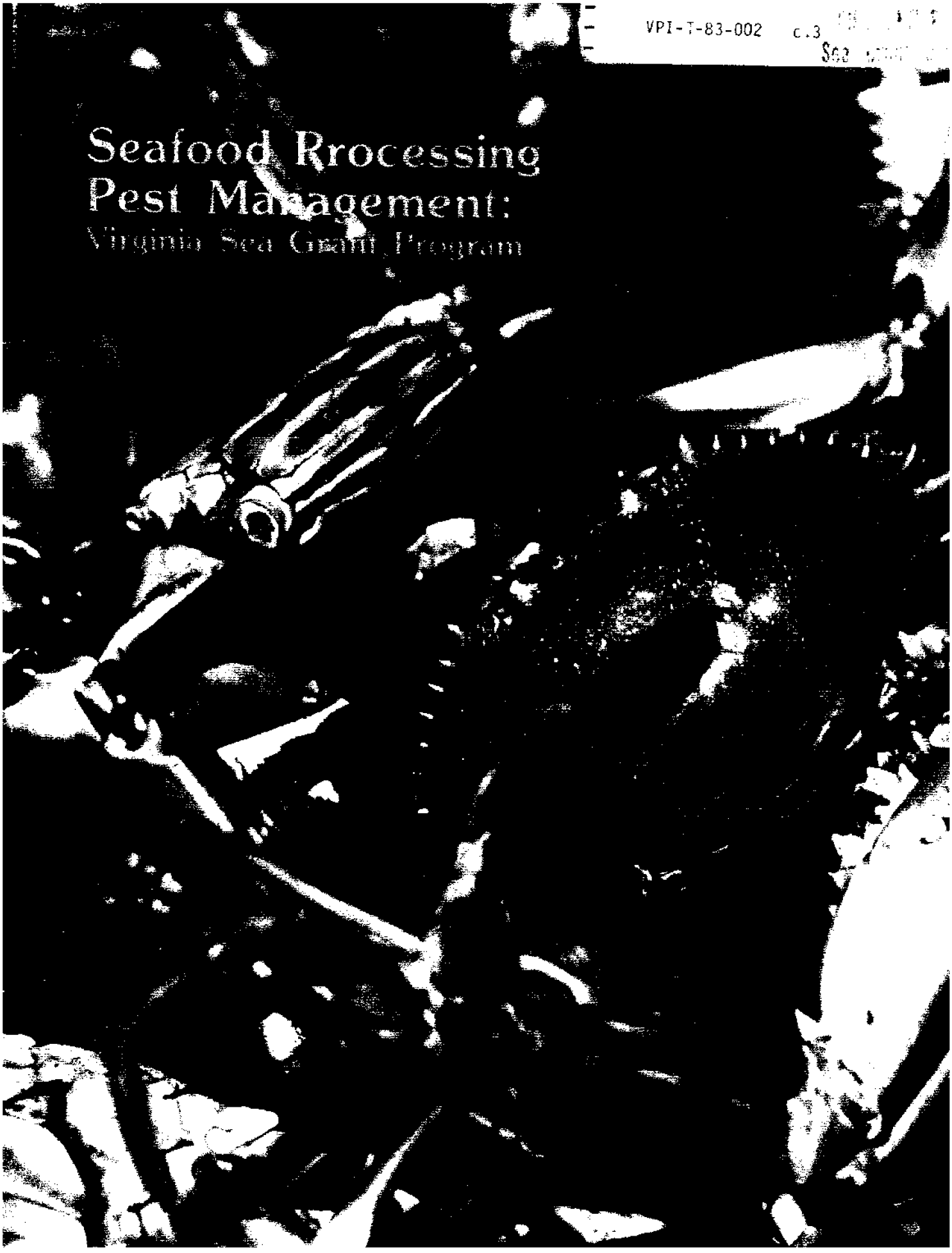
Seafood Rrocessing Pest Management:

Virginia Sea Grant Program



Seafood Processing Pest Management: Materials and Methods

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INTRODUCTION

The application of pesticides in and around food preparation, processing, and storage areas requires knowledge of and respect for the pests, the chemicals, and the regulations governing their use.

Controlling insect and rodent pests is an important part of maintaining the sanitation and quality control standards necessary in seafood processing. Each establishment has its own particular quality control standards and a program to achieve them. An effective pest control program involves the participation of *management* and *pest control* personnel. The Plant Manager or Quality Control Manager must work closely with the pest control personnel.

The majority of seafood processing operations assign the most capable and dependable employees to handle pest control. However, their training and experience in pest control may be limited. The objective of this training-resource manual is to provide pest control personnel with the detailed and specific information necessary to design and conduct an effective pest control program. The topics covered in this manual include

Management and pest control personnel,
Pest control and objectives,
Pesticide storage and mixing,
Spraying techniques,
Pest identification,
Rodent control,
Equipment.

MANAGEMENT AND PEST CONTROL PERSONNEL

Plant Manager and Pest Control Personnel

A good pest management or pest control program in seafood processing operations is not based on pesticides, equipment, or frequency of application. Rather, it should be based on a coordinated effort between the processing plant management and the pest control personnel. Both groups must understand the other's role and priorities.

The pest control personnel usually can accomplish little without full involvement and cooperation of management in an overall sanitation effort. Both must understand that controlling pests requires a complete sanitation program, accounting for all facets of the operation from raw material to shipping and distribution.

Management and pest control personnel should survey the facility and discuss the operating and cleaning schedules, physical conditions inside and outside the facility, employee and operating practices, and storage of pest control chemicals and equipment. Both should become aware of the other's limitations. For example, if the facility is not on a thorough cleaning schedule, which helps to control insects and rodents within equipment and around the building, the pest control personnel will have great difficulty eliminating or managing these pests. If the processor receives rodent or insect-infested materials or doesn't properly store materials, the pest control personnel will not be able to control infestations of ingredients. Rodent trapping programs and crack and crevice treatments can't be properly carried out if storage and processing areas are not organized to allow for perimeter access. Before a pest control program can be developed and carried out, both management and pest control personnel must understand each other's responsibilities and role in pest control.

PEST CONTROL AND PEST MANAGEMENT OBJECTIVES

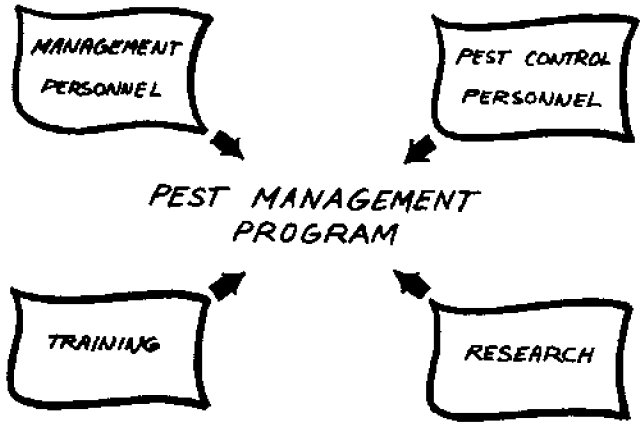
Control of pests associated with seafood processing operations must be based on both chemical and non-chemical control methods. Controlling cockroaches and other pests with chemicals alone is becoming increasingly more difficult. In most insect and rodent populations there is some degree of resistance to the commonly used pesticides. Continued dependence on chemicals for the control of pests will increase insecticide and rodenticide resistance in the pest population — and may result in an uncontrollable increase in the pests. Future pest control programs must integrate chemical and nonchemical (sanitation, traps, preventive measures) methods into an ongoing ***program***, under the direction of ***trained*** and ***properly equipped*** personnel, and with the objective of ***pest management***.

Guidelines for designing a *pest management program* for seafood processing operations are as follows:

1) Orient the program to the *entire pest population*, rather than to localized infestations. Individual pests — rats, cockroaches — should be interpreted as members of a large group or population that may occupy an entire building.

2) Design a program for the ***entire processing operation***, rather than for specific rooms or parts of the operation. Most insect and rodent pests are not limited to infesting one part of a building, but probably move throughout the building. Pest control in only one part may simply force the pests to an untreated portion, and reduce the effectiveness of the control effort.

3) The objective of the program is to ***manage*** those pests that are present year round, and are present in large numbers. The objective is to decrease the level of abundance of these pests rather than eliminate or eradicate them.



For some pests and in some situations, elimination may be possible or even necessary. For example, rodents are serious health hazards to food processing operations, and it is necessary to eliminate them from all areas of the operation. Elimination of rodents and some other pests may be possible, perhaps after the pest population is reduced through pest management practices. However, it is more realistic to think in terms of a continuous or ***on-going pest management program***, designed to keep pest populations low, than to work toward pest elimination and program conclusion. It is virtually impossible to eliminate or eradicate most pests from an environment favorable for them. Pest control programs must be on-going and continuously improved.

The ***concept of pest management*** involves dealing with pest populations interacting with the total environment. Pest management requires the integration of sanitation, prevention, exclusion, mechanical control methods, and chemical pesticides into a program with the goal of significantly reducing (and possibly eliminating) a pest population.

PESTICIDES

Insecticides

Understanding both the way insecticides kill insects and the dangers of overexposure to humans is an important aspect of pest management programs.

Exposure. At the present time, the most widely used organic insecticides are the organophosphates, carbamates, and pyrethroids. These and other pesticide chemicals may enter the body in a wet or dry state through the skin (dermal absorption), through breathing (respiratory absorption), and through the mouth (oral absorption). Dermal absorption is the most common route of exposure.

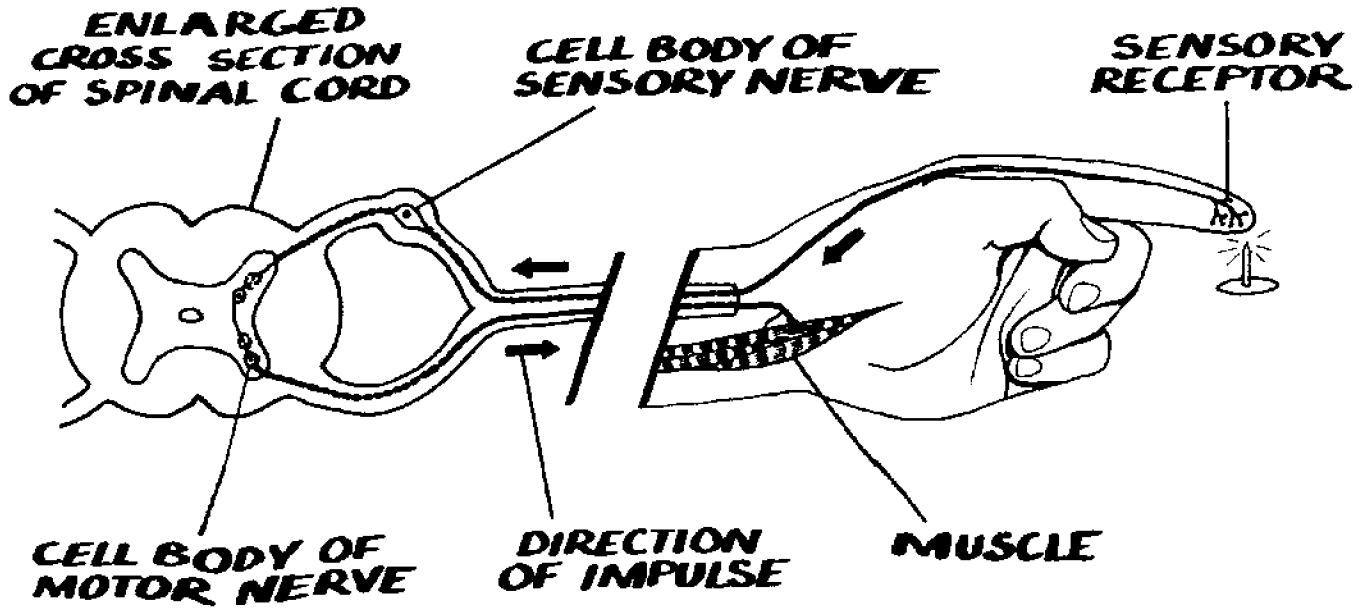
Insecticides are absorbed at different rates on various areas of the body. Protective clothing should be worn to prevent skin absorption. Special care should be given to protect the scalp, ear canal, and forehead. The abdominal area and waistline should be protected to prevent chemical access to the scrotum area.

Data have shown that most accidents occur during the mixing and loading operations. It is extremely important to wear protective clothing when concentrated chemicals are being handled, as well as during application.

How Insecticides Work. The normal life of an insect depends on a vast number of complex chemical reactions (metabolic processes). Alteration of any of the metabolic processes will affect the insect. Some alterations result in sudden death, while others are less drastic. Different kinds of insecticides may alter metabolic processes in one or more ways; that is, they may have one or more modes of action. As an example, the organophosphate and carbamate insecticides, once inside the body, interfere primarily with the nervous system by inhibiting or depressing the enzyme cholinesterase. All living things with cholinesterase in the nervous system — such as insects, birds, animals, and humans — may be poisoned by these chemicals. However, in order to understand how these insecticides affect the nervous system, and thereby the symptoms and treatments of poisonings, it is necessary to see how the nervous system works.

The nervous system — which includes the brain — is the most complex system in the body. It consists of millions of cells which make up a message or communication system throughout the body. The messages (or stimuli) travel along this network in the form of an electrical impulse. Think of it as a spark!

Nerve Poisons



Rat Poisons

The nerve cells are "connected" at the synapse. The ends of the connecting nerve cells intertwine, but do not actually touch each other. Stimuli "spark" across the synapse in a chemical known as acetycholine. After the stimulus is across the synapse, the acetylcholine is broken down by cholinesterase. Then the cholinesterase breaks down and the synapse is back to "normal."

In the drawing, a stimulus (sticking your thumb with a pin) begins at the skin. The stimulus or spark travels down thousands of nerve fibers and across the synapses. Some of the stimuli go to the muscles to make you jerk back, while others go to the brain where they are interpreted as the feeling of pain. This example is extremely simplified, but it serves to illustrate the basic components and workings of the nervous system.

Organophosphate and carbamate insecticides each inhibit a type of cholinesterase, causing an accumulation of acetycholine so that all stimuli or "sparks" continue to arc across the synapses, stimulating continuous muscle contractions or tremors. Thus, the nervous system is "poisoned."

Rodenticides

Rodenticides are pesticides used to control rodents such as rats, mice, and squirrels. They are normally employed in solid baits, in liquid forms, as dusts, or as volatile chemicals used as fumigants. The most effective rodenticides are those with a high toxicity and palatibility, and with one or more safety features. Rodenticides used in solid baits or liquid forms can be divided into two groups based on the mode of action: 1) the acute rodenticides; 2) the chronic rodenticides.

Single-Dose Poison

The ***acute rodenticides*** are those in which a lethal quantity of poison is ingested in a single dose with the food or drink of a rodent. They cause death by heart paralysis, by gastrointestinal and liver damage, or by attacking the central nervous system. The target animal must consume a lethal dose before the onset of poisoning symptoms. A sub-lethal dose may produce side effects which will make the rodent "bait shy." Pre-baiting is recommended before applying acute rodenticides so the animal will be conditioned to the bait. The unpoisoned bait is first presented to the rodents until they freely feed regularly and then it is replaced by bait containing the poison.

Multiple-Dose Poisons

Chronic rodenticides bring about death of an animal only after the poisoned bait or liquid has been consumed on a number of occasions. Because the poison is consumed over a period of time, a low dosage is lethal. For example, a brown rat can survive a single 50 mg/kg dose, but succumbs to 5 consecutive doses of 1 mg/kg taken on successive days. The symptoms of the poison are so delayed that the animal never learns to associate discomfort with the bait consumption, and continues to feed until a lethal dose has been ingested. The main components possessing chronic poisoning action are the anti-coagulants, which interrupt the synthesis of blood-clotting factors so the poisoned animals die from internal bleeding. Chronic rodenticides are relatively nontoxic to domestic animals and man; however, there is no such thing as a "safe" rodenticide.

However toxic a chemical poison may be, it will not be lethal unless a rodent, of its own volition, consumes a lethal dose. Additives are sometimes included in the bait to improve performance. Attractants such as flavoring or oils are sometimes added to bait to make it more appealing by enhancing the taste or masking disagreeable odors. Anticoagulants may be made more lethal by adding potentiating agents that accentuate the action of the anticoagulants. Preservatives and binders are used in baits to keep them from deteriorating over time. To guard against accidental consumption of the poisoned bait by nontarget animals, safety additives may be incorporated. Since rodents are unable to vomit, it is often the practice to incorporate an emetic agent in the bait. The emetic agent will induce vomiting and provide a safety factor for non-target animals.

Secondary poisoning to animals which feed on dead or dying rodents should be anticipated. The danger may be reduced by removing rodent carcasses whenever possible.

Acute or chronic poisons may be used in dust formulations. A poisoned dust is

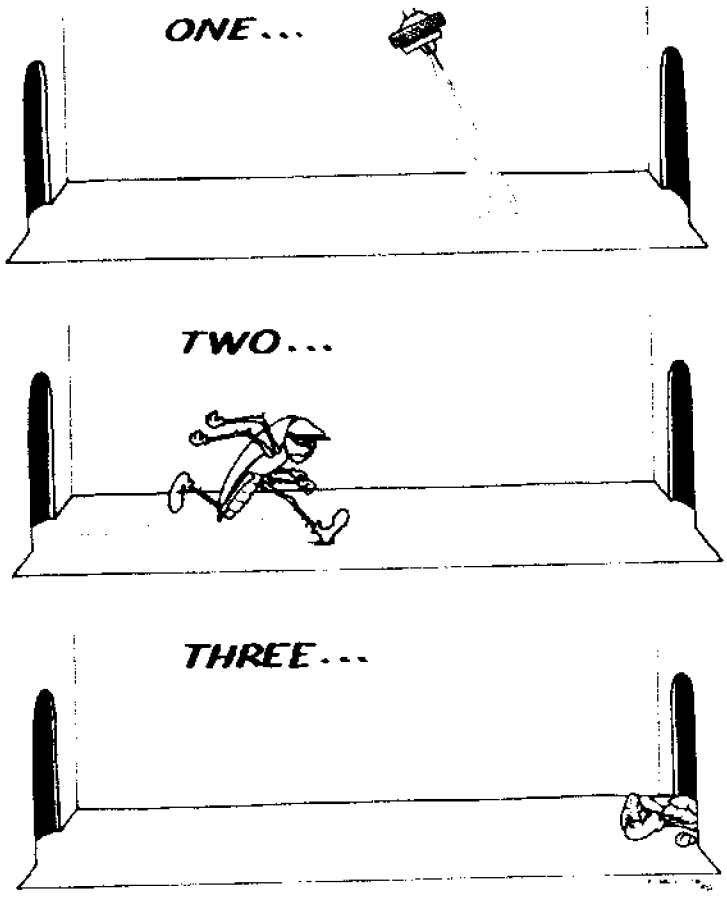
placed in the holes and burrows of rodents where it adheres to their feet and fur and is transferred to the mouth during normal cleaning and grooming activities. This method requires a high concentration of poison since the animal can be expected to consume only small amounts. The advantage of contact dusts is that rodents do not suspect the source of illness.

In situations where rodents do not respond to poisoned baits or dusts, a fumigation technique can be used. Rodents breathe the volatile substances and gases which cause death.

Avicides

Avicides are pesticides used to control birds in pest situations. Some common avicides include compound DRC 1339 and Avitrol. Most avicides are acute poisons which act on the central nervous system. The reaction time required to kill a bird varies with the type of poison. Strychnine used as an avicide will kill birds shortly after the bait is consumed while the avicide containing the compound DRC 1339 does not kill the birds for several hours, generally after they go to roost. This difference in mode of action is important in reducing the effects of secondary poisoning to animals that consume dead birds. Birds dying at the roost sites can be easily picked up and disposed of.

No avicide has been found that is specific for a given bird; thus, there is always a danger that non-target birds will be affected. A poison such as strychnine is lethal to all animals while DRC 1339 is more lethal to starlings and blackbirds, but will also kill smaller birds. Avitrol is an avicide which is used to control blackbirds. A bird ingesting avitrol reacts with distress symptoms and calls which frighten away the remainder of its flock from the feeding area with a minimum of mortality. The advantage of Avitrol is that only a few birds need to ingest the bait; thus a relatively small amount of bait needs to be put out.



Bird Control

PESTS ASSOCIATED WITH SEAFOOD PROCESSING

A variety of insects and other animals are attracted to seafood materials, processing equipment, and plants. Some of these animals can be serious pests in seafood processing plants; others are only occasionally associated with these operations. The most common pests include insects (cockroaches, flies, flour beetles), rodents (rats, mice), and some birds.

Control of pests associated with seafood processing requires a thorough knowledge of their biology, habits, and seasonal occurrence. Chemical or non-chemical methods can be more effective when the applicator knows the target pest.

INSECTS

Insects are the most common and probably the most difficult pests to control in seafood processing operations. Control strategies depend on the life history and habits of the individual pest, and on the chemicals registered for use against that pest. Some insects, such as house flies, fruit flies, and crickets are seasonal pests; they usually breed outside the processing plant, and are most common in late summer (August, September). Cockroaches and flour beetles are year-round pests, but may be more numerous at certain times of the year.

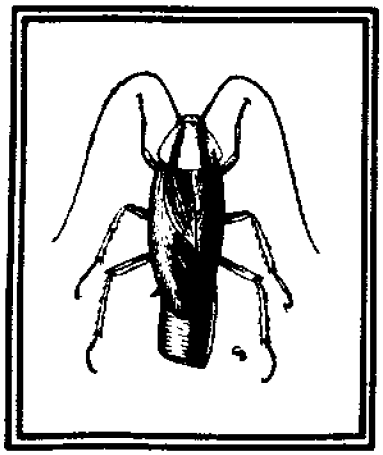
Information on the biology, habits, and certain aspects of control of common and occasional insect pests is presented below.

Cockroaches

Roaches

The most common and most important pests of food-processing plants are cockroaches. Most common because they occur around the world — in every plant, in every food industry; most important because they can carry and spread numerous disease organisms. Cockroaches are known to carry four strains of poliomyelitis, more than 40 different pathogenic bacteria, and the eggs of several pathogenic worms. It has been estimated that a single cockroach can carry a total of 13,470 bacteria.

Females cockroaches do not lay eggs one at a time; instead they produce small egg cases that contain from 6 to 40 eggs. This ***egg case*** is deposited in a hiding place with adequate food and water. ***Young*** cockroaches begin feeding soon after they hatch from the egg case. They feed on the same materials as the adults, and look like adults except for size and absence of wings. After shedding their skin several times to grow larger, they become winged adults. ***Adult*** cockroaches live for a few months to over a year, depending on the species. They mate several times and the females generally produce one egg case per month.

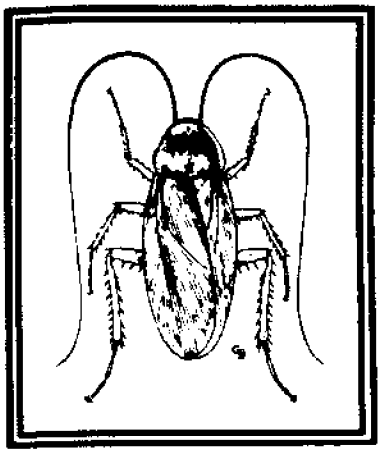


The **mouthparts** of cockroaches are the ***biting-and-chewing type***. These insects can feed on a variety of foods, but they prefer starchy and sugary material. They will sip milk, nibble at cheese, meats, pastry, flour, meal, grease, chocolate, and other foods. They can feed just as freely on book binding, shoe lining, dead insects, other cockroaches, and human waste. They usually feed at night when they are not likely to be disturbed by human activities.

German Cockroach. This is the most common and widespread cockroach in food processing plants — around the world. It is a small insect, about 3/4" long, and is yellowish brown with two dark-brown stripes behind the head. Both male and female have well-developed wings.

The female carries the egg case protruding from the tip of the abdomen until hatching time. The egg cases are hidden in areas with abundant food, water, and hiding places. The adult female may live for about 9 months and produce about 140 young.

In seafood processing plants, German cockroaches will infest the main food preparation (ground level) and storage areas, as well as offices, clothing lockers, and restrooms. They are not usually found in storage areas below ground level.



American Cockroach. This is the largest cockroach in the United States; adults may reach a length of 2 inches. Adult cockroaches are brown, and the young are pale brown.

The female American cockroach hides her egg cases as soon as they are produced. The adult female may live for 12 to 18 months and produce as many as 33 egg cases.

American cockroaches usually inhabit basements, storage rooms, garbage areas, and sewers. These places are slightly cooler than the habitats of the German cockroach, and the cracks and crevices to hide in are larger.

In seafood processing plants the American cockroach usually infests large storage areas (below ground level), loading docks, and basements. This cockroach is frequently associated with outdoor trash bins and storage areas. Adults may move into the building from these areas at night.

Oriental Cockroach. This pest is about 1" long, dark brown to black; the wings are very short in the male and absent in the female. The young are pale brown.

The female hides the egg case soon after it is formed. Each female can produce one egg case per month for the 5-6 months of her life.

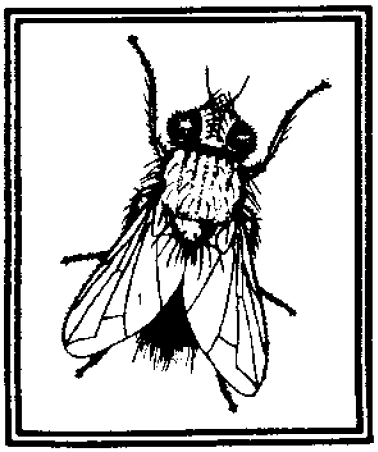
The preferred habitat of the oriental cockroach is similar to that of the American cockroach. They usually inhabit areas below ground level, such as basements, storage areas, sewers. In seafood processing plants they are common in below-ground storage areas.

Cockroach Control. Cockroaches are a year-round pest in all food processing plants. Therefore, control of these pests has to be a year-round project, and it has to be in the form of sanitation and the use of chemicals.

The first step and most important aspect of control is sanitation. Recognizing that cockroaches require food, water, and a hiding place, and then moving against these areas with an ongoing sanitation program, is the foundation of cockroach control. Chemical control has to follow sanitation; it can not be used alone or in place of it.

Flies

The most common of the seasonal pests of seafood processing plants are flies. A variety of flies are associated with these plants, but the most common are the house fly and the fruit fly.



House Fly. This insect is found all over the world. It is a pest to all segments of society -- from households to industry. Like cockroaches, house flies can spread pathogenic organisms to humans and their food. It has been estimated that a single fly can carry 3,680,000 bacteria. The pathogenic organisms are collected on the feet and mouthparts when the fly visits garbage, and some of the organisms are taken into the gut. The organisms are deposited when the fly crawls on human food or are deposited in the fly's excrements.

The house fly passes through three stages on its way to becoming an adult. From 75 to 150 eggs are deposited at one time, and there are several such layings at intervals of 3 or 4 days. Under warm summer temperatures, the egg requires 8-12 hours to hatch. The ***maggot*** that hatches from the egg begins feeding and gnawing. The ***maggot stage*** lasts about 5 days. When full-grown, the maggot changes to the ***pupa stage***. This is a resting stage, and lasts about 4 days. The adult fly comes out of the small seed-like pupa stage — and the cycle starts all over.

The maggot stage in the fly's life does most of the feedings; the adult simply takes in a little fluid for quick energy. The adults may be attracted to rotting garbage by the smell and also by a desire to lay eggs. They are attracted to window screens and picnics for the same reason — the smell of food. The danger comes when flies move from garbage or manure to human food.

House Fly

House flies are more abundant in the late summer and fall because the population has been building during the warm summer months. The adults enter buildings in search of food and shelter from the cool nights. Once inside they seldom leave.

House Fly Control. Since house flies are probably breeding away from the plant site, and flying to the site, there is little hope of controlling the size of the fly population outside the plant. Control must be aimed at 1) preventing entrance to the plant and 2) reducing the number inside the plant.

Most food-processing plants use air screens and appropriate doors. These are excellent mechanical controls for flies, *if* they are ***strong*** enough. The stronger the better.

Control inside the plant can be achieved with electric grids. These work by attracting the adult flies to a special blue light and killing them with an electrical shock. These traps should be run day and night, and the catch basin should be cleaned out every day.

Fruit Flies. These tiny flies are also seasonal pests. They are abundant in the late summer and fall. The adults are small (about 1/10" long), with light brown bodies and red eyes. The adults are attracted to fruit, especially rotting fruit. Since they are not attracted to sewage or animal waste, the food-damaging bacteria they carry is probably limited.

The life cycle and feeding habits of fruit flies are similar to those of house flies. In the late summer there is an abundance of rotting plants and fruit, thus allowing the fruit fly population to increase rapidly. The adult flies live about a month.

Fruit Fly Control. Complete control of these pests — like most insect pests — is nearly impossible. Air curtains and electric traps may be somewhat effective. Removal of all attractive material (rotting fruit, fermenting foods) around the building will help.

Meal Moths

Flour Moths

The flour moths are among the most common insect pests of grain products. They are called flour moths because they prefer milled cereal products such as flour and meal; they seldom attack sound kernels of grain.

Flour moths and other insect pests of grain products are present throughout the flour manufacturing and distribution scheme. These pests can be found at the mill, in warehouses, in delivery trucks, and at their final destination. Therefore, these insects are likely to be a constant problem and will need constant attention.

Female moths lay **eggs** singly or in small groups, not in egg cases like cockroaches. ***Caterpillars*** hatch from the eggs and feed on the foodstuff. The caterpillars grow and shed their skin several times before they are fully grown. The caterpillar spins a silken cocoon and transforms into a ***pupa***, from which the ***adult*** develops and later emerges. Males and females live for a short time; the females die soon after the eggs are laid.

The infestation and damage to the flour is done by the caterpillar stage. Adult moths do not feed; they return to the flour only to lay eggs.

Indian Meal Moth. This medium-sized moth has a wing expanse of about three-fourths inch. The adult moth is easily distinguished from other grain pests by the color bands on the large, front wings. The outer two-thirds of the wings are reddish brown; the region behind the head is gray.

Female moths can lay from 100 to 300 eggs, singly or in groups, on food material. The eggs hatch in about three days. The caterpillars feed upon grain products, dried fruits, nuts, and a wide variety of foodstuffs.

When full grown, the Indian meal moth caterpillar is about half an inch long and is grayish white, sometimes varying to greenish and pinkish colors. The caterpillar spins a web as it becomes fully grown and leaves a silken thread behind wherever it crawls. This webbing is often dense enough to attract attention when sacks of flour or meal have become heavily infested.

During warm weather, the Indian meal moth may pass through the egg, larval, and pupal stages in 6-8 weeks.

Mediterranean Flour Moth. This small moth has a wingspread of about 1 inch. Its large front wings are gray with wavy black markings.

The female moth lays small white eggs in accumulations of flour and meal. The caterpillars feed on flour and meal. The full-grown caterpillar spins a silken cocoon, in which it transforms into a reddish-brown pupa.

During warm weather, the Mediterranean flour moth requires 8-9 weeks to pass through the egg, larval, and pupal stages.

Flour Beetles

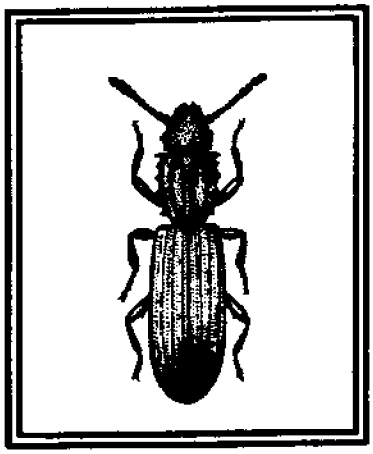
Flour Beetles

Such a great number of beetles infest stores of flour that listing them all or providing life history data is not practical. Three of the most common species are presented here; the other species have similar habits and life histories.

Flour beetles are often present throughout the manufacturing and distribution process. Like flour moths they can be a pest at the mill and in the food processing operation, and require constant attention.

Female beetles lay **eggs** singly in the flour. The larva or "grub" that hatches from the egg will feed on the foodstuff. The ***grub*** stage may last 14-16 months. The full-grown grub builds a cocoon out of scraps of the food material and transforms to a ***pupa***. Male and female beetles often live for several months to a year.

The infestation and damage to the flour is done by the adult and grub stages. Adults and grubs have chewing mouthparts.



Sawtoothed Grain Beetle. This small, brown beetle is probably the most common flour pest. It is slender, about one-tenth inch long, with six sawtooth projections on each side of the thorax.

Adult beetles usually live 6-10 months, but some may live as long as 3 years. The female lays 43-285 **eggs** loosely in the flour and meal. The eggs hatch in about 4 days and the grub begins feeding. The adult and grub stages feed on all food of plant origin, especially grain products such as flours, meals, nut meats, candies, and dried fruits.

After about 2 weeks (in warm weather) the grubs become full grown and construct a cocoon out of fragments of foodstuffs. Within these cells, the grub changes to the pupal stage, then to the adult. In summer, the development period from egg to adult is about 4 weeks.

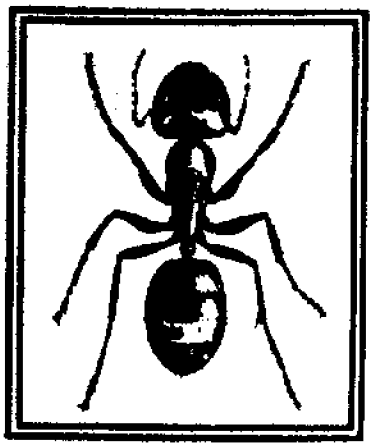
Red Flour Beetle and Confused Flour Beetle. These small, shiny, reddish-brown beetles are about one-seventh inch long. They are distributed over the world and are very abundant in the United States. They are general feeders on grain products, and are the most abundant and injurious insect pests of flour mills in the United States.

The average life of the adults is about 1 year. The female lays an average of 450 **eggs** loosely in flour or food material in which the adults live. The eggs hatch in 5-12 days and small worm-like grubs emerge. The **grub** stage feeds on flour or other food material made from grain.

When fully grown, the larvae transform into pupae; they do not construct a cocoon. Shortly afterwards they transform to adults. In summer, the period from egg to adult is about 6 weeks. The life cycle is prolonged by cold weather, as is true of all grain pests.

Cigarette Beetle. As its name implies, the cigarette beetle is primarily a pest of dried tobacco either in the stored, bundled form or in cigars and cigarettes. But they can feed on a variety of stored grain products including cereal products, ginger, raisins, dates, pepper, and dried fish.

The adult beetles are oval, about one-tenth of an inch long, and are covered with small hairs which give them a silky, yellowish-brown color. The female produces about 100 eggs, and they are deposited on or near the adult beetles. The larvae are creamy white except for the yellow head and brown mouthparts. They become full-grown in about 40 days. The entire life cycle can be completed in 45-50 days, and there may be 3-6 generations a year.



Casual Invaders

There are several different insects and other arthropods that occasionally invade food processing operations. They represent no threat or potential infestation, but may cause concern.

Silverfish. These insects are often found in food processing operations, but are not a serious or potentially harmful pest. These insects prefer vegetable matter with a high carbohydrate and protein content. However, indoors they will feed on flour, starch, paper, glue, sugar, molds, and dried fish. They can go for up to 1 year without food, so sanitation alone will not eliminate an infestation, although it may prevent new ones from starting.

Ground Beetles. These blackish-brown beetles are common in late summer and fall. The adults are good fliers, and will come to lights at night. The larval stages live outdoors.

Sowbugs. These small relatives of the crawfish are usually found in dark, moist environments. They feed on vegetation, and will not infest buildings unless there is a moisture problem.

Centipedes. These fast-moving, predacious animals are usually not seen in numbers. They feed on insects and spiders inside and outside buildings. Control is rarely recommended for these animals.

Ants. Only a few ants build their nests inside buildings. Most have their nests outside in the soil and invade buildings looking for food. Control must be directed at the point of entry, outside the building.

Crickets. These insects are most common in late summer and fall, when the population is composed of adults. They are good fliers, are attracted to lights at night, and will seek a warm location on cool fall nights.

Spiders. Spiders are usually pests in the spring and fall. They are abundant in the spring when males and females are mating, and in the fall when some seek shelter from the cool weather. It may be very difficult to eliminate this problem, but there is some relief in knowing that spiders are beneficial animals —feeding on insects and other spiders.

The black widow and brown recluse spider are the only poisonous species in eastern United States.

RODENTS

Mice. Mice can cause a great deal of damage to household materials. Because of their habit of nibbling, they contaminate much of the material not actually destroyed. A knowledge of mouse habits is important in developing effective control programs. Each male mouse stakes out a territory around his nest. He may not travel more than ten feet from his nest if food is close by. For this reason, baits should be placed 10-20 feet apart. Mice are not suspicious of new foods and eagerly sample them. Mice also investigate any new object in their territory, so that changing bait or trap placements will improve control.

Rats. Rats are serious pests because they contaminate and destroy food products, carry diseases and external parasites, and often bite people. A knowledge of rat behavior is essential to successful control.

Rats which have become conditioned to eating a particular food approach new food cautiously. If it tastes bad or makes them sick, they won't eat it again (= bait shyness). When baiting, more effective control can be obtained by using a bait that is fresh and identical to the food the rats are using. If different food is used, it may be necessary to prebait a few nights before adding a toxicant to the bait. Rats also require free water to drink. If water sources can be eliminated, liquid baits are effective. Rats, especially males, establish "territories" and fight to preserve this area from strange males. Reducing or eliminating food sources and harborage increases this competition, and the rat population decreases. Rats also prefer to run next to walls or other surfaces; therefore, traps and baits should be placed in these runways.

The first part of any good rat control program consists of determining just where the rats are living, feeding, and traveling, and the extent of the infestation. Once this has been done, it is essential to eliminate their shelter areas and their food and water supplies. These sanitation measures are the backbone of successful control. However, in many instances, it may be best to poison or trap before upsetting the environment so that the rats do not scatter. It is also necessary to close off all entrances and exits rats can use to come and go from buildings. This is called rat-proofing, and must be done in many instances to obtain adequate control.

PEST BIRDS

There are many species of birds in the United States, but only three are normally considered pests around food manufacturing plants. All three cause problems in cities. All three survive well in close association with man. They are objectionable primarily because their droppings can be a serious food contaminant. They may also spread diseases. Their droppings deface buildings, and their nests plug gutters and cause roofs to leak. Their noise and odor are offensive to many people. They sometimes also carry mites which can bite people.

English Sparrows (House Sparrow). These birds are grayish, 3-4 inches long. The male has a prominent black throat, and a small black conical beak. The voice is a non-musical chirp. The egg is creamy white.

The nest is made of loosely-woven grasses, paper, and string. Sparrows prefer openings or hollows for nesting and will use any sort of nesting box, cavity, or opening in buildings.

They produce several broods each year using the same nesting areas over and over.

Pigeons. These birds are 6-10 inches long and vary in colors. They have a fan-shaped tail during take-off and landing, and the head bobs when walking. Their voice is a long, soft coo-oo-o. The eggs are white. They prefer to live and roost on roofs and high ledges.

The nest on ledges is not woven, but made with twigs and often soiled with excrement.

Starlings. The body and wings are gold-flecked, iridescent blue-black. They have large spear-like bills that are yellow or olive.

In flight, they can be recognized by their short square tails and their short triangular wings. The eggs are bluish green.

Control — Shooting may be hazardous in some locations and may not be allowed by some local ordinances. It is a very effective means of killing scattered individuals or small flocks. It is best carried out by no more than a few individuals with low-powered guns who understand what they are doing. Where permissible, shooting with a 22-calibre gun, using # 12 birdshot, is effective.

Chemical control with avicides or other pesticides in certain situations may be the only means of effective control. Pesticides may not be used in a manner inconsistent with the label. Decisions as to the need, type of toxicant used, and manner in which it is used should be made by professionals. Information on current registered uses of specific compounds is available from the manufacturer or retailer. Sources of up-to-date pesticide recommendations include: industry representatives; the Cooperative Extension Service; local health, environmental, and agricultural departments; and technical experts in universities and state and federal agencies.

Poisons may be prohibited or may be too risky to use because of the dangers to humans, pets, or desirable birds. Poison sprays on roosts may be effective but dangerous; label directions must be followed precisely.

Toxicant baits, when eaten by pigeons, starlings, or sparrows, produce distress reactions in some birds, which frighten the rest of the flock away from the area.

Prebaiting is necessary when chemical baits are used, just as when trapping is to be done.

Chemical baits are most effective when used against small flocks and when conditions can be carefully controlled.

Sparrows and Starlings

Associated Problems. Dry, dusty droppings may contain fungus spores which can cause human diseases. Workers cleaning such areas, or involved in hand-capture of birds, should wear approved respirators. A worker should not smoke, eat, or drink anything until after his dusty clothes are removed and he has washed thoroughly.

Ectoparasites such as mites, made homeless when pigeons are removed, may migrate into areas where humans work and live. This problem can be prevented by spraying or dusting nesting or roosting areas as part of the control operations. Any good acaricide can be used if the label directions are followed.

RODENTS AND THEIR CONTROL

Domestic rodents constitute a major food industry pest problem. There are three major domestic rodents in the United States, the house mouse, *Mus musculus*; the Norway (brown or sewer) rat, *Rattus norvegicus*; and the roof (black or ship) rat, *Rattus rattus*. Rats eat almost everything people or livestock use as food. They contaminate much more than they eat, with the result that contaminated food products must be destroyed. Damaged packages must be repaired or replaced. Before you can control rodents, it is important you identify the correct species and know its behavior patterns.

Senses, Agility, and Reactions of Rodents

Touch. Well developed in highly sensitive whiskers (vibrissae) and certain guard (tactile) hairs. Rats and mice prefer to run along walls or between things where they can keep their whiskers in contact with side surfaces.

Vision. Apparently they are color blind, so any distinctive coloring of poison baits does not reduce their acceptance to rats and mice.

Smell. Rodents apparently like the odors of most foods eaten by humans. They are accustomed to the smell of humans, so their odor on baits and traps does not repel them.

Taste. Rats and mice associate sickness caused by poison bait with the bait and not the poison. They prefer fresh food to decayed food.

Hearing. They can locate the source of a noise within 6 inches. Unusual noises cause rodents to attempt to escape.

Balance. A falling rodent always lands on his feet. The roof rat even maintains its balance well while walking on suspended wires.

Reaction to Strange Objects. Rats may avoid a new sound or a strange object in their environment for three or more days, particularly if their associates are alarmed by it. Other objects are readily accepted by them (examples: food, garbage). As rodent population pressures build, the rats frequently exhibit "chain-fright reaction" to disturbances. Mice are more likely to explore new objects, and to be caught in newly set traps.

Climbing. Roof rats and house mice are good climbers, and the Norway rat can climb quite well when necessary.

Jumping and Reaching. Rats can jump nearly 2 feet vertically, 3 feet with a running start; they can jump 4 feet horizontally, and 8 feet from an elevation that is 15 feet above the finish point. Rats can reach upward about 18 inches.

Swimming. Rodents are good swimmers. They are able to swim up through floor drains and toilet-bowl traps.

Recognizing Rat and Mouse Signs. Rats and mice are habitually nocturnal and secretive and are rarely seen during the day except when infestations are heavy. Therefore, it is necessary to interpret signs of their activities properly in order to plan control work. These signs are found in secluded places, such as along walls, under piles of rubbish, and behind or under boxes, boards, and thick vegetation. From the rodent signs, one can tell the species present and whether a rodent infestation is current or old, heavy or light.

Droppings. Fresh droppings of feces are usually moist, soft, shiny, and dark, but in a few days they become dry and hard. Old droppings are dull and grayish and crumble when pressed with a stick.

Runways. Rats habitually use the same runways between food, water, and harborage. Because of the keenly developed sense of touch in their vibrissae (whiskers) and in specialized hairs along the body, rats prefer continual body contact with at least one vertical surface, such as a fence or wall. Rats also follow "odor trails." Outdoors, their runways are narrow pathways of beaten earth swept clear of debris. Indoors, greasy runways are found along walls, steps, and rafters. Undisturbed cobwebs and dust in a runway indicate that it is not in use.

Rubmarks. Along regularly traveled runways, a dark, greasy mark forms from contact by the rodent's body. Fresh marks are soft and will smear if rubbed. As the grease ages, it dries and gathers dust and will flake off when scratched with a fingernail. The rubmarks of the Norway rat are most commonly found along runways near ground or floor level, while those made by the roof rat are most commonly seen overhead as swing marks beneath beams or rafters at the point where they connect to the walls. Mice do not leave detectable rubmarks except when the infestation is heavy.

Burrows. The Norway rat prefers burrows for nesting and harborage; the roof rat burrows only occasionally. Burrows are found in earth banks, along walls, under rubbish or concrete slabs, and in similar places. If a burrow is in use, its entrance will be free of cobwebs and dust. Fresh rubmarks on hard-packed soil at the opening indicate a well established and currently used burrow. The presence of fresh fragments of food or freshly dug earth at the burrow entrances also indicates current use by rats.

Gnawings. The incisor teeth of rats grow 4 to 5 inches a year, so these rodents must do some gnawing each day in order to keep their teeth short enough to use. Rats also gnaw to gain entrance and to obtain food. When gnawings in wood are fresh, they are light colored and show distinct teeth marks. Small chips of wood or other materials indicate recent gnawing. With age, wood gnawings become dark and smooth from weathering and from frequent contact with the rodent's body.

Tracks. Fresh tracks are sharp and distinct, whereas old tracks are covered with dust and are, therefore, less distinct. The tracks of the 5-toed rear paws are more commonly observed than are those of the 4-toed front paws, but both may be present. Smooth tracking patches of any dust material, such as flour or talc, placed along runways are of value in checking for rodent activity. To see tracks in the dust, the inspector should hold a flashlight at an angle that causes the tracks to cast distinct shadows. Tail marks, too, are often visible in dust or tracking patches.

Urine. Dried rodent urine will fluoresce bluish white to yellowish white. Commercial black lights are often used to detect the rodent urine. Fluorescence caused by the use of black light does not guarantee that the substance is rodent urine; numerous items will fluoresce when under a black light, including bleaches found in many detergents and lubricating oils. For positive identification, one uses a Brom Thymol Blue Urease Test. Place the suspected material on Brom Thymol Blue Urease test paper. Moisten with water, cover with a cover glass. If a bluish spot appears after three to five minutes, it is rodent urine.

Rodent Control Procedures

Complete control of rats and mice is essential to every food and feed processing plant and storage facility and must be accomplished to satisfy legal requirements, prevent losses, and meet individual company operating standards. While the degree of emphasis on any single phase of rodent control varies with the building structure, location, and species of rodent involved, an effective control program must start by building rodents out.

Build Rodents OUT

Exclude rodents from plants and warehouses by having every possible opening in outer walls, at floor/wall junctions, and at all exterior doors tight enough to prevent rodent entry, and by installing guards across runways to prevent entry at loading doors. There should be no openings larger than 1/4 inch.

Bait Stations

Good housekeeping and proper storage practices discourage rodents by eliminating their food and harborages. It is important to maintain a clearance of 18 inches between pallets of merchandise and the wall. This clearance allows room behind the stock for proper cleaning and pest control. A stock rotation system, utilizing the first in — first out method, is a necessity in all sound warehousing programs.

After taking every practical measure to build rodents out, and to eliminate their food and harborages, these preventive controls can be supplemented with baiting and trapping. In most cases, only those rodenticides falling within the anticoagulant group can be used in specific areas of food processing facilities. These are available in several forms such as granular, cereal-based bait, paraffinized bait pellets, and bait blocks. Paraffinized bait pellets and bait blocks should be limited to exterior use only. It is not advisable to use canary seed bait inside food plants because of its similarity in appearance to caraway seeds. Thus, anticoagulant baits, to be used inside non-food areas in food plants, should be limited to granular or cereal-based materials.

Unless there is a possibility of rat entry into a plant, liquid baits will be ineffective, since rodents require little water and they can live for many months on a grain diet, obtaining sufficient moisture from their food. The toxic ingredient in all of these baits is one of several anticoagulants, so named because they inhibit the normal coagulation of blood. The use of colored dyes for rodent baits helps prevent accidental human consumption through mistaken identity. Those cereal baits dyed with alkali-fast green appear to have the greatest rodent acceptance.

Proper placement of bait stations is very important. It is necessary to place bait stations around the exterior boundaries of food plants because the purpose in exterior perimeter baiting is to attract and eliminate rodents in the area before they can invade the building. On the outside, bait stations should be positioned approximately every 50-100 feet around the perimeter of the building, which has been cleared of all vegetative matter and trash. Also the perimeter of the property line should be included in the baiting program. Again, the bait stations should be positioned approximately every 50-100 feet around the perimeter.

Bait stations being used around the exterior of the building should be large enough to accommodate more than one rat at a time. Each station should have at least two openings approximately 2 1/2 inches in diameter. The bait stations for exterior use may be constructed of metal or wood, so as to protect the bait from the weather and from disturbance by nontarget animals and children.

If bait stations are used inside plants, they need to be limited to non-food storage areas.

Two inexpensive materials for bait stations, which can be used in non-food storage areas, are water-resistant cardboard and formed plastic. Bait stations should be placed against walls and the adjacent areas kept clean.

When handling any baits, do not smoke, eat, drink, or put your hands near your mouth. After handling baits, wash your hands, using soap and water. As a safety factor, it is suggested that only ready-mixed baits be used.

All rodenticides received and used must be properly labeled. Labels contain directions for safe use, caution statement, and first aid and medical instructions. It is important that you read the label, understand label instructions, and follow label instructions during use. All bait stations and bait handling containers must also be properly labeled.

Store unused rodenticides in a locked area with access restricted to authorized personnel. The locations of all bait stations should be noted so that inspections can be made rapidly and the bait that has been consumed can be quickly replaced. At each inspection, smooth the surface of the granular baits so that new signs of feeding will show readily. Also, examine bait blocks for signs of rodent gnawing. Replace moldy, wet, caked, or insect-infested baits with fresh ones.

Records should be maintained indicating where baits have been disturbed, dead rodents found, droppings or tracks observed, or rodents have been caught in traps.

Traps

Some rats prefer burrows for nesting and harboraging. Burrows are found in earthbanks, in grassy areas, around weeds, under trash, around concrete slabs and railroad tracks, and in similar secluded places.

Reliance entirely upon bait stations for rodent control will not produce the desired results. It is necessary to kill rodents quickly upon entry into a building and, therefore, trapping must be used. The most popular, least expensive, and probably the most effective trap is the wooden 4-way snap trap. An enlarged trigger can be fitted into the wooden trap by inserting a piece of cardboard on the tripping device. This provides a treadle, covering nearly half the trap, which is easily sprung by a rodent traveling from any angle. Different size traps are used to catch mice and rats. To be effective, traps must be placed along walls or other runways with the trigger end abutted to the passage. An ample number of traps should be placed in each area requiring preventive control.

Be sure that the trap is properly set and in place.

Overhead beams, trusses, and ceiling wall junctions should not be overlooked as potential runways. Traps should be set across any obvious runways in overhead areas. On vertical structures, traps can be glued or otherwise fastened across runways.

When a rodent is suspected of being in a particular area, whether inside or out, lightly smooth a dusty material, such as talcum powder, around the suspected area. If rodents are present, you can observe their tracks in the dust. Then cover all possible avenues of escape with traps. Traps can be placed either unbaited or baited. When baiting traps, a variety of baits can be used, such as gum drops, peanut butter, bacon, or a piece of hotdog or cheese. The proper method of applying bait to traps is to place a small amount on the trigger. Too much bait could prevent the trigger from activating properly, plus it looks messy.

Where a variety of food is plentiful, it is often just as effective to use traps without bait on them. The key is to place the trap properly so it is tripped by the rodent as it travels the wall/floor functions. All traps should be checked at least 3 times a week to be sure they are properly set and that dead rodents have been removed.

In order to indicate locations where traps are to be placed, a marking can be painted about the trap.

The automatic Ketch-All trap is especially good in wet areas and where other mouse traps are frequently tripped accidentally. A Ketch-All is a spring-powered box-type trap capable of catching up to 10 or more mice in one setting. These traps must be properly positioned against the wall. The easiest method of disposing of mice caught in a Ketch-All trap is to dunk the entire trap into a bucket of water to drown the mice. The mice can then be disposed of in a covered waste container.

Remember the three fundamentals for effective rodent control:

— build them out by proofing
— good housekeeping and proper storage
— trapping and baiting

Mouse and Rat Facts

Preventing rodents from entering buildings requires some knowledge of their biology and behavior. The following list of facts will help in providing basic information on rats and mice.

— A mouse can squeeze through a 1/4" wide crack under or beside a door. A rat needs 1/2" wide crack to get in.

— Mice live successfully outside or inside buildings. They can live in trash, grass, even in a small hole in the soil. Mice do not construct long, wandering burrow systems like rats do.

Characteristics of Domestic Rodents

	Norway Rat	Roof Rat	House Mouse
Weight	10 - 17 oz.	8 - 12 oz.	1/2 - 3/4 oz.
Total Length: nose to tip of tail	12 3/4 - 18 in.	13 3/4 - 17 3/4 in.	6 - 7 1/2 in.
Head and Body	Blunt muzzle Heavy, thick body 7 - 10 in.	Pointed muzzle Slender body 6 1/2 - 8 in.	Small 2 1/2 - 3 1/2 in.
Tail	Shorter than head plus body Carried with less movement, comparatively, than roof rat Lighter-colored on underside 6 - 8 1/2 in.	Longer than head plus body Generally moving whiplike Uniform coloring top and bottom at all ages and for all subspecies 7 1/2 - 10 in.	Equal to or a little longer than body plus head 3 - 4 in.
Ears	Small, close-set, appear prominent	Half buried in fur, large for size of animal	Large, prominent, stand out from head
Fur	Coarse, generally red-brown to gray-brown	Black to slate gray; tawny above, gray-white below; or tawny above, white to lemon belly	Silky, dusky gray

— A mouse needs only a 3" x 1" hole for a home. A stable, protected place available for only a few days will induce a mouse to build a nest. Rats require a larger, more protected place, stable for several days before nest building.

— Mice are very inquisitive. The average mouse takes only 10 minutes to investigate a new feeder. Rats will wait about 30 hours to explore a new food source.

— A house mouse will eat at 2 or 3 locations, and just nose around 20 others in a 2-hour period (9:00 p.m. — 11 p.m.) in one night. The next night it will completely change the feeding locations, but still nose around those visited the first night. Rats will eat at the same location night after night.

— A mouse may not seek out water in a dry location, but it will drink if water is available.

— Mice are "stay-at-homes" compared to rats. Home territory is about 15 ft. to 30 ft. from an established nest. A rat has a home territory of 150 ft., but may travel 1/2 mile from its nest site.

— Mice can travel in some rail car and truck shipments, particularly in wrapped pallets. Rats have rarely been received in shipments of merchandise.

— The four incisor teeth of rats and mice are as hard as steel. These animals can chew through asphalt, cinder block, most plastics, plaster, sheet aluminum, wood, etc.

— Building materials which will resist the "cutting" attack of rats and mice are: concrete block, brick or tile, 26 gauge or thicker galvanized sheet steel, 1/4" glass, 1/4" mesh, 19-gauge steel wire mesh or hardware cloth, 1/4" 26 gauge perforated metal.

Physical Control

There are four goals for an effective physical control program for rodents:

1) stable nesting sites inside and outside the building must be eliminated;
2) all access holes must be closed;
3) traps, glue boards, bait stations, and all other safe control measures must be used inside and out to control rodents; and
4) a reliable inspection program must be established to prevent rodents from being introduced in delivered merchandise.

A good physical control program would include the following control measures:

— Fill *all* potential nesting holes inside the building.
— Eliminate all entry or nesting holes on the exterior of the building walls by closing holes down to an 1/8" gap under doors; filling holes around pipes, electrical service through walls, around vents and cover drains.
— Remove weeds and grass around outside of building.
— Clean up spilled food as soon as possible.
— Use multi-catch mouse traps inside and outside every entrance leading into the building. They catch mice and small rats outside more easily than inside.
— Use trigger mouse traps where a severe problem exists and manpower is available for twice daily inspection.
— The careful and correct use of ultrasonic devices can be very helpful.

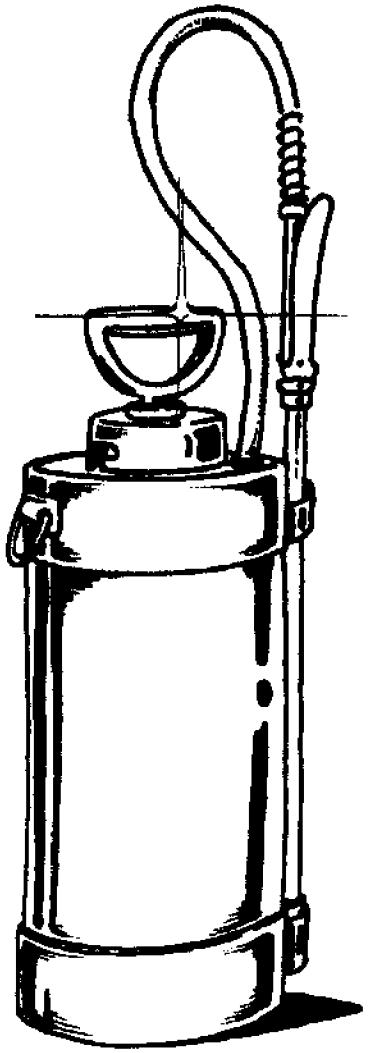
EQUIPMENT

Pest control personnel cannot carry out an effective program without quality equipment and chemicals. The most important pieces of equipment include

- stainless steel, compressed air sprayer,
- mechanical or thermal fogging device (ULV/ULD)
- bulb duster,
- flashlight.

Two especially useful items of equipment are air screens (or air curtains) and insect electrocuting units.

The proper use and maintenance of pest control equipment is an important part of any program.



Compressed Air Sprayer

The one-gallon sprayer is the most important tool for insect control. A stainless-steel sprayer with a multiple-spray nozzle can apply insecticides safely and accurately to insect harborages. Routine maintenance to keep this piece of equipment in proper working order will insure the safe and accurate placement of chemicals in a seafood plant.

Inspection. Periodically inspect the outside and inside of the spray tank for pinholes and stripped threads. Also examine check valve and plunger cup of the pump unit for wear and damage. Inspect the hose for cracks and soft spots, and replace as needed. When replacing the hose, *do not over tighten the female hose fitting or the hose will clog.*

Cleaning. If the sprayer is used daily, it should be cleaned weekly. If used less often, clean it after each use to prevent corrosion and clogging.

To clean the tank, fill it one-fourth full of hot water and detergent. Some manufacturers recommend an ammonia detergent. Scrub the inside and bottom of the tank with a brush to remove any accumulated residues. Replace the pump and shake the tank. Add a few strokes of pressure and flush the hose (remove nozzle and clean separately). Rinse and drain the tank, remove the hose, and store the tank upside down to dry.

Regularly clean residues from the bottom of the pump tube with coarse sandpaper or scouring pad to maintain proper seating of the check valve.

Lubrication. Periodically lubricate the leather plunger cup with about 10 drops of clean oil to keep the pump cylinder moist enough to attain pressure.

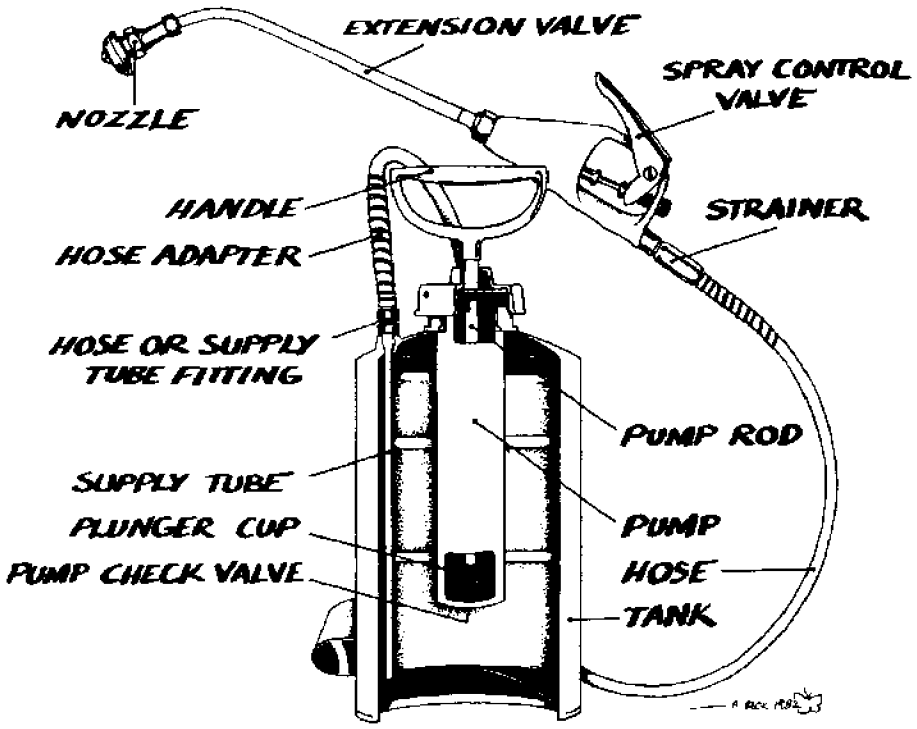
Troubleshooting. Air or liquid leaks around or in the tank opening are caused by a worn tank gasket or loose cap. Leaks in the pump cylinder, causing the cylinder to fill with liquid, are the result of a worn check valve, or dirt residue under the check valve. A tank not getting pressure may have a worn leather cup.

The remedy for a sprayer that will not spray is to clean the strainer and nozzles and flush out the hose. If the hose leaks near the tank, usually washers from the supply tube and hose connector need replacing.

Fogging Devices

Mechanical fogging devices are relatively simple to operate and require little maintenance. The aerosol particles are produced by spinning discs and rotors. In some of the units these discs and rotors need periodic adjustment to keep the size of the droplets small. If they are out of adjustment, the droplet size in the fog will be large and the fog will not travel into cracks and crevices to reach insects.

Examine the pesticide tank for residues, clean tank regularly to prevent clogging. Check the hose to the pesticide tank for dirt, clean regularly.



Bulb Duster

Small bulb dusters can be effective tools for applying insecticide powder into small cracks and crevices. When used properly, these small (4 to 8 oz.), hand-operated dusters can apply a thin layer of dust to insect harborages. Clumps of powder or thick layers of dust should be avoided. A small pebble or bearing in the bulb will aid in breaking up clumps of powder, and will agitate the contents of the duster, thus making it easier to apply a fine layer of dust.

Insect Electrocuting Units

Most insects are attracted to light. Flies in a dark room will move toward a window, moths and other insects will fly to lights at night, and even some cockroaches will fly to lights. Insects are attracted to both visible light and ultraviolet (black) light (light just beyond the violet end of the visible spectrum). Some flies and moths are strongly attracted to ultraviolet light, and this attractancy can be used against them in a control device - an electrocuting unit.

Electrocuting units are designed for either indoor or outdoor use. They are usually aluminized frame construction, with chrome-plated electrical grids and guards, and removable insect-catch traps. Units are available in a variety of sizes and shapes, and are designed to hang from the ceiling, attach to a wall, or stand free. The attractant lamps are usually 40 or 80 watt.

How the units work. Insects attracted to ultraviolet (black) light are lured to the electrocuting unit through the strong attraction of the 40 or 80 watt bulb. In flying toward the light, the insects contact the electric grid in front of the bulb. When contact is made, night and day-flying insects — such as house flies, fruit flies, moths — are electrocuted by the grid charged with high voltage (about 4000 V) and low current (9 milliamps). This charge is harmless to humans should the units be accidentally touched.

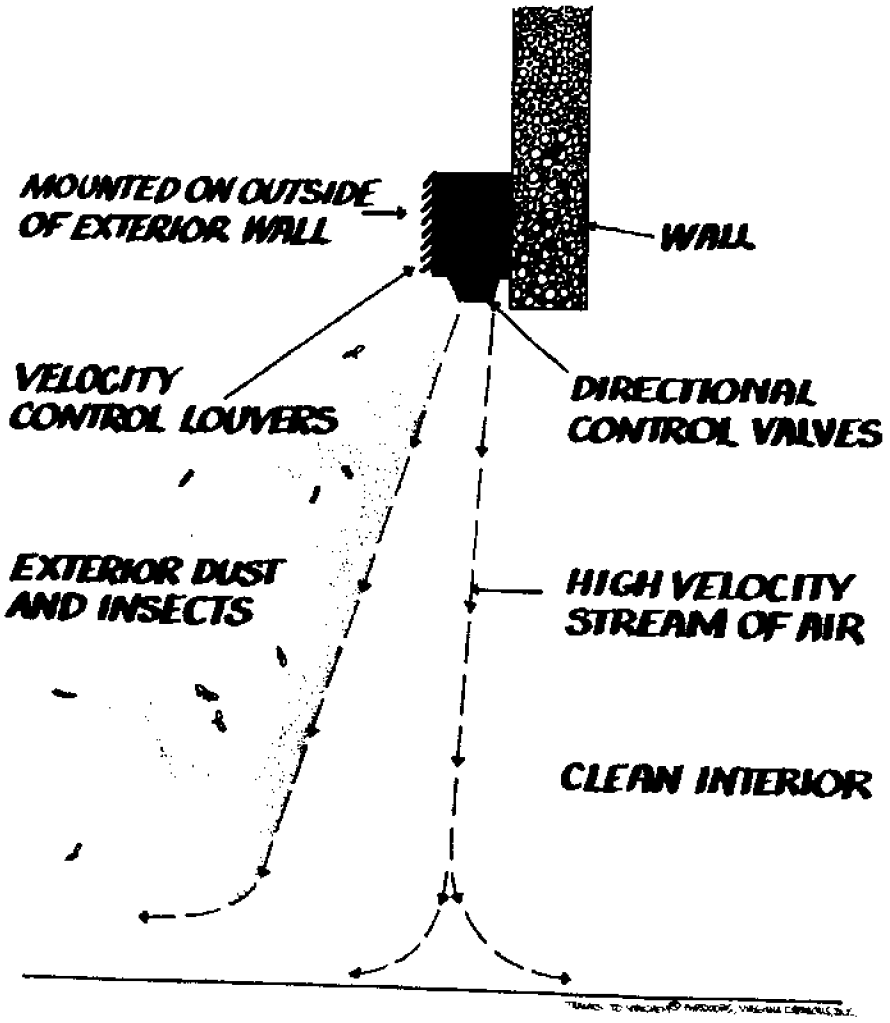
Range. The attractant range of electrocuting units is difficult to measure. Each insect species has a different eye structure with a different range of visual activity, ranging from 2 feet to 90 feet. Effective results with an electrocuting unit depend on the visual range of the insect, and the power factor of the attractant bulb. A 40 to 80 watt bulb will usually perform 3 to 10 times more effectively than a 15 to 40 watt bulb.

Light Traps

Placement. Correct placement is a key factor in the degree of control achieved with electrocuting units. The units should be placed so as to attract and/or intercept the target pests. Moths and other night-flying insects are best controlled with ceiling-mounted units, while house flies are more likely to be intercepted from floor level up to a four to five foot height. Because sunlight or other strong light sources, as well as air currents, affect insect behavior and flight patterns, units should be placed out of drafts and away from strong light.

Air Screens

Air screens (or air curtains) are the most effective method of keeping flies and other flying insects out of food preparation areas. Air screens create an invisible barrier of high velocity air to stop insects from infiltrating food facilities and other clean work areas. To assure maximum efficiency in repelling insects, select a model that fits the door size and can provide adequate air velocity at ground level as well as at the nozzle. Flies may be prevented from entering a doorway at the doorknob level, but walk easily through the door at ground level. To be effective, air screens must be installed on the outside of the doorway, be aimed properly to repel insects, and have adequate velocity at the top and bottom of the doorway. Conventional fans mounted above doors do not provide effective air screens.



An air screen or air curtain.

CALCULATIONS AND MIXING

Directions for mixing pesticides are always given on the pesticide label. Always read the directions before mixing; do not rely on old labels or directions — labels and mixing directions are frequently updated. When mixing a pesticide to spray, it is most important to add the correct amount of chemical to the water. Too little may result in a poor control job, while too much chemical may result in illegal residues, exposure to non-target animals, or unnecessary expense. Read the label and follow the directions to achieve effective control and safe use.

Sometimes it is necessary to prepare large quantities of a pesticide, and the calculations may not be explained on the label. The calculations necessary for large quantities are relatively simple; some examples are presented below.

Calculations

Sometimes you will find directions on how to make a finished spray of a specific percentage, for instance a 1% spray for cockroaches. The pesticide may be formulated as a 57% emulsifiable concentrate (EC). To make a 1% finished spray you would add 1 part of pesticide to 56 parts of water. For example, 1 fluid ounce in 56 fluid ounces (1-3/4 quarts) of water.

When mixing percentages you should remember that 1 gallon of water weighs about 8.3 pounds. Thus, to make a 1% mix of pesticide in 100 gallons of water you must add 8.3 pounds of active ingredient (actual pesticide) of pesticide to 100 gallons of water.

Formula for wettable powder percentage mixing. To figure the amount of wettable powder (WP) to add to get a given percentage of active ingredient in the tank:

$$\frac{\textit{(gallons of spray wanted) x (\% pesticide wanted) x 8.3 (lbs/gal)}}{\textit{(\% active ingredient in pesticide used)}}$$

Formula for emulsifiable concentrate percentage mixing. To figure the amount of emulsifiable concentrate (EC) to add to get a given percentage of active ingredient (actual pesticide) in the tank:

$$\frac{\textit{(gallons of spray wanted) x (\% of pesticide wanted) x 8.3 lbs/gal}}{\textit{(pounds of active ingredient per gallon of concentrate) x 100}}$$

Useful Facts to Remember

- 1 gallon of water weighs about 8.3 pounds
- 1 pound = 16 ounces = 453.6 grams
- 1 pint = 16 fluid ounces = 473 milliliters
- 1 quart = 32 fluid ounces = 946 milliliters

to figure how much 80% WP I need to make 50 gallons of a 3.5% spray:

$$\frac{50\ (\text{gallons wanted}) \times 3.5\ (\%\ \text{wanted}) \times 8.3\ (\text{lb./gallon})}{80\ (\%\ \text{active ingredient})}$$

So

$$50 \times 3.5 \times 8.3 = 1452.53$$

50
×3.5
250
150
175.0
×8.3
5253
14000
145253

then

18.15
80) 1452.53
80
652
640
125
80
453
400

18.2 pounds of the 80% WP

Figuring the amount of wettable powder (WP) to add.

To figure how many gallons of a 25% EC I need to make 100 gallons of a 1% spray.

(25% EC = 2 lbs active ingred. / gallon.)

$$\frac{100\ (\text{gallons wanted}) \times 1\ (\%\ \text{wanted}) \times 8.3\ (\text{pounds/gallon})}{2\ (\text{lbs active}) \times 100}$$

So,

$100 \times 1 \times 8.3 = 830$

divided by

$2 \times 100 = 200$

$$200\overline{)830.00} \quad 4.15$$

$800.$

300

200

1000

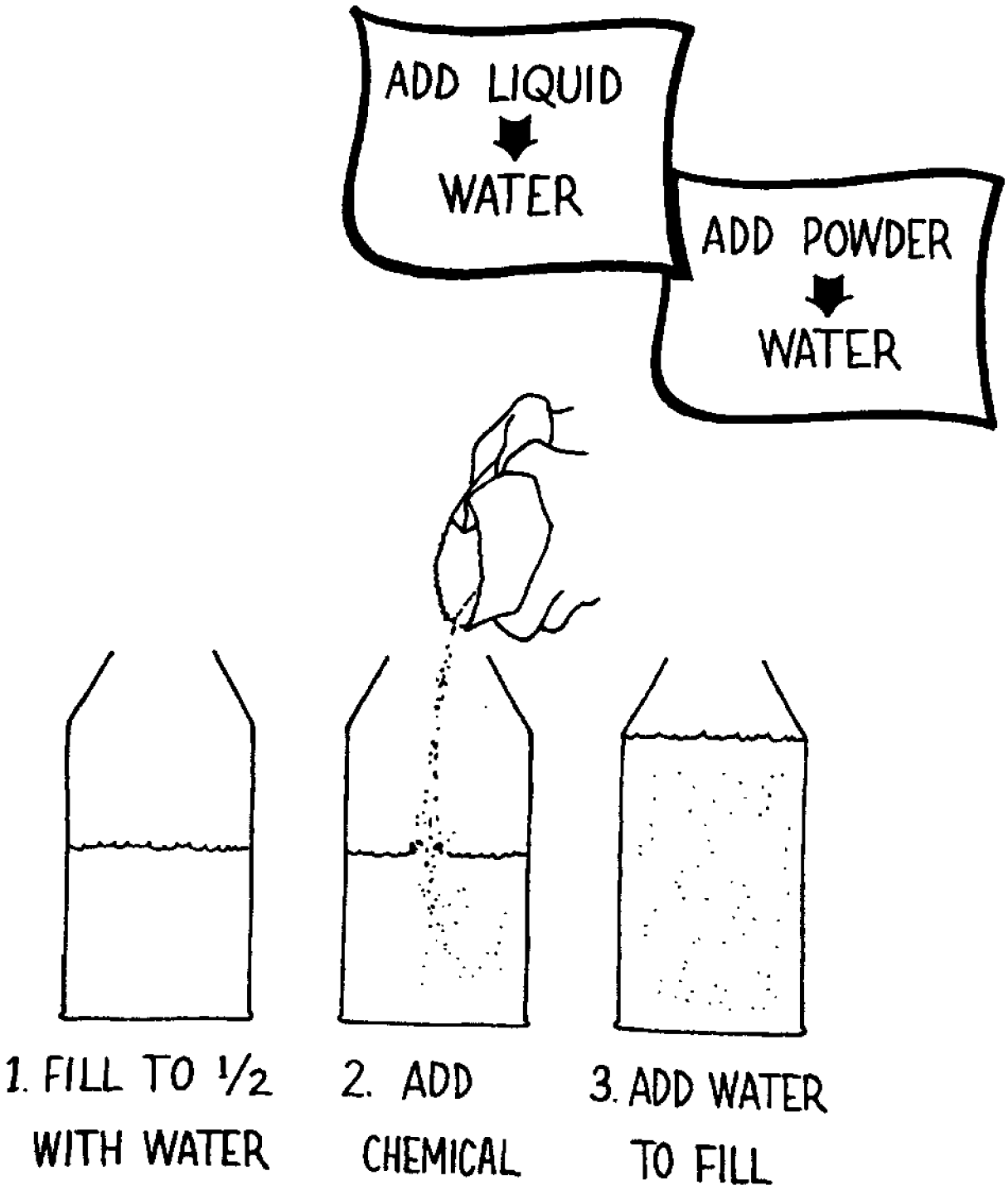
4.15 gallons of 25% EC

Figuring the amount of emulsification concentrate (EC) to add.

Mixing

Most modern pesticides are designed to be mixed with water, then applied to control specific pests. Mixing wettable powders and emulsifiable concentrates requires careful attention to some simple rules:

1) fill spray can or container to 1/2 with water,
2) add the measured amount of pesticide,
3) add the remainder of water to the full mark



PESTICIDE APPLICATION METHODS

Before undertaking insect control with an insecticide near food processing, it is essential to recognize that EPA has established some definitions to assist in the regulation and control of insecticides in food handling establishments. The definitions they use are as follows:

1. **Food** is defined by Section 201 (f) of the Federal Food, Drug, and Cosmetic Act to mean (1) articles used for food or drink for man and animals, (2) chewing gum, and (3) articles used for components of any such article.
2. **A Food Handling Establishment** is an area or place other than a private residence in which food is held, processed, prepared, and/or served.
    a. **Non-Food Areas** of food-handling establishments include garbage rooms, lavatories, floor drains (to sewers), entrances and vestibules, offices, locker rooms, machine rooms, boiler rooms, garages, mop closets, and storage areas (after packing, canning, or bottling).
    b. **Food Areas** of food handling establishments include areas of receiving, serving, storage (dry, cold, frozen, raw), packaging (canning, bottling, wrapping, boxing), preparing (cleaning, slicing, cooking, grinding), edible waste storage, and closed processing systems (mills, dairies, edible oils, syrups).
3. **Non-Residual Insecticides** are those products applied to obtain insecticidal effects only during the time of treatment and are applied either as space treatments or contact treatments.
    a. **Space Treatment** is the dispersal of insecticides into the air by foggers, misters, and aerosol devices for control of flying insects and exposed crawling insects.
    b. **Contact Treatment** is the application of a wet spray for immediate effect.
4. **Residual Insecticides** are those products applied to obtain insecticidal effects lasting several hours or longer and are applied as general, spot, or crack and crevice treatment.
    a. **General Treatment** is application to broad expanses of surface such as walls, floors, ceilings, or as outside treatment.
    b. **Spot Treatment** is application to limited areas on which insects are likely to occur, but which will not be in contact with workers. These areas may be floors, walls, and bases or outsides of equipment. For this purpose, a "spot" will not exceed 2 square feet.
    c. **Crack and Crevice Treatment** is application of small amounts of insecticides into cracks and crevices in which insects hide or through which they may enter the building. Such openings commonly occur in expansion joints, between different elements of construction, and between equipment and floors. These openings lead to voids such as hollow walls, equipment legs and bases, conduits, motor housings, and electrical junctions or switch boxes.

Application Methods for Specific Pests

Cockroaches. These pests are associated with almost all aspects of seafood processing, and are present throughout the year. Cockroach control must be an ongoing program, and includes sanitation along with accurate placement of chemical insecticides.

Cockroaches require food, water, and a hiding place to successfully infest an area. Sanitation can eliminate some of the food and water, and therefore help to control cockroaches. Chemical ***insecticides applied to cockroach hiding places*** can be very effective in controlling cockroach infestations. Chemicals applied along baseboards, or as a general spray or fog are ***not*** effective in controlling cockroaches. Indeed, these "general applications" may promote infestations that are resistant to insecticides and difficult to kill. Chemicals should be placed where cockroaches hide —cracks and crevices, in equipment, behind sinks, etc. — so that they will be forced to come in contact with the insecticide so that the insecticide can kill them.

Chemicals applied to open spaces, exposed to air, light, and heat, can lose their potency in a short period of time. Cockroaches contacting these chemicals may not die because the residue is not potent enough. However, chemicals applied to cracks and crevices, where cockroaches hide, will remain potent longer, and contact more individual cockroaches.

The best ***application method*** for cockroach control is to use a compressed air sprayer with the nozzle set on ***pin stream*** or a nozzle equipped with a special, plastic crack and crevice tip. Use the pin stream or the special tip to direct the chemical into suspected cockroach hiding places. Dust formulations can be effective if applied to dry areas where there is little or no air movement.

Some of the typical places to treat for cockroaches include:

- compressor area of refrigerators and freezers
- drip pan of a "frost free" refrigerator
- electrical boxes
- floor drains
- above drop ceilings
- boxes stored near food or water, especially near refrigerators
- employee locker room and lunch areas
- soft drink machines
- dishwashing machines

Periodically changing the chemical used for cockroach control is ***not*** recommended, unless the effectiveness of the chemical is decreasing. Cockroaches can become resistant to some chemicals when used over a long period of time (and used improperly). Changing chemicals every six months or year may result in resistance to several insecticides, and leave nothing that provides control. Continue to use one chemical; switch to another **only** when it fails to give control.

Flies. Several species of flies can be pests of seafood processing operations, including house flies, fruit flies, and cluster flies. These pests are a seasonal problem; the warm summer and fall weather provide excellent breeding conditions for the larvae. Rarely do house flies and fruit flies breed inside food processing operations. The adults present inside have come in through doors and windows. Fly control must include sanitation outside buildings, and the exclusion of adult flies. Chemical control of flies is limited to fogging or space sprays. Mechanical and electrical devices are effective.

There have been several improvements on the traditional "fly paper" strips for fly control. Devices that attract adult flies to a sticky surface are effective, and have been approved for food handling areas.

The placement of electrocuting devices can influence how effectively they control indoor flies. Consider these facts about house flies and black light (= looks blue) electrocuting units:

- 3-day old male house flies are most attracted to black lights
- 5 to 6-day old male house flies are not attracted to black lights
- the older (in days) and the more hungry male and female are, the more they are attracted to black lights that are about 1 foot off the floor

When positioning black light electrocuting units, consider placing at least one unit 1 to 2 ft. off the floor, and other units 6-8 ft. off the floor. This arrangement should provide maximum coverage.

There are some chemical methods of controlling flies inside and outside seafood processing plants. Granular baits (commonly called "fly grits") can be

scattered around garbage and refuse areas. Adult flies are attracted to these baits and are killed. Some of these baits are effective even in damp or wet conditions, and some are not effective in wet areas. Chemical control inside buildings is usually limited to aerosol sprays, fogging, or ULV/ULD treatment. Each of these methods disperses chemicals into the air to kill various flying insects, including flies. The chemicals most commonly used include pyrethrins, resmethrin. In general, these chemicals provide quick knockdown and kill, but provide no residual control. Fogging and ULV/ULD treatment methods must be used when production is stopped. All exposed surfaces must be cleaned before being exposed to food or preparation materials.

Flour beetles, mealworms, silverfish, etc. There are a variety of pests that must be treated on a need basis. Treatment with insecticides should follow a thorough **inspection** and **clean up** program. Flour beetles and mealworms do not move far from the site of infestation. The use of a heavy-duty vacuum cleaner can be very effective in controlling these pests. Direct the hose into cracks and crevices to pick up loose flour and other food particles. A strong vacuum will pick up infested food and insects.

Chemical control of these insects requires the use of a residual insecticide in cracks and crevices, and spot application. Apply the insecticide in an area where the insects are most often seen. Repeat application on a 10 to 15 day schedule.

COMMONLY USED INSECTICIDES AND RODENTICIDES

Insecticides

A variety of insecticides are registered for use in and around food processing operations. They differ in residual activity and in where (crack and crevice, food storage, food preparation areas) they can be applied.

BAYGON (propoxur) — A carbamate insecticide characterized by fast knockdown, long residual and flushing effect. Particularly effective against insects such as cockroaches and flies where rapid knockdown and residual properties are important.

BAYTEX (fenthion) — An organophosphate insecticide characterized by long residual activity. For general use as a residual insecticide in crack and crevice application indoors and general treatment outdoors for a wide variety of pests.

BORIC ACID — A common household or medicine cabinet item that can be used as an insecticide, primarily for the control of cockroaches. Applied as a dry, light dust, boric acid has residual activity. It can be used as a crack and crevice treatment, but must be kept dry to be effective.

CYGON (dimethoate) — An organophosphate insecticide used as a residual spray for controlling houseflies and other insects. For treating the outside of buildings.

DIAZINON (diazinon) — An organophosphate insecticide used extensively in controlling a variety of insects, particularly cockroaches. It is characterized by a long residual effect and broad-spectrum control of insects indoors and outdoors. Available in dust, emulsifiable concentrate, and encapsulated formulations.

DURSBAN (chlorpyrifos) — An organophosphate insecticide effective in controlling a variety of insects. Particularly effective against insects such as cockroaches where residual activity is necessary. Can be used in crack and crevice treatment of food areas and general treatment outdoors.

DDVP (dichlorvos) — An organophosphate insecticide. A contact and stomach poison, it acts also as a fumigant. Can be applied as a crack and crevice, and as a general spray, to both food and non-food areas. Effective against a wide range of insects. Available formulations include: emulsifiable concentrations, wettable powder, oil-base concentrations, aerosols, resin strips, and baits.

DRIONE — A combination of amorphous silica gel and pyrethrins synergized with piperonyl butoxide. This insecticide dust can be applied as a crack and crevice treatment to food and non-food areas. It is effective against a wide variety of pests.

FICAM (bendiocarb) — A carbamate insecticide. A contact insecticide, it has no fumigant action at normal working temperatures, and is characterized as a non-repellent/non-flushing, odorless, and non-staining insecticide. Effective against a wide range of insects, it can be applied as a crack and crevice and general spray to both food and non-food areas. Available formulations include a wettable powder and a dust

KNOX OUT (diazinon) — An organophosphate insecticide in which diazinon is enclosed in tiny capsules (or beads) of thin plastic material to control release of the chemical and extend the residual life. It is effective against a wide range of insects.

KILLMASTER (chlorpyrifos) — An organophosphate insecticide in which chlorpyrifos is held in an organic solvent or binder and released a little at a time at the top surface of the coating. Applications can be made as a paint-on, spot, or crack and crevice treatment.

MALATHION (malathion) — An organophosphate insecticide, characterized by its broad spectrum control and its low toxicity to mammals. Cythion (a brand name for malathion) is a low-odor product manufactured by a patented process, and is recommended for indoor use. Malathion can be applied as a crack and crevice and general spray to food areas and non-food areas.

ORTHENE (acephate) — An organophosphate insecticide. Spot treatments can be applied to food and non-food areas, but not while food is being prepared. Effective against resistant strains of German cockroaches.

PYRENONE — This combination of pyrethrins and piperonyl butoxide is used in ratios ranging from 5:1 to 20:1 by weight, as pressurized sprays, solutions, wettable powders. It is effective against a variety of insects.

PYRETHRINS — A botanical insecticide, the flowers of a chrysanthemum plant are the source of the active principle of this insecticide. Pyrethrins are characterized by a flushing action and rapid knockdown of a wide range of insects. However, there is little residual activity. Pyrethrins have a low order of toxicity to mammals, and can be applied as a spray to both food areas and non-food areas.

PYRETHROIDS — Pyrethroids are synthetic pyrethrin-like compounds produced to duplicate the activity of natural pyrethrins.

RESMETHRIN — A synthetic pyrethroid insecticide, characterized by flushing activity and a moderate residual life. It can be applied to non-food areas and outside areas.

SAFROTIN (propetemphos) — An organophosphate insecticide, effective against cockroaches, ants, silverfish, and other insect pests. It may be used only in non-food areas of food-handling establishments.

SEVIN (carbaryl) — A carbamate insecticide, characterized by short residual activity. This insecticide can be applied only to non-food areas and outside areas.

Rodenticides

Rodenticides differ widely in their chemical nature. They also differ widely in the hazard they present under practical conditions.

WARFARIN — An anticoagulant that is effective in controlling rats and mice. It is odorless and tasteless and effective in very low dosages. Action is not rapid; usually about a week is required before a reduction in the rodent population is effected. Warfarin has found ready acceptance where rodents do not tend to become bait shy after once tasting the material. They continue to consume it until its anti-clotting properties have produced death through internal bleeding.

FUMARIN — An anticoagulant that is effective in controlling rats and mice. It is recommended as a multiple dose rat poison. Three to five consecutive feedings, daily or not over two days apart, cause death by internal bleeding.

RED SQUILL — A rodenticide made from plant material. It is specific for rats and non-toxic to other warm-blooded animals when used in recommended dosages. The specific toxicity to rats is due to their inability to vomit; the product induces vomiting in other animals. Red Squill is mixed in baits.

DIPHACIN, PIVAL — Anticoagulants that have the same anticoagulant properties as Warfarin, and have replaced Warfarin where rodent avoidance behavior (bait shyness) has made it ineffective. Sold as baits, they must be ingested for several consecutive days before they become effective.

TALON — An anticoagulant that is effective against a variety of pest rodents. It is effective against rodents which are resistant to conventional anticoagulants. Only a single feeding is necessary for rodent death to occur.

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