Section V. DISPERSAL OF INSECTICIDES

10–51. General Principles

(1) *Modern insecticides.*—The new insecticides have made possible and necessary the development of new methods of dispersal that take full advantage of their special characteristics of great toxicity to insects and residual effect. The residual quality of DDT and similar materials makes it possible to kill by contact long after the insecticide has been applied to walls and ceilings and to vegetation or other resting places of insects. Also, the high degree of effectiveness calls for dispersal of space sprays in much smaller particles for efficient utilization. Laboratory tests have shown that a droplet with a radius of 8 microns from an 8-percent DDT solution contains a lethal dose for a mosquito. Thus, coarse sprays are inefficient because the total number of droplets is less, with consequent decreased chances that one droplet will hit an insect, and those particles which do contact an insect contain many times the amount of insecticide needed to kill. Also, large particles fall to the ground very rapidly, while small particles may be airborne for long periods during which there is more opportunity to contact insects. In this respect there is also a disadvantage in that when air currents are unfavorable or wind speed is high, the small insecticide particles may be wasted by too-rapid dispersal into the atmosphere. Under favorable conditions, however, aerosols or fogs—which are suspensions of minute particles of solids or liquids in a gas, such as air—are most efficient for killing insects by means of space treatments.

(2) *Particle size.*—Many types of equipment which utilize several different principles have been designed to produce and disperse insecticides. Table 10–1 illustrates the range in particle sizes which may be produced:

Table 10–1.—Particle-Size Range of Dispersed Insecticides

Approximate diameter	Type	Most efficient usage
Microns		
Under 0.1	Vapors, fumes, smokes.	Closed spaces, fumigation.
0.1–0.5	Dense white screening smokes.	Not suitable for good control except in closed spaces.
0.5–10	Dry fog	Best for inside treatments.
10–50	Aerosols and other-type fogs.	Outside and inside space treatment, short-time residuals.
50–100	Mists	Larvicides, light residuals.
100–400	Fine spray	Larvicides and residuals.
Over 400	Coarse spray	Heavy residuals and fly-breeding areas.

(3) *Selection of method.*—The development of residual applications and space treatments has resulted in a shift of emphasis in mosquito control from measures directed solely against the larvae to measures designed mainly to kill adults, at least in respect to most *Anopheles* control programs. In many parts of the world malaria has been virtually eliminated by mass DDT residual treatment of dwellings without any attempt at larval control. Successful as such programs have been, however, it is not always possible to rely on this method or to ignore the habits of the mosquitoes, for in some areas the vector does not enter houses at all or enters only to feed and leaves without resting for any considerable periods within the dwelling. In some cases space treatments of critical areas by airplane or large-scale ground dispersal are indicated; for example, when it is not practical to control the extensive breeding areas of pest mosquitoes and when residuals would act too slowly to provide the required control of rapidly infiltrating adults. Usually, however, larviciding continues to play an important role in control of pest mosquitoes. Each local situation will require analysis before a decision is made as to whether the most practical and efficient control program should emphasize interior or exterior residuals, space treatments, larviciding, or permanent-type controls such as drainage, filling, and water management. In most cases it is probable that a combination of methods will be required, but in every program first consideration should be given to nonchemical methods (arts. 10–1 (2) and 10–21). This principle should also be applied to

the control of vectors other than mosquitoes, particularly houseflies.

10–52. Equipment for Larviciding Operations

(1) *Dosage and output.*—The use of DDT and the newer insecticides of equal or greater effectiveness for mosquito larviciding requires a fine spray or mist; if the mist is too fine the material may be blown away, and if too coarse, overdosage occurs or excessive transportation of dilute solutions is necessary. Simple hand-operated sprayers and power sprayers of various types are suitable for larviciding purposes, but variation in output should be adjusted by varying the insecticide concentration and speed of operation. Five-percent DDT at an output of from 1 to 2 quarts per acre or 0.5 to 1-percent DDT at 1 to 2 gallons per acre is usually adequate for 6 to 9 days' control, although heavier dosages may be desired under adverse conditions or when control over longer periods is necessary and danger to fish is not a problem. Heavier dosages up to 5 gallons of 1 percent per acre are also required for satisfactory control of most pest mosquitoes.

(2) *Standard or recommended items*

(*a*) The decontaminating-type sprayer, insect, 3-gallon (Stock No. G41–S–4125), figure 10–1, is the most commonly used hand-powered portable sprayer and is suitable for larviciding work when equipped with the fine-spray nozzle and for residual applications with the fan-spray nozzle. A new type of portable 2-gallon hand sprayer will soon replace this item under the same stock number.

(*b*) The 3-quart sprayer equipped with an atomizing nozzle (Stock No. G41–S–4120), figure 10–2, is a useful instrument for the application of 5-percent DDT emulsion or oil solution. Larger areas can be covered in a single workday with less effort than when using knapsack sprayers. The mist provided by these sprayers is distributed in still air, or even more effectively, drifted by a slight wind. Operators are trained to take advantage of wind direction to obtain maximum coverage with a minimum amount of larvicide. A visible film of oil need not be detectable on the water. The best criterion of coverage is a larval survey before spraying and 24 hours after spraying.

(*c*) Power sprayers may be used for larviciding when equipped with misting nozzles. Standard Stock No. G40–S–2590–18, sprayer, insect, liquid, pressure, gasoline-driven, 50-gallon capacity, skid-mounted, with oil-resistant hose and fittings, pressure regulator, double-outlet, may be used for many purposes by interchanging nozzles. A similar sprayer, Stock No. G40–S–2589–555, without the tank, is designed for mounting on an oil drum.

(*d*) A type of equipment which combines the essential features of a residual sprayer, mist applicator, and power duster will be available at some activities. Currently these machines are produced by conversion of Todd (Type E) obsolete screening-smoke generators and will, therefore, not be a continuing item. The basic gasoline-engine compressor and blower are utilized, and interchangeable nozzles

Figure 10–1.—Portable hand sprayer (2-gal.).

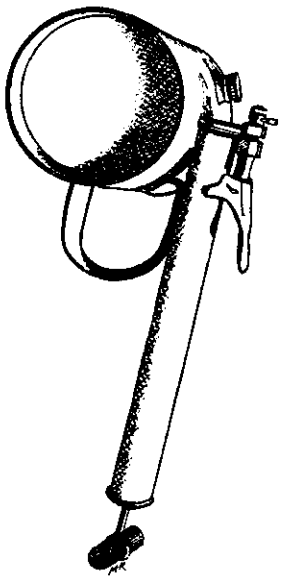


Figure 10–2.—Hand sprayer (3–qt.).

and attachments are provided to produce a spray, mist, or dust. It is referred to as the MIDA (fig. 10–3) (from Malaria and Mosquito Control Unit insecticide and dust applicator). Only a limited number of obsolete smoke generators are available, so general distribution cannot be made. Instructions and plans for conversion may be obtained on request to Preventive Medicine Unit No. 1, Naval Air Station, Jacksonville, Florida.

(*e*) Accessories No. 6 and No. 7 to the insecticidal-fog applicator (MIL–A–898A) permit use of the basic power and compressor units to provide an air-atomized mist. Large-capacity mist blowers may sometimes be indicated but would not be required at most naval activities and should only be procured on recommendation of a responsible area or district entomologist.

10–53. Equipment for Residual Applications

(1) Equipment which produces a medium to coarse spray is suitable for residual applications. The decontaminating-type hand-operated sprayer

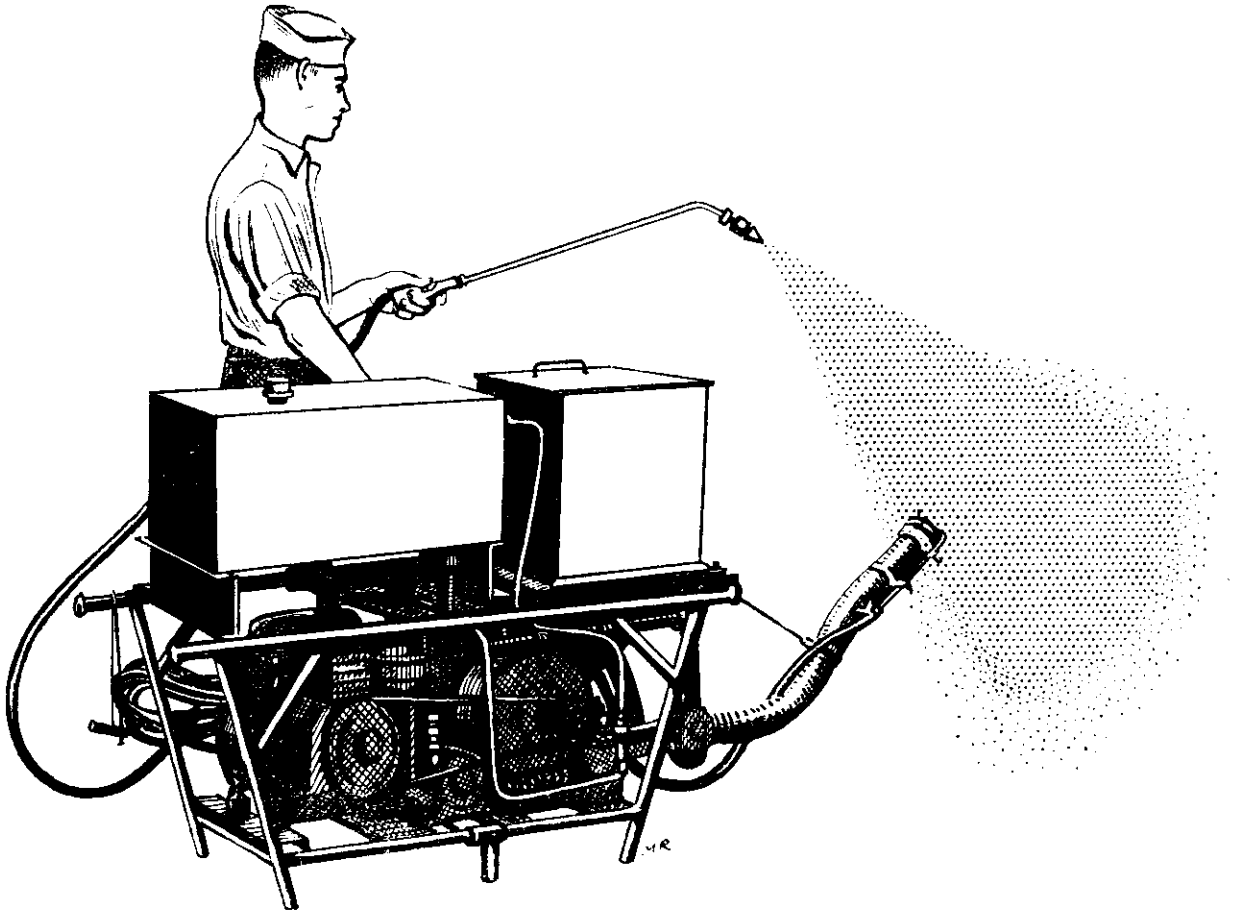


Figure 10–3.—MIDA insecticide applicator.

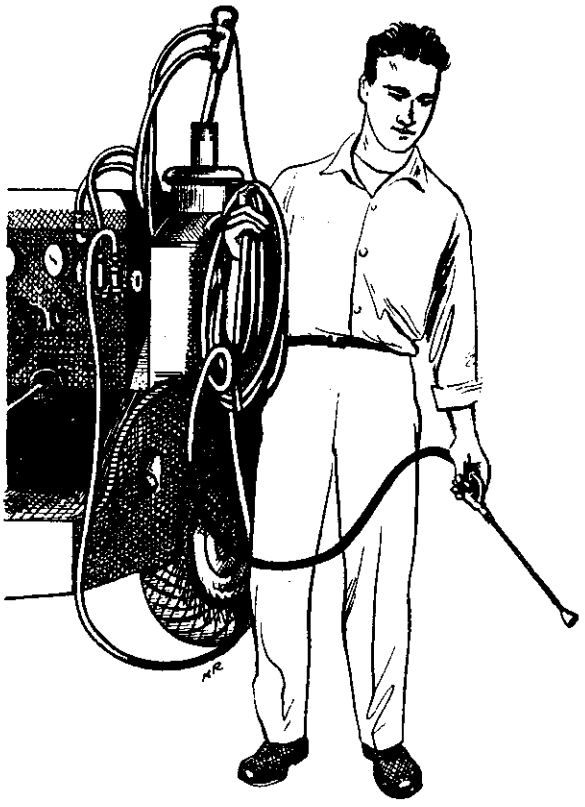


Figure 10–4.—Fog applicator with spray accessories.

or power sprayer (art. 10–52 (2)) will usually be available, and the coarse-spray nozzle provided should be used. A flat, fan-shaped spray is best for treating wall surfaces and permits rapid coverage. Accessory No. 8 to the insecticidal-fog applicator (MIL–A–898A), with a light extension hose, provides for a mechanically atomized spray (fig. 10–4). Paint brushes are useful for treating screens. A small hand sprayer which produces a coarse, narrow spray is useful for spot residual applications in roach control (art. 10–22 (3)). Mist applicator (art. 10–52 (2) (*d*) and (*e*)) may be used for large-scale application of residuals, particularly to vegetation and other outside surfaces where insects rest frequently. Treatments of this type are often recommended for area tick and mite control and, under conditions where mosquitoes rest in vegetation, for adult-mosquito control. Good fly control has been obtained by such treatments applied to vegetation which houseflies often utilize as a night resting place. Any type of exterior residual application for fly control should be used only as a last resort, however, since it is now believed that this kind of widespread use of heavy dosages is an important factor in development of resistance.

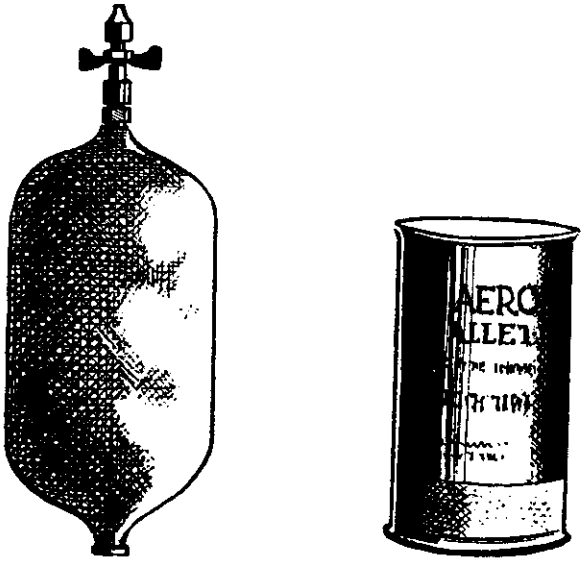
10–54. Equipment for Space Treatments

(1) *Definition.*—The development of the aerosol dispenser was a first step in the increase of efficiency of equipment for space treatments over the simple "flit gun." Later machines were perfected for the large-scale dispersal of aerosols or fogs and mists. There are no generally accepted definitions to distinguish between insecticidal smokes, aerosols, fogs, and mists; and for purposes of discussion, the term "fog" will be used herein to designate a type of dispersion which utilizes heat, either in the form of exhaust gases, steam, or compressed hot air, to break up and dispense insecticide solutions or emulsions as small particles. (See table 10–1.) The following paragraphs list some of the types of equipment which have been devised, with indicated uses, advantages and disadvantages:

(2) *Aerosols or fogs*

(*a*) *Gas-propelled aerosols.*—The high-pressure aerosol bomb and the low-pressure (beer-can) (fig. 10–5), nonrefillable types are well known and are designed primarily for control of mosquitoes and other flying insects indoors. They should not be used for outside space treatments or for roach control. Aerosol bombs may be procured under Stock Nos. G51–G–120–31 and G51–C–2031–10 (1-lb. cylinder) (art. 10–12 (1) (*f*)).

(*b*) *Thermal-generated fogs.*—Several types of machines have been developed which will produce a large volume of an insecticidal fog suitable for outside-area treatments to control adult mosquitoes and flies as well as for inside treatments against stored-product pests and other household and warehouse pests. (See art. 10–56.)



A B

Figure 10–5.—A, High-pressure aerosol bomb. B, Low-pressure bomb (beer-can type).

(c) *Mechanically generated aerosols.*—Types of equipment which will produce aerosols without the use of heat or gas propellants are relatively new developments. A hand-operated, refillable aerosol gun which produces an aerosol similar to that of the conventional freon bomb is currently undergoing field trials. A portable, electrically driven aerosol generator is now available commercially which is suitable for use in medium-size interior areas such as barracks and mess halls (fig. 10–6). Large models, powered by electricity or gasoline, are designed for warehouse or outside-area treatments and may eventually be standardized, particularly if models which will produce smaller particle sizes are developed.

Figure 10–6.—Mechanical aerosol generator.

(3) *Mists.*—Mists are produced in most cases by the action of high-velocity air streams which break up the insecticide spray into fine mist particles, or by the forcing of liquids under pressure through specially designed nozzles. The particles produced are larger than those of true fogs or aerosols and consequently fall to the ground more rapidly. However, the initial velocity in the case of mist blowers is so great that with the large-size machines and with favorable winds an effective range (see art. 10–56 (2) (*a*)) equal to or greater than that of the fog generators may be obtained. There is also more control of direction, and their use is not limited seriously by meteorological conditions. A disadvantage of mist blowers which limits their use in built-up areas and for inside treatments is the occurrence of objectionable deposits. Several makes are available commercially in either large size for mounting on trailers, trucks, or jeeps, or a small size mounted on skids for jeep or wheelbarrow-type transport. The small-size mist blowers have a reduced blower capacity and consequent limited range and output and are less satisfactory for large-scale area treatments. In general, mist blowers are particularly adapted to agricultural work or for larviciding where suitable access for vehicles is present. They may also be used for large-scale residual deposits on vegetation and for outside-area treatments against adults where objectionable deposits, such as on automobiles or shrubbery, are not a factor. (See art. 10–52 (2).)

(4) *Vapors.*—Devices for interior space treatments which release an insecticidal vapor continuously cannot be recommended until more information is available on the relative efficiency, particularly in ventilated spaces, as compared with other methods of dispersal. However, it is known that lindane vapors in closed spaces are very effective against flies, mosquitoes, and other flying insects. Development of resistance to lindane is a serious objection to procurement of these devices. The restrictions and precautions listed in article 10–23 (4) should be observed wherever such devices already procured are used at naval activities.

(5) *Sprays.*—Although sprays do not obtain maximum efficiency from the new insecticides in space treatments, it is probable that the common "flit gun" will continue to be a useful item until equally cheap, simple, and dependable equipment which will produce aerosols is developed. New models of small hand and power sprayers are designed to produce much finer particles for interior space treatments but still do not match the efficiency of true aerosols. The following items for the application of space sprays are currently available as standard items in the Catalog of Navy Material:

Sprayer, liquid, 1-quart, hand-pump type—Stock No. G41–S–4112.
Sprayer, liquid, 3-quart, continuous—Stock No. G41–S–4120.
Sprayer, electric, portable, 1-quart—Stock No. G40–S–2590.

(6) *Fumigants.*—Fumigation is the application of gaseous materials in closed spaces and is usually associated with the use of highly toxic chemicals, such as hydrocyanic acid gas or methyl bromide, which leave no residual effect. Fumigation is not required for most vector-control operations and does not prevent reinfestation. It is not recommended except under special circumstances where other methods are not satisfactory. Fumigation is almost never indicated for control of cockroaches, bedbugs, fleas, lice, ants, etc. In the relatively rare instances when fumigation is required, it will be accomplished by specialists, and adequate precautions must be taken to prevent access of unauthorized personnel to areas undergoing fumigation. The use of hydrocyanic acid gas for fumigation by naval personnel or on naval ships is prohibited except when undertaken by the U. S. Public Health

Service (Manual of the Medical Department, art. 22–37). The dispersal of lindane or chlordane as a vapor is technically a form of fumigation, but these chemicals do remain as residual deposits and have continued insecticidal action, depending on the amounts deposited. This type of dispersal is discussed in articles 10–23 (4) and 10–56 (6).

10–55. Equipment for Dusting

(1) Hand dusters, Stock No. G41–D–4510 (fig. 10–7) are useful in the treatment of personnel for typhus control. Where large numbers must be processed, a multioutlet power duster is more efficient (Army Quartermaster Stock No. 66–O–800). Dusts are not recommended for most larviciding and adult control since diluents are not available and it is necessary to ship bulky amounts of talc or other inert substance. Dusts are sometimes desirable for treatment of areas difficult to reach, such as spaces under buildings and rodent burrows. The duster, rotary-blower, Stock No. G41–D–4530 (5 to 10 pounds), is useful for area dusting (fig. 10–8). The converted smoke generator, article 10–52 (2) (*d*), may also be used for dust application.

10–56. Insecticidal Fogging

(1) *Operators.*—Whenever fogging is a responsibility of the medical department it should be accomplished only by trained and qualified operators as determined according to directives currently in effect.

(2) *Advantages and limitations of fogs*

(*a*) *Exterior treatments.*—Equipment for the dispersal of insecticidal fogs should be considered as only one tool in the kit of an efficient pest-control unit or operator. It is not a cure-all, and it has definite limitations, but it is nevertheless one of the most useful methods for the application of insecticides. The conflicting opinions as to the effectiveness of this method no doubt arise from a lack of understanding of the limitations of fogging and from improper application. Fogs are almost entirely dependent upon air currents for dispersal, and therefore meteorological conditions must be satisfactory or the fog will be wasted. The major disadvantage of fogging outdoors is this dependence on favorable air currents and consequent limitation to periods when they may be used efficiently. Only accessible areas can be fogged satisfactorily since

Figure 10–7.—Hand duster, small.

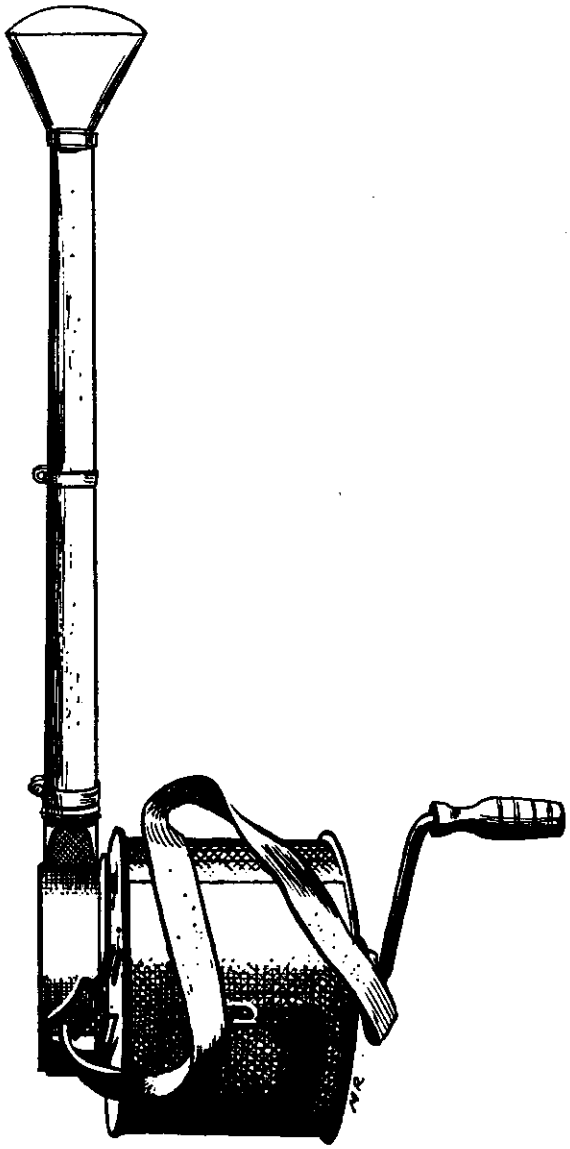


Figure 10–8.—Hand duster, rotary-blower.

the distance a fog can be drifted effectively is limited. It has been reported that fogs have been effective when drifted as far as one-half mile, but tests show that about 200 to 400 feet is the maximum dependable limit. This distance may be zero when the desirable winds do not exist and when connection currents are such that the fog cloud is dispelled into the atmosphere. Advantages which derive from the small particle size are the absence of objectionable deposits on vehicles and in and around buildings and populated areas, efficient distribution of the insecticide in vastly greater numbers of droplets, and quick coverage of relatively large areas. Since minimal amounts of insecticide and small particles are used, long-time residual effects outdoors cannot be expected, but deposits may be insecticidally effective for longer periods when the more potent insecticides are used in confined spaces. This may be an advantage in that development of resistance appears much less commonly where DDT has not been used as a widespread, heavy residual. Probably the most serious limitation is the short period of control obtained when extremely heavy mosquito populations are infiltrating rapidly. Under such conditions retreatments every 12 hours or less may be required. Residential or barracks areas, working areas such as shipyards and docks, parade grounds, dumps, sewage-treatment areas, sport arenas, beaches, and parks are locations where outside fogging may be useful.

(*b*) *Interior treatments.*—Fogs are particularly suited to inside treatments where drapes, furniture, fixtures, and highly polished surfaces may be damaged by many methods of insecticide dispersal. Homes, offices, warehouses, dairies, sewerage plants, and sewerage-collection systems (pipe lines and manholes) constitute a few inside situations where fogging may be applicable. Interior spaces should be fogged only with materials approved for this work by cognizant safety and fire officials. Limitations on inside use of fogs derive from the necessity for personnel to vacate the premises for from 4 to 6 hours, existence of dead air spaces or corridors difficult to reach, and necessary precautions to shut off open flames and electric devices. However, where numerous large barracks or warehouses must be treated, the limitations are more than offset by the speed with which extensive areas are covered.

(c) *Unnecessary applications.*—Routine applications of fog regardless of the need are wasteful, and orders to perform this work should be based on real justification provided by qualified technicians.

(3) *Types of fog equipment*

(*a*) *Converted fog applicators.*—The first attempts to disperse insecticides as fogs on a large scale utilized screening-smoke generators, and later several devices were designed which produced fogs by injection of an insecticide solution into the exhaust of automotive vehicles. Conversion of screening-smoke generators into thermal-fog applicators is no longer recommended; see article 10–52 (2) (*d*) for recommended utilization of obsolete screening-smoke generators. Fire hazard, destruction of insecticide by excessive heat, lack of particle-size uniformity and control, or maintenance problems are some of the objections to attempted conversions into true fog applicators. Thermal generators which utilize the exhaust of a jeep or other automotive vehicle are for the most part unsatisfactory due to the low output volume and the damaging effects of back pressure on the motors. Designs which have eliminated the latter objection may be used where coverage of extensive areas is not required or to supplement equipment of greater capacity, but most small activities will find the equipment recommended in article 10–52 (2) more versatile and useful except where fogging is essential. The capacity of most of the automotive fog devices is only from 4 to 6 gallons per hour so that the vehicle must be operated up to five times as long a period as specially designed equipment. All activities should request advice from a medical or public works area or district entomologist before procurement of nonstandard dispersal equipment is initiated.

(*b*) *Fog applicators designed specifically for insecticidal-fog dispersal.*—Machines designed specifically for insecticidal-fog dispersal have proved to be more satisfactory in the long run than makeshift conversions. Some commercial machines which have been widely accepted for civilian and military use permit selection of particle size from a very fine, dry fog up to a fine spray, are approved by the Underwriters' Laboratories, and have a large output capacity. Many types of fog applicators have been tested by Navy insect-control specialists. Some machines employ steam as a source of heat as well as a propellent, and tanks of water are required in addition to tanks of insecticide. Another type utilizes a small jet engine and requires no auxiliary pumps or blowers. A military specification is available for a fog applicator which extensive field experience has shown to be most versatile and suitable for general Navy use[2] (fig. 10–9). The fog applicator may be mounted on a jeep or on a small trailer if full-time vehicles are not required or assigned to control operations. This equipment with accessories may also be used for mist applications or residual sprays (arts. 10–52 (2) and 10–53). It is to be expected that this specification will be revised and extended to cover new and improved types or modifications as they are approved.

(4) *Maintenance and service.*—Proper maintenance is of course essential for safe and efficient operation. The instruction manuals provided by

[2] Applicator, fog, insecticidal (MIL–A–898A), Index of Specifications and Standards, Department of the Navy, NAVSANDA Publication No. 62.

the manufacturer of each type of equipment must be carefully observed. This is particularly important in the case of equipment for the production of thermal fogs, as a fire hazard will exist if defective machines are used or if unqualified personnel are assigned as operators. Inspecting officials should take particular note of the condition of equipment, provision of effective fire extinguishers, formulations used, and qualifications of operators.

(5) *Outside fogging operations*

(*a*) *Meteorological conditions.*—Fogs are almost entirely dependent upon air currents for dispersion, and therefore meteorological conditions must be satisfactory or the materials will be wasted. Winds over 6 miles per hour tend to disperse the insecticide cloud too rapidly, and best results are obtained at wind speeds of less than 4 miles per hour. When air temperatures at ground level are above those at the higher levels, air currents will rise and carry the fog upward, where it is dispersed into the atmosphere. This is known as a lapse or unstable condition. Fogging should be attempted only when temperature of the air at 6 feet is higher than the temperature at 6 inches. This

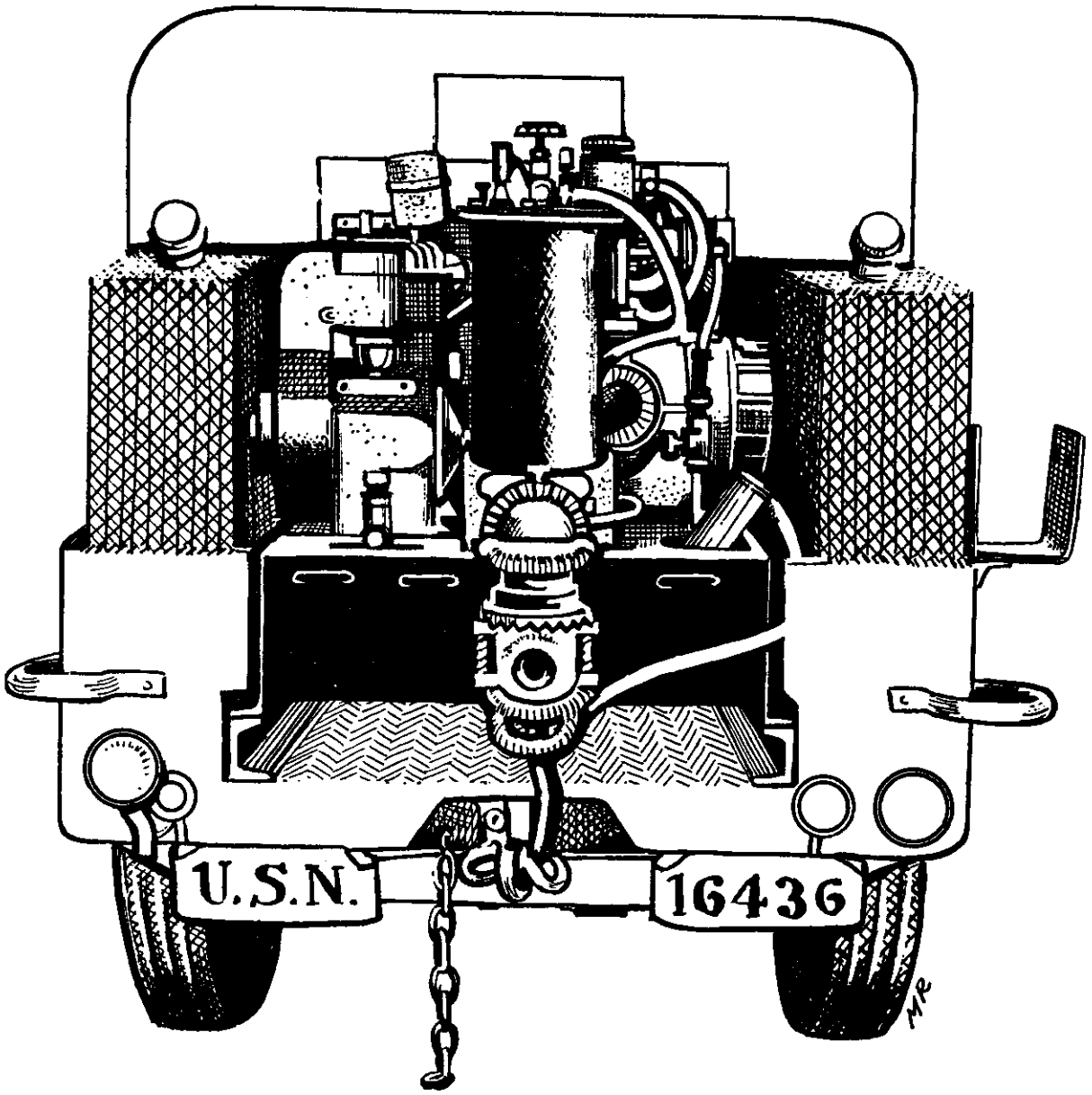
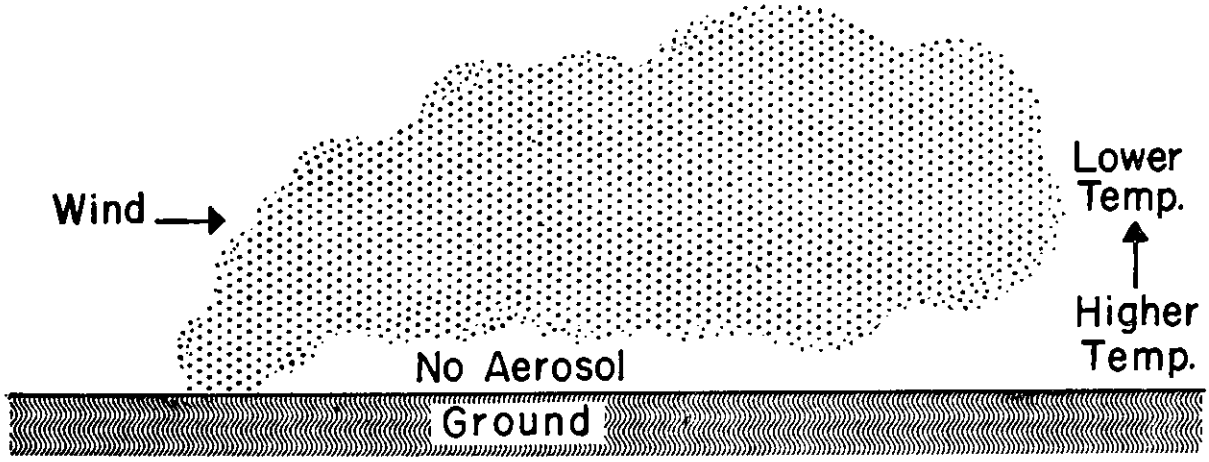


Figure 10–9.—Insecticidal-fog applicator.

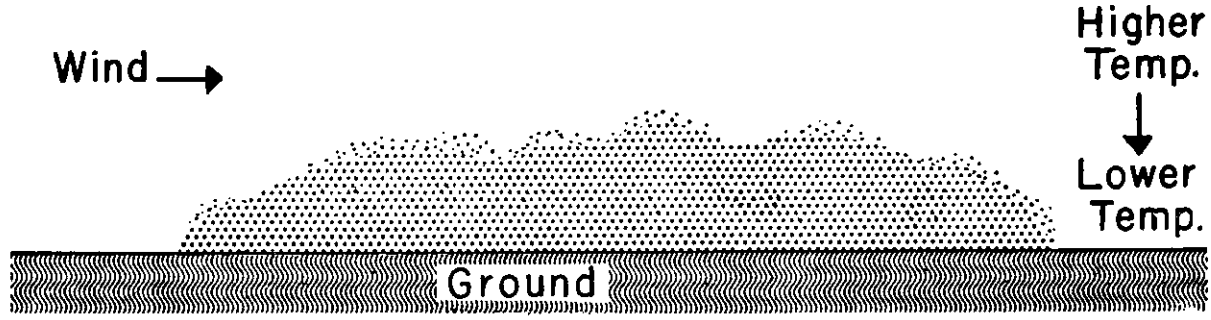
condition usually occurs during the evening, night, and early morning and is known as inversion or a stable, stratified condition (fig. 10–10). Temperature readings are facilitated by the use of a simple thermometer standard which will provide for comparison of the temperature at these levels. Observation of nearby smokestacks will often indicate how suitable the conditions are for fogging operations.

(*b*) *Vehicle travel.*—The vehicle carrying the fog generator should travel at a speed of not over 6 miles per hour (lower speeds and frequent stops are often desirable) and should run as nearly as possible at right angles to the wind direction.

(*c*) *Dosage.*—A great variation in effectiveness of a given dosage will be found due to changing meteorological conditions, infiltration rates, fogging techniques, and susceptibility to insecticide formulation used. Therefore, it is not possible to recommend a fixed application rate or frequency. It will be necessary for operators and supervisors to determine the most satisfactory dosage for each local situation. Most outside operational procedures for insect control are based on results with DDT or related compounds and call for a 5- to 10-percent DDT formulation. In general, the best procedure is to use the lowest effective concentration and to make repeated applications by traversing



Lapse or unstable condition



Inversion or stable stratified condition

Figure 10–10.—Effect of temperatures on dispersal of thermal-aerosol clouds.

the same roads so that areas missed because of temporary currents and updrafts on the first run will be covered on the second application. Daily treatments may be required under conditions of rapid infiltration, but in most areas such extreme mosquito density occurs only during a limited time period during pest-mosquito flights. In general, the required dosage will range from 5 to 40 gallons of 5-percent DDT per front mile (distance the applicator travels at right angles to the wind direction, or a theoretical average of from 0.04 to 0.4 pounds per acre for a depth of 300 feet). Table 10–2 may be used as a sample guide for estimating desired dosage in terms of flow rates, insecticide concentration, vehicle speed, and number of "runs." Dial setting for different flow rates and particle sizes are given in the manufacturer's manual.

Table 10–2.—Sample Guide for Estimated Dosages of DDT Applied by Outdoor Fogging Machines Operated on a Moving Vehicle

Flow rate (gallons per minute)	Percent DDT in solution	Speed of vehicles (miles per hour)	Gallons of solution per front mile	Number of runs	Equivalent number of gallons of 5-percent DDT per front mile	Pounds per acre (300-foot depth)
0.33	5	4	5	1	5	0.05
.33	5	2	10	1	10	.10
.33	5	2	10	2	20	.20
.33	10	4	5	1	10	.10
.33	10	4	5	2	20	.20
.33	10	2	10	2	40	.40

(*d*) *Formulations.*—DDT formulations are effective in most areas and should be used unless resistance to DDT has been conclusively demonstrated. Resistance is often assumed when the real cause of unsatisfactory control arises from faulty techniques or equipment. Mosquito resistance to DDT is found ordinarily only where there has been widespread application of DDT as a larvicide, especially by aircraft over a period of several years. Housefly resistance is more common and occurs most often where there has been extensive use of residuals outdoors, particularly around dumps or other breeding areas. The following formulas are recommended and in most cases may be made up from standard stock items. If greater concentrations are desired, decrease amount of diluent proportionately.

(1) General outside fog (5-percent DDT)

Insecticide solution (20-percent DDT) Stock No. G51–I–157–138	1 gallon
Diesel oil No. 2	3 gallons
or	
Technical DDT	2 pounds
Sovacide F, or equal auxiliary solvent	1 gallon
Diesel oil No. 2 or kerosene	4 gallons

(2) General outside fog (5-percent DDT with thiocyanates)

Insecticide solution (20-percent DDT) Stock No. G51–I–157–138	1 gallon
Liquid insecticide, Stock No. G51–I–165	2 gallons
Diesel oil No. 2	2 gallons

(3) BHC fog (where resistance to DDT is confirmed)

BHC (11-percent gamma)	1 gallon
Diesel oil No. 2	10 gallons

(4) DDT emulsion (5-percent)

Stock No. G51–I–165–55	1 gallon
Water	4 gallons

(5) Chlordane emulsion

Chlordane concentrate (46-percent) Stock No. G51–I–155–355	1 gallon
Water	18 gallons

Formulations (4) and (5) are water-base formulations, which may be used for fogging where oil solutions are not desirable, but the fog produced is less dense, and is likely to leave objectionable deposits. When water-base formulations are used, equipment-manufacturer's instructions for dial settings should be followed.

(6) *Inside fogging operations.*—Fogging of interiors is not usually indicated for control of insects of medical significance but may be of great value in the treatment of warehouses and similar large structures. Interior fogging for insect control is not considered to be a major preventive-medicine technique, so that where this method is employed, it will normally be a public works responsibility. Medical-department personnel will be authorized to recommend and direct interior fogging only in exceptional circumstances where other methods are inadequate and if personnel trained in this technique are available. Comprehensive safeguards against fire are required, and recommended precautionary measures contained in Research Report No. 9, Fire and Explosion Hazards of Thermal Insecticidal Fogging, 1952, the National Board of Fire Underwriters,[4] should be strictly observed. The final responsibility and cognizance of approval rests with local fire officials. Chlordane shall not be applied as a fog in living spaces at a rate greater than 1 gallon of 2.5-percent solution per 50,000 cubic feet or more often than once in 60 days. Lindane shall not be applied as a fog in living spaces at a rate greater than 1 gallon of 2-percent solution per 50,000 cubic feet or more often than once in 30 days. Insecticide, DDT and lindane, Army Quartermaster Stock No. 51–I–158–500, is recommended for fogging operations inside warehouses. Organic vapor masks or air-line masks must be worn by operators exposed to this material (art. 10–46).

[4] Copies may be obtained by application to the National Board of Fire Underwriters, 85 John Street, New York 38, N. Y., or Merchants Exchange Building, San Francisco 4, Calif.

10–57. Dispersal by Aircraft

(1) *Advantages and limitations.*—The dispersal of insecticides from the air provides for coverage of large inaccessible areas in a minimum of time. It is, therefore, a particularly effective weapon for military preventive medicine. Limitations to this method derive from the need for control of the time and exact location of deposition if great waste is to be prevented. It follows that it is essential to have the utmost co-ordination between the pilot and the entomologist or the medical technician, who has determined by biological surveys the actual areas which require spraying. The use of local facilities, whenever feasible, will greatly facilitate this co-ordination and result in a minimum of unnecessary or misplaced spray applications. Aerial dispersal should never be recommended until qualified technicians have determined from their surveys that ground control methods are inadequate or less efficient. In wartime in foreign areas, aerial insecticiding is justified if the taking and holding of advance positions may be affected by insect pests and/or insect-borne diseases, even where preliminary surveys are unavailable or impractical. In peacetime, however, consideration must be given to its possible harmful effects on beneficial insects, fish, wildlife and agricultural crops, and evaluation must be made as to whether the requirements for aerial dispersal are sufficient to justify the additional expense and risk involved over the use of other efficacious methods of insect control. This is particularly necessary in those instances where disease transmission is not a factor in the control problem. Where pest mosquitoes constitute the problem, these must be considered in terms of their effects on morale and real loss of working efficiency. Another problem which must be considered in connection with aircraft dispersal is the mounting evidence that widespread application of insecticide to areas where larvae breed encourages a development of resistance in some species to the extent that control by chemicals becomes impractical within a few years. There are other limitations to be considered, such as ground cover, which controls penetration to the exact spot desired; meteorological conditions; availability of the type of aircraft and equipment suitable for the particular conditions which exist; and proper maintenance of all apparatus.

(2) *Justification*

(*a*) There is good reason to expect valuable control to result from proper application of insecticides by airplane against such diseases as are transmitted by out-of-door mosquitoes. There is much less likelihood of good control of larval mosquitoes from airplane application against such mosquitoes as breed in cisterns, rain barrels, etc., and live inside human habitations (e. g., *Aedes aegypti*), or those that breed in sewage effluent (common *Culex* pest mosquitoes). While a fair degree of adult kill will result, larval control of pest mosquitoes is much less satisfactory than that obtained against anophelines. Control of flies by airplane spraying of insecticides is most transient because the adult flies in the open are the only ones affected. Larvae, pupae, and adults inside buildings are not killed. There is no evidence that spraying of insecticides from aircraft is of any value in reducing the incidence of poliomyelitis in an epidemic of that disease.

(*b*) Aerial dispersal for control of mosquito larvae will ordinarily be justified in continental areas only under the following conditions:

(1) Where permanent measures (drainage, filling, etc.) are not feasible.

(2) Where there is no access for ground dispersal equipment.

(3) Where it is economically practical to cover a major portion of the total breeding areas which contribute to the adult pest population. Treatments which cover limited portions of the total breeding areas will seldom be worth while since adult control on the station will still be required.

(*c*) Aerial dispersal for adult mosquito control will be justified ordinarily in continental areas only under the following conditions:

(1) Where screening, repellents, space sprays, and residual treatments are not adequate to prevent diseases or decreases in work efficiency equivalent to the costs of aerial dispersal.

(2) Where fog or mist applications from the ground during periods of rapidly infiltrating swarms are unable to reduce the insect population in critical areas sufficiently to prevent disease or serious loss in working efficiency.

(3) *Qualified personnel and liaison required.*—Although little, if any, direct damage is related to controlled use of DDT when dispersed by planes, indirect damages are worthy of careful consideration. Presence of DDT has been shown in milk from cattle which have eaten excessive or regular amounts of DDT on forage crops. Excessive amounts of DDT may affect poultry, farm animals, bees, insectivorous birds, shellfish, fish, and various other forms of wildlife. Many of the extremely toxic insecticides developed since the advent of DDT introduce much greater hazards to both animal life and operating personnel, including pilots. Supervisory personnel must be familiar with safe dosage rates for local conditions and must make sure that the allowable rates are not exceeded. Contacts with local representatives of the following organizations which may have cognizance or interest should be made with reference to the advisability of spraying the area and for recommendations as to safe dosages: the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine; U. S. Public Health Service; State

public health service and local health authorities; State entomologist; and the Fish and Wildlife Service. Where the area to be sprayed borders on or includes civilian-owned land, all property owners must be contacted and their permission obtained. Control operations outside of naval reservations must also be in accordance with SECNAV Instruction 6250.1. The many problems involved in preliminary surveys for justification of aerial dispersal, liaison and clearances, and determination of suitable aircraft, equipment, materials, and qualifications of operating personnel require the services of qualified entomologists and biologists. Control programs should be reviewed annually to determine where economy may be effected by elimination or reduction in number of spraying operations. Pilots have been killed and aircraft and expensive materials wasted on nonessential aerial dispersal operations. Consideration of these factors is essential but need not minimize the value of the application of insecticides by aircraft under conditions where this method can be justified and is carried out under adequate supervision.

(4) *Types of aircraft and equipment.*—The availability of military aircraft and the relatively infrequent requirements for aerial dispersal have resulted in the development of different types of aircraft and equipment than are used for most civilian aerial spray operations. The following are currently favored for military requirements:

(*a*) *Large aircraft* (C–47) with permanently installed insecticidal-dispersal equipment such as the straight-discharge pipe or wing-boom-nozzle attachment. The capacity is from 600 to 800 gallons. This type of aircraft is most efficient for routine spraying where extensive areas must be covered or where handling and loading facilities are not available within a practical range. The Air Force is the only service which maintains this type of aircraft with permanently installed equipment for dispersal of insecticides.

(*b*) *Fighter-bomber-attack-type Navy aircraft* with detachable aero 1B or other approved dispersal equipment. The capacity is from 300 to 450 gallons. This type is suitable for routine spraying at permanent installations, medium-size areas, medium- and short-range or carrier-based operations, and is particularly adapted to combat and amphibious conditions where the larger type aircraft are vulnerable. The dispersal gear and insecticide tanks are attached to bomb racks (fig. 10–11) and may be jettisoned by the pilot whenever necessary.

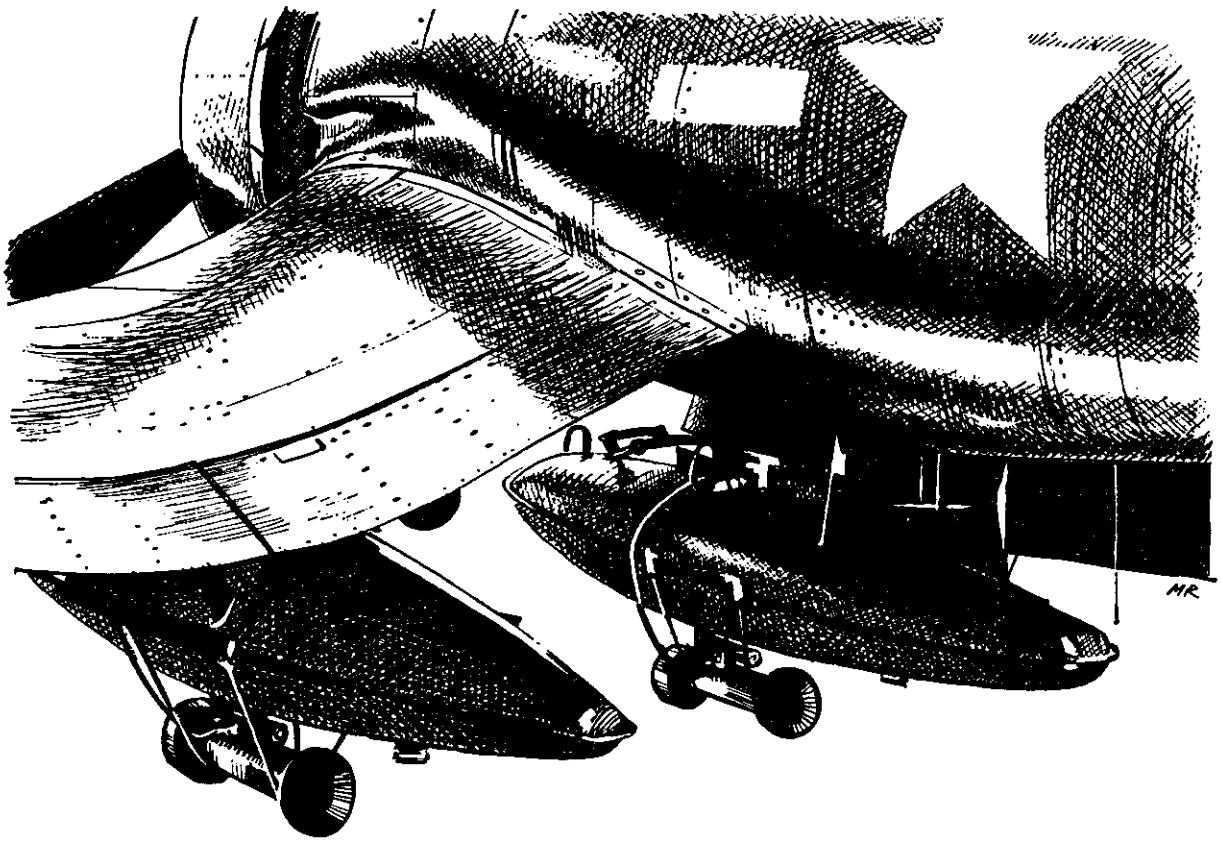


Figure 10–11.—Aero 1B dispersal gear.

(c) *Liaison or trainer-type aircraft* with detachable or permanently installed dispersal equipment. The capacity varies from 30 to 200 gallons. This type is most suitable for emergency operations, very short range, spot treatments, small areas, and unfavorable terrains. This type will not be available normally at naval activities.

(d) *Helicopter* with dispersal equipment adapted for quick installation and removal. This type is suitable only for treatment of small areas, emergency operations, very short range, spot applications, and for areas difficult to reach with conventional-type aircraft.

(5) *Procedure for obtaining aerial dispersal services*

(a) The services of a preventive-medicine unit or an area medical entomologist should be requested to establish justification for aerial dispersal and the availability of technicians qualified to direct spray operations.

(b) The availability of suitable aircraft and equipment should be determined by request to the nearest naval or Marine Corps air activity, or, where joint utilization is provided, to an Air Force aerial spray unit.

(c) Request for authority to conduct aerial spray operations should be submitted in accordance with applicable SECNAV and CNO Instructions in the 6250 series.

(d) After a request is approved, it is the responsibility of the designated supervisory personnel to maintain liaison with the air-operations officer adequate to insure efficient timing of spray missions and placing of insecticides, including the briefing of pilots and provision of ground markers where required.

10–58. Other Dispersal Methods

(1) Oil-soaked sawdust bags or drip oilers for continuous treatment of slowly flowing streams or fluctuating pools are often useful. Gelatin capsules containing DDT emulsifiable concentrate may be tossed into fire barrels, small pools, or similar locations. The emulsion spreads through the water when the capsule dissolves. The use of capsules may be unsatisfactory if water temperatures do not become high enough to dissolve the gelatin. Insecticides are sometimes used in the form of pellets or granules for distribution by dusters or from aircraft. The pellets penetrate heavy vegetation more readily than dust or sprays and may often be used to disseminate residual larvicides either before or after flooding.

10–59. Conditions Affecting the Use of Insecticides

(1) *Rain.*—In areas of heavy rainfall, larvicidal applications are frequently flushed away, and dusts are readily washed off with each rain. However, if a good spray residue has been laid down and has adequately dried, heavy rains will not rapidly destroy its killing power.

(2) *Wind.*—The object in applying dusts or sprays is to disperse the material above the breeding area so that particles will settle on the water surface. To be successful, application must be made at a time when wind and convection currents over the water or land are not sufficient to dissipate the dust, spray, or smoke before it can settle. Application from the ground is less limited by wind than is plane spraying. In either case, however, a moderate drift of the material is helpful in giving a more even distribution of the poison and in carrying it to parts of the breeding areas not otherwise readily accessible. Dusting and spraying should, therefore, be done to windward of the breeding area. When fogs and mists are used, even more attention must be given to winds and convection currents (art. 10–56 (4) (a)).

(3) *Vegetation.*—Vegetation tends to protect the surface coverage from wind, thus making the larvicidal treatment longer lasting; when vegetation is excessively dense, however, heavier applications may be necessary in order to reach inaccessible places and to cover the water surface adequately. Better results will also be obtained if the vegetation is not covered with dew. Thermal-generated fogs are effective in penetrating dense vegetation for adult control.

(4) *Dust and salt.*—When dust or salt sprays cover insecticide residues, insects fail to contact the poison or to obtain a toxic dose. Buildings exposed to excessive salt sprays or dusts must be treated at more frequent intervals.

(5) *Washing.*—Bulkheads, screens, and other surfaces treated with residues should not be washed unless absolutely necessary. Surfaces that are washed or are repeatedly wet will require more frequent applications.

(There is no art. 10–60.)

Section VI. SUMMARY TABLE

10–61. Summary Table

(1) Table 10–3 summarizes standard or recommended equipment and insecticides for routine projects.

Table 10–3.—Standard or recommended equipment

Projects	Equipment				
	Hand sprayers and dusters	Power sprayers and dusters	Mist applicators	Fog applicators	Aerial dispersal
1. Mosquitoes:					
a. Larvae	3-gallon, mist-nozzle, G41–S–4125; 3-quart, mist-nozzle, G41–S–4120.	50-gallon, gas-engine, G40–S–2590–18; MIL–A–898A accessory No. 8.	MIDA; MIL–A–898A accessories No. 6 and No. 7.		
					When ground methods not practical.
b. Adults:					
(1) Residual:					
(a) Interior	3-gallon, coarse-nozzle, G41–S–4125; 3-quart, coarse-adjustment, G41–S–4120.	50-gallon, fan-nozzle, G40–S–2590–18; MIDA; MIL–A–898A accessory No. 8.			
(b) Exterior	3-gallon, G41–S–4125	50-gallon, G40–S–2590–18; MIDA.	MIL–A–898A accessories No. 6 and No. 7		
(2) Space spray:					
(a) Interior	3-quart, mist-nozzle, G41–S–4120; 1-quart, G41–S–4112.	Portable electric G40–S–2590.	Microsol 202; MIDA		
				Aerosol dispenser, G51–G–120–31.	
(b) Exterior			MIDA	MIL 898A	
					When ground methods not practical.
2. Houseflies:					
a. Adults:					
(1) Residual[1]	3-gallon, fan-nozzle, G41–S–4125; 3-quart, coarse-nozzle, G41–S–4120.	G40–S–2590–18; MIDA; MIL–A–898A accessory No. 8.			
(2) Space spray:					
(a) Interior	1-quart, G41–S–4112; 3-quart, G41–S–4120.	Portable electric, G40–S–2590.	Microsol 202; MIDA		
				Aerosol dispenser, G51–G–120–31 (small areas).	
(b) Exterior			MIDA; MIL–A–898A accessories No. 6 and No. 7.		
b. Larvae	3-gallon, coarse-nozzle, G–41–S–4120.	G40–S–2590–18; MIDA; MIL–A–898A accessory No. 8.			

[1] Warning: Continual use of heavy residuals and larvicides will result in resistance

and insecticides for routine projects

Insecticide		
Agent [1]	Formulation	Dosage
DDT: 20-percent solution G51-I-157-138; emulsion concentrate, G51-I-156-55; technical, G51-I-157-25.	0.5- to 1-percent solution or emulsion	1 to 5 gallons per acre (0.05 to 0.4 pounds per acre).
	20-percent DDT	2 gallons per acre for long residual effect in small ponds where wildlife is of no importance (3 pounds per acre).
BHC	0.5-percent gamma emulsion	0.5 to 3 gallons per acre (2 gallons per acre effective for 1 month in small ponds without damage to fish).
Chlordane	2-percent emulsion or solution	2 to 3 gallons per acre.
DDT	10- to 20-percent solution	1 pint to 2 quarts per acre. (Use lowest dosages for anophelines.)
BHC	2.5- to 5-percent gamma solution	1 pint to 2 quarts per acre.
DDT	5-percent solution, emulsion, or wettable powder	1 gallon to 900 square feet (200 milligrams per square foot).
Lindane	0.5-percent emulsion	1 gallon to 750 square feet (25 milligrams per square foot); spot treatment only in living spaces.
DDT	1- to 3-percent emulsion or wettable powder	10 to 20 gallons per acre (local areas only).
BHC	0.5 to 1-percent gamma emulsion	5 to 10 gallons per acre (local areas only).
Chlordane	1- to 2-percent emulsion	5 to 10 gallons per acre (local areas only).
Standard Navy insecticide, G51-I-165	Thiocyanates and DDT	Up to 3 ounces per thousand cubic feet.
DDT-pyrethrins		6 seconds per thousand cubic feet.
DDT	5- to 10-percent solution or emulsion	1 pint to 1 gallon per acre.
DDT and SNI	5- to 10-percent DDT with 2-percent lethane	Do.
BHC (gamma)	1- to 2-percent gamma solution or emulsion	Do.
Chlordane	2-percent solution or emulsion	Do.
DDT	10- to 20-percent solution	1 to 2 quarts per acre.
BHC (gamma)	2.5- to 5-percent gamma solution	Do.
DDT	5-percent solution, emulsion or wettable powder	1 gallon to 900 square feet (200 milligrams per square foot).
Lindane	0.5-percent emulsion	1 gallon to 750 square feet (25 milligrams per square foot); spot treatment only in living quarters.
Chlordane (exterior only)	2-percent emulsion	1 gallon to 900 square feet.
Standard Navy insecticide, G51-I-165	Thiocyanates and DDT	1 to 3 ounces per thousand cubic feet.
DDT-pyrethrins aerosol		6 seconds per thousand cubic feet in closed spaces.
DDT	5- to 10-percent solution or emulsion	1 pint to 1 gallon per acre.
DDT and SNI	Thiocyanates and DDT	Do.
BHC	1- to 2-percent gamma solution or emulsion	Do.
Chlordane	2½-percent solution or emulsion	Do.
Chlordane, G51-I-155-385	2-percent solution or emulsion	1 gallon to 700 square feet of surface area of breeding material.
BHC (gamma)	0.5-percent solution or emulsion	1 to 2 gallons per 750 square feet.

[1] Where DDT is listed first it should be used until resistance has been confirmed.

Table 10–3.—Standard or recommended equipment

Projects	Equipment				
	Hand sprayers and dusters	Power sprayers and dusters	Mist applicators	Fog applicators	Aerial dispersal
3. Lice	Duster, G41-D-4510	Multiple-outlet (66-0-900), (Army QM).			
4. Fleas	Duster, rotary, G41-D-4530.	MIDA dust attachment			
	3-gallon, G41-S-4530	G40-S-2590-18; MIDA			
5. Mites and ticks	3-gallon; coarse-nozzle, G41-S-4125.	G40-S-2590-18; MIDA; MIL-A-898A accessory No. 8.	MIL-A-898A accessories No. 6 and No. 7.		
	Duster, rotary, G41-D-4530.				
6. Bedbugs	3-gallon; coarse-nozzle; G41-S-4125.	G40-S-2590-18; MIDA; MIL-A-898A accessory No. 8.			
7. Cockroaches	3-gallon, G41-S-4125; 3-quart, coarse-nozzle, G-41-S-4120; 1-quart, G-41-S-4112; oiler, 1-pump, G42-O-35-115 (art. 10-22 (3)).	Portable electric, G40-S-2590; MIDA.			

and insecticides for routine projects—Continued

Insecticide		
Agent [2]	Formulation	Dosage
DDT: G51-I-157-600; G51-I-171	10-percent dust	About 1 ounce per person and clothes.
Lindane	1-percent dust	Where lice are resistant to DDT. See art. 10-23 (2).
MYL-type powder		
DDT: G51-I-157-600	10-percent dust	Rat fleas—dust burrows and rooms in buildings.
Chlordane	10-percent dust	Outdoors only; soil treatment for cat and dog fleas.
BHC	0.5-percent gamma emulsion	10 to 20 gallons per acre.
DDT	5-percent emulsion or solution	1 gallon per 900 square feet.
BHC	0.5-percent gamma emulsion	10 to 20 gallons per acre.
Chlordane	1-percent emulsion	Do.
DDT (ticks only)	5-percent emulsion or wettable powder	1 gallon to 900 square feet (along roadsides and trails).
DDT (rodent parasites)	10-percent dust	Dust burrows and runways.
DDT	5-percent kerosene solution or emulsion	100 milliliters per mattress, springs and bunk; walls to 6 feet; 1 gallon per 900 square feet.
Lindane (only if resistant to DDT)	0.5-percent emulsion	100 milliliters per mattress, springs and bunk only.
Chlordane, G51-I-155-375	2-percent solution	1 pint per 125 linear feet; spot residual only; see art. 10-22 (3) and (4).
Lindane	0.5 percent emulsion	1 pint per 125 linear feet, spot residual only in living quarters.

[2] Where DDT is listed first it should be used until resistance has been confirmed.

REFERENCES

1. Pest Control, Bureau of Yards and Docks Technical Publication, NAVDOCKS Tp–Pu–2.
2. SECNAV Instruction 6250.2. Nonstandard pesticides and pesticide dispersal devices; procurement and utilization of.
3. BUMED Instruction 6250.3. Insecticides, precautions in use of.
4. CNO C/L 46–2182. Large-scale dispersal of insecticides, justification for.
5. Clinical Memoranda on Economic Poisons, USPHS, CDC Technical Development Services, Savannah, Ga., TDB 1952.
6. Operational Memoranda on Economic Poisons, USPHS, CDC Technical Development Services, Savannah, Ga., TDB 1952.
7. Ground Equipment and Insecticides for Mosquito Control, American Mosquito Control Association Bulletin No. 2, Mar. 1952.
8. Fire and Explosion Hazards of Thermal Insecticidal Fogging. National Board of Fire Underwriters, Research Report No. 9, 1952.
9. Catalog of Navy Material, General Stores Section.
10. DDT and Other Insecticides and Repellents, Miscellaneous Publication No. 606, USDA, 1946.
11. Insect and Rodent Control, Repairs and Utilities, Department of the Army Technical Manual TM–5–632.
12. Insects, the Yearbook of Agriculture, 1952, USDA.
13. U. S. Navy Manual of Safety Equipment, NAVEXOS P–422.
14. Index of Specifications and Standards, Department of the Navy, NAVSANDA Publication No. 62.

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MANUAL OF NAVAL PREVENTIVE MEDICINE

CHAPTER 11

SAFE AND PROPER HANDLING OF PESTICIDES

DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY
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CONTENTS

Chapter 11

SAFE AND PROPER HANDLING OF PESTICIDES

Section I. INTRODUCTION

11–1. Definition of Pesticides

(1) In the strictest grammatical sense, pesticides are materials which kill all pests. From the more practical standpoint, pesticides are any substances or mixtures of substances, usually economic poisons, intended for use in preventing, inhibiting, destroying, or otherwise mitigating the effects of noxious animals and plants, such as certain insects, mites, spiders, and other arthropods; fungi, bacteria, rodents, weeds or other forms of undesirable animal and plant life.

11–2. Purpose and Scope

(1) The purpose of this chapter is to provide all Navy personnel engaged directly or indirectly in pest control operations with information regarding safe and proper use of pesticides.

(2) Information in this chapter is related primarily to pesticides in the *Federal Supply Catalogue FSC Group 68, Department of Defense Section.* It includes information on:

(a) hazards and precautions in handling and using pesticides,

(b) protective equipment and proper practices to safeguard health of personnel,

(c) precautions to minimize adverse effects on wildlife and domestic animals,

(d) first aid for pesticidal contamination and poisoning, and

(e) hazards and use restrictions for pesticides.

(3) Information required by the medical officer for diagnosing and treating pesticidal poisoning is not included because such information is revised periodically and maintained in the Medical Library of all naval activities having a medical officer aboard.

11–3. Personnel Qualifications

(1) Department of Defense policies, as promulgated to the Navy by the current directive, restrict the handling and use of pesticides at military activities. Normally, the application of pesticides is accomplished by or supervised by personnel qualified in pest control procedures. Where personnel certified in accordance with BUDOCKS Instruction 6250.5 are available, the use of most military standard pesticides is permitted. In cases where certified personnel are not available, such as aboard ships or at small Navy stations, several general-use standard pesticides are available for controlling routine problems by locally indoctrinated personnel under Medical Department supervision. Usually, pesticides cannot be safely and properly used without special knowledge about them. Thus, most pesticides are applied only by or under supervision of Navy certified civilian or military personnel. Restricted use items are marked in Chapter 10.

(2) In all cases when standard pesticides fail to provide satisfactory control of pests, and where certified personnel are not available, consultation should be held with a military entomologist.*

*A military entomologist is either a Medical Service Corps or BioMedical Sciences Corps officer with a specialty in entomology or a civilian graduate entomologist employed by the armed services (usually the engineering services of the Army, Navy, or Air Force).

Section II. HAZARDS ASSOCIATED WITH HANDLING PESTICIDES

11–11. General

(1) With minor exceptions, pesticides are toxic to man and animals. In various formulations, they can damage economic property such as structural materials and furnishings, various materials in storage, and valuable plants. It is essential, therefore, that all personnel engaged directly or indirectly in handling and using pesticides be fully acquainted with the hazards involved so as to prevent the accidental poisoning of man, his domestic animals, and of fish and wildlife and to prevent economic losses. In addition, pest-control personnel must be cognizant of precautions to be observed in handling and using toxic materials and of appropriate first aid techniques to be used in the event of accidental contamination or poisoning.

(2) With reasonable precautions, most pesticides can be handled and used without undue hazards to health. However, many of the newer pesticides are more toxic to man and animals than some older compounds. In some instances outside of the Armed Forces, pesticides have been put to use before complete evaluation has been made of their acute or chronic effects on man or other animals. This explains the requirement for close supervision of pesticide usage in the Navy concerning nonstandard materials. Accordingly, all pesticides should be handled or used with caution and care.

11–12. Assessment of Pesticidal Hazards

(1) The hazards associated with handling and using pesticides are related to one or more of the following factors:

(a) oral and inhalation toxicity,

(b) effect on the skin, including possible absorption through the skin,

(c) accumulative effect on body organs,

(d) effect of exposure to small dosages over long periods,

(e) composition of the formulated pesticide,

(f) concentration of toxicants handled in mixing or application,

(g) rate of deposit required to achieve desired control,

(h) frequency of pesticidal application,

(i) degree of exposure to pesticidal residues, and

(j) physical and chemical properties of the pesticide.

(2) Constant awareness of hazards associated with handling and using pesticides, and careful attention to safeguards make it possible to use all military standard pesticides with minimum risk.

11–13. Toxicity of Pesticides

(1) The many variables governing accurate interpretation of data on the toxicity of pesticides preclude an itemization of toxicological data in this manual. Standard pharmacological data on the hazards of pesticides must be tempered by sound judgment of such factors as:

(a) species of animals or plants involved,

(b) chemical and physical form of the pesticide,

(c) toxicity of solvents, emulsifiers and carriers,

(d) metabolism of the pesticide in the body, and

(e) actual experience with man and animals.

(2) Data on acute and chronic effects of feeding pesticides to man and animals are limited and inconclusive. Furthermore, the oral LD_{50} (dosage level at which 50 percent mortality occurs) dose for acute poisoning is of no significance for use in predicting subacute or chronic poisoning by skin exposure or by inhalation.

(3) As a general rule, pesticides which are solids, or are formulated as wettable powders and dusts, pose less of a hazard by dermal poisoning than pesticidal solutions, even though they may be more easily inhaled during handling and use. Dieldrin is a notable exception; see article 11–66, paragraph (2)(b)(3). However, inasmuch as all pesticides are toxic by inhalation, due care shall be used to avoid breathing them unnecessarily.

11–14. Mode of Pesticidal Action

(1) Successful control of noxious pests is very often dependent upon the proper use of pesticides. However, before pesticides can be used properly, it is necessary to understand the principal ways they affect the organisms.

(2) Pesticides are most commonly classified into groups according to their mode of entry, such as:

(a) stomach poisons,

(b) contact poisons,

(c) repellents and deterrents,

(d) attractants,

(e) systemics, and

(f) fumigants

Many pesticides kill either by oral ingestion or by contact and some are capable of exerting lethal effects by fumigation as well. Repellents and deter-

rents, as the name implies, are used solely to keep noxious pests away.

(3) Knowledge of the mode of entry of pesticides, combined with knowledge of the several ways noxious pests can best be killed, together with handling and using pesticides according to recommended procedures, should result in effective pest control operations with complete safety to all concerned.

Section III. PRECAUTIONS IN HANDLING PESTICIDES

11-21. General

(1) Strict adherence to basic precautions in handling and using pesticides will insure safe pest control operations at all Navy installations. Basic precautions are designed to:

(a) protect individuals who handle and use pesticides,

(b) protect those who are required to mix and store them, and

(c) protect those who will be exposed to pesticides during or after application.

11-22. Precautions to Protect Personnel Who Handle Pesticides

(1) In handling, mixing or applying pesticides, care shall be taken to avoid:

(a) Contamination of mouth, eyes, and skin.

(b) Inhalation of dust, vapors, and aerosols.

(c) Contamination of clothing.

(2) Protective devices and clothing shall be used when necessary to effect this protection. Work areas must be well ventilated to reduce inhalation of dusts and fumes.

(3) Personnel routinely handling, mixing, or applying pesticides should bathe and change clothing as often as needed to keep pesticidal materials from the skin. However, this must be accomplished *immediately* in cases where *concentrated* pesticides are spilled on the skin or clothing. Contaminated clothing should always be thoroughly laundered or drycleaned before it is worn again. Personnel applying pesticides should wash hands and face frequently during the work day, and *always* before handling food or smoking.

(4) Personnel routinely handling pesticides who experience nausea, vomiting, loss of weight, loss of appetite, dizziness, double or blurred vision, ringing in the ears, extreme fatigue, headache, abdominal pain, speech difficulties, or dermatitis should report to the Medical Department for evaluation.

(5) Personnel routinely handling pesticides should be given the appropriate periodic physical examination as directed in Navy Civilian Personnel Instruction 792, and as determined by the industrial medical officer.

(6) First aid suggestions as recommended for pesticidal contamination or poisoning should be posted in a readily available location.

11-23. Precautions in Storing and Mixing Pesticides

(1) All pesticides shall be stored in a safe place and in an orderly manner. All pesticides, except pyrethrum aerosols, shall be kept secured under lock and key.

(2) All pesticide containers must be plainly labeled and kept tightly closed. Emptied food or drink containers must never be used for storing pesticides.

(3) Pesticides shall not be stored in the vicinity of foodstuffs, and the consumption of food in pesticide storage areas shall not be permitted.

(4) Facilities for storing pesticides should be kept cool and dry. Never store pesticides in the vicinity of open flames or strong oxidizing materials.

(5) All pesticides should be mixed in a well-ventilated area (out of doors if possible) so as to reduce the likelihood of inhaling dusts and fumes. If pesticides must be mixed indoors, an exhaust system should be provided which is capable of changing the air completely in about 15 minutes, *and within about 5 minutes in emergency situations.* Never use food or drink containers for pouring, portioning or mixing pesticides. Check all directions for mixing, and if any doubt exists, request the advice of the appropriate military entomologist.

(6) Special precautions should be taken in transporting pesticides to avoid spillage and to insure they do not become available to unauthorized personnel.

(7) Fire prevention practices shall be observed at all times when pesticides are being mixed, and in mixing areas.

11-24. Precautions in Using Pesticides

(1) Before using any pesticide, read all labels on the pesticide container carefully and comply fully with directions and precautions.

(2) Ascertain the characteristics of pesticides, and their possible adverse effects to man, other animals, plants, finished surfaces, fabrics and other materials before applying them. For example, oil-base sprays must not be applied to man or animals in quantities sufficient to wet skin surfaces, and not at all to plants. Never use pesticides in amounts exceeding the recommended dosage. Excess dosages will not yield a higher degree of control. They

will, however, pose a threat to fish, fish-food organisms, and other animals.

(3) Avoid pesticide contamination of food, foodstuffs, and cooking and eating utensils by removing them from areas to be treated. Tables and work surfaces, and immovable equipment and supplies should be covered with clean dropcloths or wax paper before treatment. After residual treatment aboard ship, bulkheads and other surfaces not likely to cause food contamination should *not* be washed down.

(4) Oil-base pesticide solutions shall not be used in the presence of open flames or in temperatures within 50° F. of the solvent flash point. Solvent-soaked waste material shall be discarded in covered cans. Fire prevention practices shall be observed at all times.

(5) House plants, aquariums, birds, pets, and experimental animals must be removed from rooms before pesticides are applied. They may be returned safely as soon as the application is completed and the room is properly ventilated.

(6) All hose and pipe connections on pesticide dispersal equipment shall be maintained leakproof for positive action when pesticides are applied. These measures will minimize contamination of personnel and environment and conserve materials.

(7) Cloths shall be used to clean up any spray material inadvertently spilled indoors. Do not store contaminated cloths; clean or dispose safely.

(8) Care must be used in discarding unused and unlabeled pesticides. Never dispose of them in streams or watering ponds or in sanitary sewers or storm drains. Empty pesticide containers must be disposed of in an approved manner to prevent their recovery and use as containers for food or water.

(a) Do not reuse the containers.

(b) Completely empty contents and bury the unused chemical at least 18 inches deep in an isolated location away from water supplies.

(c) Glass containers: Break and bury pieces at least 18 inches deep in an isolated location away from water supplies.

(d) Fiber and paper containers: Burn empty containers completely. Exercise caution to stay well away from smoke.

(e) Metal containers: Punch holes in the top and bottom, crush and bury deeply in an isolated area, or burn in hot fire until all of the paint has been completely burned off the container. Extreme caution should be exercised to insure that the containers are completely empty and that persons stay well away from the smoke and fumes. *Do not* attempt to burn more than five containers at one time.

Section IV. FUMIGATION PRECAUTIONS

11–31. General

(1) Fumigants are chemical agents used to control noxious pests in closed spaces. All are, or become, toxic gases at ordinary temperatures and pressures. They are of two general types, as follows:

(a) Liquids under relatively high pressure (carboxide, methyl bromide, hydrogen cyanide) which become gases at atmospheric pressure.

(b) Solids (naphthalene, paradichlorobenzene, calcium cyanide dust) which volatilize or hydrolize to produce gases.

(2) With the exception of protecting stored products against pests with naphthalene or paradichlorobenzene, and of the use of calcium cyanide dust for rodent burrows, the use of fumigants requires:

(a) Written approval of the commanding officer.

(b) Knowledge and consent of the medical officer.

(c) Authorization by a military entomologist.

(d) Supervision by specially trained personnel.

(e) Complete conformity with regulations in current applicable directives.

(3) The technical details regarding vault, vacuum, paulin, or space fumigation for controlling pests in dry food stores, in wood and wooden products, and in other supplies and equipment are contained in NAVSANDA PUB 284 "*Joint Storage and Materials Handling.*" See also TIM No. 5, Armed Forces Pest Control Board.

(4) Technical details regarding the fumigation of naval vessels with carboxide are contained in Chapter 9 of this manual. The use of calcium cyanide dust to fumigate rodent burrows is explained in NAVDOCKS MO–310, "Military Entomology," or NAVMED P–5052–26, *Rodent Control.*

11–32. Precautions During Fumigation

(1) The following special precautions must be observed in any type of vault, vacuum, paulin or space fumigation.

(a) Fumigation shall be attempted only by qualified personnel and those also trained in first aid, with special reference to gas poisoning. First aid training should include instructions in the use of approved artificial respiration. A first aid kit containing sodium thiosulfate ampoules and resuscitating drugs should be readily available, and the medical officer must be familiar with their use. When fumigating with hydrogen cyanide, liquid foods shall not be exposed, since they will absorb the cyanide. House plants must be removed from spaces to be fumigated.

(b) Fumigation shall never be attempted by individuals working alone. It shall be accomplished by two or more persons working together.

(c) All spaces to be closed off for fumigation must be thoroughly inspected before treatment to insure that all persons are out.

(d) All spaces being fumigated should be locked and warning signs posted at all possible entrances.

(e) All spaces normally utilized by personnel should be guarded against entry throughout the fumigation and aeration period.

(f) All personnel engaged in fumigation procedures must be fully clothed and must use appropriate gas masks.

(g) Appropriate tests must be conducted by certified personnel to assure the complete absence of the fumigant before reoccupancy of fumigated space is permitted.

11–33. Precautions for Specific Fumigants

(1) *Hydrogen Cyanide (Hydrocyanic Acid Gas).*—Hydrocyanic acid gas is extremely poisonous to all forms of animal life. Operators using it must wear appropriate gas masks and proper protective clothing. Spaces to be fumigated must be securely sealed and guarded against inadvertent entry. Great care must be taken to insure thorough airing of fumigated space and contents before reentry and reuse is permitted.

(2) *Calcium Cyanide.*—This produces hydrocyanic acid gas on exposure to moist air. Its use is restricted to the dusting of rodent burrows. It may be used only 3 feet or more from occupied buildings. Gloves and respirators or gas masks shall be worn. Respirators will prevent inhalation of the dust but not of the gas.

(3) *Methyl Bromide.*—Methyl bromide gas is highly toxic to man and animals. It is available with 2 percent chloropicrin (tear gas) as a warning agent. Repeated exposure causes cumulative damage to the body. Personnel using it must guard against inhalation and skin contamination. The safe upper limit of concentration for inhalation is about 17 ppm; above such concentration gas masks equipped with canisters effective against organic vapors shall be worn. The manufacturer's instructions on each canister shall be followed rigidly.

Gloves should not be worn when handling it because accidental spillage through them could lead to serious skin burns. Shoes also present a hazard for methyl bromide burns; if liquid contamination occurs, remove immediately.

(4) *Carboxide.*—Carboxide gas is 10 percent ethylene oxide and 90 percent carbon dioxide. It is a liquid under pressure and is toxic as a gas. Ethylene oxide condenses to a liquid at about 52° F. Therefore, carboxide shall not be used at temperatures below 55° F. Operators should guard against inhaling it and insure that fumigated spaces are thoroughly aerated before permission is granted for reoccupancy. Cylinders should be grounded to prevent explosion by static electricity.

(5) *Paradichlorobenzene.* — Paradichlorobenzene is harmful to humans only after prolonged inhalation of its vapors. Personnel using it are cautioned against prolonged exposure in treated spaces.

(6) *Naphthalene.*—Naphthalene is not particularly harmful to humans. However, strong vapors are irritating to the eyes and nose and personnel using it should guard against overexposure to its fumes. Naphthalene should not be used near open flames.

Section V. PROTECTIVE EQUIPMENT FOR HANDLING PESTICIDES

11–41. General

(1) Protective equipment is an integral part of the safe and proper use of pesticides. Under open field conditions, protective equipment may not be required while applying dilute dusts or water sprays of certain materials. It must be borne in mind that protective equipment is not a substitute for sensible precautions. The rules for proper storage of pesticides and the rules for proper storage of protective equipment are equally important. These rules do not permit the storage of protective equipment where it will become contaminated with the very substances against which it has been designed for the protection of the operator. The care of protective equipment is a necessary insurance for protection from pesticidal exposure.

(2) Protective equipment for handling pesticides consists of:

(a) devices to guard against eye contamination, and against inhalation of dusts, fumes, vapors and aerosols, and

(b) protective clothing to prevent skin contamination.

11–42. Respirators, Goggles and Masks

(1) Respirators are advised for protecting pest-control personnel against the inhalation of dusts, fumes, vapors, and mists of droplets which are small enough to present an aerosol hazard. Under certain open-field conditions, protective devices may not be required while dispensing certain diluted dusts or water dispersible sprays. Respirators shall always be used, however, while storing toxic materials in warehouses or while loading operating equipment. Personnel shall also wear respirators when exposure will be continuous during the day, or for successive days, to small amounts of toxic pesticides—even those not readily detected. When respirators are used, the following practices are necessary:

(a) Change filters twice a day or oftener if breathing becomes difficult.

(b) Change cartridges after 8 hours of actual use or oftener if any odor of the pesticide is detected.

(c) Remove filters and cartridges and wash the facepiece with soap and warm water after use. After washing, rinse it thoroughly to remove all traces of soap. Dry the facepiece with a clean cloth that is not contaminated with the pesticide. Place the facepiece in a well ventilated area to dry.

(d) Check flutter valve to see that it is functioning properly.

(e) Store the respirator, filters, and cartridges in a clean, dry place—preferably in a tightly closed paper or plastic bag.

(2) At present, no Federal supply catalogue respirators are considered acceptable for all pesticides. Until this deficiency is corrected the manufacturer and model number must be checked with the listing shown in reference 3 to this chapter; open purchase of respirators will be necessary. The following respirator-cartridge-filter combinations are satisfactory for adequate protection of operators from most pesticides (dusts, vapors, fumes, and fine mists or aerosols). Letter designations of items are as listed in reference 3.

J. C–241 Respirator, with CMP cartridge and C–241–7 filter. (Pulmosan Safety Equipment Corp., 644 Pacific Street, Brooklyn, N.Y.)

L. Respirator No. 6058, equipped with combination filter-cartridge R–58. (American Optical Co., Safety Division, Southbridge, Mass.).

O. Agritox Respirator, equipped with cartridge 11P and filter R553. (Willson Products Division, Ray-O-Vac Co., a division of Electric Storage Battery Co., Reading, Penna.).

P. Protex Respirator, equipped with 7500–21 cartridge and 7500–23 filter. (Welsh Manufacturing Co., Providence, R.I.).

(3) For planning purposes, it must be considered that respirators do not protect the eyes and that goggles will probably be necessary. Goggles, Industrial Rubber Frame, unventilated are available to meet this requirement.

(4) Masks and even air-supplied breathing devices are necessary for adequate protection against heavy concentrations of pesticidal dusts, mists and vapors encountered during certain operating conditions indoors or in closed spaces without adequate ventilation. Under conditions of severe exposure, protection cannot be assured by relying only on a chemical cartridge or canister respirator. Assistance and advice from the appropriate military entomologist should be requested when these conditions are anticipated.

11–43. Protective Clothing

(1) Proper clothing provides great protection to personnel handling and using pesticides.

(2) All clothing should be changed after mixing and applying pesticides.

(3) Contaminated clothing should always be laundered or drycleaned before it is reworn.

(4) Inexpensive coveralls are available and practical. Three pairs make up the minimum requirement for a pest-control operator. An inexpensive cap or normal covering for the head will help to keep pesticides out of the hair.

(5) Rubber gloves, solvent resistant, should be worn. Washable canvas gloves may meet the need if they are removed when contaminated and washed frequently. Protective waterproof gloves are more desirable.

(6) Standard safety shoes are always required when working with heavy equipment. Field shoes with solvent-resistant soles will be very satisfactory. Frequent changes of working socks will help prevent contamination from pesticides which may enter through the shoes. Rubber boots are often worn by pest control operators in the open field and also may be valuable as protective equipment while working with large-scale pesticide mixing and application.

(7) Protective aprons can be useful when pesticides are mixed.

NOTE: All protective clothing, masks, respirators and other safety equipment should be supplied by the Naval activity where the pesticides are being stored, issued, or handled.

(8) Even the best protective equipment will not replace the need for washing hands and face frequently, especially before smoking and eating. Shower stalls or bathing facilities must be available for a quick bath if extensive contamination by pesticides should occur.

(9) The exposed skin around the face mask, the forehead, neck, ears and arms may require protection during certain pest control operations. The skin-protective compound, Type II in 1-pound jars is recommended.

Section VI. FIRST AID FOR PESTICIDAL EXPOSURE

11–51. General

(1) Strict adherence to basic principles in rendering first aid to victims of pesticidal contamination and poisoning will avert disfigurement, impairment of health, and possibly the loss of life. Post a First Aid Chart on the bulletin board and in other conspicuous places where pesticides are stored, issued, mixed or handled. (See reference 13.)

11–52. First Aid for Pesticidal Contamination

(1) In the event of *serious skin contamination* by pesticides, *particularly by pesticidal concentrates;* render first aid, as follows:

(a) Remove all clothing from the victim and flood the contaminated area of the skin with copious amounts of water.

(b) Follow with a thorough washing of the contaminated area of the skin with warm, soapy water.

(c) If eyes, nose or mouth are contaminated, flush thoroughly with plain water.

(d) Rush the victim, with sample label of the material to which he has been exposed, to the nearest physician for examination.

(e) In the following articles, attention to the victim is emphasized. However, the person who administers first aid is in a vulnerable position for self exposure. Exercise care at all times to avoid contact with the toxicant on the patient's clothes, on his skin or in his eyes, mouth or nose. In removing his contaminated clothes, or washing his exposed skin surfaces DO NOT CONTAMINATE YOURSELF. When artificial respiration is necessary, mouth-to-mouth resuscitation requires special cleansing of the victim to avoid personal exposure to the same poison during mouth to mouth contact. Since certain pesticides produce some paralysis of the muscles of respiration, the chest may be collapsed and there is very little expiratory reserve. Hence, methods of artificial respiration which depend upon compression of the chest and elastic recoil (e.g., Shaefer prone pressure method) are not efficient. For this special condition, manual methods which actively assist both inspiration and expiration are more effective (e.g., the Holger-Nielsen back-pressure, arm-lift method).

11–53. First Aid for Internal Poisoning From Pesticides

(1) In the event of internal pesticidal poisoning, render first aid as follows:

(a) Obtain immediate on-the-spot services of a physician. If this is not practicable or possible, administer the antidote treatment recommended on the label of the pesticide container, then rush the victim to the nearest medical facility. Never attempt to administer an oral antidote to an unconscious victim.

(b) In the event no specific antidote is recommended on the label of the pesticide container, administer the following universal antidote: If the victim is conscious, give one tablespoon of salt dissolved in a glass of warm water. Repeat salt-water dosage until vomit fluid is clear. Follow with a serving of hot coffee or tea and two tablespoons of Epsom salt in water; avoid giving the patient oil cathartics or fatty substances, such as milk; keep the patient quiet and in a prone position.

(c) If the victim is cold, cover him with a light blanket. Hot objects should not be used to warm the patient.

(d) In the event the victim stops breathing, or breathing becomes difficult, administer mouth-to-mouth resuscitation.

11–54. First Aid for Poisoning by Fumigants

(1) In the event of poisoning by toxic gases, render first aid as follows:

(a) Move the victim outdoors to fresh air quickly.

(b) Summon a physician promptly, or rush patient to the nearest medical facility.

(c) Remove contaminated clothing, but keep the patient warm.

(d) If the prompt services of a physician are not available, administer the antidote recommended on the label of the fumigant container.

(e) In the event the victim stops breathing, or if breathing becomes difficult, administer mouth-to-mouth resuscitation.

11–55. Organic Phosphorus Pesticide Poisoning and Suggestions for Treatment

(1) The use of organic phosphorous pesticides has become greater as insect species continue to exhibit resistance to many of the insecticides previously employed.

The following information may be of value as a guide to the physician who may be called upon to treat persons poisoned by *organic phosphorous* compounds (anticholinesterase compounds).

(a) In very severe cases, the order of treatment should be as follows:

(*1*) ARTIFICIAL RESPIRATION, preferably by mechanical means.

(*2*) ATROPINE, 2 to 4 mg. (1/30 to 1/15 grain) intravenously as soon as cyanosis is overcome. Repeat at 5- to 10-minute intervals until signs of atropinization appear (dry, flushed skin and tachycardia as high as 140 per minute).

(*3*) 2-PAM, 1 g., slowly, intravenously (not for use in Diazinon poisoning).

(*4*) DECONTAMINATION of the skin, stomach, and eyes as indicated.

(*5*) SYMPTOMATIC TREATMENT.

(b) In the more usual case, proceed as follows:

(*1*) ATROPINE, 1 to 2 mg. (1/60 to 1/30 grain) if symptoms appear. If excessive secretions occur, keep the patient fully atropinized. Give atropine sulfate every hour up to 25 to 50 mg. in a day.

(*2*) DECONTAMINATION of the skin, stomach, and eyes as indicated.

(*3*) 2-PAM, 1 g., slowly, intravenously if the patient fails to respond satisfactorily to atropine (not for use in Diazinon poisoning).

(*4*) SYMPTOMATIC TREATMENT. LOCATE THE NEAREST "POISON CENTERS" AND KEEP THE ADDRESSES AND PHONE NUMBERS READILY AVAILABLE.

NOTE: Do *not* use 2-PAM for Diazinon poisoning or for poisoning with the carbamate insecticide Sevin (Carbaryl).

Section VII. PESTICIDAL HAZARDS AND USE RESTRICTIONS

11–61. General

(1) Most of the substances available for controlling pests are toxic to man and other animals. With minor exceptions, the most effective pesticides are also the most toxic to fish, fish-food organisms, and to warm-blooded animals. Inasmuch as most pesticides pose a degree of threat to personnel who handle, mix, and apply them, and since their improper use could have a deleterious effect on fish, wildlife, and man, it is highly important to know the basic characteristics of pesticides and the restrictions and precautions in using them in order to minimize or eliminate hazards.

11–62. Purpose and Scope

(1) Information in this section is intended to point up the major hazards posed by substances used for controlling pests at Navy installations and to itemize precautions and use restrictions for pesticides. *Basic precautions and restrictions in handling and using pesticides, as specified in Section III, must be observed and they are not repeated here.*

11–63. Classification of Pesticides

(1) Pesticides are commonly classified into groups according to their mode of entry, (a) stomach poisons; (b) contact poisons; and (c) respiratory poisons. However, relatively few pesticides act exclusively as stomach, contact, or respiratory poisons. Instead, many of them act in a dual capacity. For example, some stomach poisons also act as contact poisons. Likewise, some contact poisons also exert a fumigation effect. A few act in all three ways, i.e., stomach, contact and respiratory poisoning.

(2) Pesticides are sometimes classified into groups according to their mode of action, as (a) physical, (b) tissue, (c) respiratory-nerve, or (d) general poison. Pesticides could also be classified by terms denoting their principal proposed use, as (a) insecticides, (b) rodenticides, and (c) herbicides. This use classification could be enlarged by adding fungicides, molluscicides, acaricides, repellents, deterrents, systemics, and others.

(3) For convenience in discussing the hazards posed by substances used for controlling arthropods and rodents at Navy installations, and in itemizing precautions and restrictions in using them, the common three group classification will be followed. Insecticides and rodenticides are considered the most important pesticides for the purpose of this chapter and discussion will be limited to these two.

11–64. Insecticides

(1) *Stomach Poisons.*—Stomach poisons are used primarily to kill insects that chew and swallow their food. They also are used to kill insects that rasp the surface of the food plant and suck up the resulting pulp; eat food or take moisture from surfaces that can be poisoned; feed upon artificial foods, such as poisoned baits; or possess the habit of using the mouthparts to clean the body and appendages, and in so doing swallow poisons. The most common stomach poisons are inorganic substances such as:

Lead Arsenate
Paris Green
Sodium Fluoride

In addition, Kepone, a synthetic chlorinated hydrocarbon, is available for use as a cockroach stomach poison.

(2) *Contact Poisons.*—Contact poisons, as the name implies, are used to kill insects on contact. Many insects obtain their food by piercing the object fed upon and sucking the fluids from beneath the surface. All such insects are unaffected by the usual stomach poisons, thus must be killed by contact poisons, or on occasion by respiratory poisons. Some contact poisons remain toxic to insects for extended periods and thus are extremely useful for killing insects that later come in contact with treated surfaces. Contact poisons with residual toxicity are normally referred to as residual poisons. The most common contact poisons, some having prolonged residual actions, are:

(a) *Chlorinated Hydrocarbons*
Chlordane
DDT
Dieldrin
Lindane-BHC

(b) *Organic Phosphorous Compounds*
Diazinon
Dichlorvos (DDVP)
Fenthion
Malathion
Naled
Parathion

(c) *Carbamates*
Baygon (Bayer 39007)
Carbaryl (Sevin)

(d) *Plant Products*
Nicotine Sulfate
Pyrethrum
Rotenone

(3) *Respiratory Poisons.*—The habits of many insect pests are such that they cannot be easily killed by stomach or contact poisons. Those that conceal themselves within their host plant, in cereal and grain supplies, packaged containers, dry-stores, wood products and other similar places usually can only be killed effectively by respiratory poisons. In some cases, scale insects, maggots, soil-infesting grubs, and other pests also are controlled by fumigation. All of the respiratory poisons are fumigants, such as:

Hydrogen cyanide
Methyl bromide
Carboxide (10% Ethylene Oxide—90% Carbon Dioxide)
PDB (Paradichlorobenzene)
Naphthalene

11–65. Rodenticides

(1) *Stomach Poisons.*—Satisfactory control of noxious rodents, primarily rats and mice, is largely dependent on eliminating their harborage and food. However, these rodents, especially rats, have a remarkable ability to adapt to every environment. This, coupled with their natural cunning sometimes makes it impossible to completely eliminate access to harborage and food. Supplementary measures for controlling rodents normally are needed at all Navy installations, and poisoning and trapping is standard operating procedure. The most common stomach poisons which are used to control rodents include:

(a) Anticoagulant Bait, ready-to-use, or concentrate,

(b) Zinc Phosphide, and

(c) Sodium Monofluoroacetate (1080) (no longer catalogued); obtain from Disease Vector Control Center or Preventive Medicine Unit); the approval of the Officer in Charge of a Disease Vector Control Center or Preventive Medicine Unit, or of the Bureau of Medicine and Surgery is required before use.

(2) *Contact Poisons.*—The habits of rodents generally preclude the use of contact poisons for their control. On occasion, poisonous dusts (DDT, for example) are spread on rodent runways and if the animal's feet, sensory hairs, and body are thus contaminated, they could be killed by ingesting the poison after cleaning body parts with their mouth and tongue.

(3) *Respiratory Poisons.*—Respiratory poisons are highly effective for controlling rodents because many of them live in burrows and other enclosed spaces easily fumigated. The most common respiratory poison used for controlling rodents is calcium cyanide dust.

11–66. Hazards and Use Restrictions for Insecticides

(1) *Stomach Poisons.*—Most of the substances used as stomach poisons to control insects are also toxic to man and other animals. Although some are more toxic than others, each must be handled with care and used only in the amounts recommended for specific pests.

(a) *Hazards.*—All of the inorganic substances are highly toxic to warm-blooded animals. Great care must be exercised in handling, mixing, and using all stomach poisons to prevent inhalation or ingestion of any of them. Contamination of the skin with arsenical compounds often results in troublesome inflammation and ulceration, thus due precaution should be taken to avoid spillage and possible skin contamination.

(b) *Use Restrictions*

(1) *Lead Arsenate* is nonstandard, and will not be used except under the direction of a military entomologist. More recently developed insecticides have supplanted the use of this insecticide for most military purposes.

(2) *Paris Green* is nonstandard, and will be used only as a mosquito larvicide under the direction of a military entomologist.

(3) *Sodium Flouride* is nonstandard. It may have use in 78–90 percent dusting powder form for cockroach control, under the direction of certified personnel or a military entomologist. Operators will wear protective clothing and avoid breathing dust.

(4) *Kepone* is a relatively new, nonstandard insecticide which will be used only in ready-to-use paste or pelleted form. In these forms, it consists of an attractive food bait containing 0.125 percent Kepone. It will be used by, or under the direction of certified personnel or a military entomologist. When used as directed, it has a very minor toxicological hazard.

(2) *Contact Poisons.*—The substance used to control insects on contact, initially or through residual action, are all relatively toxic to man and other animals. The degree of their toxicity is dependent not only on the chemical itself but also on the way in which each is formulated for use.

(a) *Hazards.*—Care must be exercised in handling, mixing, and using all contact poisons to avoid skin, eye, nose, and mouth contamination, accidental ingestion or inhalation of compounds, aerosols or dusts, and to avoid dosages which have adverse effects on fish and wildlife.

(b) *Use Restrictions*

(1) *Chlordane*

(a) Do not apply chlordane directly on man, or other animals,* to foods, water, or feeding equipment, or for mothproofing fabrics.

(b) Restrict the application of residual chlordane sprays to infested areas. Overall treatment of interior surfaces of occupied spaces is prohibited. Liquid formulations of residual sprays shall not contain more than 2 percent chlordane by weight. Dry formulations shall not exceed 6 percent by weight.

(c) Never use chlordane as a residual spray to surfaces likely to receive frequent skin contact.

(d) Place lawns that have been treated with chlordane "off limits" until the pesticide leaches into the soil.

(e) Do not apply chlordane sprays to spaces while occupied and do not permit reoccupancy until quarters are thoroughly aired. Cover all food, food-handling areas, bedding, garments, and similar articles before spraying.

(f) The use of chlordane concentrates is restricted to supervision or application by certified personnel.

(2) *DDT*

(a) Do not use a DDT emulsion spray over water. DDT emulsions are highly toxic to some beneficial aquatic life.

(b) Do not use DDT spray on dairy animals, in dairy barns or on food fed to cows. Doing so will cause contamination of milk.

(c) Avoid using oil solutions of DDT at rates exceeding 0.2 pounds per acre and do not apply residual sprays to vegetation or ground cover at rates exceeding 1 pound per acre if desirable wildlife is present. Application rates above these amounts usually are destructive to fish and wildlife.

(d) Although DDT is toxic for higher animals (as well as many lower organisms, other than insects), with appropriate understanding and precautions, hazard is low. The toxicity is less than many substances in popular use before the discovery of DDT, such as sodium fluoride, Paris Green, and nicotine sulfate.

(3) *Dieldrin*

(a) Apply dieldrin to premise interiors only as a limited or "spot" surface treatment by coarse sprays or by painting with a brush.

(b) Never use dieldrin as an aerosol fog, mist or fine spray in occupied spaces.

(c) Restrict the use of dieldrin to insect harborages or places frequented by them. Never apply dieldrin to surfaces exposed to frequent skin contact, because it is extremely hazardous to man when the skin is contaminated by *either dusts* or *sprays.*

(d) When dieldrin is to be used to treat premises, liquid formulations should not exceed 0.5 percent by weight.

(e) Never apply dieldrin to man or animals, to food, or in the vicinity of fish ponds or dairy barns.

(f) The use of dieldrin concentrates is restricted to supervision or application by certified personnel.

(4) *Lindane and BHC* (Benzene Hexachloride)

(a) Avoid all unnecessary or excessive exposure to lindane and BHC.

(b) Use no more than 60 grams of a 1-percent lindane powder per person for controlling body lice that are resistant to DDT. Never repeat applications at intervals of less than 7 days.

(c) Do not attempt to control scabies with lindane lotions in strengths above 1 percent.

(d) Never use lindane to mothproof fabrics.

(e) Use lindane aerosols, fogs, mists, or sprays in living quarters only at rates not to exceed 5 milligrams per square foot, or 2 grams per 1,500 cubic feet. Do not use in food storage areas.

(f) Restrict the application of residual lindane sprays to infested areas. Never treat more than 20 percent of the total wall and floor area.

(g) Liquid formulations of lindane intended for indoor residual treatments must not contain more than 0.5 percent of the toxicant by weight. Dry formulations should not contain more than 1 percent by weight.

(h) Do not apply lindane sprays to areas that are occupied and do not permit reoccupancy until quarters are thoroughly aired.

(i) Avoid using lindane spray on surfaces where flaking or condensed droplets may subsequently contaminate food.

(j) Insecticide, DDT-Lindane (10% DDT—2% Lindane) must not be used in food storage areas.

(k) The use of lindane concentrates is restricted to supervision or application by certified personnel.

(5) *Diazinon*

(a) Avoid all unnecessary or excessive exposure to diazinon.

(b) Residual applications of diazinon may be made with 0.5 percent formulations. In special cases, the military entomologist may authorize use of 1 percent formulations.

(c) No more than 2 percent diazinon dust is permitted for treating indoors.

(d) The use of diazinon concentrates is restricted to supervision or application by certified personnel.

NOTE: *Up to 4 percent chlordane dust may be used safely on dogs over two months of age for tick or flea control.

(6) *Dichlorvos* (DDVP)

(*a*) This organic phosphorus compound is included as an example of an insecticide which may become a standard military item. It has been considered for extensive testing because of its high toxicity for insects and comparatively low toxicity for mammals at effective dilutions. The use of 20 percent dichlorvos in resin strips as a "residual fumigant" may find wide application. The normal hazards of organic phosphates accompany the use of dichlorvos, and this insecticide will not be used unless under the supervision or recommendation of a military entomologist.

(7) *Fenthion*

(*a*) This is also a promising organic phosphorus compound, and has potential military use against mosquitoes, flies, and cockroaches. Other designations for this compound have been Bayer 29493, Entex, and Baytex. It will be used only upon the recommendation of a military entomologist.

(8) *Malathion*

(*a*) Avoid all unnecessary or excessive exposures to malathion.

(*b*) Interior residual applications of malathion are permitted only when formulations do not exceed 5 percent. Such applications shall be applied to surfaces only as coarse wet sprays or with a paint brush. Use only to treat infested areas.

(*c*) Malathion may be used to control fleas on cats and dogs only if spray formulations do not exceed 0.5 percent or if dusts do not exceed 4 percent.

(*d*) Never mix or dilute malathion in containers used for free chlorine (for example, calcium hypochlorite). A spontaneously combustible mixture may result.

(*e*) The use of malathion concentrates is restricted to supervision or application by certified personnel.

(9) *Naled* (Dibrom)

(*a*) This is still another promising organic phosphorous compound, potentially useful against mosquitoes and flies. It will be used only upon the recommendation of a military entomologist.

(10) *Parathion*

(*a*) This is a well known, and very hazardous organic phosphorous insecticide. It is used by some organizations for mosquito and fly control, and is rather extensively used in agricultural pest control. It is not recommended for military use in any form, however, due to the hazards involved.

(11) *Baygon* (Bayer 39007)

(*a*) This is an example of a newer group of insecticides called carbamates. Baygon has proven very effective for the control of resistant German cockroaches, and has been tested against several other pests and vectors. It will be used only upon the recommendation of a military entomologist.

(12) *Carbaryl* (Sevin)

(*a*) This is another carbamate, and has been in use longer and for more different insects (including several agricultural pests) than has Baygon. Both of these carbamates are nonstandard, but carbaryl is undergoing military tests for use in dust form as a standby control for resistant body lice, and could become a standard item later. At present, it will be used only upon the recommendation of a military entomologist.

(13) *Nicotine Sulfate*

(*a*) Protective clothing and goggles must be worn when nicotine sulfate is handled and a respirator must be worn by persons using it as a spray.

(*b*) It is intensely toxic to mammals by inhalation or dermal application, being rapidly absorbed through the skin. It is absorbed more rapidly via the tongue or the eye than via the stomach. Protective clothing is essential to the operator.

(c) Never use nicotine sulfate to control insects on food plants within one week of harvest.

(14) *Petroleum Oils*

(*a*) Avoid gross contamination of the skin with any petroleum oil.

(*b*) Basic fire precautions must be followed when petroleum oils are used as sprays.

(c) Do not spray foliage with petroleum oils bearing sulfur residues.

(15) *Pyrethrum* (and Allethrin)

(*a*) Pyrethrum or allethrin can be used safely at recommended dosage rates. Some formulas contain DDT. When they do, use restrictions listed for DDT shall be followed.

(*b*) Pyrethrum, synergized, is available in an aerosol (bomb) dispenser.

(3) *Respiratory Poisons*

(a) *Hazards.*—With the exception of naphthalene and paradichlorobenzene, respiratory poisons used for controlling insects are extremely toxic to man and other warm-blooded animals. Exposure to them, even for a short period of time, usually is fatal. Most fumigants are heavier than air and each is capable of penetrating deeply into most packaged goods, voids in walls, floors and other such places. Although some of them have distinctive and characteristic odors, even at very low concentrations, the detection of their presence should never be attempted by using odor as a criterion. Inasmuch as fumigants are so highly toxic to man and other warm-blooded animals, their use is largely restricted to specially trained personnel.

(b) *Use Restrictions*

(1) *Napthalene*

(*a*) Avoid prolonged breathing of naphthalene vapors. They are irritating to eyes, nose, and throat.

(*b*) Do not use naphthalene near open flames. Vapors can be ignited and cause an explosion.

(c) Do not use naphthalene in closed spaces having varnished finishes.

(2) *Paradichlorobenzene* (PDB)

(a) Avoid prolonged breathing of paradichlorobenzene vapors. They are irritating to eyes, nose, and throat.

(b) Air saturated with paradichlorobenzene vapors will soften plexiglass, vinylite, paint, and varnish. Avoid its use in the presence of such materials.

(3) *Ethylene Oxide* (Carboxide active ingredient)

(a) The vapors are deleterious to man and higher animals. It produces an intense irritation to the eyes and nose.

(b) Produces cyanosis on long inhalation.

(c) The use of Ethylene Oxide is recommended only for closed spaces.

(d) Store filled containers in a very well-ventilated area outside inhabited buildings. Protect all cylinders and valves.

(e) The use of Ethylene Oxide is restricted to specially trained personnel, and it is used only when recommended by the appropriate military entomologist and when approved and authorized by the commanding officer and medical officer.

(f) Never permit reoccupancy of fumigated spaces until tests prove the complete absence of this fumigant.

(4) *Methyl Bromide*

(a) The use of methyl bromide is restricted to specially trained personnel, and it is used only when recommended by the appropriate military entomologist and when specifically authorized by the commanding officer and the medical officer.

(b) Store all methyl bromide containers in a cool, well-ventilated area, outside inhabited buildings. Protect the valves on all cylinders and containers.

(c) Always use gastight equipment in well-ventilated space or in the open air downwind of personnel when fumigating with methyl bromide.

(d) Methyl bromide gas is odorless. *Guard against inhaling it.* Never permit reoccupancy of fumigated spaces without using standard techniques to test for its presence.

(e) Do not use methyl bromide to fumigate dried beans or peas, salted foods, or prepared flour.

(f) Do not use methyl bromide to fumigate foam rubber, rubber-backed rugs, wool, or leather items, or clothing containing perspiration.

11–67. Hazards and Use Restrictions for Rodenticides

(1) *Calcium Cyanide* (liberates hydrocyanic acid gas).

(a) Keep containers tightly closed and inspect at regular intervals to be sure containers are in good condition. Calcium cyanide reacts slowly with water in moist air to yield HCN. Keep it dry.

(b) Like all cyanides it is intensely poisonous and hazardous to all living animals adequately exposed.

(c) The vapor of HCN is toxic not only by inhalation but by skin absorption.

(d) Appropriate masks should be used where high concentrations are possible. Avoid inhalation and skin contact.

(e) Precautions must be taken in situations where the use of calcium cyanide in enclosed spaces may lead to high concentrations of hydrocyanic acid vapor.

(f) The use of calcium cyanide as a rodenticide indicates the hazard involved for domestic and wild animals.

(2) *Anticoagulant Bait*

(a) Do not breathe the dust or take internally.

(b) Forms of this compound may be used in dry baits or as liquid baits. All baits must be protected from access by animals other than rats and mice.

(c) When properly diluted for use as a dry bait or a liquid bait it has very limited toxicity to higher animals.

(d) All normal pesticide precautions apply.

(3) *Sodium Monofluoroacetate* (1080)

(a) All requisitions for this material must be approved by the Officer in Charge of a Disease Vector Control Center or Preventive Medicine Unit, or by the Bureau of Medicine and Surgery prior to issue in order to assure that sodium monofluoroacetate is issued only to personnel who are qualified to use it.

(b) Must not be stored under conditions that might result in the contamination of food supplies or water. Must be stored in a locked space which is inaccessible to unauthorized personnel. Store in a dry place. This material is highly soluble in water.

(4) *Zinc Phosphide*

(a) Do not breathe dust or fumes.

(b) Do not contaminate feed or foodstuffs.

(c) Keep away from children and domestic animals.

(d) Must be mixed with bait material before use.

(e) Every precaution in distribution of baits is essential.

REFERENCES

Section VIII.

1. Special Committee, National Agricultural Chemicals Association Report, 8 March 1962.
2. Safe Handling of Pesticides, Technical Report Series No. 153 of The World Health Organization.
3. "Respiratory Devices for Protection Against Certain Pesticides" (ARS–33–76, June 1964). U.S. Department of Agriculture.
4. Durham, W. F., Hayes, W. J. Jr.,: "Organic Phosphorus Poisoning and Its Therapy," Reprinted from the Archives of Environmental Health, vol. 5, pp. 21–47, July 1962.
5. Manns, Marshall: "How To Use Insecticides and Fumigants Safely." Pest Control, January 1963.
6. "Treatment of Chemical Warfare Casualties" NAVMED P–5041.
7. "Clinical Handbook on Economic Poisons," U.S. Department of Health, Education, and Welfare, Toxicology Section, Communicable Disease Center, Atlanta, Ga., 1963.
8. "Entoma" 14th Edition 1961–62, published by the Entomological Society of America.
9. "Handbook of Toxicology," vol. III, Insecticides. A Compendium, WADC Technical Report 55–16.
10. Respiratory Protective Devices, TB MED 223; AFP 161–1–1, 20 August 1962.
11. The Safe Use of Pesticides. TIM No. 10, AFPCB, July 1963.
12. The Mediterranean Snail Problem. TIM No. 5, AFPCB, January 1962.
13. Emergency Medical Treatment for Acute Pesticide Poisoning. 1962. U.S. Navy Disease Vector Control Center, Jacksonville, Fla.
14. "Manual of Fumigation for Insect Control," Food and Agricultural Organization of the United Nations, FAO Agricultural Studies No. 56, 1961.