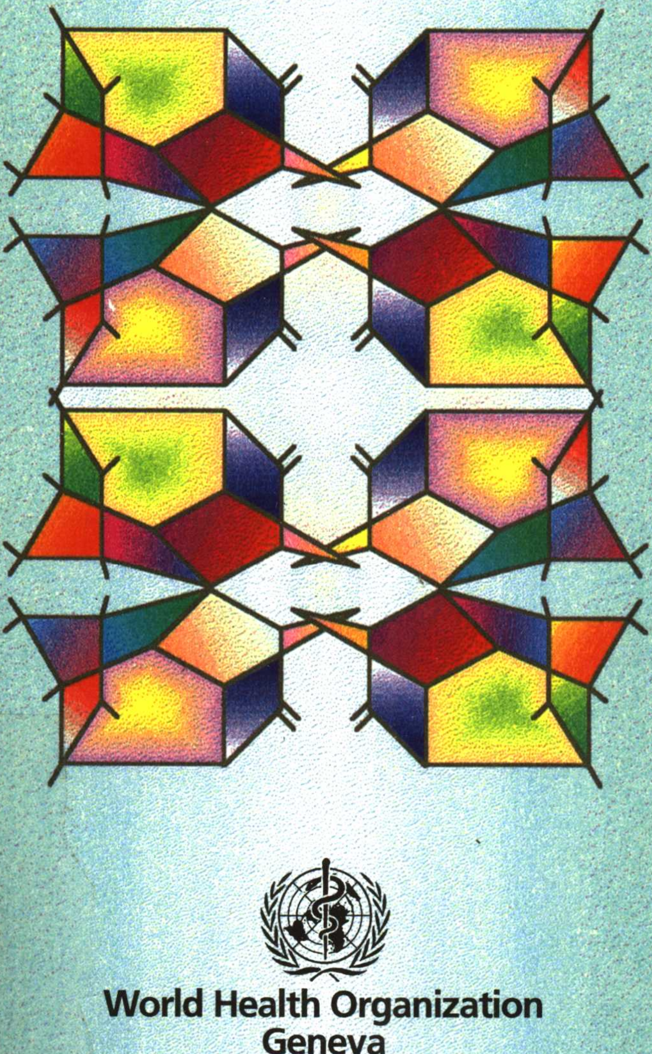
Control technology for the formulation and packing of PESTICIDES



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CONTROL TECHNOLOGY FOR THE FORMULATION AND PACKING OF PESTICIDES

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PREFACE

Industrial development can introduce various health risks into workplaces, particularly where there is limited attention to control measures. The United Nations Industrial Development Organization's (UNIDO) New Delhi Declaration of February 1980 stated that:

> Industrial policies to be adopted . . . should take into consideration the necessity for protecting occupational and environmental health.

In resolution WHA33.31,[1] the Thirty-third World Health Assembly in May 1980 requested the Director-General of the World Health Organization (WHO):

> . . . to support the developing countries in ensuring safe working conditions and effective protective measures for workers' health in agriculture, in mining and in industrial enterprises which already exist or which will be set up in the process of industrialization, by using the experience available in this field in both industrialized and developing countries . . .

In implementing this resolution, and in consultation with UNIDO, WHO developed a proposal for drawing up these control technology guidelines. The proposal was reviewed by the United Nations Environment Programme joint thematic planning exercise held in Rome in September 1980.

In June 1981, there was an Interagency Consultation on "Guidelines on Occupational Health for the Establishment and Operation of Specific Industries". The objective of this consultation was to establish a plan of action, to select priority industries, and decide on a basic outline for guidelines "to collate information on occupational health control technology and other preventive occupational health measures for specific industries and to disseminate this information for use by various countries, industrialized and developing".

In developing countries, the guidelines in this publication are intended to help in introducing control measures before and during

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[1] *Handbook of resolutions and decisions*, Vol. II (1973–1984). Geneva, World Health Organization, 1985.

the operation of new industries as well as in the identification and control of existing occupational health hazards in the workplace, including agricultural and mining environments. Furthermore, there is evidence that the health of workers in many industrialized countries would benefit from the application of control technology developed in less industrialized countries.

The guidelines were prepared initially by the United States National Institute for Occupational Safety and Health (NIOSH), except for the section on storage and transport which is based on *Guidelines for the safe handling of pesticides during their formulation, packing, storage and transport*, published by the International Group of National Associations of Manufacturers of Agrochemical Products (GIFAP) (*1*).

The guidelines were circulated to a large number of WHO Collaborating Centres for Occupational Health, and were discussed at a meeting of a WHO Working Group on Control Technology. In 1989, the guidelines were further reviewed and updated by NIOSH.

This publication is the result of collaboration between the World Health Organization and the United States National Institute for Occupational Safety and Health (NIOSH). It is based on a control technology assessment study under the direction of Paul Caplan.

INTRODUCTION

The present guidelines concern health and certain safety aspects of the formulation and packing of pesticides. The safe use of pesticides has been considered in a number of World Health Organization publications (*2–5*). Other United Nations agencies, often in collaboration with WHO, have also published specifications and guidelines for the production and use of pesticides (*6, 7*). The Food and Agriculture Organization of the United Nations (FAO) publishes specifications for pesticides used in agriculture in the form of booklets for individual pesticides.[1] The United Nations Industrial Development Organization (UNIDO) has also published material relevant to the safe production and use of pesticides (*8–10*). General aspects of control technology are discussed in the specialized literature (*11–14*).

FAO has defined a pesticide as any substance or mixture of substances for preventing, destroying, or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during, or otherwise interfering with, the production, processing, storage, transport, or marketing of food, agricultural commodities, wood and wood products, or animal feedstuffs, or which may be administered to animals for the control of insects, arachnids, or other pests in or on their bodies.

Pesticides include insecticides, acaricides, molluscicides, rodenticides, nematocides, anthelminthics, fungicides, and herbicides. The term excludes fertilizers, plant and animal nutrients, food additives, and animal drugs. A pesticide formulation generally combines a biologically active agent or agents with a diluent or carrier to simplify its application. "Packing" is used to mean the dispensing of pesticides into containers for use in the field.

Although reference to different hazards (e.g. fire) is made throughout this publication, it is concerned primarily with the occupational health hazards of pesticide formulation. Occupational accidents are nevertheless very important and safety programmes for their prevention should exist in every workplace.

[1] Available from FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

A thorough discussion of the environmental impact of pesticide formulation is beyond the scope of this publication. However, this is an extremely important issue that should be dealt with by professionals with specialized knowledge.

Most synthetic insecticides are of the organochlorine, organophosphorus, or carbamate types. Much is known about the toxic effects of these pesticides, but there is relatively little information on precautionary measures to be taken and effective control of exposure during their manufacture and formulation. To fill the gap, this publication documents current technology and practices in the safe formulation and packing of pesticides.

Few pesticides are absolutely specific to their target so great care must be taken to avoid unintentional harm to crops, domestic animals, wildlife, or people. Farm workers who use these products generally handle small quantities at a time, but, even so, require training in their safe use.

During the formulation and distribution of pesticides, however, much larger quantities are handled, and special procedures and precautions are needed to avoid hazards. The siting, design and maintenance of formulation, packing, storage and transport operations must be planned and managed with the utmost care.

The concepts of control technology outlined in these guidelines offer special opportunities for developing countries that are establishing or expanding their industrial base. Such countries can introduce control technology from the start and avoid many of the environmental and health problems that developed countries have had to face when adding hazard controls to established production systems.

FORMULATION PROCESSES

The formulation process usually involves combining a concentrated active ingredient from a manufacturer or supplier with inert substances to yield various forms of product, for example, dusts, powders, granules, pellets, emulsifiable concentrates, and aerosols. Such formulations may be dry or wet.

Dry formulations

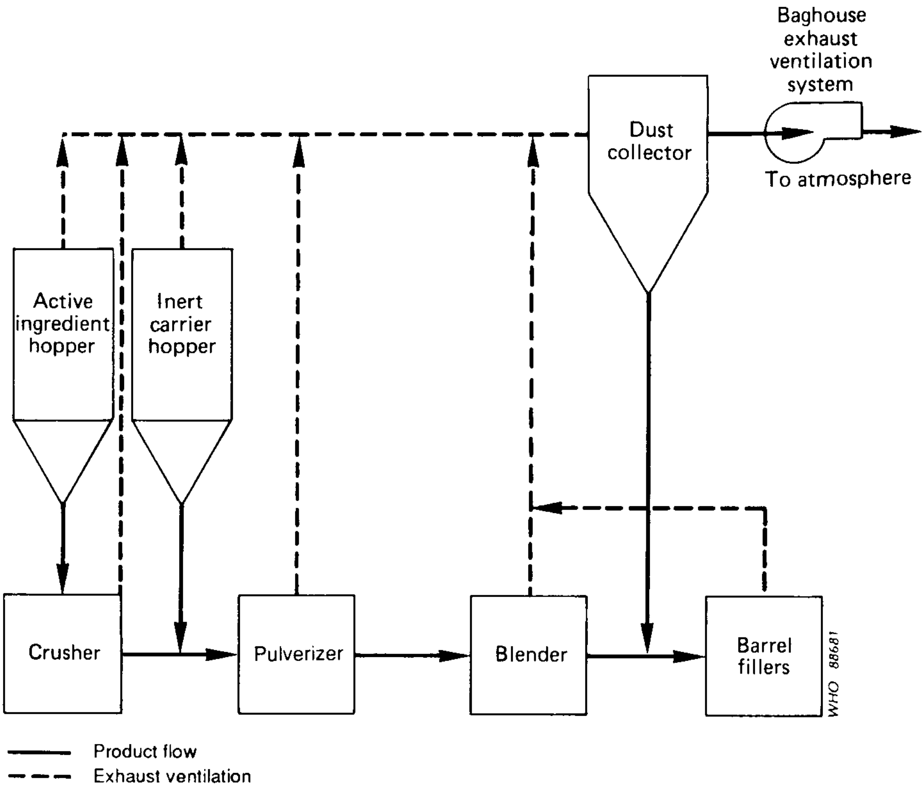
The important types of dry formulation are dust bases or dust concentrates, dusts, powders (soluble or water-dispersible), granules, and pellets. Dusts and powders are manufactured by mixing the technical-grade pesticide with the appropriate inert carrier (for example, silica, sulfur, lime, gypsum, talc, or clay). Sometimes a liquid carrier such as kerosene is used. If the active ingredient is a liquid, it is introduced into the mixer through spray nozzles.

The operations of a dry formulation unit are summarized in Table 1 and Figs 1 and 2. After the pre-mix has been made (Fig. 1) it is allowed to age before being passed to the final grinding and blending unit (Fig. 2) where stabilizers and wetting agents are

Table 1. Dry formulation unit operations

Sequence of operations
Handling incoming materials.
Storage and warehousing of incoming materials.
Transfer of materials to the pre-mix operators.
Opening containers.
Filling pre-mix bins or hoppers.
Pre-mix treatment (grinding in the pre-mix grinding unit, see Fig. 1).
Transfer of the mixture to the blender or mixer.
Mixing, blending and grinding in the final grinding and blending unit.
Storage of blend for aging.
Transfer of blend to packing area.
Packing and labelling of blended products.
Storage and warehousing of products.
Shipping of products.
Decontamination of liquid or solid spills.
Treatment of emissions (solid, liquid, or gas).
Disposal of wastes (solid, liquid, or gas).

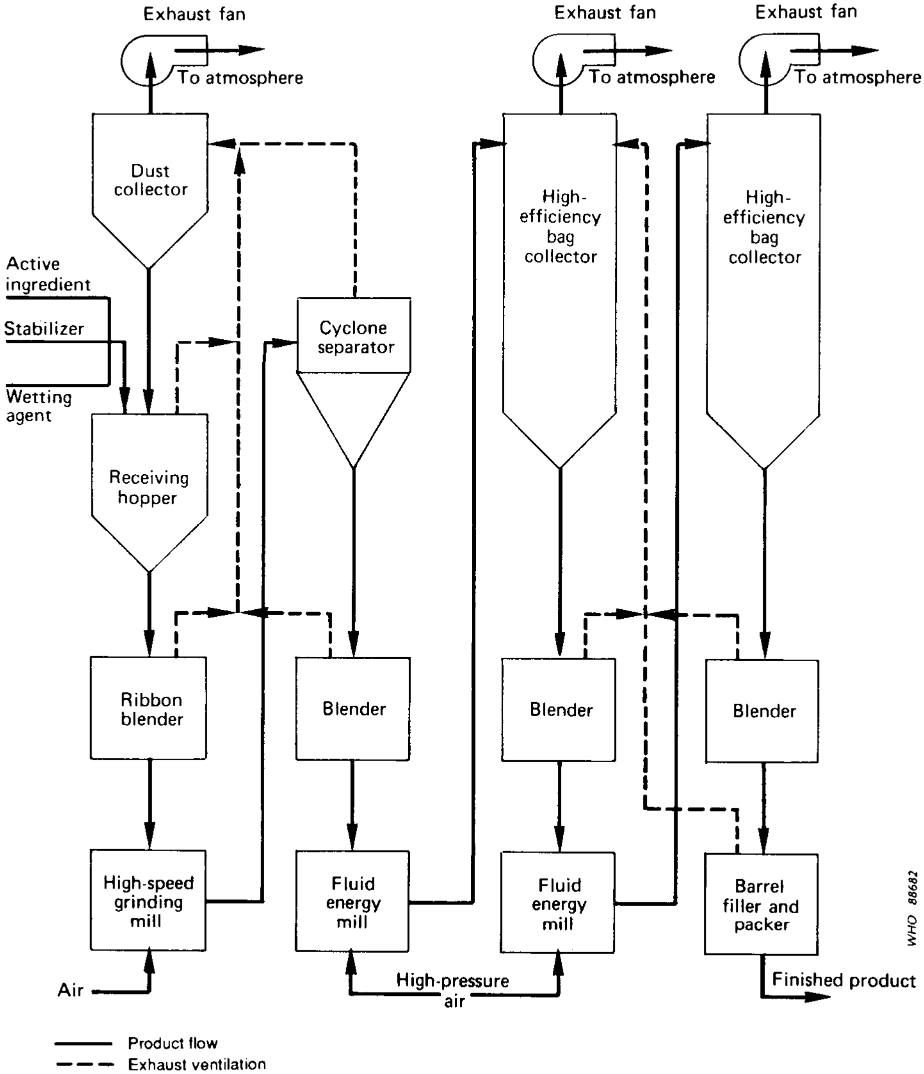
Fig. 1. Solid formulations — pre-mix grinding unit
Reproduced by permission of the National Institute for Occupational Safety and Health, Cincinnati, USA.



added. After blending in a ribbon blender, the mix is conveyed to a high-speed grinding mill with rotating blades to shear the pesticide mixture. A pneumatic conveying system then carries the material to a cyclone separator from which it drops into another blender. The blend is finely ground by high-pressure air in a fluid energy mill, then air-conveyed to a high-efficiency bag collector. This grinding is repeated before barrels are filled and packed.

Particulate emissions constitute the main hazard from grinding and blending processes, and can be most efficiently controlled by exhaust ventilation with a bag-house system. Vents from feed hoppers, crushers, pulverizers, blenders, mills, and cyclones are typically routed by mechanical ventilation to bag-houses for product recovery.

Fig. 2. Solid formulations — final grinding and blending unit
Reproduced by permission of the National Institute for Occupational Safety and Health, Cincinnati, USA.



The main causes or sources of occupational exposure (see page 16) are the manual handling of technical-grade pesticides (solid and liquid); leaks from liquid-handling equipment, for example, pumps, valves, and hoses; spills; vapour leaks; cleaning and maintenance procedures; reworking of products that do not comply with specifications; and packaging operations.

Liquid formulations

Liquid pesticides are produced as solutions (e.g. solvent solutions or oil concentrates), emulsions, or suspensions. A solid active ingredient is introduced into a liquid carrier in the presence of an emulsifying agent, or a liquid active ingredient is blended into a diluent. The mixture is agitated until the desired state is achieved and the finished product is pumped to a drum-filling station for packing.

Liquid carriers include organic solvents, oils, and water. It is essential to investigate the toxic properties of the carrier to determine whether it may be hazardous to health. Liquid carriers can also create a safety hazard, such as the risk of fire or explosion. Solvents that are used as carriers include aromatic hydrocarbons (for example, xylene or heavy aromatic naphtha), isopropanol, cyclohexane, and kerosene. The oils most commonly used as solvents are fuel oil and diesel oil.

Some liquid formulations (for example, aqueous concentrates and water-dispersible suspensions) consist of pesticidal chemicals dissolved in water. However, some water-soluble concentrates, such as the phosphoric ester insecticides, are not diluted with water but with a polar solvent.

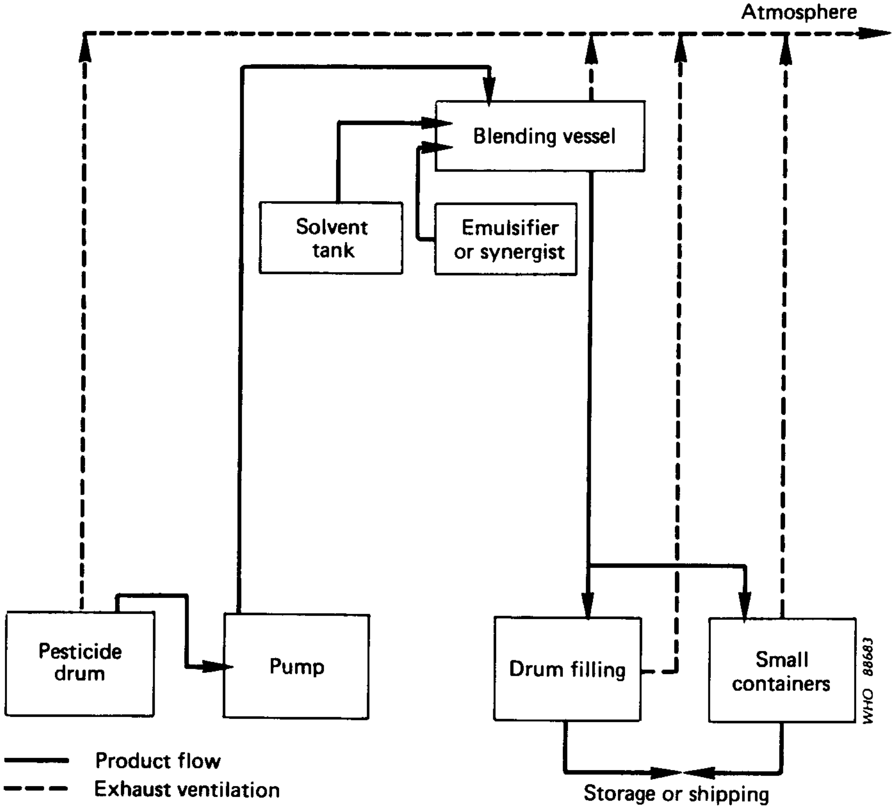
Table 2 summarizes the operations most often used for liquid formulations, and Fig. 3 shows a typical liquid formulation unit.

Blending vessels (batch-mixing tanks) are frequently open-topped and have a standard agitator, and may be equipped with a heating/cooling system. When solid technical material is to be used,

Table 2. Liquid formulation unit operations

Sequence of operations
Handling incoming materials.
Storage and warehousing of incoming materials.
Transfer of incoming materials to pre-mix.
Weighing concentrate.
Weighing solvent or emulsifier.
Transferring concentrate, solvent, or emulsifier to blender or mixer.
Mixing and blending.
Filtration.
Transfer of blend to packing.
Packing and labelling of blended products.
Storage and warehousing of products.
Shipping products.
Decontamination of spills.
Treatment of emissions (solid, liquid, or gas).
Disposal of wastes (solid, liquid, or gas).

Fig. 3. A typical liquid formulation unit
From: Technical Bulletin No. AG-1b, Monsanto Company Agricultural Division, St Louis, Missouri, USA. Adapted by courtesy of the Monsanto Company.



a melt process is required before this material is added to the blending vessel. Technical-grade pesticide is usually stored in its original container in the warehouse section of the plant until it is needed. Solvents are normally stored in bulk tanks, and the desired quantity is then measured into the blending vessel. Blending agents (for example, emulsifiers and synergists) are added directly.

The formulated pesticide may be pumped into a holding tank before being put into drums or small containers for shipment. Many liquid formulations need to be filtered to remove precipitates and other solid contaminants before packing.

Other formulation types

A number of other formulation types are used for special purposes. These include aerosols, seed dressings, poison baits, encapsulated formulations, plastic formulations, and fertilizer–pesticide mixtures.

HAZARDS IN FORMULATION AND PACKING

Research and experience show that pesticides can be formulated safely, provided that recommended precautions are followed. However, accidents or failure to observe these precautions may lead to poisoning and other adverse effects upon people and the environment. Some knowledge of the hazards associated with occupational exposure in pesticide formulating plants, and of the principal sources of exposure, is necessary in order to understand the application of control technology.

Toxicity

The most significant hazard in the formulation of pesticides is acute poisoning. The chemicals used as pesticides are all poisonous to some biological systems; otherwise they would not be effective as pest-control agents. Each year, a number of people are poisoned and some die because of the misuse of, or accidental over-exposure to, pesticides (*2–5*). The toxic effects of exposure to pesticides are well discussed in the literature (*14–17*).[1]

Systemic poisoning is usually the most serious risk associated with the formulation and packing of pesticides, but there are additional hazards such as acute or chronic irritation and inflammation of the skin, eyes, and respiratory tract, and sometimes allergic responses. The hazards may arise not only from the active ingredients, but also from the "inactive" ones, for example talc and silica, or from solvent vapours. Because of this, it is important that the properties of all the components of a pesticide formulation are known.

International agreement has been reached on a recommended classification of pesticides by toxic hazard (*18*), and an extract of this agreement appears in Annex 1, p. 72.

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[1] An important source of information on the toxicology of pesticides is found in the *Environmental Health Criteria* series, published by WHO for the International Programme on Chemical Safety (IPCS). Issues concerning over 35 pesticides have already been published, and many others are in preparation. Health and Safety Guides for about 35 pesticides have also been published by WHO for IPCS. International Chemical Safety Cards are published by the Commission of the European Communities in Luxembourg. Further information may be obtained from Promotion of Chemical Safety, World Health Organization, 1211 Geneva 27, Switzerland.

Lists of technical products categorized by class are reviewed biennially by WHO and current information is issued in *The WHO recommended classification of pesticides by hazard and guidelines to classification, 1992–1993* (*18*). A number of countries have prepared similar lists, so in each of these countries reference should be made to the appropriate national authority for information on the classification of pesticides and on any regulations for their formulation, storage and transport.

Flammability

The greatest fire risk is associated with the use of organic solvents. The flammability hazards of substances can be classified within ranges of flash-points (Table 3). Several classifications of solvents are used in different countries and by certain international organizations. Table 4 gives a sample classification of flammable substances, and some liquid pesticides may contain solvents from all the classes listed. Even liquefied gases may be used as solvents, such as in spray-can aerosols.

Table 3. Some commonly used solvents and their flash-points

Solvent	Flash-point (°C) (closed-cup determination)
Acetone	−17.8
Butanol	28.9
Kerosene (odourless)	79[a]
Toluene	4
Turpentine	35
Xylenes (mixed)	25

[a] The flash-point for kerosene may vary according to how it is produced and much lower values may be applicable. When using kerosene, information on the flash-point and other relevant characteristics should be requested from the supplier.

Table 4. Sample classification of flammable substances[a]

Class		Flash-point (°C)		Initial boiling-point (°C)
		Closed-cup determination	Open-cup determination	
I	Very hazardous	−18	−13	⩽ 35
II	Moderately hazardous	−18 to +23	−13 to +27	> 35
III	Hazardous at raised temperatures	23 to 61	27 to 66	> 35

[a] Except for the last column, the classification is that of Panov & Polozkov (*19*).

Primary good practice dictates that air and flammable vapours should never be allowed to mix; nevertheless, every precaution should be taken to ensure the absence of ignition sources. Where a flammable mixture exists, electrical equipment should be explosion-proof or at least spark-proof. Naked flames or spark-producing tools should be avoided. Workers, containers and equipment should be sufficiently earthed to prevent a build-up of static electricity that might create a spark on discharge.

Many powdered organic pesticides, when finely divided in air, can explode violently if ignited with sufficient energy. Sources of ignition are mostly foreign bodies entering fast-moving mills, fires, or explosions of solvent–air mixtures. Powder and dust lying on ledges can often be shaken loose by a first explosion and contribute to an even larger secondary explosion. Good housekeeping, therefore, is essential to avoid dust accumulation. All surfaces, including those in roof spaces, must be kept free from dust.

Sources of exposure

Some of the common potential sources of occupational exposure to pesticides are as follows:

Operation	Source of exposure
1. Handling incoming materials.	Spills and leaks during emptying and disposal of containers; displacement of contaminated air.
2. Storage and warehousing of incoming materials.	Breathing vents; leaks during transfer; dispersal by fire.
3. Movement or transfer of liquids within the plant.	Leaks through seals, bearings, and loose fittings.
4. Movement or transfer of liquids within the plant.	Leaks through seals and joints; displaced vapour vents.
5. Size modification of solids (drying, grinding).	Leaks through bearings and seals; during cleanout.
6. Blending and formulation of solids.	Leaks; spills during transfer, loading, inspection, and cleanout.
7. Blending and formulation of liquids.	Leaks; spills during transfer, vapour displacement, inspection, and cleanout.
8. (*a*) Quality-control sampling. (*b*) Laboratory analysis.	Spills; leaking valves; open sampling points. Chemical processes on open benches; fume hoods.
9. Product packing—solids.	Dust from bagging and valves; broken containers; overfilled containers.
10. Product packing—liquids.	Container leaks; drips; spilled contents of containers; overfilled containers.