Unstable/reactive chemicals. Unstable/reactive chemicals produce or release hazards under commonly occurring temperatures, pressures, or light conditions.

c. Fire hazards include:

(1) Pyrophorics. Pyrophorics ignite easily at temperatures below 130°F.

(2) Flammable liquids. Flammable liquids ignite easily at temperatures below 100°F. Turpentine, which ignites at 95°F, is a flammable liquid.

(3) Combustible liquids. Combustible liquids ignite easily at or above 100°F, but below 200°F. Kerosene, which ignites at 100-165°F, is a combustible liquid.

(4) Oxidizers. Oxidizers supply the oxygen required to start or support fire.

d. Unstable/reactive chemicals include:

(1) Decomposition hazards. Decomposition hazards easily break up into simpler substances.

(2) Polymerization hazards. Polymerization hazards self-react to form long molecular chains, releasing heat and/or hazardous chemical in the process.

(3) Water-reactive chemicals. Water-reactive chemicals react violently with water resulting in physical and/or health hazards.

4-9. DOs AND DON'Ts OF PHYSICAL HAZARDS

a. Proper disposal of waste containing flammable liquids is essential. Covered waste containers should be used to reduce the danger of exposure to an ignition source that could start a fire. Failure to properly dispose of cleaning and paint-covered rags could also present a spontaneous combustion hazard. Fire extinguishers should be provided whenever a fire hazard exists.

b. Smoking and electric heaters are potential ignition sources and are not allowed in areas where flammable liquids are present.

c. No ashtrays should be provided in the area because no one should smoke near flammables. Ashtrays should be provided in designated smoking areas so cigarettes may be disposed of properly before entering the area.

d. Sparking tools (electric saws, drills, etc.) should not be used near fire hazards.

e. Compressed gases contain a lot of stored energy. A power wrench could easily break the valve stem and turn the cylinder into a powerful rocket. Securing cylinders and handling them properly helps avoid physical damage that could result in a disaster.

f. Although not flammable itself, oxygen gas must be kept away from ignition sources and flammable materials because it makes fires start easily and burn with great intensity.

g. Hand trucks should be used to transport all compressed gas cylinders. This helps prevent cylinder damage or shock that could release the energy stored in the compressed gas.

4-10. TYPES OF HEALTH HAZARDS

a. Health hazards are chemicals that can cause injury or illness when exposed to the skin or eye contact, skin absorption, inhalation, or ingestion. The type of injury or illness ranges from short-term irritation to permanent damage or death, and depends on the type of health hazard.

b. Health hazards include:

(1) Irritants. Irritants cause reddening, itching, or other irritation on contact.

(2) Corrosives. Corrosives burn or eat away body tissues on contact.

(3) Cryogenics. Cryogenics freeze body tissue on contact.

(4) Reproductive hazards. Reproductive hazards target the reproductive system, causing sterility, miscarriage, fetal injury, or birth defects. They include:

(a) Mutagens, which damage genes in egg or sperm cells.

(b) Teratogens, which damage the fetus during its development.

(5) Sensitizers. Sensitizers cause an allergic-like response in many people who are repeatedly exposed.

(6) Carcinogens. Carcinogens cause cancer.

4-11. CHARACTERISTICS OF HEALTH HAZARDS

a. There is no way to tell who will become sensitized to a chemical nor how long it may take. The allergic-like response can appear on any exposure after the first exposure.

b. Some workers become sensitized over time. Suddenly they develop symptoms that they never had before. This is usually itching, a skin rash, or difficulty breathing. Others who are repeatedly exposed to the same sensitizer never develop allergic-like response.

c. Corrosives burn on contact. They can damage the skin, eyes, digestive tract, or respiratory system. The tissue damaged depends on the exposure route.

Section IV. CONTROLLING CHEMICAL HAZARDS

4-12. INTRODUCTION

Everyone who works with chemicals that can cause hazards needs to know how the hazards are controlled. This section introduces you to engineering controls, personal protective equipment, and administrative controls that may be required to protect you from chemical hazards in your workplace.

4-13. ENGINEERING CONTROLS

Engineering controls include the following:

a. **Substitution**--replacing a chemical, process, or piece of equipment with a less hazardous or more efficient one. Example: steam instead of a solvent cleaner.

b. **Isolation**--using an enclosed place, barrier, or safe distance to separate workers from exposure hazards. Example: flammable storage room in a warehouse.

c. **General Ventilation**--mixing an airborne hazard with fresh air to reduce exposure levels (this is only suitable for hazards of low toxicity that mix readily with air). Examples: fans and air vents.

d. **Local Exhaust Ventilation**--capturing an airborne hazard as it is released and taking it out of the workplace to eliminate exposure. Examples: hoods, slots, and dust collectors.

4-14. PERSONAL PROTECTIVE EQUIPMENT

a. Personal protective equipment (PPE) puts a barrier between the hazard and the individual who wears it. It can protect against both physical and health hazards. Personal protective equipment includes:

(1) <u>Protective gloves and clothing</u>. Examples: hats, hoods, boots, impervious gloves, cloth gloves, rubber aprons, lab coats, and impervious boots.

(2) <u>Eye and face protection</u>. Examples: safety glasses, splash goggles, face masks, and shields.

(3) <u>Air-purifying respirators</u>. Examples: respirators with a cartridge or filter that removes contaminants from the air you breathe.

(4) Air-supplied respirators. Examples: Self-contained units that supply air from a tank carried on the back and air-line units that provide air from a remote source.

b. To protect you, PPE must be matched to the specific hazard. For example, cloth gloves are useless for protection against a corrosive liquid. PPE is also useless unless you wear it. Proper fit, correct use, and routine maintenance of the equipment are also critical. All PPE must fit properly. Proper fit is critical for respirators because a leaky facemask allows the wearer to breathe the airborne hazard. Although an oversized glove may still prevent skin contact, it also hinders dexterity. This hazard can cause an accident that results in injury or exposure to a health hazard.

4-15. ADMINISTRATIVE CONTROLS

a. In addition to engineering and personal protective equipment, controlling chemical hazards requires information and training, safe work practices, good housekeeping, good personal hygiene, and monitoring.

(1) Documentation, information, and training. Examples: warning labels, Material Safety Data Sheets (MSDS), hazardous chemical inventory, and a written hazard communication program.

(2) Work practices. Examples: using all available controls correctly and reporting controlled hazards promptly.

(3) Housekeeping--containing and removing hazards. Examples: vacuuming toxic dusts, cleaning up chemical spills, proper storage and handling, and correct disposal of chemical wastes.

(4) Monitoring--checking the effectiveness of other controls. Examples: Air and wipe samples for area monitoring, personal sampling for individual monitoring, medical exams, and laboratory tests.

b. Always be alert for uncontrolled chemical hazards in the workplace. You can see bulk liquids and solids, but most airborne hazards are invisible. You can smell or taste some airborne airborne chemicals, but not others. Some chemicals deaden the sense of smell, and others cannot be detected by smell at the very low levels that can harm you. Remember, anything you taste or smell is entering your body.

c. In addition to sensing the chemical itself, you can detect exposure hazards by doing the following:

(1) Spotting equipment failures such as a ventilation system that stops working, damaged chemical containers, and faulty PPE.

(2) Spotting leaks, spills, fires, explosives, uncontrolled chemical reactions, or other emergency/accident situations.

(3) Recognizing health effects produced by exposure, such as headache, dizziness, coughing, irritation, or nausea.

(4) Watching for anything unusual or out of the ordinary.

Section V. MATERIAL SAFETY DATA SHEETS AND PHYSICAL HAZARD INFORMATION

4-16. INTRODUCTION

Material Safety Data Sheet (MSDS) contains a great deal of useful information about chemical hazards. Everyone who works around or with chemicals has the right to review a copy of the MSDS for any chemical material in your work area simply by asking. The MSDS must be available in the storage or workplace at all times. This section will help you understand how to read an MSDS. You will see what kinds of general information and physical data the MSDS contains and how to use MSDSs to help protect yourself from physical hazards of the hazardous chemical in your workplace. A completed MSDS for methanol alcohol is shown in Figure 4-1.

4-17. GENERAL INFORMATION (SECTION I)

Every MSDS must contain the following general information:

a. Name, address, and telephone number of the party responsible for preparing or distributing the MSDS who can provide additional information on the hazardous chemical and appropriate emergency procedures.

b. Name of the chemical material as it appears on the warning label and Hazardous Chemical Inventory in your workplace.

4-18. HAZARDOUS INGREDIENTS/IDENTITY INFORMATION (SECTION II)

This section contains a list of all chemicals that are contained in the product and the concentration (parts per million) of each chemical.

4-19. PHYSICAL/CHEMICAL CHARACTERISTICS (SECTION III)

Each MSDS must contain certain characteristics of the chemical.

a. **Boiling Point.** The boiling point is the temperature at which the product changes from a liquid to a gas. If the boiling point is below normal room temperature, which is about 68°F, the product is a gas.

b. **Specific Gravity.** Specific gravity tells you whether a liquid is lighter than water or heavier than water. Water has a specific gravity of 1. If the product is lighter than water (less than 1) it will float on water if not soluble in water. If the product is heavier than water (greater than 1) it will sink in the water if not soluble in water.

c. **Vapor Pressure.** Vapor forms above the liquid surface inside a closed container. This vapor exerts a force in the walls of the container. The force is the vapor pressure of the liquid. Vapor pressure is measured in millimeters of mercury (mm Hg). Vapor pressure increases as the temperature of a liquid rises. Liquids with a high vapor pressure at room temperature (greater than 100 mm Hg) present a special hazard. The pressure inside a sealed container can make the container swell or burst open. This releases a hazard and is most likely to happen if a sealed container is exposed to heat. High vapor pressure will tell you how fast it gets into the air, as well.

d. **Melting Point.** This is the temperature at which a sold substance melts.

e. **Vapor Density.** Vapor density tells you whether a vapor is lighter than air or heavier than air. Air has a density of 1. If the product is lighter than air (less than 1), it will tend to rise and get out of your breathing zone. If it is heavier than air (greater than 1), it tends to sink and will stay in your breathing zone. It will also accumulate in low spots.

f. **Evaporation Rate.** Evaporation rates are reported as comparisons. The evaporation rate tells you how fast a liquid evaporates compared to water, which is 1. Evaporation rates greater than 1 vaporize faster than water. Evaporation rates less than 1 vaporize slower than water.

g. **Solubility in Water.** Solubility is the quantity of the chemical or product that is capable of being dissolved in water.

h. **Appearance and Odor.** The appearance and odor block describes physical form/appearance, color, and odor (if any).

4-20. FIRE AND EXPLOSION HAZARD DATA (SECTION IV)

Physical hazards include explosion hazards, fire hazards, and unstable or reactive chemicals. The MSDS identifies these types of hazards and provides information to help you control them.

a. **Flash Point.** The flash point is the lowest temperature at which a liquid gives off enough vapor to ignite in the presence of an ignition source, such as a match, spark, or cigarette. Flammable liquids have a flash point below 100°F. In general, materials with lower flash points are more hazardous than materials with higher flash points.

b. **Flammable Limits.** The lower explosive limit (LEL) is the minimum amount of airborne chemical that must be present in an air-chemical mixture to make it explosive. The upper explosive limit (UEL) is the maximum amount of airborne chemical that can be present in an air-chemical mixture and still have it be explosive. A low LEL or wide explosive range is most hazardous.

c. **Extinguishing Media.** The MSDS informs you of what type of fire extinguisher or material should be used to put out a fire.

d. **Special Fire and Explosion Hazards.** The information given is instructions on how professional fire fighters should put out a fire.

e. **Unusual Fire and Explosion Hazards.** The information given will state if the product is a fire hazard and whether or not it will explode.

4-21. REACTIVITY DATA (SECTION V)

The reactivity data section of the MSDS lists conditions to avoid for unstable chemicals and polymerization hazards and incompatible reaction of materials. The conditions to avoid are those that might cause the chemical to decompose (break down into simpler molecules) or to polymerize (self-react to form larger molecules). Reactive chemicals become hazardous when in contact with certain other chemical materials . Contact may cause a fire, explosion, or other violent chemical reaction. It may also produce or release a hazardous chemical. For this reason, the reactivity data section lists materials to avoid for reactive chemicals. The following information is furnished.

a. **Stability.** Unstable or stable is checked and any conditions to avoid are listed.

b. **Incompatibility.** Materials to avoid, if any, are listed. Whenever the MSDS lists any materials to avoid, the chemical is reactive.

c. **Hazardous Decomposition or By-Products.** Any chemicals listed will be toxic gases that are formed when the chemical burns or decomposes. Carbon monoxide, phosgene, and hydrogen chloride are deadly.

d. **Hazardous Polymerization.** The "may" or "will not occur" will be checked and conditions to avoid, if any, will be listed.

MATERIAL SAFETY DATA SHEET

IDENTITY
Methanol/Wood Alcohol

SECTION I

Manufacturer's Name A Chemical Company	Emergency Telephone Number 215-555-6500
Address 1300 Beacon Street Some City, N.J 99999	Telephone Number for Information 215-555-1207
	Date Prepared 11/09/85

SECTION II - Hazardous Ingredients/Identity Information

Methanol (Wood alcohol; wood naphtha)	200 ppm	200 ppm	100%

SECTION III - Physical/Chemical Characteristics

Boiling Point:	64.51^{o}C	Specific Gravity: (H2O = 1)	0.7924
Vapor Pressure: @ 20^{o}C	97.30	Melting Point	-97.8^{o}C
Vapor Density:	1.1	Evaporation Rate	5.9

Solubility in Water: Complete

Appearance and Odor: Clear. colorless, liquid with an alcohol odor.

SECTION IV - Fire and Explosion Hazard Data:

Flash Point (Method Used)	Flammable Limits	LEL	UEL
11^{o}C(52^{o}F) (Closed cup)		6.0%	36%

Extinguishing Media:
Dry chemical. foam, carbon dioxide, water fog.

Special Fire Fighting Procedures:
Use water spray to keep exposed containers cool. Water spray may be used to disperse liquid and dilute to nonflammable mixture. Do not enter confined fire space without full Bunker gear, including a positive pressure NIOSH-approved self-contained breathing apparatus.

Unusual Fire and Explosion Hazards:
Fire exposed containers will explode. Vapors are heavier than air and may travel a considerable distance to an ignition source and flashback.

Figure 4-1. Material Safety Data Sheet (continued).

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METHANOL/WOOD ALCOHOL

SECTION V - Reactivity Data:

Stability:	Unstable	Conditions to Avoid:	Heat, sparks, open flame, contact with strong oxidizers.
	Stable	X	

Incompatibility (Materials to Avoid):
Oxidizers, active metals such as Aluminum and Zinc.

Hazardous Decomposition or Byproducts: (Combustion) Carbon Dioxide, Carbon Monoxide, Aldehydes and unidentified organic compounds.

Conditions to Avoid: N/A

Will Not Occur: X

SECTION VI - Health Hazard Data:

Routes of Entry:	Inhalation?	Skin?	Ingestion?
	YES	YES	YES

Health Hazards (Acute and Chronic):
ACUTE: Drowsiness, drunkenness, headache, eye irritation and visual disturbances leading to blindness, coughing, shortness of breath and respiratory tract irritation. In extreme cases can result in collapse and death. Eye irritation may occur.
CHRONIC: Prolonged and repeated skin contact can result in dermatitis. Will be absorbed through the intact skin. Prolonged or repeated overexposure by all routes can result in damage to the central nervous system, liver, kidneys, and eyes, blindness and death.

Carcinogenicity:	NTP	ARC Monographs?	OSHA Regulated?
	NO	NO	NO

A 1985 publication reported caratogenicity in rats inhaling 20,000 pps 7 hours/day during gestation with little material toxicity (Fund. Appl. Tox. 5:727 1985).

Signs and Symptoms of Exposure:
Irritation to nose, throat, respiratory tract and eyes. Headache, dizziness, nausea; changes in urinary output; edema; loss of appetite; jaundice; fatigue.

Medical Conditions: Impaired liver and kidney functions; eve disease; skin and respiratory disorders.

Figure 4-1. Material Safety Data Sheet (continued).

Page 3
METHANOL/WOOD ALCOHOL

Emergency and First Aid Procedures: Ingestion: Induce vomiting; Inhalation: If overcome by exposure, move the victim immediately to fresh air and provide oxygen if breathing difficult. Keep warm and quiet. Administer artificial respiration if not breathing. Get medical attention. For eye and skin contact, flush with water for 15 minutes.

SECTION VII Precautions for Safe Handling and Use:

Steps to be taken in Case Material is Released or Spilled: Dike the spill, eliminate sources of ignition. For large spills, evacuate hazard area. Soak up spill with absorbent material and place in non-leaking containers. Do not flush into drains. Use only grounded equipment to prevent sparking. Wear appropriate protective clothing and equipment. Suppress vapor cloud with water fog.

Waste Disposal Method: May be incinerated or disposed of as a hazardous waste in an approved landfill. Refer to latest EPA or state regulations regarding proper disposal.

Precautions to Be Taken in Handling and Storing:
Store in tightly closed vented containers away from heat, flame, sparks, and oxidizing agents. Ground & Bond when dispensing. Use non-sparking tools. Extinguish pilot lights and other sources of ignition until all vapors are gone.

Other Precautions:
Do not reuse contaminated clothing or shoes until cleaned.

SECTION VIII - Control Measures:

Respiratory Protection (Specify Type)
Air supplied only.

Ventilation: Local Exhaust: Explosion-proof ventilation should be used to control vapor accumulation.

Special: Explosion-proof ventilation

Mechanical (General): Explosion-proof

Other: N/A

Protective Gloves: Impervious, chemical resistant

Eye Protection: Splash proof safety glasses or goggles as appropriate.

Other Protective Clothing or Equipment:
Chemical protective aprons, boots, and face shield as necessary when splashing may occur.

Work/Hygienic Practices:
Avoid prolonged or repeated contact with skin.
DO NOT USE AIR PURIFYING RESPIRATOR. METHANOL HAS POOR WARNING PROPERTIES AND CARTRIDGES HAVE VERY SHORT BREAK-THROUGH TIMES.

Figure 4-1. Material Safety Data Sheet (concluded).

Section VI. MATERIAL SAFETY DATA SHEETS AND HEALTH HAZARD INFORMATION

4-22. INTRODUCTION

In addition to physical hazard information, Material Safety Data Sheets contain a great deal of information about health hazards. This section will show how you can use the MSDS to identify the following:

a. Health hazards.

b. Exposure routes.

c. Health effects.

d. First-aid procedures.

e. Required protective equipment.

f. Special handling and storage precautions.

4-23. MSDS HEALTH HAZARD INFORMATION (SECTIONS VI, VII, AND VIII)

Sections VI, VII, and VIII of Figure 4-1 show entries on the health hazards, precautions, and control measures to be taken for methanol alcohol. Review these sections and the information provided to become familiar with the type of information that is available on all hazardous material.

Section VII. USING LABELS AND THE HAZARDOUS CHEMICAL INVENTORY

4-24. INTRODUCTION

The Hazardous Communication Standard requires the use of warning labels. It also requires a Hazardous Chemical Inventory that names all hazardous chemical materials stored or used in your workplace. In this section, you will see what information these documents contain and how to use the labels and inventories available in your workplace. OSHA also requires a local written Hazard Communication Program.

4-25. WARNING LABELS

a. The Hazard Communication Standard requires the use of hazard warning labels (Figure 4-2) that include:

(1) The name and identity of the chemical that matches the name and identity on the MSDS and Hazardous Chemical Inventory.

(2) All appropriate hazard warnings.

b. Labels on containers that leave the workplace must also contain the name and address of the responsible part. The warning label is often your first source of information about chemical hazards. The name and identity in the label can be used to find the right MSDS, where you will find additional information.

c. Warning labels must be affixed to bags, barrels, bottles, boxes, cans, cylinders, drums, storage tanks, and other chemical containers. Placards or bin labels can be used for stationary containers as long as the placard clearly identifies the containers to which it applies and provides the same information required for any other type of hazard warning label.

d. The following types of chemicals are exempt from the OSHA labeling requirement because labeling is required by other federal laws.

(1) Pesticides covered by the Federal Insecticide, Fungicide, and Rodenticide Act (MSDSs must be available for pesticides).

(2) Food, food additives, color additives, drugs, cosmetics, and ingredients in these products covered by the Federal Food, Drug, and Cosmetic Act.

(3) Distilled spirits, wine, or malt beverages not intended for industrial use covered by the Federal Alcohol Administration Act. MSDSs must be available if the use of these products results in worker exposure significantly greater than those of consumers.

(4) Consumer products and hazardous substances covered by the Consumer Product Safety and Federal Hazardous Substances Acts. MSDSs must be available if the use of these products results in worker exposure significantly greater than those of consumers.

Chemical/Common Name: Methanol, Wood Alcohol

NSN/LSN: 5910-01-018-3021 Part Number: 5160-081

Item Name:

HAZARD CODE

HAZARDS — **ACUTE** (IMMEDIATE) / **CHRONIC** (DELAYED)

	NONE	SLIGHT	MODERATE	SEVERE	CHRONIC (DELAYED)
HEALTH	☐	☐	☐	X	X
CONTACT	☐	☐	X	☐	
FIRE	☐	☐	☐	X	
REACTIVITY	☐	X	☐	☐	

SPECIFIC HAZARDS and PRECAUTIONS (INCLUDING TARGET ORGAN EFFECTS)

DANGER! Flammable Liquid

Acute: Overexposure to vapors may cause drowsiness, headache, nausea visual disturbances, blindness. May irritate lungs and cause coughing, shortness of breath, collapse and death. Liquid is absorbe through intact skin. Causes skin and eye irritation.

Chronic: May damage the central nervous system; may cause liver enlargement; may cause blindness.

Flammable! Avoid oxidizers, active metals, e.g. aluminum, zinc.

PROTECT: EYE [X] SKIN [X] RESPIRATORY [X]

Name ABC Chemical Company

Address 2345 Flower Street, Any City, NW 00078

Emergency Telephone (978) 555-0987

See MSCS for Further Information

DD FORM ________ YEAR 1988

Figure 4-2. Hazard warning label.

4-26. HAZARDOUS CHEMICAL INVENTORY

The Hazardous Chemical Inventory (Figure 4-3) must list all hazardous chemical materials currently stored or used in your workplace. Containers of materials on the Hazardous Chemical Inventory must be labeled, tagged, or placarded and MSDSs must be available for every material in the inventory. You can use the inventory to find out whether a hazardous chemical material is used or stored in your workplace. You can also use the inventory to see if a material you work around is considered hazardous. If it is hazardous, it must be on the Hazardous Chemical Inventory.

Continue with Exercises

Product Name	Manufacturer	Use Point
Acetone	Best Chemical Corp	Pitkin Shop
AC Dark Blue Lacquer	American Paint Co	Base Shop East Base Shop East Depot Yukon Depot
AC Lt. Blue Lacquer	American Paint Co	Base Shop East Base Shop East Depot Walnut Depot Yukon Depot
Air Lube	Panfax Oil Corp	Base Shop East Base Shop
All-Purpose Cutting Fluid	Jones Industrial Corp	Maintenance Shop
Ammonia	Weston Chemical	Plant Service Jamaica Shop
Anti-Freeze	Texas Oil Co	East Depot 239th Street Maintenance Shop
Blue Spray Paint	Presco Paints	East Shop East Depot Paint Shop Walnut Depot Yukon Depot
Clear Spray	Chemco	Power Test Station
Contact Adhesive D-220	Jones Industrial Corp	Pitkin Shops
Epoxy Paint - Beige 201	Federated Paints	Paint Shop
Epoxy Paint - Blue 207	Federated Paints	Paint Shop
Freon 22	Applied Gases	Maintenance Shop Pelham Shop Pitkin Shop

Figure 4-3. Hazardous Chemical Inventory.

EXERCISES, LESSON 4

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. A goal of the Hazard Communication Standard is to reduce the incidence of injury and illness caused by ____ .

2. The Standard requires that a(n) ____________ be maintained for every hazardous chemical maintained and/or stored.

3. The two main categories of chemical hazards are ___________ and __________.

4. The various routes that chemicals enter the body are called _________________.

5. Explosives are an example of a __________________ hazard.

6. Corrosives are an example of a __________________ hazard.

7. Isolation is a type of ___________________________ control.

8. Material Safety Data Sheets, warning labels, and the hazardous chemical inventory are examples of ____________________________ controls.

9. The specific gravity of a chemical tells you if the chemical will ____.

10. Material Safety Data Sheets are required on all hazardous products in the workplace but the _____________________________ is not required for chemicals covered by the Federal Insecticide, Fungicide, and Rodenticide Act.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 4

1. Hazardous chemicals (para 4-2a(1))

2. MSDS (para 4-2c(1))

3. Physical, health (para 4-4a)

4. Exposure routes (para 4-5)

5. Physical (para 4-8b(2))

6. Health (para 4-10b(2))

7. Engineering (para 4-13b)

8. Administrative (para 4-15a(1))

9. Float or sink in water (para 4-19b)

10. Warning label (para 4-25d(1))

End of Lesson 4

COMMENT SHEET

SUBCOURSE MD0173 Pesticides in the Military 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.

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2. List any errors.

paragraph error correction

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3. List any suggestions you have to improve this subcourse.

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