As of April 30 2007, this document is NO LONGER IN USE by the World Bank Group. The new versions of the World Bank Group Environmental, Health, and Safety Guidelines are available at http://www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

Pesticides Formulation

Industry Description and Practices

This document addresses the formulation of pesticides from active ingredients. Manufacture of pesticides is the subject of a separate document.

The major chemical groups that are formulated include:

- Insecticides (organophosphates, carbamates, organochlorines, pyrethroids, biorationals, and botanicals)
- Fungicides (dithiocarbamates, triazoles, MBCs, morpholines, pyrimidines, phthalamides, and inorganics)
- Herbicides (triazines, carbamates, phenyl ureas, phenoxy acids, bipyridyls, glyphosates, sulfonyl ureas, amide xylenols, and imidazole inones)
- Rodenticides (coumarins).

The main purpose of pesticide formulation is to manufacture a product that has optimum biological efficiency, is convenient to use, and minimizes environmental impacts. The active ingredients are mixed with solvents, adjuvants (boosters), and fillers as necessary to achieve the desired formulation. The types of formulations include wettable powders, soluble concentrates, emulsion concentrates, oil-in-water emulsions, suspension concentrates, suspoemulsions, water-dispersible granules, dry granules, and controlled release, in which the active ingredient is released into the environment from a polymeric carrier, binder, absorbent, or encapsulant at a slow and effective rate. The formulation steps may generate air emissions, liquid effluents, and solid wastes.

Waste Characteristics

The principal air pollutants are particulate matter (PM) and volatile organic compounds (VOCs). These are released from mixing and coating operations.

Most liquid effluents result from spills, the cleaning of equipment, and process wastewaters. The effluents may contain toxic organics, including pesticide residues.

Major solid wastes of concern include contaminated discarded packaging and process residues. There will also be effluent treatment sludges. The solid wastes generated depend on the process. They can be amount to about 3.3 grams per kilogram (g/kg) of product and may contain 40% active ingredient.

Pollution Prevention and Control

The recommended pollution prevention measures are as follows:

- Use equipment washdown waters as makeup solutions for subsequent batches.
- Use dedicated dust collectors to recycle recovered materials.
- Use suction hoods to collect vapors and other fugitive emissions.
- Return toxic materials packaging to the supplier for reuse.
- Find productive uses for off-specification products to avoid disposal problems.
- Minimize raw material and product inventory to avoid degradation and wastage.
- Label and store toxic and hazardous materials in secure, bunded areas.

A pesticide formulation plant should prepare and implement an emergency preparedness and response plan that takes into account neighboring land uses and the potential consequences of an emergency or accidental release of harmful substances. Measures to avoid the release of harmful substances should be incorporated in the design, operation, maintenance, and management of the plant. Additional guidance on the selection and use of pesticides is provided in Guidelines and Best Practice, GB 4.03, "Agricultural Pest Management" (World Bank 1993).

Treatment Technologies

Baghouses for removal of particulate matter and carbon adsorption for removal of VOCs are applicable and effective technologies.

Reverse osmosis or ultrafiltration is used to recover process materials from wastewater. Effluent treatment may include carbon adsorption, detoxification of pesticides by oxidation (using ultraviolet systems or peroxide solutions), and biological treatment. Exhausted carbon from absorption processes may be sent for regeneration or combustion.

Due to the relatively small volumes of solid wastes, it is difficult to find acceptable and affordable methods of disposal. Ideally, solid wastes should be incinerated in a facility where combustion conditions such as 1,100°C and at least 0.5 second flame residence time are maintained, to ensure effective destruction of toxics.

Emissions Guidelines

Emissions levels for the design and operation of each project must be established through the environmental assessment (EA) process on the basis of country legislation and the *Pollution Prevention and Abatement Handbook*, as applied to local conditions. The emissions levels selected must be justified in the EA and acceptable to the World Bank Group.

The guidelines given below present emissions levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance. Any deviations from these levels must be described in the World Bank Group project documentation. The emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

Air Emissions

The emissions levels presented in Table 1 should be achieved.

Liquid Effluents

The effluent levels presented in Table 2 should be achieved.

Solid Wastes

Toxic solid wastes should be treated to destroy toxic organics and bring them to levels below 0.05 milligrams per kilogram (mg/kg).

Ambient Noise

Noise abatement measures should achieve either the levels given below or a maximum increase in background levels of 3 decibels (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

Table 1. Emissions from Pesticides Formulation

(milligrams per normal cubic meter)

Parameter	*Maximum value*
PM	20; 5 where very toxic compounds are present[a]
VOCs	20
Chlorine (or chloride)	5

a. See the World Health Organization's list of extremely hazardous substances (WHO 1996).

Table 2. Effluents from Pesticides Formulation
(milligrams per liter, except for pH)

Parameter	*Maximum value*
pH	6–9
AOX	1
COD	150
TSS[a]	20
Oil and grease	10
Organochlorines	0.05
Nitroorganics	0.05
Pyrethroids	0.05
Phenoxy compounds	0.05
Active ingredients (each)	0.05
Arsenic and hexavalent chrome (each)	0.1
Copper	0.5
Mercury	0.01

Note: Effluent requirements are for direct discharge to surface waters.
a. Monthly average, but in no case more than 50 mg/l.

	Maximum allowable log equivalent (hourly measurements), in dB(A)	
Receptor	*Day (07:00–22:00)*	*Night (22:00–07:00)*
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Monitoring and Reporting

Frequent sampling may be required during start-up and upset conditions. Once a record of consistent performance has been established, sampling for the parameters listed in this document should be as described below:

- Continuously monitor air emissions exiting the air pollution control system where toxic organics are being emitted at rates greater than 0.5 kilograms per hour (kg / h).
- Analyze liquid effluents generated from the process before discharge (or at least once per shift). Where the effluents are suspected to be toxic, a bioassay test should be performed to assess their acceptability in the environment. The toxicity factor for fish should not be greater than 2; toxicity to *Daphnia* = 8; toxicity to algae = 16; and toxicity to bacteria = 8.)

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. The results should be reported to the responsible authorities and relevant parties, as required.

Key Issues

The key production and control practices that will lead to compliance with emissions guidelines can be summarized as follows:

- Good management practices, especially cleanliness and materials control, are essential and must be put in place.
- Return packaging for refilling.
- Incinerate all toxic organic wastes (except those containing toxic volatile metals).

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