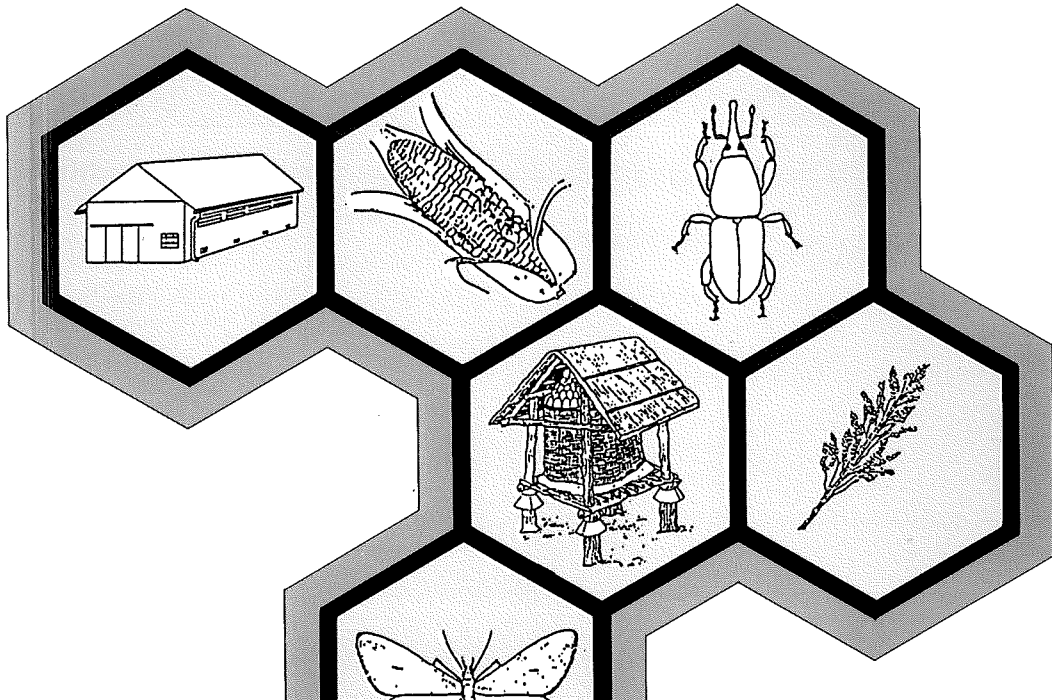




MANUAL ON THE PREVENTION OF POST-HARVEST GRAIN LOSSES

J. GWINNER R. HARNISCH O. MÜCK

PREVENTION OF POST-HARVEST GRAIN LOSSES



7.8 Further Literature

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Scotti, G. 1978. Les insectes et les acariens des céréales stockées, AFNOR/ITCF, Paris, 238 pp.

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8 Pest Control Using Insecticides

In pest control there are two kinds of treatment which complement each other: preventive and curative measures.

The preventive measures, which consist above all in suitable storage buildings and the careful observance of all hygiene measures, form the basis of all pest control. Without these, any other measures are bound to be of no effect and uneconomic. Preventive pest control is described in detail in Section 5.2; Section 3.3 also contains relevant information.

The most important curative measure in stored-product pest control is the use of chemicals. A distinction is made between insecticides and fumigants (see Chapter 9).

The parts of this chapter concerned with the application of insecticides apply only to central storage. Section 4.4.3 deals with the application of insecticides in small farm storage. The remaining parts of this chapter are equally relevant for both types of storage.

8.1 Insecticides

8.1.1 General Principles

- Insecticides are always used as a supplement to hygiene measures and can never substitute them.
- A high level of infestation makes control with insecticides more difficult. Care should therefore be taken to perform control of any pest infestation in time.

- The choice of the correct products is made by taking into account the following aspects:
 - Insect species present (sensitivity, resistance)
 - Method of storage (bags, bulk)
 - Climatic conditions (decomposition of the products by moisture and high temperatures)
 - Stored commodity
 - Legal restrictions (Use only approved products. If the country has no legislation, refer to the FAO/WHO code of conduct)
 - Availability and price
- Insecticides must not be stored for longer than the indicated shelf life. Buy only quantities which will certainly be used within one storage season (also see Section 8.4) in order to avoid overstorage and decomposition of the product.
- Prevent the development of resistance by changing the active ingredient annually.
- The safety regulations for handling of insecticides must always be followed. Attention must be paid to any warning signs on packages which draw the user's attention to particular dangers in the use of the insecticide concerned. (see also Section 8.4.2).

8.1.2 Scope of Application in Central Storage

Good store management and high standards of hygiene are the basic requirements for successful pest control.

In central storage, i.e. in warehouses, the following scopes of application for insecticides apply:

- Surface treatment of empty warehouses

This is an efficient curative control method to clean up warehouses before intake of new stocks. Attention must be paid to the use of suitable insecticide formulations. All insecticides are more persistent on smooth, concrete surfaces than on rough and alkaline (white washed) ones.

- Surface treatment of bag stacks

Bags stacks should be protected from becoming infested by means of treatment with long-term contact insecticides. However, up to now this method is unsatisfactory as the pesticides decompose too rapidly. This particularly applies to EC formulations, and somewhat less to WP formulations. Pyrethroids form an exception, being considerably more persistent.

It is more effective to treat the individual layers of bags during stacking. Anyway, this is regarded as being less practicable.

An alternative to surface treatment consists in covering the stack of bags with light cotton or nylon sheets which provide a barrier to crawling or flying insects. Impregnation of the sheets with repellent substances (e.g. neem oil, see Section 4.3.2.2) increases the

effectivity. However, control of the stack becomes more difficult and the costs must be considered.

- Space treatment of warehouses

Space treatment is best done by fogging. It requires a tightly sealable store. This method is particularly suited for curative control of flying pests.

Evaporation strips hanging up in a well closed store serve for preventive moth control.

All treatments in stores must be followed up in order to check the success.

8.1.3 Formulations

The insecticides sold on the market by manufacturers are referred to as **commercial products**. They contain one or more **active ingredients** as well as **carriers** and **special additives**. The latter improve the adhesion of the active ingredient on the surface treated and the stability, acts as synergist or simply colour the insecticide as a warning agent.

Depending on the formulation, the commercial products either have to be mixed with a liquid, which is generally water, to form a **spraying mixture** or are sold ready for use.

The most common formulations are listed below:
(Abbreviations are in accordance with the FAO specifications)

- **Dust formulations (DP)** to be mixed with the stored produce or for surface treatment. They contain between 0.1 and 5 % active ingredient and are ready-for-use. They are mainly applied in small farm storage.

- **Emulsifiable concentrates (EC)** for surface treatment. They contain between 1 and 100 % active ingredient and are mixed with water, giving a stable emulsion, and primarily used in warehouses.

- **Wettable powders (WP)** for surface treatment. They contain between 10 and 50 % active ingredient. They are mixed with water, giving instable suspensions, which have to be constantly stirred as the powder will otherwise settle.

- **Flowable concentrates (SC)** for surface treatment. These are liquid concentrates which are relatively stable and similar to the EC formulations. They are not yet commonly used in storage pest control.

- **Hot fogging concentrates (HN)**. The so called 'FOG'-formulations contain up to 100 % active ingredient. They are either ready-for-use or must be diluted with diesel or kerosene. Some heat resistant EC formulations can also be used for fogging.

- **Aerosols as evaporation strips (VP)** or in the form of **smoke tins (FD)** or **smoke cartridges (FP)** for use against moths. They are ready-for use. Smoke cartridges are also used to a certain extent in small farm and village storage. They have a good knock-down effect on adult insects.

- ULV formulations (UL) for surface treatment. They are ready-for-use and applied with special ULV applicators. Their utilisation in storage is very limited.

8.1.4 Requirements for Insecticides in Storage

While there is a great number of products against agricultural pests there are only few products available which meet the special requirements of pest control in storage.

Insecticides for stored product protection should meet the following requirements. None of the existing products will entirely fulfill all of them:

- Good effect against most storage pests (broad spectrum effect)
- Long persistence
- Stable under various climatic conditions
- Low toxicity to warm-blooded animals
- No residue left in stored produce
- No influence on the smell or taste of the stored produce
- No chemical reaction with the ingredients of the stored produce (proteins, fats etc.)
- Simple to use
- Low price

It is part of the user's responsibility to select the correct insecticide meeting most of his specific requirements. The following information is intended as an aid for the right choice.

8.1.5 Groups of Active Ingredients in Storage Pest Control

There are two main groups of active ingredients used in stored product protection, organophosphorous compounds and pyrethroids:

- Organophosphorus compounds

They are effective against most storage pests, although less against the Bostrychidae (Rhizopertha dominica, Prostephanus truncatus, Dinoderus spp.). Some of these compounds are sensitive to hot and moist conditions.

<u>Active Ingredient:</u>	<u>Trade Name:</u>
Pirimiphos-methyl	("Actellic")
Fenitrothion	("Folithion", "Sumithion")
Chlorpyrifos-methyl	("Reldan")
Methacrifos	("Damfin")
Dichlorvos (DDVP)	("Nuvan", "Vapona")
Iodofenphos	("Nuvanol")
Tetrachlorvinphos	("Gardona")
Phoxim	("Baythion")
Etrimfos	("Satisfar")
Bromophos	("Nexion")
Malathion	("Malathion", "Malagrain" etc.)

- Pyrethroids

They are very effective against Bostrychidae, though less against other species of beetles. They also provide a good moth control.

The most common are:

Deltamethrin	("K-Othrin")
Permethrin	("Permethrin")
Fenvalerate	("Sumicidin")
Cyfluthrin	("Baythroid")

- Combined products

Combined products also known as 'cocktails' containing an organophosphorus compound and a pyrethroid have been used as broadspectrum insecticides for some years. However, up to date, no official registration has been submitted worldwide (1990).

Pirimiphos-methyl + Permethrin	("Actellic Super")
Pirimiphos-methyl + Deltamethrin	("K-Othrine Combi")
Fenitrothion + Cyfluthrin	("Baythroid Combi")
Fenitrothion + Fenvalerate	("Sumicombi")

- Other groups of active ingredients

Chlorinated hydrocarbons which were used for a long time in storage pest control are today no longer admissible due to their high persistence and health hazard.

In the group of Carbamates, Carbaryl ("Sevin") is used to a limited degree in storage pest control. It is quite effective against Rhizopertha dominica.

8.1.6 Choice of Insecticide with Respect of the Species and the Properties of the Surfaces to be Treated

- In the case of infestation with beetles other than Bostrychidae organophosphorus compounds should be applied.

- Where Bostrychidae predominate (Rhizopertha dominica, Prostephanus truncatus, Dinoderus spp.) pyrethroids are recommended.

- In the case of mixed infestation with Bostrychidae and other species of beetles, a combined insecticide may be used provided this is permitted by local regulations. Otherwise an organophosphorus insecticide and a pyrethroid may be applied alternately.

- Against moths, the organophosphate Dichlorvos (DDVP) gives good control. The most effective application is by fogging, otherwise by surface treatment.

- For the treatment of whitewashed walls (rapid decomposition of most insecticides under alkaline conditions), Iodofenphos and Tetrachlorvinphos are the most favourable.

The following applies in general for sprayed insecticides:

- Their effect is better
 - on clean than on dirty surfaces
 - on smooth than on rough surfaces
- The persistence is better
 - on woods and metals than on concrete or alkaline paint
 - with WP formulations than with EC formulations

The table on the following pages provides a summary of the most commonly used insecticides in storage pest control and their properties, as well as notes on their application.

Grain Protectants and their Properties
(ways of application and dosage rates)

Active ingredient	Toxicity LD 50 (mg/kg)	Maximum residue limits(1) ppm	Admixture with cereals(2) ppm	Surface treatment(3) stores/silos/bags (concentration rate)	Fog-solution 5% in stores	Remarks:
Organophosphorous compounds:						
Bromophos	1600	10	10	0.2% (empty stores)	Fog-solution 5% (1-2 l/1000m ³)	Similar to Malathion but more potent to some species. It is weak against <i>Rhizopertha dominica</i> and in moth control. Has a relatively high rate of degradation under warm and humid conditions. Is stable on concrete and therefore useful for structural treatments of warehouses and silos
Chlorpyrifos-methyl	3000	10	10	0.5 - 1%		Insecticide with contact, stomach and vapour action. Has a moderate persistence/stability and controls a wide spectrum of beetles, except <i>Rhizopertha dominica</i> , weevils and moths.
Dichlorvos	55	2	2	0.25%	dilute with diesel up to solution (1-2 l/1000m ³) ↓ strip/50m ²	Often referred to as DDVP. Short-term insecticide with a high vapour pressure and strong 'knock down' effect. Is very active against most stored product pests; especially against larval stages within the grain (high penetrating effect) and against moths. Short residual stability.
Etrinfos	1800	10	10	0.5 - 0.75%		Acts as a contact and stomach poison on most stored-product pests. It appears to be fairly stable on grain.
Fenitrothion	500	10	10	0.5%		Has a broad-spectrum effect against all species, though it is not fully effective against <i>Rhizopertha dominica</i> . Good stability for 9 to 12 months. Suitable for use under traditional storage conditions as dilute dust.
Iodofenphos	2100	no recom.	-	1 - 2%		It has a wide range effect against stored product pests, though less effective against <i>Rhizopertha dominica</i> and <i>Trogoderma granarium</i> . Often used for pest control on cement surfaces in warehouses as it shows good stability under alkaline conditions. Persistence lower than that of Fenitrothion.
Malathion	2100	8	8	2%		Widely used for over 20 years what has led to a marked resistency of stored product pests worldwide. It has a weaker effect than many of the other organophosphorous insecticides. Susceptible to warm and humid conditions (degradation).
Methactrifos	680	10	10	0.5%	Fog-solution 5% (1 l/1000m ³)	Compound acts as contact, vapour and stomach poison against all important storage pests and its larval stages within the grain. Effective against major Malathion-resistant insects. Has a pronounced 'knock-down' effect and does not show a particular weakness against <i>Rhizopertha dominica</i> as many other organophosphorous insecticides. It degrades significantly at high temperature and humidity.
Phoxim	1975	no recom.	-	0.2% (empty stores)	Fog-solution 5% (1-2 l/1000m ³)	Broad spectrum of activity with stomach and contact effects. Short term insecticide with 'knock-down' effect. Shows cross-resistance to Malathion-resistant insects. Today mainly used for structural treatments (walls) in empty warehouses and concrete silos.

Active ingredient	Toxicity LD 50 (mg/kg)	Maximum residue limits(1) ppm	Admixture with cereals(2) ppm	Surface treatment(3) stores/silos/bags (concentration rate)	Space treatment in stores	Remarks:
Pirimiphos-methyl	2050	10	10	0.5%	dilute with diesel up to a 1-2 l/1000m ³ (1-2 l/1000m ³)	Fast acting wide range insecticide with contact and vapour action. Has long lasting effect on a wide range of stored insects. It is not sufficiently effective against <u>Rhizopertha dominica</u> . Approximately equal in effect to Fenitrothion and Chlorpyrifos-methyl but appears more potent to Malathion-resistant strains.
Tetrachlorvinphos	4000	no recom.	15	1 - 2%		Has shown to be effective against many species of stored product pests. Good persistence on alkaline surfaces what has justified its use for structural treatments of warehouses and concrete silos to control grain insects.

Pyrethroids:

Cyfluthrin	500	2 (4)	1-2	0.4 - 0.8%		Provides reliable protection of stored products against crawling and flying insects. Controls insect strains resistant to organophosphorus compounds. Has long lasting activity also on alkaline surfaces.
Deltamethrin	135	2	2	0.1 - 0.15%	dilute with diesel up to 1% solution (1 l/1000m ³)	One of the most potent a.i. of the synthetic pyrethroids. Effective at a low dosage (1-2 ppm) against the whole spectrum of storage pests, in particular against all species of the family of Bostrichidae (e.g. <u>Rhizopertha dominica</u>). It shows a delayed but long lasting action.

Fenvalerate	450	5	5	0.5%		Has shown to be effective at low doses against <u>Rhizopertha dominica</u> . Effective as a contact and stomach poison with adequate stability at higher doses against most species.
Permethrin	4000	2	2	0.25%		Although effective against a wide range of stored product pests, it is particularly effective against <u>Rhizopertha dominica</u> and <u>Prostephanus truncatus</u> , but shows especially weakness against <u>Tribolium</u> spp. Most valuable when used in combination with organophosphorous insecticides. Long stability.

Product combinations:

Pirimiphos-methyl + Deltamethrin	5/0.5					Product combinations are not yet registered as grain protectants; have gained importance with the outbreak of <u>Prostephanus truncatus</u> in Africa
Pirimiphos-methyl + Permethrin	8/1.5					
Fenitrothion + Fenvalerate	5/1.0					
Fenitrothion + Cyfluthrin	8/0.2					

(1) Recommendations for Cereals grains (FAO/WHO)

(2) 10 ppm is equivalent to 1 kg of a 1% dust/t grain

(3) application rate for spraying liquids:

smooth surfaces/plastic bags = 3-5 l/100m²

rough surfaces/jute bags = 5-8 l/100m²

(4) in Australia

8.1.7 Toxicity of Insecticides

Insecticides are not only poisonous to the target organisms but also in varying degrees to humans, animals and the environment.

The "LD₅₀" of an insecticide is used to assess its potential danger. LD stands for lethal dose. The LD₅₀ is stated in milligrammes (mg) of the relevant insecticide per kilogramme body weight of test animals, usually rats. The LD₅₀ is the concentration of an insecticide which will lead to the death of 50 % of a group of test animals after a single application.

As the toxicity of an insecticide also varies according to the kind of contact with the body, a distinction is made between LD₅₀ (oral) and LD₅₀ (dermal).

Insecticides are classified according to their toxicity:

Classification	LD ₅₀ for rats (mg/kg body weight)	
	oral	dermal
Extremely hazardous	under 25	under 50
Highly hazardous	25 - 200	50 - 400
Moderately hazardous	200 - 2000	400 - 2000
Slightly hazardous	over 2000	over 2000

The LD₅₀ applies to the pure active ingredient of an insecticide although the concentration as well as the type of formulation and application also play a role.

Insecticides with a high LD₅₀ have a relatively low acute toxicity. This does not affect, however, possible long-term (chronic) dangers to health.

In order to estimate the long-term effects of an insecticide, the "no effect dose" is used. This refers to the highest concentration of an active ingredient in mg/kg body weight of test animals administered daily in long-term tests without causing any symptoms of poisoning. This value is divided by a safety factor, usually of 100. The result is the maximum amount of an active ingredient (in mg/kg body weight) which a person can consume daily without any damage to his health according to the present state of knowledge. This value is called the ADI (acceptable daily intake). Regrettably, adequate data are still lacking today in many respects, particularly as far as the combined effect of a number of chemicals is concerned.

8.1.8. Residues

Contamination with insecticide residues takes place first and foremost by eating contaminated produce. Insecticides and their decomposition products can still be found as residues in the produce treated for a fairly long period. If the insecticide concerned has a high acute toxicity, immediate illness may result (see Section 8.4.3).

Active ingredients which are chemically very stable and thus decompose slowly (i.e. which have a high persistence) may have a long term effect. Even with lower acute toxicity they may lead to chronic poisoning as a result of their accumulation, particularly in fatty tissue. This is the case, for example, with DDT and other chlorinated

hydrocarbons. Regrettably, these are still used in stored product pest control, even though they are no longer officially permitted in most countries.

"Maximum Residue Limits" (MRL) have been laid down for all insecticides to protect consumers. MRL refer to the relevant foodstuff. As a large amount of the insecticide is decomposed in processing, higher residue limits are permitted in primary products (e.g. raw grain) than in processed products (e.g. flour). It is assumed that people eating foods containing insecticide residues not exceeding the MRL will not reach the amount stated in the ADI value (see Section 8.1.7).

As it may occur that produce treated, e.g. grain, will be eaten soon after treatment, the amount of insecticide applied must not exceed the admissible maximum residue limits. Attention is paid to this requirement in the recommendations of the FAO/WHO Joint Committee and in national legislations.

In order to keep the intake of insecticides as low as possible, the following measures should be taken:

- Only use active ingredients and formulations which are officially approved for use in stored product pest control!
- Exactly observe the recommended application rates!
- Avoid any unnecessary insecticide treatment!
- Do not treat the produce shortly before it is sold or eaten!

8.1.9 Resistance

Resistance means that the target pests are no longer controlled by the recommended application rate of an insecticide.

Resistance develops as a result of a selection process. In a pest population there are always individuals which react less sensitively than the majority to any insecticide treatment. They have the chance of surviving and of reproducing. They pass on their insensibility to the next generation. Thus, over a period of time, a process of selection of resistant insects takes place.

Insect species with a high rate of reproduction (short generation periods, large number of offspring) build up resistance more rapidly than others. The climate in the tropics and the resulting short generation periods are particularly favourable to the development of resistance.

The process of resistance development is speeded up, if:

- the same active ingredient is used over a long period
- the insecticide is underdosed
- the insecticide is partly degraded due to overstorage
- the active ingredient is unevenly distributed
- insecticide applications are performed frequently
- bad hygiene conditions exist

An insect population may become resistant to two different insecticides, even if they have only been treated with one of them. This phenomenon is called **cross resistance** and may even occur if the two insecticides belong to two different chemical groups.

When insects show resistance against different active ingredients as well as against different groups of insecticides **multi-resistance** appears.

A distinction is made between various forms of resistance:

- **Physiological resistance:** the insects have the ability to neutralize the active ingredient in their body before it can take toxic effect.
- **Morphological resistance:** the insects have adapted their physical structure, e.g. wax layer or hairs to avoid penetration of the insecticide into the insect's body.
- **Behavioural resistance:** the insects actively avoid coming into contact with the insecticide.

The following **measures** should be taken to prevent resistance:

- Change the active ingredient regularly (once a year)!
- Use insecticides only under perfect hygiene conditions!
- Ensure that dosage and application are correct!
- Do not use insecticides unless necessary!

Increasing the amount of insecticide is no solution as it promotes further resistance. This approach is also uneconomical and not permitted because of legal stipulations of maximum residue limits.

Note: As a result of the intensive application of Malathion in recent years, resistance to this insecticide has developed worldwide. It is therefore no longer possible to generally recommend it for pest control in storage. Attention should be paid to the fact, that first resistances against Pirimiphos-methyl have already appeared in countries, where it is applied frequently.

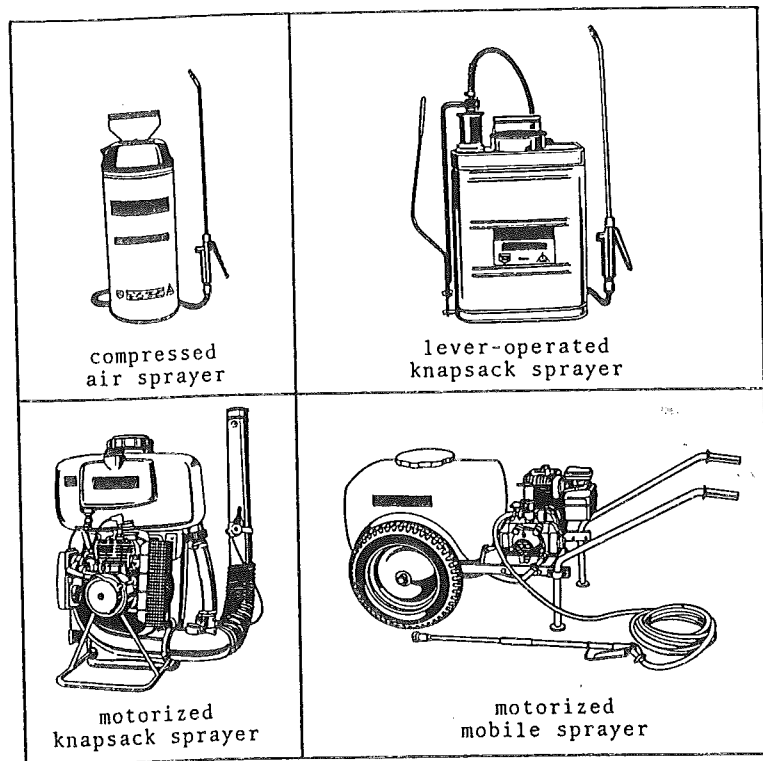
8.2 Application Techniques

8.2.1 Surface Treatment Using Sprays

Sprays for storage pest control are prepared of EC- and WP-formulations (see Section 8.1.3). They are used for surface treatment of both storage rooms and stacks of bags. They may also be used to spray produce during its transportation on conveyor belts into silos.

8.2.1.1 Sprayers

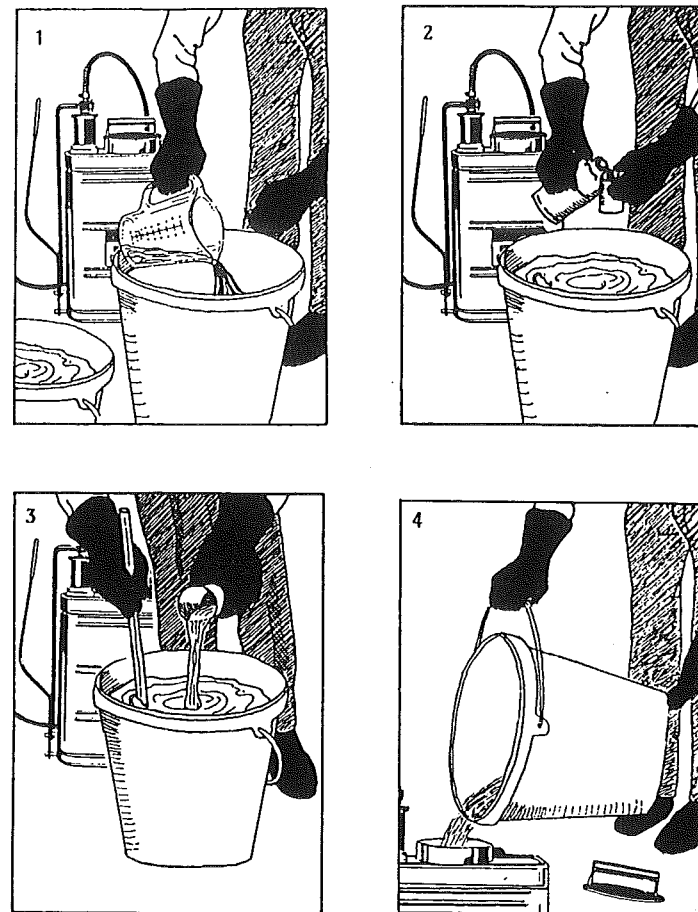
Depending on the height and size of the area being treated, manually operated or motor-driven knapsack or mobile pump sprayers with a capacity of between 10 and 100 litres are used. The latter are particularly recommendable for the treatment of the roof area in large stores. Illustrations of some of the most common models are shown below:



The operating instructions must be carefully observed when using the sprayers in order to avoid any incorrect treatment, health damage or damage to the sprayers. Regular care and maintenance of the sprayers is a matter of course. Thorough cleaning after use is particularly necessary.

8.2.1.2 Preparing the Spraying Liquid

The spraying liquid should always be prepared in a bucket and not directly in the sprayer. This ensures a thorough mixing.



For the preparation of EC formulations pour the required amount of water in a bucket (1), add the calculated amount of insecticide with a measuring cup (2) and thoroughly mix using a stick (3). The mixture should then be filled into the sprayer through the filter located on the insecticide

tank (4) in order to avoid the clogging of the nozzle by dirt.

EC liquids for spraying are stable mixtures (emulsions) which do not separate even after longer periods.

For the preparation of WP formulations weigh the necessary amount, mix it to a thick paste with a little water and then dilute by slowly adding the remaining water. Stir thoroughly with a stick.

WP mixtures for spraying are instable suspensions and must be continually stirred while being applied to avoid the powder settling on the bottom of the spray tank.

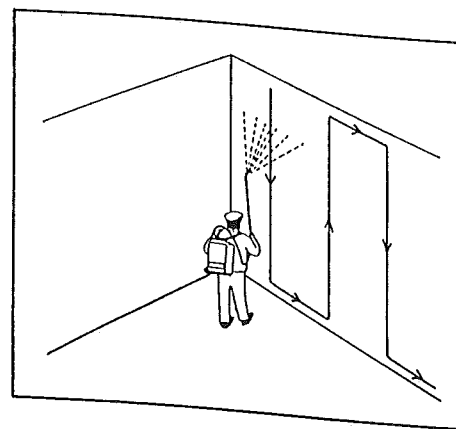
8.2.1.3 Application of the Spray

Treatment should start immediately after the mixture is ready. If any liquid is left in the sprayer for a while, it should be mixed again before being applied.

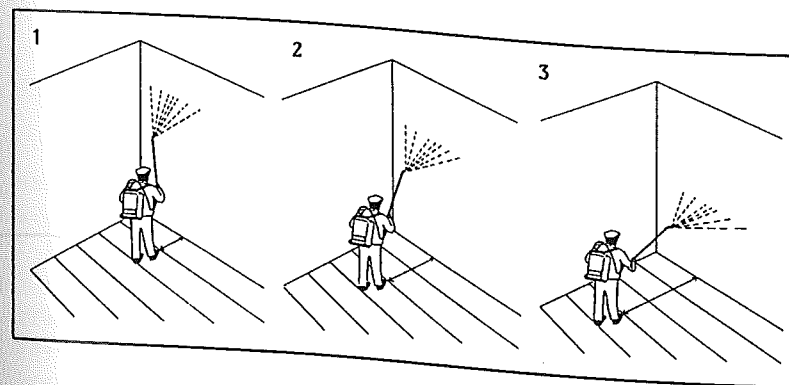
It is important that the amount calculated and prepared for the area being treated (see Section 8.3.2.1) is applied evenly. This requires some experience on the part of the user.

In case of remaining or not sufficient spraying liquid quicker or slower operation should be performed the next time in order to treat the intended area.

When treating surfaces it is important to proceed systematically. On walls, even distribution is achieved by proceeding like shown in the following illustration:



In doing so, markers such as joints, beams or patches should be used as orientation points to avoid leaving any spaces or treating other parts twice. The standing distance from the wall should be chosen so that the spray covers the wall with the smallest possible droplets. This means in practice that it is necessary to stand closer to the wall when treating the upper parts and further away when treating the bottom:



Standing too far away from the wall will mean that the insecticide spray only partly reaches the surface of the wall.

Standing too near to the wall means that a large amount of insecticide will be concentrated on a small area, causing the liquid to run down the wall.

Both of these faults must definitely be avoided.

The roof can be best treated from the bag stacks if no motor operated pump sprayer is available.

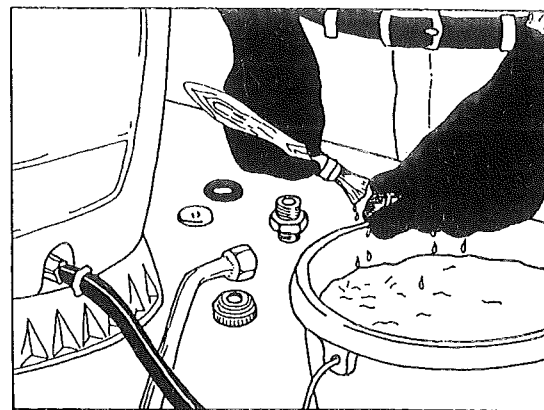
When treating bag stacks, the upper surface should be treated first, followed by the sides. Particular attention should be paid to the spaces between the bags in order to prevent untreated places.

The area underneath the pallets should be sprayed as far as the range of the sprayer being used permits.

The floor of a store is treated last working from the back of the store towards the doors.

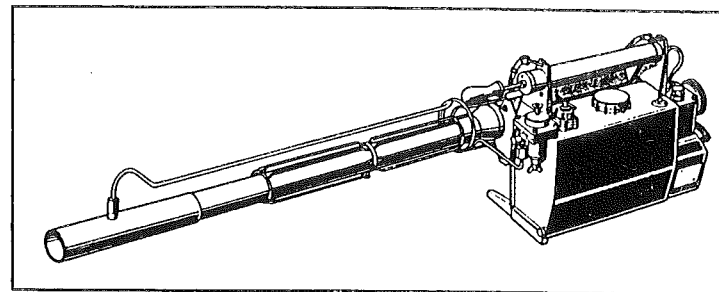
Any remaining spray can be used for areas of particular risk, such as edges and gaps or empty pallets where insects may hide.

After treatment, the sprayer must be rinsed immediately using clean water. Special care should be given to the nozzle.



8.2.2 Fogging

Fogging is performed using FOG (HN) formulations which are ready-for-use or where suitable (heat resistant) commercial products are mixed with diesel oil and applied using a thermal fogger. This method is particularly suited for dealing with flying pests (moths).

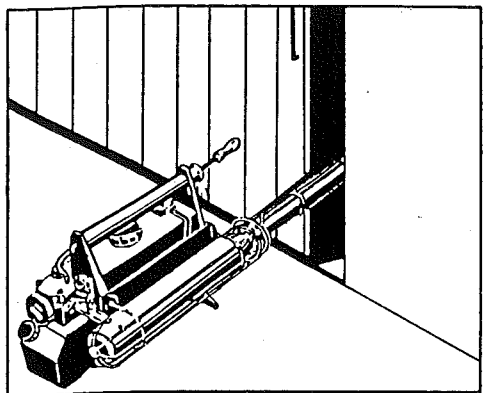


FOG formulations do not penetrate the stored produce. Therefore, fogging is of no use against infestation with beetles or larvae.

It is advisable to repeat fogging after about a fortnight in order to deal with any moths which have hatched in the meantime. Anyway, the necessity of this procedure has to be checked.

The basic requirement for the success of fogging is that the active ingredient acts for at least 12 hours. This means that the store must be adequately sealed. If the fog is able to escape through holes, gaps, ventilation openings, doors etc. the treatment will not be very effective.

Application is simple. The FOG formulation has to be filled into the (insecticide!) tank of the fogger. Place the machine in the ajar door of the store and start it.



Switch off any electric lights in the store before treatment as explosion might occur. Keep attention that the tube of the fogging machine is not too close to the bag stack as fire is possible.

When fogging stops remove the machine and lock the door. Remember to put up warning signs!

In very large halls, it is advisable to enter the store with the fogger, switch it on and slowly move backwards to the exit in front of the cloud of fog. Wear a mask!

It is advisable to fog during the weekend when nobody is working. After treatment, ventilate the store well for several hours before entering.

Commercial smoke cartridges may be used if no thermal fogger is available.

8.3 Calculating the Dosage of Insecticides in Stored Product Pest Control

Great care should be paid in calculating the amount of insecticide to be used, because:

if the dosage is too low, it means:

- lack of efficient control
- waste of money
- promotion of resistance

if the dosage is too high, it means:

- danger to users and consumers
- uneconomic usage

Only the correct dosage guarantees optimum pest control whilst also keeping all risks to a minimum (see Sections 8.1.5 and 8.1.6).

The details as to the recommended application rates and to the active ingredient content are to be found on the label of the container in which the insecticide is sold.

Stored produce which is to be treated directly must be weighed.

Surface areas to be treated must be measured and calculated.

For organizations with a number of stores, it is advisable to introduce standardized stack sizes and issue technical instructions for treatments. These must include the following details on making up spray mixtures:

- Amount of water per standardized stack (in litres)
- Specification and amount of insecticide per standardized stack (in ml for EC formulations and g for WP formulations)

This simplifies carrying out treatments and avoids wrong dosages being made.

8.3.1 Calculating the Dosage for Surface Treatment Using Dust Formulations

- Recommended application rates given in g/m² (= g commercial product/m² surface area)

Details required for calculation:

- surface area to be treated (in m²)
- recommended application rate of insecticide (in g/m²)

The calculated surface area to be treated (in m²) is multiplied by the recommended application rate of the insecticide.

Example:

A stack of bags has a surface area of 120 m². It is to be treated with a 5 % dust formulation. The recommended application rate is 10 g/m².

$$10 \text{ g/m}^2 \times 120 \text{ m}^2 = \underline{1200 \text{ g}}$$

of the 5 % dust formulation is thus required to treat the stack.

8.3.2 Calculating the Dosage for Surface Treatment Using EC and WP Formulations

Two questions have to be answered in order to calculate the dosage for EC and WP formulations:

- 1. How much spray mixture is required to treat the surface area?
- 2. How much insecticide is required for the correct amount of spray mixture?

8.3.2.1 Amount of Spray Mixture for Surface Treatments

Details for calculation:

- surface area to be treated (in m²)
- recommended application rate of spray mixture (in 1/100 m²)

The following basic principles apply:

- The smoother the surface, the less spray mixture will be required.

The following amounts are recommended for surface treatments of:

smooth walls:	3 - 5 l/100 m ²
rough walls:	6 - 8 l/100 m ²
jute bags:	8 - 10 l/100 m ²
plastic bags:	3 - 5 l/100 m ²

To calculate the required amount of spray mixture, the recommended application rate is multiplied by the actual surface area to be treated.

Example:

A stack of jute bags has a surface area of 160 m². The recommended application rate is 8 l/100 m².

8 l/100 m² x 160 m² = 12.8 l of spray mixture is thus required to treat the stack.

8.3.2.2 Calculating the Amount of Insecticide Required for the Spray Mixture

- Recommended application rate given in ml/l (EC) or g/l (WP) (= ml or g of commercial product/l of spray mixture)

Details for calculation:

- amount of spray mixture (in l)
- recommended application rate of insecticide (in ml/l for EC or g/l for WP formulations)

The recommended application rate of the insecticide is multiplied by the amount of spray mixture calculated.

Example:

12.8 l of spray mixture is required to treat a stack of bags

a) It is to be treated with an EC formulation with 50 % active ingredient.

The recommended application rate is 20 ml/l.

$$20 \text{ ml/l} \times 12.8 \text{ l} = \underline{256 \text{ ml}}$$

of the EC formulation is thus required.

b) It is to be treated with a WP formulation with 40 % active ingredient.

The recommended application rate is 30 g/l.

$$30 \text{ g/l} \times 12.8 \text{ l} = \underline{384 \text{ g}}$$

of the WP formulation is thus required.

- Recommended application rate of insecticide given in % (= % of active ingredient in spray mixture)

Details for calculation:

- Amount of spray mixture required (in l)
- Active ingredient content of the insecticide (in %)
- Recommended application rate of the insecticide (in %)

In this case, the amount of insecticide required can be seen from the % table (annex 2) by means of the concentration of active ingredient in the commercial product and the recommended rate of the active ingredient in the spray mixture. The amounts of insecticide listed are in ml/l for EC and g/l of spray mixture for WP formulations.

The dosage can be calculated in four steps with the aid of the % table:

- The top row shows various application rates in %.

Find the correct column for the amount stated!

- The left column shows various concentrations of active ingredients in insecticides in %.

Find the correct row for the concentration of the active ingredient stated on the label of the insecticide used!

- Find the intersection of the chosen row and column! The figure listed there is the amount of EC or WP formulation in ml or g required for 1 litre of spray mixture.

- Calculate the amount of insecticide to make the actual amount of spray mixture required!

Example:

12.8 litres of spray mixture are required.

A 50 EC insecticide is to be used (concentration of active ingredient = 50 %).

The recommended application rate is 0.25 % (concentration of active ingredient in the spraying mixture)

The point where the 50 % row crosses the 0.25 % column shows the amount required for 1 litre of spray mixture: 5 ml of the EC 50 formulation.

$$5 \text{ ml/l} \times 12.8 \text{ l} = \underline{64 \text{ ml}}$$

of the insecticide are thus required for 12.8 litres of spray mixture.

The increase in volume of the spray mixture resulting from adding the insecticide to the water can be disregarded.

Calculations of WP formulations are made as for EC formulations.

8.3.3 Calculating the Dosage for Fogging

The dosage of a fogging concentrate depends on the volume of the free space in the store. It is thus necessary to first determine the total volume of the store and deduct the volume of the stacks from this figure.

Recommended application rates of ready-to-use fog formulations are generally stated in ml/100 m³ volume.

Example:

A store which is 40 m long, 15 m wide and 8 m high contains 10 stacks of bags of the same size, all measuring 5 m x 5 m x 4 m.

Infestation with moths is to be dealt with using Dichlorvos, a ready-to-use commercial fog formulation.

The recommended application rate is 100 ml/100 m³.

Calculation of the volume of empty space in the store:

Store: 40 m x 15 m x 8 m = 4800 m³

Stacks: 5 m x 5 m x 4 m = 100 m³ x 10 = 1000 m³

Free space : 4800 m³ - 1000 m³ = 3800 m³

100 ml/100 m³ x 3800 m³ = 3800 ml = 3.8 l

of the fog formulation are thus required.

8.4 Precautionary Measures

Insecticides constitute greater or lesser dangers to humans and to all other living organisms. In order to minimize the risk of damage being caused, precautionary measures must be strictly adhered to when dealing with insecticides. Even apparently inconsequential violations of safety regulations may have serious results, many of which will not be immediately recognizable.

8.4.1 Storing Insecticides

When storing insecticides, it is imperative:

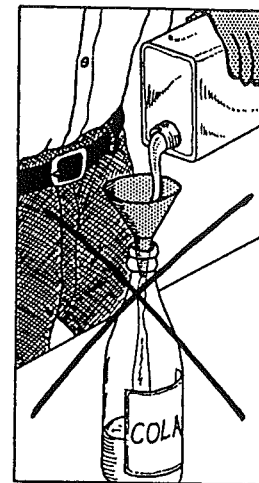
- that any danger to humans, animals or the environment be excluded
- that the insecticides remain effective as long as possible

The following points must therefore be observed:

- Keep insecticides locked away so that no unauthorized persons have access to them! For small amounts, a poison cabinet in a well-ventilated room will suffice; a pesticide store will be necessary for larger amounts.



- Store insecticides away from other commodities and never in offices or other rooms where people often spend time!
- Store insecticides only in their original packaging in order to prevent any possibility of confusion! Never fill insecticides into empty bottles or tins!



- Store insecticides in cool, dry and shadowed places!
- Note the shelf life stated on the insecticide packs and avoid storing them beyond these dates as they will degrade and lose their effectivity!

Purchase only amounts which can be expected to be used up in a single storage period. Additionally this allows to change active ingredients regularly in order to prevent the development of resistance.

The 'first in - first out!' rule must always apply to insecticides.

Any insecticides stored for longer than the prescribed period should certainly be checked as to their effectivity.

8.4.2 Handling Insecticides

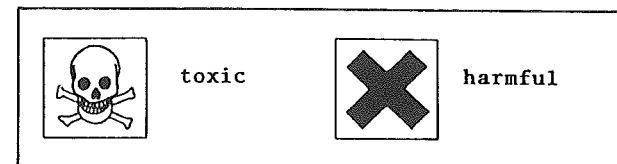
When treating produce with insecticides, it is particularly important that the user is protected. Due to the great responsibility connected to this activity, treatment must only be performed by people who are sufficiently familiar with techniques and possible dangers. When less-qualified personnel apply insecticides, they must be instructed and supervised by a qualified technician.

The following rules must be observed:

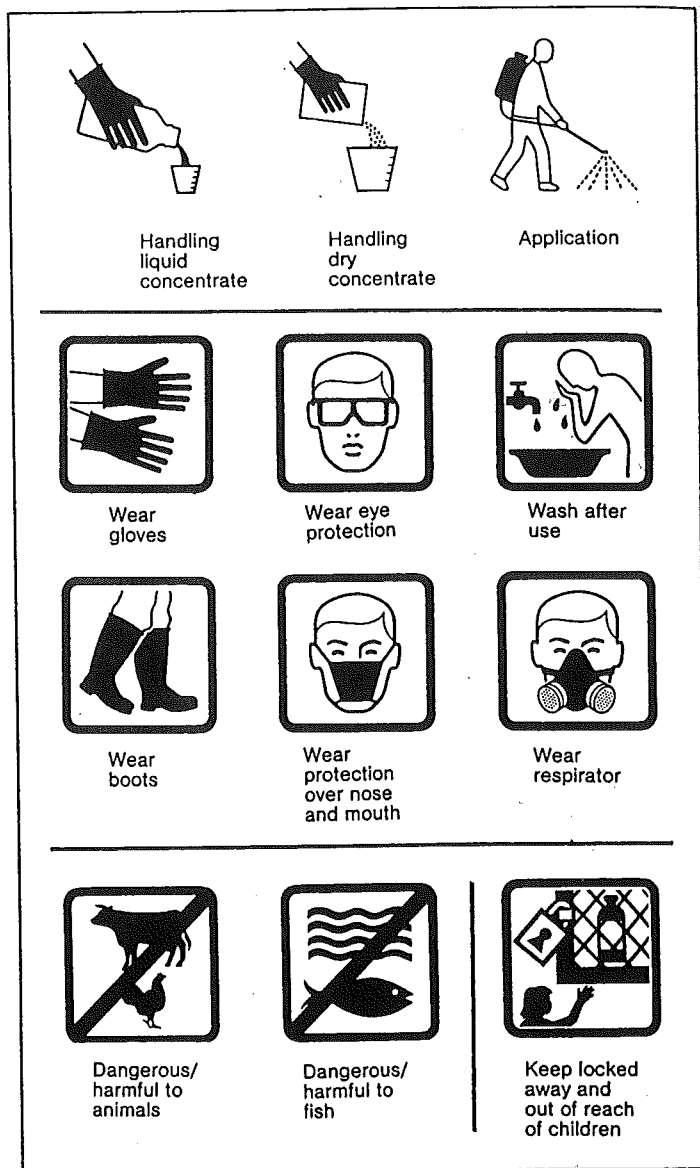
- Always read the label and follow the manufacturer's instructions!



- Pay attention to the warning signs on the packaging and take them seriously! Highly toxic products bear the "skull and crossbones" symbol. Less toxic ones bear a cross:



Simple graphic designs without words (pictograms) have been devised to communicate key safety informations to people of varied levels of literacy. Their meaning is shown on the next page.



- Preplan for emergencies: inform a nearby doctor about chemicals used, be aware of first aid measures and always have plenty of soap and water and medical charcoal at hand!

- Check that the machines used for applying the insecticides are in good conditions (dusters, sprayers, fogging machines)!

- Mix spraying liquids in the open air, not in the store!

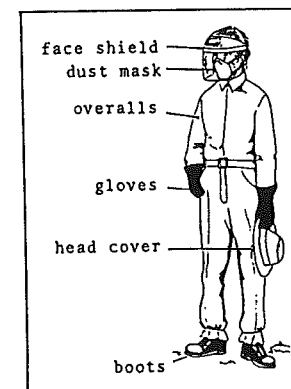
- Avoid any contact with the insecticides!

- Do not inhale any insecticide fumes!

- Never use your hands to mix insecticides! Always use a clean stick!

- Never use your mouth to blow into blocked nozzles!

- Always wear protective clothing when mixing and applying insecticides!

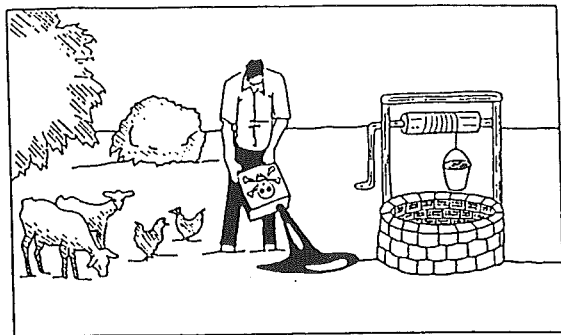


Protective clothing consists of:

- Overall (made of light cotton material in the tropics) or trousers and long-sleeved shirt
 - Hat (preferably with a rim)
 - Respirator or a face shield with a fine dust filter
 - Rubber gloves
 - Wellington boots or firm leather footwear (no sandals)
- Do not drink, eat or smoke when working with insecticides!

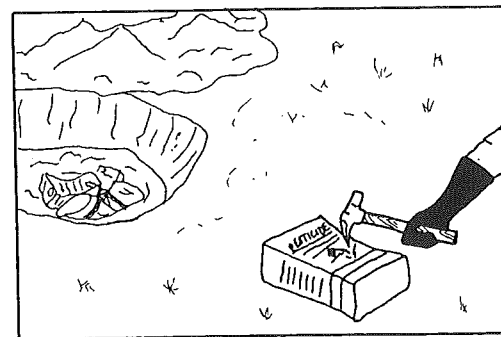
Do not drink any alcohol either directly before or directly after handling insecticides, as this accelerates the body's intake of toxic substances.

- Use buckets solely for mixing insecticides and never for any other purpose, not even if they have been thoroughly cleaned!
- Never spill any left-over spray mixture!



Only mix up as much spraying liquid as required in accordance with the calculated dosage. Small left-over amounts of the mixture can always be used for places in the store which are particularly endangered or for treating empty pallets.

- Dispose of all empty insecticide packages! They still contain traces of the insecticide even after being thoroughly cleaned.

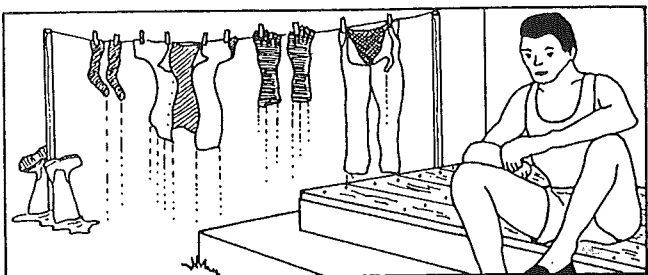


The safest way of disposing is by destroying them (crushing cans, cutting up plastic containers, breaking bottles). Bury them in waste land, far away from wells, settlements or cultivated areas.

It is not advisable to burn them, as very dangerous toxic gases may be produced on doing so.

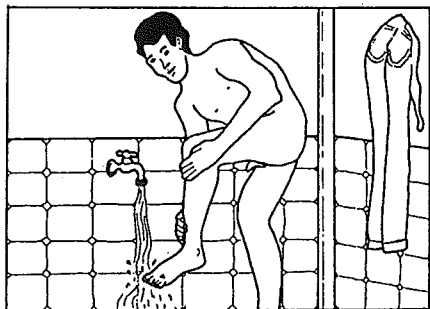
- Thoroughly clean all material and machines used! Rinse spraying equipment, buckets, measuring cups, etc. using plenty of water.

- Wash protective clothing with sufficient soap (or washing powder) and water! Wash separately from other clothes!



Take care that wells or other water sources do not become contaminated when you wash your clothes!

- Take a shower or wash thoroughly after using insecticides for treatment:



Always put on clean clothes after washing!

- If necessary, fix warning signs (e.g. after fogging) and lock buildings which have been treated to prevent any danger to other persons!

8.4.3 Poisoning and First Aid

If insecticides are used correctly, poisoning is not likely to occur. Most accidents are due to carelessness and disregarding rules and regulations.

Contamination with insecticide will take place:

- by swallowing (oral contamination)
- by absorption through the skin (dermal contamination)
- by inhaling the fumes of insecticides (respiratory contamination).

In addition, insecticides may directly enter the bloodstream through open wounds.

A distinction is made between two types of poisoning:

- Acute poisoning, when symptoms can be seen after absorbing the insecticide a single time.
- Chronic poisoning, when symptoms do only become apparent after absorbing the insecticide a number of times. Chronic poisoning may not be detected in some cases until years later.

Depending on the type of contamination, the toxicity, the amount absorbed, the type of insecticide formulation and the constitution of the person affected, the following symptoms may appear in varying degrees:

Degree of poisoning:

mild	moderate	severe (can lead to death)
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Dermal contamination:

irritation, perspiration, headache, nausea, dizziness, fatigue, weakness	excessive perspiration, rapid pulse, fatigue, nervous distress, slurred speech, confusion	convulsions, loss of consciousness, loss of pulse, respiratory failure
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Contamination of the eyes:

irritation, watering	blurred vision, widened or narrowed pupils of the eyes
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Ingestion:

diarrhoea, perspiration, loss of appetite, irritated mouth and throat	nausea, vomiting, stomach cramps, extreme salivation, trembling and twitching of muscles	convulsions, respiratory failure, loss of consciousness, loss of pulse
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Inhalation:

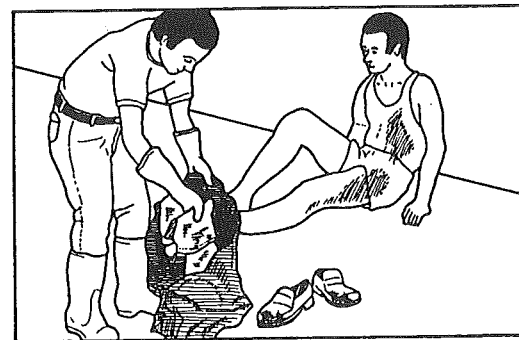
coughing	chest pain, difficulty in breathing	respiratory failure, convulsions, loss of consciousness, loss of pulse
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Should any of these symptoms occur, even slightly, first-aid treatment should be given immediately and the person concerned should be taken to the nearest doctor as soon as possible.

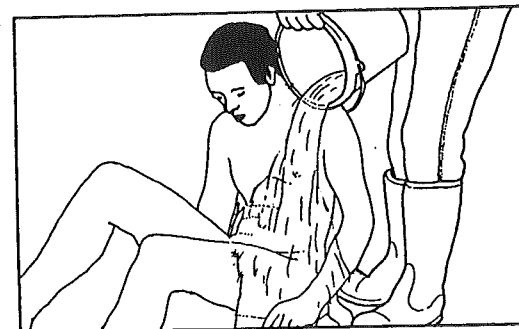
The following first-aid measures should be carried out without any delay in the case of poisoning:

- In case of skin contact:

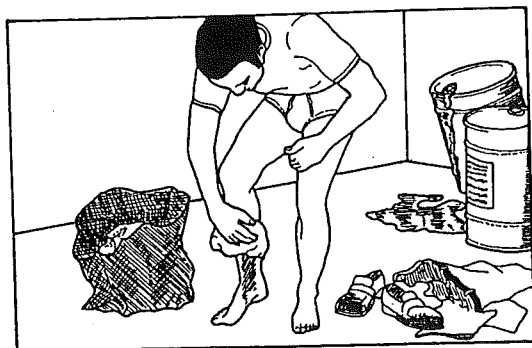
- Remove any contaminated clothing!



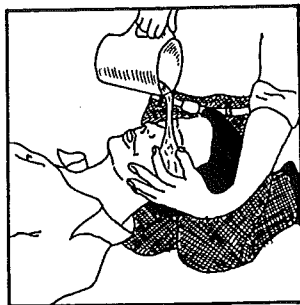
- Wash the affected part of the body with plenty of soap and water!



- Should there be no water immediately available, wipe the insecticide off using a cloth and look for water!



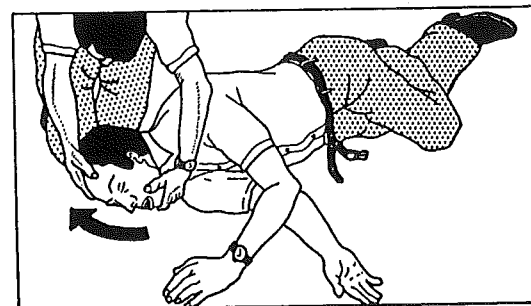
- If the insecticide has come into contact with the person's eyes, rinse under running water for 10 - 15 minutes!



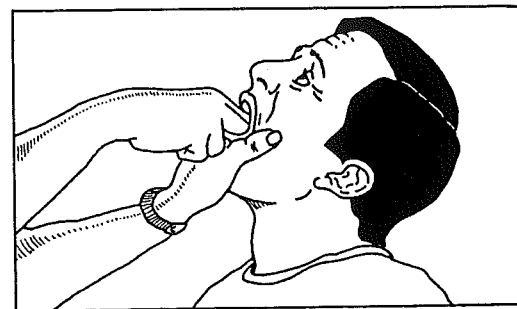
- In case of inhalation or swallowing:

- Put the person affected in a shady place, open any tight clothing and lay him in a comfortable position until there is a possibility of taking him to a doctor!

- If the person affected is unconscious, lay him on his side and take care that he is able to breathe freely (clear the respiration tract if necessary)!



- Make any affected person who is not unconscious vomit (by putting his fingers down his throat or giving him salt-water to drink (1 teaspoon of salt in a glass of water) in order to remove any toxic substances still in his stomach!



- Apart from water and, if available, activated carbon, do not give the affected person anything to eat or to drink! Water will dilute any toxic substances ingested (important for caustic substances) and activated carbon will absorb most toxic substances.

Never offer affected persons eggs, milk, alcohol, etc.! All of these substances accelerate the body's intake of toxic substances.

- In every case of poisoning or suspicion of poisoning, visit a doctor, even if the symptoms are not present! Symptoms often do not appear until several hours later, and important time may be lost for treatment.
- Take the packaging or the label of the insecticide with you in order to provide the doctor with all necessary details!

8.5 Equipment

Equipment for the use of insecticides includes:

- Application equipment (dusters, sprayers, fogging machines)
- Buckets
- Measuring cups (1 - 2 litre, 100 ml)
- Insecticide scales
- Stirring stick
- Tape measure
- Approved insecticide
- Clean water
- Protective clothing, consisting of:
 - light overall
 - headwear
 - respirator or face shield with dust mask
 - rubber gloves
 - boots

8.6 Further Literature

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