APPLY PESTICIDES CORRECTLY
A GUIDE FOR COMMERCIAL APPLICATORS

HOW TO USE ANTIMICROBIAL PESTICIDES

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDE PROGRAMS
WASHINGTON, D.C. 20460

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ACKNOWLEDGMENTS

This guide has been developed by the Cooperative Extension Service, University of Georgia, from funds provided by the Operations Division, Office of Pesticide Programs, Environmental Protection Agency (EPA) through the Extension Service, U.S. Department of Agriculture. The group effort was organized and led by Burton R. Evans, University of Georgia. Editor was Mary Ann Wamsley, EPA.

Contributors were:
Carl E. Bruch, Food and Drug Administration, Department of Health, Education, and Welfare
S. John Cobis, Veterans Administration
Norman E. Dewar, Vestal Laboratories
Frank E. Halleck, American Sterilizer Company, Inc.
Bertha Yanis Litsky, Research Consultant
Charles R. McDuff, Economics Laboratory, Inc.
Darlene K. McLeod, Department of the Army, Office of the Surgeon General
G. Briggs Phillips, Health Industry Manufacturers Association
Margaret L. Wulf, The Dow Chemical Company
Charles C. Yeager, Registration Consulting Associates

Many other people in public health, industry, and government contributed greatly to the manual by reviewing it at various stages. Special thanks go to Aram Beloian, Criteria and Evaluation Division, EPA. Acknowledgment is made to Lonza, Inc., Fair Lawn, New Jersey, for use of the sample label, and to the authors of "Apply Pesticides Correctly", an EPA/USDA publication, for some of the content used in this manual.

PREFACE

Federal regulations establish general and specific standards that you must meet before you can legally use certain pesticides. This guide contains basic information to help you meet the standards for applicators who use antimicrobial agents which the Environmental Protection Agency has classified for restricted use.

Because the guide was prepared to cover the entire Nation, some information important to your State may not be included. The State agency in charge of your training can provide the other material you should study.

This guide will give you information about:

- microorganisms and their control,
- antimicrobial agents,
- labels,
- human and environmental safety,
- equipment,
- application techniques, and
- laws and regulations.

INTRODUCTION

Microorganisms, also known as microbes or "germs", are living cells so small that most can be seen only with a microscope. Algae, fungi, bacteria, and viruses are all microbes. Any substance or mixture of substances that acts against microbes is an antimicrobial agent.

This manual deals with the following types of antimicrobial agents:

- disinfectants,
- sanitizers,
- bactericides and bacteriostats,
- virucides,
- sterilants,
- algaecides,
- fungicides and fungistats,
- antifoulants,
- preservatives,
- slimicides,
- mildewcides.

Some of these chemicals may also be used to control microorganisms on or in man or other living animals and plants. This manual, however, applies only to their use in controlling microorganisms which are either in or on nonliving objects, water, or air.

Not included are antimicrobial agents used to control fungi, bacteria, or viruses in or on processed food, beverages, drugs, or cosmetics. They are regulated by the Food and Drug Administration. Likewise not included are the antimicrobial agents used to protect and preserve wood products from microorganisms.

For the purposes of this manual, the term "microorganism" will refer to only the bacteria, fungi, algae, and viruses.

The final chapter provides definitions of many of the specialized terms used to describe antimicrobial pesticides and how they work.

PESTS

Microorganisms can be found nearly everywhere–in water, air, dust, and soil; in most non-processed foods; and in all decaying matter. Man and animals have microorganisms on their skin and hair, in their intestinal tracts and feces, and in the fluid discharges of their bodies.

Most microbes are harmless under normal conditions. In fact, they may perform useful functions. For example, most plant and animal life could not exist without some kinds of microbes; other kinds of microbes are used in many industrial processes.

One of the major functions of microorganisms in nature is their role in the decay process. Consider what would happen if there were no microbial activity to break down such things as animal carcasses, vegetation, and tree stumps. Urban life depends on bacteria for sewage treatment. Microorganisms are used in the fermentation industries to produce such things as organic acids, sauerkraut, alcoholic drinks, bread, and cheese. Some are the source of antibiotics used in medicine.

Some microorganisms, however, can be harmful. They cause many kinds of diseases. Microorganisms can also damage commercial products. For example, they can cause undesirable changes in such materials as adhesives and plastics.

Bacteria

Bacteria are microscopic, one-celled organisms that lack the green pigment, chlorophyll.

Four hundred million (400,000,000) of these cells would be the same size as one grain of granulated sugar. When bacteria are magnified 1,000 times, they look no bigger than a dot on this page.

Bacterial cells reproduce by dividing in half (fission) to become two identical cells. Under ideal conditions, some bacteria can reproduce as often as once every 15 to 30 minutes. One bacterium could become 70 billion bacteria in only 12 hours.

Bacteria are divided into two major groups based on a staining technique called a Gram stain. Those that stain violet are called Gram positive; examples are the bacterium that causes tetanus (*Clostridium tetani*) and the bacterium that causes infection (*Staphylococcus aureus*). Those that do not stain violet (but take a counter stain of another color) are called Gram negative; examples are the bacterium that causes typhoid (*Salmonella typhosa*), and a bacterium that can break down or contaminate a number of living and nonliving things (*Pseudomonas aeruginosa*).

In addition to their staining characteristics, bacteria can also be grouped on the basis of their form. All of the thousands of species of bacteria have one of three general forms: spherical (round), rod-shaped, or spiral (see Figure 1).

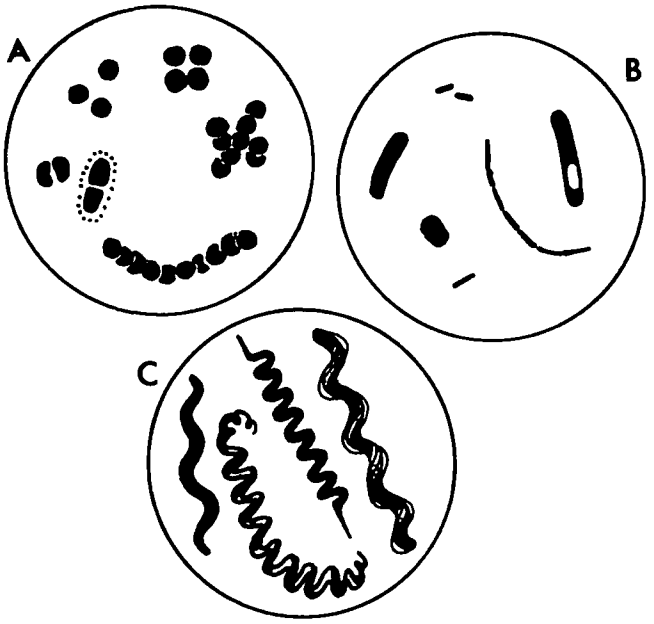


Figure 1. Shapes of Bacteria.
A. Spherical B. Rod-shaped
C. Spiral

Spherical cells are *cocci* (singular, *coccus*). Many bacteria of this shape can be identified by the patterns in which the spherical cells are arranged.

Some of the *rod-shaped* bacteria form a spore within the cell. The spore may later develop into a new cell. Bacterial spore formation is not a type of reproduction, because there is no increase in the number of organisms (see Figure 2).

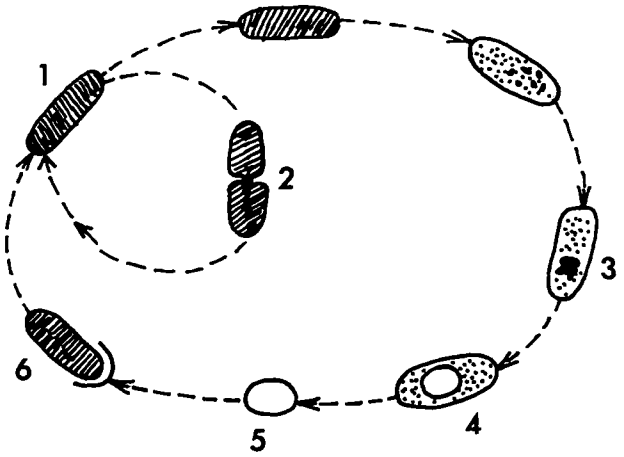


Figure 2. Life cycle of sporing bacillus. (1) Vegetative cell; (2) reproduction by fission; (3) development of prespore; (4) bacillus with endospore; (5) free spore; (6) germination of spore.

Spores are extremely resistant to heat, chemicals, and drying, but the cells that form spores are no more resistant to these adverse conditions than are other bacterial cells. While some spores may withstand boiling for many days, vegetative cells (stage of active growth) may be killed within a few minutes.

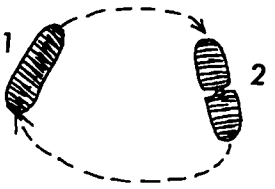


Figure 3. Life cycle of a non-sporing bacteria.. (1) Vegetative cell; (2) reproduction by fission.

Some types of bacteria do not produce spores. Their life cycle includes only reproduction by fission.

The third principal bacterial form is *spiral* or screw-shaped. This group includes the spirochetes.

Some bacteria are enclosed in a capsule, which may protect them from antimicrobial agents.

Some bacteria produce poisonous substances (toxins) that can cause diseases, such as lockjaw or food poisoning, in man. Some other bacteria produce enzymes that can, for example:

- dissolve or destroy living cells or industrial goods,
- foul surfaces that we contact daily, or
- contaminate equipment and food products.

Fungi

Fungi are a large group of nongreen plants that live by feeding on either living or dead organisms. They cannot make their own food, because they do not have the green plant pigment, chlorophyll. Some fungi, such as yeasts, occur as single cells that you would need a microscope to see. Others, such as mushrooms, are quite large. Over 100,000 species of fungi have been identified. Fungi and bacteria are often found together in nature.

Many fungi are useful. They are necessary, for example, in the making of bread, cheese, wine, and beer. Some, such as mushrooms, are used as food. Other types are troublesome because they cause decay and mildew. Fungi will grow on a wide variety of natural and industrial products.

Some fungi cause diseases in humans. Coccidiosis and aspergillosis are fungal diseases caused by inhaled spores that infect the lungs and other internal organs. Ringworm is an infection of the skin and nails caused by fungi.

Fungi reproduce in several different ways. Some reproduce from cellular fragments of the fungal organism. Others produce spores which function like seeds of higher plants. Spores of fungi are not as resistant to chemicals, heat, or drying as spores of bacteria.

Algae

The algae are similar to the fungi, but contain chlorophyll and other pigments. Algae range in size from one-celled, microscopic organisms to 200-foot-long (61-meter) seaweeds. They live in fresh or salt water, and on land.

Algae are classified by their color: blue-green, brown, red, and green. On water, they may appear as patches of green scum called "pond scum". On soil or tree trunks they may look green or blue. At the seashore, green, red, and brown seaweeds can be seen.

Algae are the source of food that makes aquatic life possible. Some types are used as human food, and others have industrial uses.

In some cases, however, algae can be quite troublesome. For example, they may:

- give drinking water a disagreeable taste or odor,
- cause itching to bathers,
- poison fish,
- clog water filtering systems and water cooling towers,
- interfere with pulp mill operations, and
- foul underwater structures.

When water temperatures and nutrients reach a favorable level, certain algae may multiply very rapidly. Some cause what is called "algal bloom" or pond scum, which may seriously affect the other forms of water life and the water quality. Large masses of algae in shallow pond and lake water can deplete the oxygen and cause fish kills.

Unlike the bacteria, viruses, and fungi, algae have little direct medical importance to man.

Slimes

Slimes are combinations of fungi, algae, bacteria, and other organisms. Slimes can be troublesome in any water systems, including industrial water-cooling towers, and in paper mill wet-end systems.

Viruses

Viruses are parasites that can live and reproduce only inside the living cells of their selected host. Viruses are about 1,000 times smaller than bacteria, and can be seen only with the aid of an electron microscope.

A virus enters a living plant or animal cell and reproduces itself within that cell. It usually destroys the cell, however, and must enter another cell to survive. A virus has no means of movement. It depends on other means, such as air, water, insects, humans, or other animals, to carry it from one host to another. Some viruses can survive away from the host for many hours or days when in organic material such as scabs, blood, and body wastes.

Some of the diseases of man caused by viruses are smallpox, rabies, yellow fever, influenza, measles, mumps, polio, and hepatitis. Canine distemper and foot-and-mouth disease are among the viral diseases that affect animals. Plant diseases caused by viruses are major agricultural problems. Plants affected include vegetables, fruits, sugarcane, and tobacco.

CONTROL OF MICROORGANISMS

Many microorganisms are helpful, but some must be controlled. To insure that patients do not contact infectious material, for example, hospitals must:

- sterilize or disinfect certain items for patient use, and
- keep floors and other surfaces free of harmful microorganisms.

In industry, control is necessary to protect raw materials, manufactured products, manufacturing processes and systems, equipment, surfaces, and areas from contamination, defacement, deterioration, fouling, and spoilage.

Principles of Control

Microorganisms are all about us. We too often think that chemicals are our only or best method of control, and forget that other methods can be used.

The major ways to control microorganisms are to:

- prevent their entry,
- keep materials and surfaces clean so that microbes will have nothing to feed on,
- keep materials and surfaces dry so that microbes will not have enough moisture to multiply,
- keep the temperature low enough or high enough so that the microbes either cannot grow or are killed, and
- use chemical agents.

A combination of methods is basic to most microbial pest control. The challenge lies in our ability to use the best method or combinations of methods to achieve the desired level of control.

Methods of Control

Nonchemical Control

Prevention of Entry—Walls and other physical barriers can be used to prevent microbes from entering certain areas. Special steps may be needed to reduce the number of organisms being brought into a critical area by people, equipment, and supplies. Some of the methods used are:

- requiring employees to wear clothing cleaned by the institution (not street clothes),
- requiring employees to change shoes or put on shoe covers when entering critical areas,
- requiring employees to wear hair covers and face masks, and
- keeping equipment and supplies clean.

Air currents often carry microorganisms into areas where they are not wanted. A combination of recirculating filtered air and positive pressure will reduce airborne microorganisms in "clean" areas.

Scrubbing—Scrubbing is usually done with water and some chemical agent, such as soap or detergent. Scrubbing removes dirt and other matter that contains microbes.

By adding an antimicrobial pesticide to certain detergents, both cleaning and antimcirobial action can be accomplished. These products are called "detergent disinfectants" or "germicidal detergents".

Air Filtration—Microorganisms, particles (such as dandruff or dirt), or droplets of liquid dispersed in a gas are referred to as aerosols. Two types of filter materials are used to remove these aerosols from the air. The fibrous mat type is the most common when large volumes of the air must be handled (such as in industries and hospitals). Membrane filters are becoming more important in critical applications.

Fluid Filtration—Filtration is the only way to make some biological and pharmaceutical fluids sterile and particle-free. This method consists of passing a mixture of fluids and solids through a porous medium. It traps any microorganisms larger than the pore size of its surface. Mat and membrane filters are most often used, sometimes in combination.

Boiling—Boiling can be used to disinfect objects. It kills fungi, most viruses, and most vegetative forms of bacteria in a few minutes. Bacterial spores may resist boiling for many days. Boiling cannot achieve sterilization.

Steam—Applying saturated steam under pressure (autoclaving) is the method most widely used to sterilize materials and articles; generally, it is also considered to be the most reliable. Many combinations of the time and temperature are considered satisfactory for steam sterilization. Autoclaving for at least 15 minutes at a minimum temperature 121°C (218°F) is an accepted *minimal* standard. The time and temperature may vary, depending on the size of the load and type of material.

The saturated steam must be at the proper temperature and it must reach all parts of the sterilizer load. Air must be removed from the chamber to be sure that the steam will penetrate the load.

Dry Heat—The use of dry heat to control microorganisms is one of the oldest known methods. Gas or electric ovens are generally used. The ovens usually have a thermostat, and some may have fans to circulate the hot air.

Any material that will withstand the temperature of dry heat sterilization can be satisfactorily treated this way.

Be sure to use the correct combination of exposure time and temperature. Exposure to a temperature of 160°C (288°F) for 2 hours or 170°C (360°F) for 1 hour will generally achieve sterilization.

Incineration is a form of dry heat sterilization. Incinerators work by completely burning microorganisms. An example is direct flaming of instruments, such as forceps.

Radiation—Artificially produced ultraviolet (UV) radiation can be used in many ways for microbial control. UV radiation can kill vegetative cell bacteria, but usually not fungal and bacterial spores. UV radiation does not penetrate well. Therefore, it may not kill microorganisms which are either in clumps or covered by dust and other debris. UV radiation has limited usefulness.

Chemical Control

Nonchemical methods cannot always give adequate control of microorganisms. For this reason, antimicrobial pesticides are often necessary. Use them:

- where they are needed, and
- where they can be used safely.

Select and use them so they work with other methods whenever possible. Be careful not to harm yourself or the environment. Remember, chemicals often will not give adequate control unless they are used in combination with other methods.

ANTIMICROBIAL PESTICIDES

Choosing the right antimicrobial agent is not easy. In 1974, over 8,000 brands of disinfectants, sanitizers, preservatives, and sterilants were registered with EPA for sale in the United States.

Chemical Groups

The most common antimicrobial agents are in one of the following chemical groups. You often may not be able to tell which chemical group an antimicrobial formulation belongs to unless you are able to interpret the chemical name(s) listed on the label as "active ingredients". Examples of a few chemical names are given for some of these groups.

Halogens

The halogens are chlorine, bromine, iodine, and fluorine. Some of these are used in antimicrobial agents. They are powerfully reactive agents and must be applied only to materials that can withstand their strong chemical activity.

Chlorine–Chlorine gas, household bleach (calcium or sodium hypochlorite), or chemicals that release chlorine (sodium dichloro-s-triazinetrione) are common antimicrobial agents. They are used on surfaces or objects that are not damaged by the oxidizing and bleaching activity. Chlorine is used to treat drinking water, swimming pools, water-cooling towers, and dairy and food processing equipment. These chemicals are also used in laundry processing and paper manufacturing.

Iodine–Both iodine itself and chemical combinations (polyethoxy polypropoxy polyethoxy ethanol – iodine complex) that release iodine are used to treat surfaces or objects that are not damaged by staining or by the strong chemical action. Products used for surface treatment are usually special iodine preparations that minimize staining.

Heavy Metals

Certain metal salts have strong antimicrobial activity even when diluted. Some (mercury, arsenic) have limited usefulness because they are highly toxic to man and other living forms.

Mercury–Salts of this element have been used to treat inanimate surfaces, but their use has been limited because of the toxic residues they leave. Mercurial formulations have been used as preservatives for leather (phenylmercuric acetate), paper pulp, paints (phenylmercuric oleate), and adhesives (phenylmercuric hydroxide).

Silver–Silver compounds have been used for many years as an antiseptic and disinfectant. Colloidal silver is sometimes used in water filters.

Copper–Soluble salts of copper are antimicrobial agents. Their use is limited, however, because they break down so quickly in the environment. Copper sulfate is used to control algae in swimming pools and other waters. More stable copper compounds control fungi and mildew in paint formulations (copper 8-quinolinolate).

Zinc–Zinc oxide is widely used as a mold inhibitor in paint.

Arsenic–Organic arsenicals are used to preserve plastics (oxybisphenoxarsine).

Tin–Organic tin compounds are used as preservatives for paint films (bistributyltin oxide), plastics (tributyltin linoleate), and textiles (tributyltin acetate), and as a fungal control agent in industrial water-cooling systems.

Phenolic Derivatives

Many synthetic chemicals related to phenol (carbolic acid) are in formulations used for disinfecting and sanitizing (orthobenzyl para-chlorophenol, ortho-phenylphenol). These formulations are for treating equipment and surfaces such as floors and walls. They also are used as preservatives for textiles, leather, and paints. Some are corrosive and must be handled with care. Chlorinated phenols identified here are also formulated with other antimicrobial chemicals for use as slimicides in the manufacture of paper and in water-cooling towers.

Quaternary Ammonium Compounds

These compounds, widely known as "quats", are related to detergents. They have weak to strong antimicrobial activity against selected groups of microorganisms, and they penetrate well. They are used to disinfect room surfaces, laundry, and other materials. Examples of such quats are:

alkyl (60%C_{14}, 30%C_{16}, 5%C_{12}, 5%C_{18}) dimethyl ethylbenzyl ammonium chloride and methldodecylbenzyltrimethyl ammonium chloride.

Some formulations are used as algaecides in swimming pools.

Acid-Anionic Surfactant Sanitizers-Disinfectants

Acid-anionic surfactant sanitizers are widely used in the dairy and food industry to sanitize stainless steel equipment, utensils, and other surfaces. In hospitals, medical and dental offices, and various other institutions, these sanitizers are used as disinfectants for instruments, hard surfaces, walls, floors, and other areas.

Alcohols

Ethyl and isopropyl alcohols–Ethyl and isopropyl alcohols in concentrations of 60 to 95 percent have bactericidal action. Methyl alcohol is not generally used for disinfection because it is toxic and is a weak bactericide. Alcohol preparations are used on equipment and other materials not damaged by their solvent action. Alcohols are flammable.

Glycols–Formulations of single or mixed glycols (such as triethylene glycol) can be applied as fine aerosols and mists. They are used to temporarily reduce bacterial numbers in the air in enclosed spaces.

Aldehydes

Formaldehyde–Gaseous formaldehyde can be used as a sporicide and disinfectant in enclosed areas (such as rooms or small chambers), but it penetrates poorly. High humidity (70 percent or more) must be maintained for effective results.

Glutaraldehyde–Glutaraldehyde formulations are used in hospitals and dental offices to disinfect and sterilize medical equipment.

Oxiranes

Ethylene oxide–Ethylene oxide (ETO) is an effective and widely used gas to sterilize medical supplies that may be damaged by heat. Some ethylene oxide products are flammable and explosive. Read the label. ETO should be used in equipment with adequate control measures.

Types of Formulations

In an antimicrobial product, the chemicals that are effective against microorganisms are called *active ingredients*. Each of these will be named on the container label.

Few products contain only active ingredients. They also contain other chemicals called *inert ingredients*. These are added to make the product safer and easier to handle, measure, and apply, or to make it effective for other uses such as cleaning.

The mixture of active and inert ingredients is called the formulation. Some formulations are ready to use just as you purchase them. Other formulations must be diluted with water. The label directions will tell you how to use each formulation. Many antimicrobial agents can be used for more than one purpose. Each use may require a different concentration. Be sure the solution you prepare is in the correct concentration for the job you need to do. *Follow the label directions carefully.*

Here are the most common types of formulations:

Concentrated Liquids

Water-based concentrates are very common. The formulation will often contain more than one active ingredient, as well as several inert ingredients. A typical concentrated liquid would be prepared for use by adding the recommended volume of the concentrate to the stated amount of water to form a diluted solution. Read the label to determine the correct dilution and whether to add water to the product, or the product to water.

For water treatment uses (slimicides for paper mills, algaecides for cooling towers, disinfectants for drinking water) a measured amount of the concentrate is normally added directly to the system.

Soluble Solids

Dry formulations, such as powders and granules, are also quite common. Some contain 100 percent active ingredient, and some are mixtures. In most cases, these formulations must be diluted before use. The diluent will be specified on the label.

For water treatment, the directions may say either to add the dry product directly at a point in the system where there is good mixing, or to prepare a liquid concentrate before adding it to the system.

Granules, pellets, or briquets for water treatment release the active ingredient slowly over a longer period of time. These formulations provide a simple way to treat circulating systems, such as cooling towers or swimming pools.

Suspensions/Dispersions

Suspensions or dispersions are either finely divided solid particles in a liquid or droplets of one liquid in another (emulsions). Either type of formulation will separate unless it is well mixed before and during use.

Aerosols

An aerosol is a suspension of very fine particles or droplets in air. Fog- or mist-generating machines are used to produce aerosols to treat large enclosed areas. Pressurized or nonpressurized packaged aerosol formulations may be solutions or emulsions. A direction to shake well before using is a reminder to get a well-mixed suspension before applying the spray.

Fogging and misting are not recommended for use in hospitals.

Gases

Gaseous antimicrobial pesticides may be used to disinfect and sterilize where other agents cannot be used or where the use of a gas is dictated by the need. Gases may be supplied in pressurized containers, or they may be

solids or liquids that are sprayed, heated, or evaporated to produce the active gases.

Ethylene oxide and its mixtures are supplied in pressurized cylinders. Formaldehyde may be purchased as a powder to be heated or as a spray solution.

Gaseous agents are always used in unoccupied, enclosed spaces. Special precautions are required to insure that they will work well and that they will not harm the applicator or other people. Pay close attention to all label instructions. Temperature and relative humidity requirements are sometimes critical. Also be sure to note the types of materials which the product may be used to treat and any post-treatment procedures that are required.

How Antimicrobial Agents Work

Antimicrobials can also be grouped according to the level of activity they provide. Many antimicrobials work at more than one level. *Read the label* to find out what each antimicrobial agent will do. Know the limitations of its activity. Antimicrobial agents work in one or more of the following ways:

- Cidal or cide: Kills microorganisms by contact (bacteri*cide*, fungi*cide*).
- Static or stat: Interferes with growth or multiplication of the microorganisms (bacterio*stat*, fungi*stat*).
- Reduces the number of microorganisms (sanitizers).

USING ANTIMICROBIAL PESTICIDES

Factors Affecting Use

You need to consider many factors when choosing an antimicrobial agent:

Types of Microorganisms

The types of microorganisms to be controlled will vary. Some are very resistant to specific chemicals, while others are easily killed. No one chemical will kill all types of microorganisms under all conditions. Learn what each chemical agent can do by reading the product label.

Number of Microorganisms

The number of microorganisms present may affect the speed at which they can be killed. A larger number of microbes may require longer exposure to the antimicrobial agent (see label directions). In some cases where there are large amounts of microorganisms, such as fecal or other organic contamination, no antimicrobial agent can be expected to work. The area must be cleaned before the antimicrobial agent is applied, even though the label may not say so.

Age and Condition of Organisms

Older microbial cells are more resistant to antimicrobial agents than younger cells are. All antimicrobial agents work best when microorganisms are actively multiplying or dividing. Most agents will have little or no effect on microbial spores.

In general, articles or materials exposed to soil or dust and kept dry will have large numbers of bacterial and fungal spores. Articles or materials exposed to organic materials such as urine, protein, carbohydrates, and cellulose in the presence of water will contain large numbers of growing bacteria and fungi in the vegetative cell state.

Nature of Surface

Porosity, smoothness, oiliness, and other surface characteristics may affect the action of antimicrobial agents. Remember, the antimicrobial agent must *contact* the microorganisms to be effective.

Concentration

The amount of antimicrobial agent you apply will influence its effectiveness. Follow label directions for diluting the product.

Contact Time

Chemical agents never act on microorganisms instantly. Some function effectively within a few seconds; others may take hours. Follow the label. If the antimicrobial agent does not contact the microbial cell, however, it will have no effect.

Hardness of Water

The hardness of water depends on the amount of calcium, magnesium, and other chemicals present. Hardness may interfere with the killing power of some antimicrobial agents. The label may set a hardness limit for the diluting water (expressed in ppm of calcium carbonate). You can determine the hardness of your local water supply by contacting municipal water supply officials or your local public health authority.

Acidity/Alkalinity (pH)

All antimicrobial agents and slimicides work best at some optimum level of acidity or alkalinity. Read the label to determine if acids or alkalis are required to help the disinfectant to work better.

Composition and Amount of Soil on Surfaces

The presence of organic matter will interfere with activity of most chemical agents. In hospitals, for example, surfaces may be contaminated with blood, pus, tissue debris, sputum, urine, or feces. In food preparation areas, fats or oils may be present. Because the organic matter protects the microorganism, it reduces and may completely stop the killing power of antimicrobial agents. Thus, the label may require very dirty materials to be exposed to a higher concentration of an antimicrobial agent for a longer time. The surface to be disinfected must be clean in order for the disinfectant to work effectively. If it is not heavily soiled, cleaning and disinfection may be done at the same time. Be sure the product is designed for use as both a cleaner and disinfectant. *Remember, if the antimicrobial agent does not contact the microbes, it will have no effect.*

Moisture or Humidity

Antimicrobial agents cannot work without water or moisture. Either the relative humidity of the treated area must be high, or water must be present in or on the material to be treated.

Temperature

In many antimicrobial agents, there is a relationship between the rate of action and an increase in temperature.

Equipment

You must understand the equipment you use to apply antimicrobial agents. Selecting the correct equipment may be the key to the success of the control program. In addition, you must know how to use and maintain it. Use and care of all equipment for applying antimicrobial pesticides require special precautions. Be sure to mix the product as the label directs. Always follow directions provided by the producer of the antimicrobial agent and by the manufacturer of the device.

Equipment that has been used with one antimicrobial agent must not be used with another until it has been cleaned and dried. Never make nonpesticide applications with equipment that has been used with antimicrobials.

Gas Sterilizers

A gas sterilizer (Figure 4) is a closed chamber in which gases are used to kill bacteria, viruses, and other microorganisms. The gas usually penetrates better if a vacuum is created in the chamber. Ethylene oxide (ETO) is the most common gas used.

Sterilizers range in size from less than 5 cubic feet (.14 cubic meters) to more than 100 cubic feet (2.8 cubic meters). The small units may be operated with manual controls at room temperature, or, like the larger units, may have fully automatic controls which often include built-in humidity controls.

Figure 4. Gas sterilizer (Courtesy of American Sterilizer Co.)

Advantages:
- Ability to sterilize a wide variety of medical articles and materials that would be destroyed in a steam sterilizer.
- Ability to sterilize materials in a suitable package, and maintain sterility after removal of the package from the sterilizer, if proper precautions are taken.
- Ability to chemically and biologically monitor the materials placed in the sterilizer for the presence of the gas and the correct functioning of the sterilizer.

Limitations:
- Chemical burns and skin and mucous membrane irritation may result when items such as surgical instruments and catheters are not properly aerated after treatment.
- Porous items absorb gas during processing. Time is needed to allow the absorbed gas to dissipate. Knowledge of aeration time is required.
- The gas cannot penetrate such materials as glass, metal, and foil.
- Must use wrapping material that gas can penetrate easily—do not use nylon, polyester, or foil.
- Sterilization takes a relatively long time (3 to 12 hours).
- There is a potential hazard to operators where venting is not adequate.

ETO sterilization should be used only when the items cannot withstand steam sterilization. Be sure to follow the manufacturer's operating instructions exactly. Remember the following when using this type of equipment:
- The ETO sterilizer should be installed in a large, well-ventilated room.
- ETO should not exceed an average of 50 ppm over an 8-hour period any time when people may be in the room.
- The sterilizer and aerator should be properly vented. This may mean venting to the outdoors or to a stream of running water such as a water-operated vacuum pump.
- The temperature in areas where ETO cartridges and cylinders are stored should never exceed 85°F (29°C).
- When the label warns that an ETO product is flammable or explosive, DANGER and NO SMOKING signs should be visible in all areas where it is used or stored.
- The sterilizer door should be opened for 5 minutes before removing sterilized materials. This allows residual ethylene oxide in the chamber to dissipate.
- Any skin, eye, and throat irritations, as well as nausea, dizziness, and disorientation should be reported immediately.
- A color-change tape is available as a quick chemical indicator of whether exposure of products has occurred. A biological indicator consisting of bacterial spores is available to confirm that sterilizing conditions were achieved. Use both indicators for adequate control.
- Follow the manufacturer's instructions carefully. If you notice any malfunction, shut off the ETO sterilizer and notify maintenance personnel.
- All items undergoing gas sterilization should be properly aerated in accordance with the guidelines published by the Association for Advancement of Medical Instrumentation (AAMI).

Formaldehyde Vacuum Process

In this process, a vacuum device is used to remove part of the air from the chamber of a pressurized container. Next, steam is admitted, and then formaldehyde gas. The steam heats the articles, maintains the temperature, and causes the formaldehyde to penetrate better.

Limitations:
- Use is restricted to certain unwrapped instruments, articles, and areas; not used for general sterilization.
- Penetration is slow.
- Porous items absorb gas during processing. Time is needed to allow the absorbed gas to dissipate.

Fumigators

This process can be used for room disinfection. A heat source (such as an electric frying pan) is used to vaporize paraformaldehyde in an enclosed space to kill microorganisms. The humidity and temperature must be controlled or the results will be poor.

Advantages:
- Disinfection of well-exposed surfaces is possible.

Limitations:
- Gas concentration is difficult to control. Requires room to be sealed, and this is difficult to achieve in large rooms.
- High risk of accidental exposure.
- Requires prolonged airing to remove deposited surface films of paraformaldehyde.
- Does not disinfect unexposed surfaces and does not penetrate porous materials.
- Recommended or necessary only in special research, "hot laboratory", or "exotic disease" situations.
- Should be used only by well-trained and experienced operators.

Fogging and Spraying Applications

An antimicrobial agent is dispersed by an automatic sprayer or atomizer. Application stops when all exposed surfaces are wet. The equipment should be designed to do the job, be durable, and provide ease in operating, filling, and cleaning.

Fogging, where used, is only an adjunct to other methods of disinfection.

Advantages:
- May remove floating infectious particles from the air.

Limitations:

- Bacteria that remain on the floor and horizontal surfaces must be removed by mechanical cleansing, regardless of whether fogging has been used.
- Soil on surfaces may keep the disinfectant from coming into direct contact with the microorganisms.
- Potentially hazardous to personnel.

Manually Operated Devices

These devices include such things as:

- mops, sponges, brushes, cloths,
- sprinkling cans,
- "pistol-grip" sprayers, and
- aerosol containers.

Figure 5.

Advantages:

- Physical "scrubbing" helps to clean surfaces so that the antimicrobial agent can come in contact with the microorganisms.
- "Pistol-grip" sprayers permit effective control of where product is applied.

Limitations:

- Pressurized aerosols can only spot-disinfect articles or surfaces.
- Frequent changes of disinfectant solution are necessary as soil increases in bucket.
- Rate of application may vary.

Application Rate and Calibration

The amount of an antimcirobial agent that must be applied per unit area (such as per cubic foot, or gallons of water) is stated on the label. Too much of the agent may damage surface areas; too little may not give good control.

Many antimicrobial agents are applied by hand (such as with a mop or cloth) to a surface area. For example, the use directions may tell you to use 2 fluid ounces of the product per gallon of water. If you want a 2-gallon mixture, how many ounces of the product would you need?

- 2 ounces per gallon x 2 gallons = 4 ounces.

To find the amount needed, you must multiply the amount of the product needed per gallon times the number of gallons desired.

In an algaecide-slimicide product for a water-cooling tower, (Figure 6) use directions may tell you that 3 gallons of the product are needed per 10,000 gallons. Your water-cooling tower contains 13,000 gallons. How much of the product do you need?

3 : 10,000 :: x : 13,000

multiply

multiply

10,000x = 39,000 (3 x 13,000)
10,000x = 39,000
10x = 39
39 ÷ 10 = 3.9
x = 3.9 gallons per 13,000 gallons

This type of problem is set up as a ratio or proportion and solved for "x". In the example, 3.9 gallons of the product would be needed in a 13,000- gallon water-cooling tower.

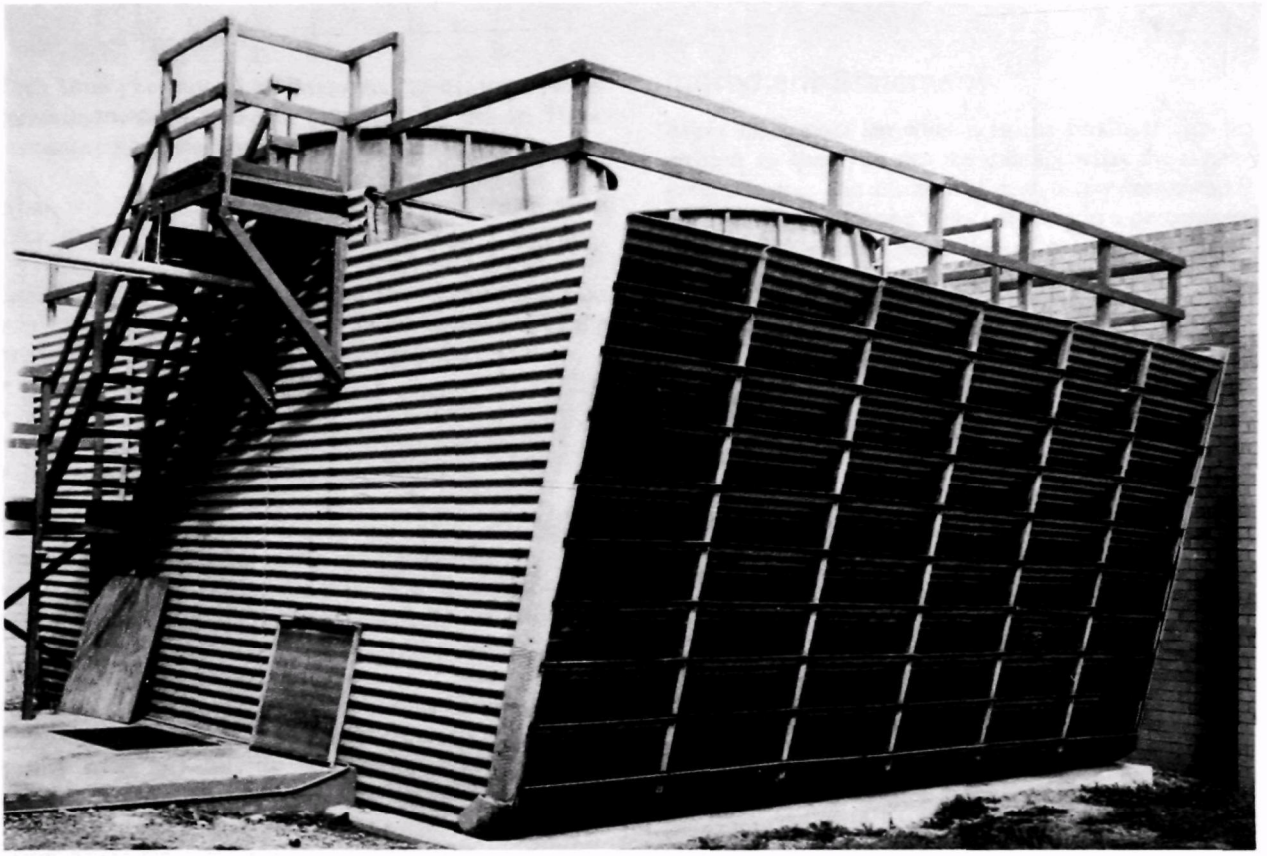


Figure 6. Industrial Water Cooling Tower (Courtesy: Bonco, Jefferson, Ga.)

LABELS AND LABELING

Each time you buy an antimicrobial agent, you also receive instructions that tell you how to use it. Those instructions are the labeling.

What is labeling? What is a label? These words seem alike, but they do not mean the same thing.

Labeling is *all* information, other than advertising, that you receive from the company or its agents about the product. Labeling includes such things as:

- the label on the product,
- technical bulletins,
- flyers, and
- information handed out by your dealer.

The *label* is the information printed on or attached to the container. This label serves many purposes:

- To the manufacturer, the label is a "license to sell."
- To the State or Federal Government, the label is a way to control the distribution, storage, sale, use, and disposal of the product.
- To the buyer or user, the label is the main source of facts on how to use the product correctly and legally.
- The label is a way to tell the users about special safety measures needed.

Some labels are easy to understand; others are complicated. But all labels can tell you how to use the product correctly. This section will explain the items that you will find on most labels.

Parts of the Label

Product Name

Each company has product names (sometimes called trade or brand names) for its products. The product name is the one used in ads. The product name shows up plainly on the front panel of the label. It is the most identifiable name for the chemical.

How the Product Works

Every label will contain a statement that tells whether the product kills (e.g., bactericide, fungicide) or controls (e.g., bacteriostat, fungistat) the growth of microorganisms. The sample label (page 5-4) is identified as a "Disinfectant-Sanitizer-Fungicide-Deodorizer".

Type of Formulation

Different types of formulations, such as solutions, gases, emulsions, suspensions, and solids require different methods of handling. The label may tell you what type of formulation the package contains. The same antimicrobial agent may be available in more than one formulation.

Ingredient Statement

Every label must list what is in the product. This list is written so that you can see quickly what the active ingredients are. The amount of each *active ingredient* (the chemical that does the work) is given as a percentage by weight or as pounds per gallon of concentrate. Each active ingredient will be listed by the chemical name. A common name may also be given. For example, hexachlorophene is the common name for the chemical name of 2,2′-methylenebis (3,4,6-trichlorophenol). The label must also show what percent of the contents is made up by the inert ingredients. The inert ingredients do not have to be named. Check the sample label.

Net Contents

The net contents number tells you how much of the product is in the container. This can be expressed in gallons, pints, pounds, quarts, or other units of measure.

Name and Address of Manufacturer

The law requires the manufacturer or distributor of a product to put the name and address of the company on the label. This is so you will know who made or sold the product.

Registration and Establishment Numbers

The registration number shows that the product has been registered with the Federal Government. It is usually found on the front panel of the label and will be written as "EPA Registration No. 00000-00." The establishment number tells what factory made the chemical, in which State the factory is located, and the number assigned to the factory. The establishment number may be written as 000-MI-0. This number does not have to be on the label, but must be somewhere on each container.

Signal Words and Symbols

To do their job, antimicrobial agents must control the target pest. By their nature, they are toxic and can be hazardous to people. You can tell the toxicity of a product by reading the *signal word* and looking at the *symbol* (if there is one) on the label.

Signal Words—One of the most important parts of the label is the *signal word*. It tells you approximately how hazardous the material is to people. The signal words that follow are set by law. Antimicrobial agents that have "Danger" on the label are usually those that may cause irreversible skin and/or eye damage. Pay attention to the signal word on the label. It is there to remind you that the contents could make you sick, or even kill you.

Each manufacturer must use the correct signal word on every label.

Signal Words	*Toxicity*
DANGER	Highly Toxic
WARNING	Moderately Toxic
CAUTION	Low toxicity or comparatively free from danger.

All products must bear the statement "Keep Out of Reach of Children", unless the EPA Administrator has waived this requirement for the product.

Symbol–One of the best ways to catch a person's eye is with symbols. This is why a skull and crossbones symbol is sometimes used on highly toxic materials along with the signal word DANGER and the word POISON.

Precautionary Statements

Hazards to Humans (and Domestic Animals)–This section will tell you ways in which the product may be harmful to people and animals. It also will tell you of any special steps you should take, such as the kind of protective equipment needed.

Environmental Hazards–Antimicrobial agents are useful chemicals, but wrong or careless use could cause undesirable effects. To help avoid this, the label contains environmental precautions that you should read and follow.

Here are some examples:
- "Keep out of lakes, streams, or ponds."
- "Treated effluent should not be discharged where it will drain into lakes, streams, ponds, or public water."
- "Do not contaminate water by cleaning of equipment or disposal of waste."

Labels may contain broader warnings against harming birds, fish, and wildlife.

Physical and Chemical Hazards–This section will tell you of any special fire, explosion, or chemical hazards that the product may pose.

Statement of Practical Treatment–If swallowing or inhaling the product or getting it in your eyes or on your skin would be harmful, the label will tell you emergency first aid measures. It also will tell you what types of exposure require medical attention.

The pesticide labeling is the most important information you can take to the physician when you think someone has been harmed or poisoned.

Statement of Use Classification

Every label will eventually show whether the product is for general use or for restricted use. EPA puts every product use into one of these two classes. The classification is based on:
- the degree of toxicity,
- the way the antimicrobial agent is used, and
- its effect on the environment.

General Use–If an antimicrobial agent will harm the applicator or the environment very little or not at all when used *exactly as directed*, it will be labeled for general use.

The label on the products will say "General Classification".

Restricted Use–A restricted use antimicrobial agent is one which *could* cause some human injury or environmental damage even when used as directed on the label. The label on these products will say:

RESTRICTED USE
PESTICIDE

For retail sale to and application only by certified applicators or persons under their direct supervision.

The restricted use statement will be at the top of the front panel of the label.

Directions for Use

The instructions on how to use the antimicrobial agent are an important part of the label or labeling for you. This is the best way you can find out the right way to apply the product.

The use instructions will tell you:
- the level of the product's antimicrobial activity.
- the type of microorganisms the product is registered to control. Labels use group names such as bacteria, fungi, algae, slime, or yeasts. Some labels will name the specific microorganisms to be controlled.
- recommended use areas (such as hospitals, industry).
- the substrate (surface or material) on or in which the product can be used.
- whether the product is for general or restricted use.
- whether the product should be diluted, and if so, how to prepare dilutions.
- how much to use.
- where the material should be applied.
- when it should be applied.
- how it should be applied.
- whether surface or objects should be precleaned before application.
- contact/exposure time.
- whether the product should be rinsed or removed from surfaces after use.

Misuse Statement

This section states: "It is a violation of Federal law to use a product in a manner inconsistent with its labeling."

Do not use an antimicrobial agent on or in any surface or article not listed on the label. Do not use it to control any group of microorganisms not related to those listed on the label. Never dilute the antimicrobial agent to form concentrations other than those specified on the label.

Before the product could be registered, EPA required the manufacturer to conduct many tests to be sure the label directions were correct. By following them exactly, you will:

- get the best results the product can give,
- avoid breaking the law, and
- protect yourself.

Reentry Statement

Some antimicrobial agents may bear a reentry statement on the label. This statement will tell you how much time must pass before a treated area is safe for entry by a person without protective clothing and/or other safety equipment. Local or regional conditions or practices may call for additional safety measures which may not be mentioned on the label. Get advice from local authorities for safety precautions to be met when reentry precautions are necessary.

Category of Applicator

If required for the product, this section will limit use to certain categories of commercial applicators.

Storage and Disposal Directions

Every antimicrobial agent should be stored and disposed of correctly. This section will tell you how to store and dispose of the product and the empty containers.

Phenol Coefficient

The AOAC (Association of Official Analytical Chemists) phenol coefficient number appears on the label of some antimicrobial products. The phenol coefficient is a ratio of the concentration of the product and the concentration of phenol required to kill certain bacteria in a specified time. It is not necessarily a good measure of the activity of the product.

Use-Dilution Method

The AOAC Use-Dilution Method or test is referred to on some labels. This is the laboratory test that measures whether a disinfectant product kills test bacteria on a standard hard surface. Some labels list the bacteria measured in the test.

These are: *Salmonella cholera-suis, Staphylococcus aureus,* and for hospital disinfectants, *Pseudomonas aeruginosa.*

Sanitizing of Food Processing Equipment and other Hard Surfaces in Food Contact Locations.

For sanitizing food processing equipment, dairy equipment, food utensils, dishes, silverware, glasses, sink tops, countertops, refrigerated storage and display equipment and other hard surfaces. **No Potable water rinse is required.**

Wash and rinse all articles thoroughly, then apply a solution of 1 oz. _____ in 4 gallons of water.

Apply to sink tops, countertops, refrigerated storage and display equipment and other stationary hard surfaces by cloth or brush. **No Potable water rinse is required.**

Dishes, silverware, glasses, cooking utensils and other similar size food processing equipment can be sanitized by immersion in a 1 oz./4 gallon dilution of _____. **No Potable water rinse is required.**

At 1 oz./4 gallons, _____ fulfills the criteria of Appendix F of the Grade "A" Pasteurized Milk Ordinances 1965 Recommendations of the U.S. Public Health Services in waters up to 1000 ppm of hardness calculated as Ca CO_3 when evaluated by the AOAC Germicidal and Detergent Sanitizer Method against Escherichia coli and Staphylococcus aureus.

The udders, flanks, and teats of dairy cows can be sanitized by washing with a solution of 1 oz. _____ in 4 gallons of warm water. **No Potable water rinse is required.** Use a fresh towel for each cow. Avoid contamination of sanitizing solution by dirt and soil. Do not dip used towel back into sanitizing solution. When solution becomes visibly dirty, discard and provide fresh solution.

Precautionary Statements

Hazards to Humans and domestic animals

DANGER

Keep out of reach of children. Corrosive. Causes eye damage and skin irritation. Do not get in eyes, on skin, or on clothing. Protect eyes and skin when handling. Harmful if swallowed. Avoid contamination of food.

STORAGE AND DISPOSAL

–DO NOT CONTAMINATE WATER, FOOD, OR FEED BY STORAGE OR DISPOSAL

–OPEN DUMPING IS PROHIBITED

–DO NOT REUSE EMPTY CONTAINER

PESTICIDE DISPOSAL

PESTICIDE OR RINSATE THAT CANNOT BE USED OR CHEMICALLY REPROCESSED SHOULD BE DISPOSED OF IN A LANDFILL APPROVED FOR PESTICIDES OR BURIED IN A SAFE PLACE AWAY FROM WATER SUPPLIES.

CONTAINER DISPOSAL

TRIPLE RINSE (OR EQUIVALENT) AND DISPOSE IN AN INCINERATOR OR LANDFILL APPROVED FOR PESTICIDE CONTAINERS, OR BURY IN A SAFE PLACE.

GENERAL

CONSULT FEDERAL, STATE OR LOCAL DISPOSAL AUTHORITIES FOR APPROVED ALTERNATIVE PROCEDURES SUCH AS LIMITED OPEN BURNING.

SAMPLE LABEL

_____ **DISINFECTANT-SANITIZER**

FUNGICIDE DEODORIZER

Disinfectant-Sanitizer-Fungicide
Deodorizer for Hospital, Institutional,
Industrial, School, Dairy and Other
Farm and Home Use

AOAC Phenol Coefficients

Staphylococcus aureus, ATCC #6538	77.5
Salmonella typhosa, ATCC #6539	77.5

Active Ingredients	
Didecyl dimethyl ammonium chloride	7.5%
Isopropanol	3.0%
Inert Ingredients	89.5%
	100.0%

KEEP OUT OF REACH OF CHILDREN.

DANGER

Statement of Practical Treatment

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. For eyes, call a physician. Remove and wash contaminated clothing before reuse.

If swallowed, drink promptly a large quantity of milk, egg whites, gelatin solution; or if these are not available, drink large quantities of water. Avoid alcohol. Call a physician immediately.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage. Measures against circulatory shock, respiratory depression, and convulsion may be needed.

SEE LEFT PANEL FOR
ADDITIONAL PRECAUTIONARY STATEMENTS

EPA Registration No.

Net Contents

Manufactured By:

Directions for Use

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

Disinfection in Hospitals, Nursing Homes and Other Health Care Institutions.

For disinfecting floors, walls, countertops, bathing areas, lavatories, bedframes, tables, chairs, garbage pails and other hard surfaces.

Add 3½ oz. _____ to 4 gallons water. Apply to previously cleaned hard surface with mop or cloth.

At this use-level, _____ is effective against Pseudomonas aeruginosa.

Disinfectant in Institutions, Industry, Schools and Homes

For disinfecting floors, walls, bedframes, countertops, tables, chairs, garbage pails, bathroom fixtures and other hard surfaces.

Add 2 oz. of _____ to 4 gallons of water. Apply to previously cleaned hard surface with mop or cloth.

At 2 oz./4 gallon use-level, _____ is effective against Staphylococcus aureus, Salmonella choleraesuis and Trichophyton interdigitale (the athlete's foot fungus).

Disinfection of Barber Tools

Barber tools (such as combs, brushes, razors, and scissors) can be disinfected by immersing in a ½-oz./gallon solution of _____.

Disinfection of Poultry Equipment, Animal Quarters and Kennels.

Poultry brooders, watering founts, feeding equipment and other animal quarters (such as stalls and kennel areas) can be disinfected after thorough cleaning by applying a solution of 2 oz. _____ in 4 gallons of water with a mop, cloth or brush. Small utensils should be immersed in this solution.

Prior to disinfection, all poultry, other animals and their feeds must be removed from the premises. This includes emptying all troughs, racks and other feeding and watering appliances. Remove all litter and droppings from floors, walls and other surfaces occupied or traversed by poultry or other animals.

After disinfection, ventilate buildings, coops and other closed spaces. Do not house poultry, or other animals, or employ equipment until treatment has been absorbed, set or dried.

All treated equipment that will contact feed or drinking water must be rinsed with potable water before reuse.

PROTECTING PEOPLE AND THE ENVIRONMENT

Protecting People

Most reported poisoning cases involving antimicrobial agents occur in the home. Many times they involve young children who have drunk disinfectants such as pine oil or phenols. These children cannot read, and think the bottle contains something good to drink. The parents may be at fault for storing these products within reach of their children. A few adults and children have received skin and eye damage from spilled concentrates.

The use of chlorine in swimming pools has resulted in a few accidents caused by gas being inhaled from leaking tanks, gaskets, or lines.

The improper dilution of a germicidal detergent for disinfecting cribs in a hospital nursery caused about 20 infants to become sick. Someone did not read the label.

Mixing concentrated calcium hypochlorite with a quaternary ammonium compound can cause an explosion. In some cases, mixing different antimicrobials can generate toxic gases. Do not mix different antimicrobial agents unless the label says you can.

Antimcirobial agents enter the body as follows:

- Through the skin (dermal)–primarily from chemicals splashed on the skin.
- Through the eyes–primarily from chemicals splashed into the eye.

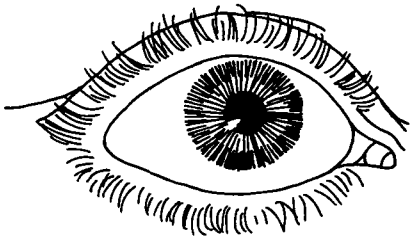
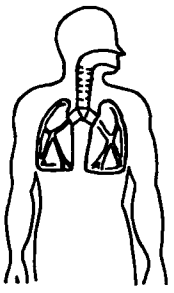


Figure 7.

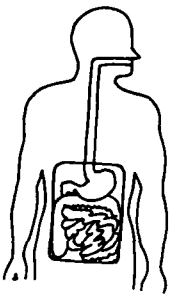
- Through the lungs (inhalation)–usually from accidental formation of aerosols during mixing of the chemicals, or the gas phase of a few compounds.

Figure 8.



- Through the mouth (oral)–frequently from residues left on treated objects but occasionally from accidental ingestion, usually by children. Food and cigarettes contaminated by unwashed hands have been the source of some poisonings.

Figure 9.



Acute toxicity occurs when a large quantity of an antimicrobial agent is inhaled, swallowed, or comes in contact with skin or eye over a very short period of time.

Chronic toxicity is the result of repeated exposures to small amounts of a chemical over a long period of time. There is little evidence that the uses of antimicrobial compounds described in this manual cause chronic toxicity. To be sure, however, follow closely label precautions on:

- skin contact,
- washing of hands,
- use of gloves, masks, and other protective devices, and
- washing of work clothes.

Symptoms of Poisoning

You should know what kinds of sickness are caused by the antimicrobial agents you use. You also should know the conditions under which each one may make you sick.

There are two kinds of clues to pesticide poisoning. Some are feelings that only the person who has been poisoned can notice – such as nausea or headache. These are *symptoms*. Others, like vomiting, also can be noticed by someone else. These are *signs*. So you should know:

- what your own feelings might mean, and
- what signs of poisoning to look for in your coworkers and others who may have been exposed.

Antimicrobial agents in the same chemical group usually cause similar kinds of sickness. This sickness may be mild or severe, depending on the chemical and the amount absorbed. But the *pattern* of illness caused by one type of antimicrobial agent is usually similar. Having

some of the signs and symptoms does not always mean you have been poisoned. Other kinds of sickness (such as influenza and food poisoning) may cause signs and symptoms much like those of antimicrobial poisoning. Headache and a feeling of being unwell, for example, may signal the start of many kinds of illness. But the pattern of particular symptoms and signs may make it possible to tell one kind of sickness from another. Certain tests of the blood and urine can sometimes help distinguish poisoning caused by antimicrobial agents from other illnesses.

Direct contact with antimicrobial agents, especially concentrates, may cause severe injury to skin and eyes. Contact is usually accompanied by irritation, burning, and pain. Skin contact with some fumigants (ethylene oxide, aldehydes) can cause severe skin damage, especially if the contaminated skin is covered by clothing or gloves.

If an antimicrobial agent has been swallowed or inhaled, the first symptoms are usually gastrointestinal upset, such as nausea, vomiting, and abdominal pain. Headache and dizziness are often present. Inhalation of air containing a high concentration of chemicals such as chlorine can cause severe respiratory irritation.

If you see such signs or if you think someone has swallowed an antimicrobial agent, get medical help immediately.

First Aid

If medical help is not immediately available, follow the first aid instructions on the label. If you suspect that a person has been poisoned, do not leave him alone. Do not allow yourself or anyone else to become dangerously sick before calling a physician or going to a hospital. It is always better to be too cautious than too late. If possible, *take the label from the container or the container itself when you seek medical aid*. To give proper treatment, the medical personnel usually will need information about the nature of the chemical that is causing the symptoms.

The label on every antimicrobial agent will contain directions for first aid treatment. Study these instructions carefully before diluting the chemical or using it in any form.

If direct contact with the chemical occurs: Flushing with a large amount of water will often remove any dangerous concentration of the antimicrobial agent. Use soap or detergents to remove the last traces of the antimicrobial agent from the skin, only if recommended on the label.

Figure 10.

Be careful and prompt when the eye is involved. Flush the eye with plain water for 10 minutes or longer to remove harmful substances. Then get medical help.

Figure 11.

If someone has inhaled an antimicrobial agent: Move the victim to fresh air as quickly as possible.

If an antimicrobial agent has been swallowed: Never induce vomiting unless the label or physician tells you to. Go to a physician immediately.

Protecting Your Body

Most contact with concentrated antimicrobial agents occurs on or through the skin and eyes. Every user should wear clothing that guards the whole body and provides specific protection to the eyes and hands. Wearing goggles or a face shield will reduce the chances of splashing a chemical in your face and eyes.

Even if your hands and arms were protected, wash them after mixing a chemical. The clothes that you wear while diluting concentrated chemicals should be washed after each use to keep chemicals from building up in them.

Any time you spill a pesticide on yourself, wash it off immediately.

Protective Clothing and Equipment

The greatest hazard to commercial applicators using antimicrobial agents is skin and eye damage. You must guard your eyes with goggles or a face shield when handling concentrated forms of toxic chemicals. Protect your hands with liquidproof gloves when mixing any toxic chemical. The gloves should be long enough to protect the wrist. Gloves should not be lined with a fabric, such as cotton. The lining is hard to clean if a chemical gets on it. Sleeves should be outside of or taped to the gloves. The hazards from skin contact are much less after the chemical is diluted.

Protective devices for the respiratory tract are not often needed with antimicrobial agents. Adequate ventilation

or fresh air should be provided whenever an antimicrobial agent (liquid, powder, or tablets) is being diluted or mixed.

If a respirator is needed, you should be aware that several types are available. The chemical cartridge respirator covers the mouth and nose. Air is filtered through a filter pad and a cartridge made to absorb certain types of chemical vapors. You should use this type of respirator when you are exposed to intermittent concentrations of a volatile and toxic antimicrobial agent.

The chemical canister respirator covers a larger area of the face, and has a larger and longer lasting canister than the cartridge respirator. This type should be used when you are exposed to a continuous concentration of a volatile and toxic chemical.

Wear a cartridge or canister approved by the National Institute of Occupational Safety and Health (NIOSH) or the Mine Safety and Health Administration (MSHA) for the specific type of chemical you are using. Remember, read the manufacturer's instructions carefully on the use and care of these respirators.

Care and Maintenance of Clothing and Equipment

Wear clean clothing daily. If clothing gets wet with a concentrate or highly toxic chemical, change clothes immediately. Do not store or wash contaminated clothing with other laundry. Wash gloves daily, inside and out, and hang them to dry. Test gloves for leaks by filling them with water and gently squeezing. Throw out damaged gloves.

Wash goggles or face shields at least once a day. Elastic or fabric headbands often absorb chemicals and are difficult to clean. Have some spares so you can launder or replace them often.

Follow carefully the manufacturer's instructions for the proper cleaning, storage, and maintenance of your respirator. Change cartridges or canisters often.

Protecting the Environment

Our environment is our surroundings, including its many forms of life. The benefits we can get from antimicrobial agents must be balanced against the harm they can do to the environment. Knowing how to use these chemicals correctly includes knowing how to minimize the pollution they cause.

How Antimicrobial Agents Harm the Environment

Antimicrobial agents must be used correctly, according to established protocols or the manufacturer's recommendations. If not used correctly, they can:

- harm plants and animals,
- leave undesirable residues, and
- damage the environment in other ways.

All antimicrobial agents adversely affect some type of microorganism. Therefore, any agent can damage the environment if not chosen, used, and disposed of with care.

Since most antimicrobial agents are used mainly indoors on specific target areas, the risk of widespread environmental contamination is less than with other types of chemicals that are applied outdoors or over wide areas.

Select the antimicrobial agent that is labeled for your specific uses.

Soil

If not disposed of correctly, antimicrobial agents can contaminate soil.

Air

The ability of an antimicrobial agent to move in air depends on the nature of the chemical, its ability to vaporize, and other factors. In general, antimicrobial agents that might be spread in this manner should be controlled by making sure that:

- no unnecessary amounts are carried by air currents, and
- those that are released are diluted to a level that is safe for the environment.

Water

It is not possible to totally prevent pollution of water supplies with antimicrobial agents used for washing and flushing. You should be aware, however, that most fish and other aquatic life are sensitive to even slight changes in their environment. For example, 25 gallons of undiluted pine oil and sodium hydroxide used to clean one city swimming pool drained into a creek and killed about 45,000 fish. Normal use (with dilution) should not cause problems unless an unusually large amount of concentrate is washed or drained directly into waterways.

When antimicrobial agents must be disposed of in water, it is most important to dilute them adequately. You should also be aware of other limits that might be required by State or local authorities. Some chemicals can be neutralized before disposal. Consult the manufacturer for the correct method.

SAFE USE PRECAUTIONS

Most parts of your job may involve some risk of illness or injury from antimicrobial agents:

- hauling, storing, opening containers, mixing, loading, or applying antimicrobial agents.
- repairing equipment,
- working with antimicrobial agents in closed areas,
- cleaning application equipment after use,
- disposing of surplus antimicrobial agents and empty containers,
- cleaning up spills, and
- cleaning protective clothing and equipment.

Most of these tasks are done indoors. Each one requires some safety measures to prevent harm to the materials being treated, to people and animals, and to soil, air, and water outside the area of use.

You can prevent harm from antimicrobial agents if you follow safety precautions and use common sense. Here are the *minimum* safety steps you should take.

Before You Buy an Antimicrobial Agent

Select the correct antimicrobial agent. The first and most important step is to determine what type of organism(s) you wish to control. Next, determine which antimicrobial agents are registered to control the organism(s) in or on the particular material. You may have a choice of several. You may need help to guide you. Common sources of information are health agencies and officials, industrial specialists, and antimicrobial manufacturers and dealers.

At the Time of Purchase

Read the label. It is important for you to find out:

- restrictions on use,
- if this is the correct antimicrobial agent for your problem,
- if the product can be used safely,
- environmental precautions needed,
- if the formulation and amount of active ingredient are right for your job,
- if you have the right equipment to apply the antimicrobial agent,
- if you have the right protective clothing and equipment,
- how much of the chemical you need,
- the rate of application, and
- special instructions.

Transportation of Antimicrobials

You are responsible for the safe transport of your antimicrobial agents.

- Fasten down all containers to prevent breakage and spillage.
- Keep these agents away from food, feed, and passengers.
- Antimicrobial agents should be transported in their original containers.
- Keep paper and cardboard packages dry.
- If any antimicrobial agent is spilled in or from the vehicle, clean it up right away. Use correct cleanup procedures (described later).
- Do not leave unlocked antimicrobial agents unattended. You are responsible if accidents occur.

Storage of Antimicrobials

The label will tell you how to store the product.

As soon as antimicrobials arrive, store them in a locked and posted place. Children and other untrained persons should not be able to get to them. They should not be stored with food or drug supplies.

The storage place should keep the antimicrobial agents dry, cool, and out of direct sunlight. It should have enough insulation to keep the chemicals from freezing or overheating.

The storage place should have:

- fire-resistant construction,
- nonabsorbent flooring,
- good ventilation,
- good lighting, and
- a lock on the door.

Keep the door locked. Store all chemicals in the original containers. Check every container often for leaks or breaks. If one is damaged, transfer the contents to a container that has held exactly the same antimicrobial agent. Clean up any spills correctly.

Keep an up-to-date inventory of the kinds and amounts of agents you have.

Mixing Antimicrobials

Keep animals and people out of the mixing area. Do not mix or load antimicrobial agents unless there is good lighting and ventilation.

Before handling an antimicrobial agent container, put on the correct protective clothing and equipment.

Each time you use an antimicrobial agent, read the directions for mixing. Do this before you open the container. *This is essential.*

When taking an antimicrobial agent out of the container, keep the container and chemical below eye level. This will avoid a splash or spill on your goggles or protective clothing. Do the same thing when pouring or dumping any antimicrobial. Containers with undiluted antimicrobial agents in the form of powders should be opened with care to avoid exposure.

If you splash or spill a concentrated antimicrobial agent while mixing:
- Stop right away.
- Remove contaminated clothing.
- Wash body thoroughly with large amounts of water. Use soap or detergent if recommended on the label. *Speed is essential.*
- Put on clean clothing.
- Clean up the spill.

When mixing antimicrobial agents, measure carefully. Use only the amount called for on the label. Mix only the amount you plan to use.

To prevent spills, replace all pour caps and close containers after use.

Applying Antimicrobials

Read the label again to find out:
- the protective equipment and clothing needed to handle the chemical,
- the specific warnings and first aid measures,
- what it can be mixed with,
- how to mix it,
- how much to use,
- safety measures,
- when and where to apply to control the microorganisms,
- how to apply,
- the rate of application, and
- special instructions.

Wear the correct protective clothing and equipment. Be sure that the pails or other measuring devices are clean and properly calibrated before using.

Before applying antimicrobial agents by spraying, be sure that all unauthorized personnel are out of the vicinity.

Cleaning Equipment

Mops, pails, and other gear used in applying an antimicrobial must be cleaned as soon as you finish using them. Don't forget to clean any measuring cups used in mixing the product. Clean both the inside and outside. Follow the manufacturer's directions.

Disposal

Excess Antimicrobial Agents

EPA recommends ways to dispose of excess pesticides (including antimicrobial agents). Consult local authorities (health or solid waste) for procedures in your area. If you have excess antimicrobial agents:
- Use them up as directed on the label, if possible.
- Burn them in a specially designated incinerator.
- If you do not have access to proper facilities for burning, bury the antimicrobial agents in a specially designated landfill.
- If you can neither burn or bury them right away, store them safely until you can.

Containers

To prepare containers containing liquids for disposal:
1. Empty the container into the mixing tank or other receptacle. Let it drain an extra 30 seconds.
2. Fill it one-fifth to one-fourth full of water.
3. Replace the closure and rotate the container. Upend the container so that rinse reaches all the side surfaces.
4. Drain the rinse water from the container into the tank. Let the container drain an extra 30 seconds after emptying.
5. Repeat steps 2 through 4 at least two more times for a total of three rinses.

Remember to empty each rinse solution into the tank.

The EPA recommendations divide containers into three groups. They tell you to dispose of each kind. Remember, however, that containers under pressure, such as aerosol cans, will explode when heated. Observe label precautions for these special containers.

Group I Containers–These are containers which will burn, and:
- held organic or metallo-organic antimicrobial agents, but not organic mercury, lead, cadmium, or arsenic compounds.

Here are ways to dispose of them:
- You may burn them in a specially designated incinerator for chemical wastes (*very few* are available).
- You may bury them in a specially designated landfill for chemical wastes.
- You may burn small numbers of them as directed by State and local regulations.

Group II Containers–These are containers which will *not* burn, and
- held organic or metallo-organic chemicals, but not organic mercury, lead, cadmium, or arsenic compounds.

Here are ways to dispose of them:
- Rinse the containers three times.

- Many large containers in good shape can be reused by your supplier. Return them to your manufacturer, formulator, or drum reconditioner.
- You may send or take them to a place that will recycle them as scrap metal or dispose of them for you.
- All rinsed containers may be crushed and buried in a sanitary landfill. Follow State and local standards.

If containers have *not* been rinsed:
- Bury them in a specially designated landfill.
- Incinerate them in a pesticide incinerator.

Group III Containers–These include any containers which held organic mercury, lead, cadmium, or arsenic, or inorganic pesticides.

Here are ways to dispose of them:
- Rinse them three times and bury them in a sanitary landfill.
- If they are not rinsed, enclose them in a tight outer container and bury them in a landfill specially designated for these materials.

Cleanup of Chemical Spills

Minor Spills

Always work carefully. Do not hurry.

Keep people away from spilled chemicals. Rope off the area and flag it to warn people. Do not leave unless someone is there to warn of the danger.

If the antimicrobial agent was spilled on anyone, give the correct first aid according to the label instructions.

Use an absorbent material to soak up the spill. You can use soil, sawdust, cat litter, or diatomaceous earth. Shovel all contaminated material into a leakproof container for disposal. Dispose of it as you would excess antimicrobial agents. Do not hose down the area. This spreads the chemical.

Spills can be neutralized to stop the chemical action. To make sure that you use the correct neutralizing chemical, call the manufacturer of the antimicrobial.

Do not let anyone enter the area until the spill is *all* cleaned up.

Major Spills

The cleanup job may be too big for you to handle. You may not be sure of what to do. In either case, keep people away, give first aid, and confine the spill. Then call the manufacturer or the National Agricultural Chemicals Association. They have a Pesticide Safety Team Network. You can call them toll-free any time at (800) 424-3900.

Report all major spills by phone to your State pesticide regulartory agency. You also may need to notify other authorities (such as State police, local sheriff, public health officials, or fish and wildlife authorities).

Reentry Times

It may be dangerous for a person not protected with proper clothing and/or equipment to enter an area immediately after some antimicrobial agents have been used. When required for safety, the label will list the minimum time interval between application and reentry into the treated area without proper protective clothing and/or equipment.

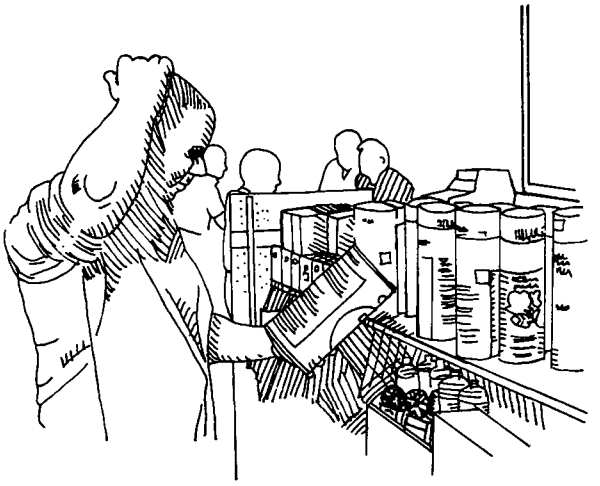


Figure 12. Read the label

LAWS AND REGULATIONS

Antimicrobial agents help to keep certain areas free from dangerous bacteria, fungi, algae, and viruses. They also protect many industrial, hospital, and home materials and systems so essential to our way of life. Because pesticides can be dangerous, Congress has passed laws affecting the use of all pesticides (including antimicrobial agents). These laws try to balance the need for antimicrobial agents against the need to protect people and the environment from their misuse.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as Amended

You are taking this training because of a law passed by Congress in 1972. It is often called by its initials – FIFRA. Because it provides that no pesticide can be registered by EPA unless it is shown to be safe and effective when used as directed, it requires you to show that you know the correct way to use and handle pesticides, including antimicrobial agents.

Here are the parts of the law which concern you the most:

- It says that all pesticide uses (including antimicrobial agents) must be *classified* as either general or restricted.
- It requires you to be *certified* as competent to use any of the antimicrobial agents classified for restricted use, and
- It provides *penalties* (fines and jail terms) for people who do not obey the law.

Classification of Pesticides

Manufacturers must register every pesticide (including antimicrobial agents) with EPA. By regulation, when each antimicrobial agent is registered, all its uses must be classified. EPA must decide whether each use is a general or a restricted one.

Under the law, an antimicrobial agent use is classified as *general* if it has little or no harmful effect on human health or the environment when used exactly as directed. It is classified as *restricted* if it could cause damage even when used as directed.

Some uses may be general under some conditions and restricted under others. Restricted-use applications must be done only:

- by someone who is certified, or
- under the supervision of a certified person (unless the label does not permit it).

Certification of Applicators

What is certification? It is proof that you know the safe and correct way to carry out restricted uses. Congress chose October 21, 1977, as the date for certification to go into effect. The Environmental Protection Agency (EPA), acting under Federal law, has by regulation set minimum standards of competency for all commercial applicators. Your State has developed a plan for certification of competency that meets minimum national standards. The certification plan in your State will be administered by a branch of your State government.

Prohibited Actions

The new law lists many things you cannot do. These two concern you most:

- You may not use an antimicrobial agent other than as the label or labeling directs, except when special regulations allow you to use it at a lower rate than the label recommends.
- You may not dispose of any antimicrobial agent or its container except as the label or labeling directs.

You also should know your State and local laws. They may prohibit more actions than the Federal law does.

The applicator is responsible for correct pesticide use.

Penalties

Anyone who violates the FIFRA is subject to civil penalties. Such penalties can be as much as $5,000 for each offense. Before anyone can be fined by EPA, he has the right to ask for a hearing in his own city or county. Violations of the law may also subject him to criminal penalties. They can be as much as $25,000 or 1 year in prison, or both.

Other Regulations

Transportation

Transportation of hazardous materials is regulated by the U.S. Department of Transportation, or in the case of intrastate shipments, by the States. Certain pesticides (including antimicrobial agents) may be among these regulated hazardous materials. Shippers of pesticides should check these regulations to determine:

- If the pesticides are regulated, and, if so,
- What classification is the material?
- What are the specific packaging, marking, labeling, and shipping paper documentation requirements?

For carriers of regulated pesticides, there may be vehicle placarding requirements. Another important requirement prohibits hauling regulated pesticides (poisons) in the same vehicle with food.

U.S. Department of Transportation requirements for transport of hazardous materials may be found in the DOT Hazardous Materials Regulations (Code of Federal Regulations, Title 49, Parts 100-199).

For State regulations on intrastate transportation of hazardous materials, contact the appropriate State agency.

Worker Safety and Health

The Occupational Safety and Health Administration (OSHA) is in the Department of Labor (DOL). OSHA recordkeeping and reporting requirements apply to employers with 11 or more workers. The records must include all work-related deaths, injuries, and illnesses. Minor injuries needing only first aid treatment need not be recorded. But a record must be made if the injury involves:

- medical treatment,
- loss of consciousness,
- restriction of work or motion, or
- transfer to another job.

Regardless of the number of employees you have, if there is a work-related death or if five or more employees are hospitalized, OSHA must be notified within 48 hours.

Residues

Antimicrobials may be used in packaging materials that contact food. Since the antimicrobial may move from the packaging materials into the food, leaving residues, a *tolerance* must be set for these residues. A tolerance is the concentration of a pesticide that is judged safe for human use. EPA sets residue tolerances under regulations authorized by the Federal Food, Drug, and Cosmetic Act. Residues in food are considered to be food additives and are regulated as such.

Most antimicrobial agents will not come in contact with food when properly used.

Follow the label exactly. Then you can be sure you are not breaking the law.

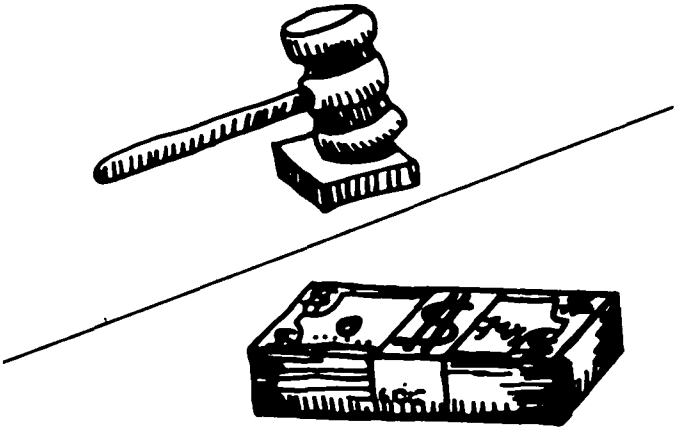


Figure 13.

DEFINITIONS

Here are the definitions of terms used either in this manual or on the label to describe the chemical's purpose:

ALGAECIDE: A chemical agent that kills algae.

ANTIFOULANT: A chemical agent that prevents growth of organisms on underwater structures.

ANTIMICROBIAL AGENT/PESTICIDE: Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest.

BACTERICIDE: A chemical agent that kills bacteria, but not ordinarily bacterial spores.

BACTERIOSTAT: A chemical agent that inhibits the growth of bacteria, without killing.

"-CIDE" or "-CIDAL": A suffix that means "to kill".

DEODORIZER: A chemical agent that prevents the formation of odors by acting upon microorganisms.

DETERGENT DISINFECTANT: A product that is both a cleaner and a disinfectant.

DISINFECTANT: A chemical product that kills microorganisms, except bacterial spores, on inanimate objects and surfaces.

DISINFECTION: A process that kills microorganisms, except bacterial spores, on inanimate objects and surfaces.

FUNGICIDE: A product that kills fungi (including yeasts).

FUNGISTAT: A product that inhibits the growth of fungi, without killing.

GERMICIDE: See "Disinfectant".

INCINERATE: Flame, burn, or reduce to ashes.

MILDEWCIDE: A chemical agent that kills mildew (a defacing fungus).

PHENOL COEFFICIENT: The ratio of the concentration of the product and the concentration of phenol required to kill certain bacteria in a specified time.

PRESERVATIVE: A chemical agent or process that prevents deterioration of materials.

SANITIZATION: The process of reducing the number of organisms to safe levels as determined by public health requirements.

SANITIZER: A chemical product that reduces microbial contaminants to safe levels as determined by public health requirements.

SLIMICIDE: A chemical preparation that prevents, inhibits, or destroys biological slimes composed of combinations of microorganisms.

SPORICIDE: A chemical agent that destroys bacterial spores as well as vegetative forms of microorganisms.

"-STAT" or "-STATIC": A suffix that means to stop growth of microorganisms without destruction.

STERILE: The condition of being free from all forms of life, especially microorganisms.

STERILIZATION: The process of effecting the complete destruction or removal of all forms of life.

STERILANT: A chemical agent intended to destroy all forms of life, including viruses, bacteria, and fungi, and their spores, on inanimate surfaces.

STERILIZER: A chemical agent or process that destroys all forms of life in or on inanimate surfaces.

USE-DILUTION METHOD: A laboratory test that measures whether or not a disinfectant product kills test bacteria on a standard hard surface.

VIRUCIDE: A chemical product that kills viruses.