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Pest Control Products Fact Sheet

To assess the risks for the consumer

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Summary

Exposure to and intake of compounds in consumer products are assessed using available mathematical models. Calculations are carried out with the computer program, CONSEXPO (Consumer Exposure). Given the huge number of consumer products, it is not possible to define exposure models and parameter values for each separate product, so a limited number of main categories containing similar products are defined. The information for each main category is described in a fact sheet. Examples of categories for which fact sheets have been created are paint, cosmetics, children's toys and floor covering. This fact sheet covers the use of pest-control products by consumers for eight product categories, including sprays, dusting powders, repellents, electrical humidifiers and baits. Information is given on the composition and the use of products within a product category. Default models and values for all eight product categories have been determined to assess exposure and intake of compounds in the pest-control products.

Samenvatting

Om de blootstelling aan stoffen uit consumentenproducten en de opname daarvan door de mens te kunnen schatten en beoordelen zijn wiskundige modellen beschikbaar. Voor de berekening wordt gebruik gemaakt van het computerprogramma CONSEXPO. Het grote aantal consumentenproducten verhindert dat voor elk afzonderlijk product blootstellingsmodellen en parameterwaarden vastgesteld kunnen worden. Daarom is een beperkt aantal hoofdcategorieën met gelijksoortige producten gedefinieerd. Voorbeelden van hoofdcategorieën zijn verf, cosmetica, kinderspeelgoed en vloerbedekking. Voor elke hoofdcategorie wordt de informatie in een factsheet weergegeven. In deze factsheet wordt informatie gegeven over het gebruik van ongediertebestrijdingsmiddelen.

Het gebruik van ongediertebestrijdingsmiddelen die verkrijgbaar zijn voor de consument ten behoeve van particuliere toepassing wordt beschreven met behulp van 8 productcategorieën, zoals spuiten, strooi poeders, elektrische verdampers, anti-muggensticks en crèmes en lokdoosjes. Het gehele gebied van het gebruik van ongediertebestrijdingsmiddelen door consumenten wordt met deze productcategorieën bestreken. Voor elke productcategorie wordt ingegaan op samenstelling en gebruik van het type producten binnen de categorie. Om de blootstelling en opname van stoffen uit ongediertebestrijdingsmiddelen te kunnen schatten en beoordelen zijn voor elke productcategorie defaultmodellen met defaultwaarden voor de parameters vastgesteld.

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1 Introduction

1.1 General

Descriptive models have been developed within the RIVM to be able to estimate and assess the exposure to substances from consumer products and the uptake of these by humans. These models are brought together in a PC computer program called CONSEXPO (Van Veen, 2001)². When a model is chosen in CONSEXPO, and the required parameters are filled in, the program calculates the exposure to, and the uptake of, the substance involved.

The large number of consumer products currently on the market means that it is not possible to determine exposure models and parameter values for each individual product. A limited number of main categories of similar products have therefore been defined. Examples of the main categories are paint, cosmetics, children's toys and floor covering. The relevant information with respect to the estimate of exposure to, and the uptake of, substances from consumer products is given in a fact sheet for each of the main categories. These fact sheets can be used to characterize and standardize the exposure.

For the risk assessment of the private user to biocides (i.e., non-agricultural pesticides), there also appears to be a significant need for characterization/standardization of the exposure. However, as a group of products, biocides vary enormously with regard to exposure and uptake. The decision was therefore taken to define the different main categories within the biocides, and to put together a fact sheet per main category. This first fact sheet deals with private (=non-professional) use of pest control products. A fact sheet about disinfectant products is being prepared.

Pest control products are used to control invertebrates (insects, arachnids, slugs and snails), mammals and birds. There is a great diversity in the types of use and application methods for the products. There are sprays, liquid repellents and strips from which the active ingredient can evaporate powders and electrical evaporators. Some of these products can be used without any preparation, while others have to be processed (mixed and loaded) before use, for example by diluting or cutting up. All of these product forms imply a different exposure, whereby differences can occur in the exposure phase (mixing and loading, during or after exposure) or the route of exposure (inhalatory, oral, dermal).

Within the pest control products main category, as few product categories as possible are defined, which together describe the whole main category. The pest control products' main category includes the following product categories: sprays, electrical evaporators and baits. The composition and the use of the type of products within the category is examined for every product category. To estimate the exposure and uptake of substances from pest control products, default models with default parameter values are determined for every product category in this fact sheet. The default-models and default-parameter values are available in the form of a database. Using this data, it is possible to standardize the exposure calculations for consumers due to

the use of pest control products.

1.2 CONSEXPO

CONSEXPO is a set of coherent, general models to be able to estimate and assess the exposure to substances from consumer products and their uptake by humans.

CONSEXPO was originally developed for the consumer exposure assessment for New and Existing Substances in scope of Directive 67/548/EC and the Council Regulation 793/93/EC, respectively. Thereafter, CONSEXPO was extended to also assess the consumer exposure to biocides.

CONSEXPO is built up using data about the use of products, and from mathematical concentration models. The program is based on relatively simple exposure and uptake models. The starting point for these models is the route of exposure, i.e. the inhalatory, dermal or oral route. The most appropriate exposure scenario and uptake model is chosen for each route. The parameters needed for the exposure scenario and the uptake models are then filled in. It is possible that exposure and uptake occur simultaneously by different routes. In addition to data about the exposure and uptake, contact data is also needed, such as the frequency of use and the duration of use. Using the data mentioned above, CONSEXPO calculates the exposure and uptake. The model is described in detail in Van Veen (2001)²⁾.

CONSEXPO 3.0, the most recent CONSEXPO version, is also able to calculate back. Thus, based on the amount of the substance that is taken in, it can work out one of the other parameters. For pest control products, one can make use of this possibility by starting with the amount of a particular substance that a person may take in (e.g. a toxicological limit for a substance) and calculating one of the other parameters. In this way, we can determine the relationship between the maximum amount of a certain product that may be taken in and the amount of product used.

With CONSEXPO's help, it is possible to calculate the exposure to pest control products in a standardized way. CONSEXPO can carry out not only calculations with point values but calculations with distributions too. Sensitivity analyses can also be carried out. The computer model is public and is therefore available to everyone.

1.3 Fact sheets

This report is one of a series of fact sheets that describe a main category of consumer products, such as paint, cosmetics, childrens toys and, in this report, pest control products. The fact sheets give information that is important for the consistent estimation and assessment of the exposure to, and the uptake of, substances from consumer products.

A separate fact sheet called the 'General fact sheet', (Bremmer and Van Veen, 2000)¹⁾ gives general information about the fact sheets, and deals with subjects that are important for several main categories. The General fact sheet gives details of:

- the boundary conditions under which the defaults are estimated,
- the way in which the reliability of the data is shown,
- parameters such as the ventilation rate and room size,
- parameters such as body weight and the surface of the human body, or parts

thereof.

In the fact sheets, information about exposure to chemical substances is bundled into certain product or exposure categories. These categories are chosen so that products with similar exposures can be combined. On the one hand, the fact sheet gives general background information, while on the other hand, it quantifies exposure parameters which, together with an exposure model, or a combination of the various exposure models, produces a quantitative estimate of the exposure.

The fact sheets are 'living' documents. As new research becomes available or as perceptions change, so the parameter values may need to be changed. New models can also be developed within CONSEXPO, describing a particular exposure better than using the currently used models. This too will require adaptations. We intend to produce updates of the published fact sheets, on a regular basis.

This fact sheet is principally aimed at exposure to the formulation (i.e., the whole product) and is, as such, independent of the active ingredient. This means that the information about the active ingredient must be added later. This mainly concerns information about the concentration and the physical-chemical properties of the active ingredient.

1.3.1 Definition of the consumer

Non-professional use only

The default values in the fact sheets have been put together for consumers (private or non-professional users). They are not applicable for people who work with pest control products in a professional capacity, such as in the agricultural sector, for example. This fact sheet therefore only describes pest control products which are available to the consumer for private use.

Using the models in CONSEXPO and the default values for consumers presented here as background data, it is nonetheless possible to calculate the exposure and uptake of pest control products by professional users. Of course, the differences in products and product use between the consumer and those using pest control products professionally must be taken into account.

Risk groups

Two groups can be distinguished in the risk assessment for consumers: the person who applies the product and those who experience the highest exposure after application; these are usually children. The person who applies the product (the user) is the one who actually uses the formulation and, if necessary, dilutes it to the required concentration ('mixing and loading'). We expect the user to be confronted with a high exposure during 'mixing and loading' and during use.

In the post-application phase, children are regarded as the risk group with a high exposure, based on the following exposure arguments: crawling children can have intensive contact with treated surfaces, they have extensive hand-mouth contact, play relatively close to the ground and, furthermore, have a relatively low body weight.

The exposure calculations are based on children of between 10 and 11 months, since this group demonstrates the most crawling and hand-mouth contact, combined with a relatively low body weight.

1.3.2 'Reasonable worst case' estimate

The parameter values in the fact sheets are formulated for (Dutch) consumers. They are chosen such that a relatively high exposure and uptake are calculated, in the order of magnitude of a 99th percentile of the distribution. To achieve this goal, the 75th or the 25th percentile is calculated for all parameters. The 75th percentile is used for parameters that give a higher exposure for higher values, and the 25th percentile is used in the reverse case.

For a significant number of parameters, there is actually too little data to calculate the 75th or 25th percentile. In such cases, an estimate is made which corresponds to the 75th or 25th percentile. The 75th/25th percentile should then be seen as a guideline.

The basis for the calculation and/or estimation of the default parameter values is consumers who frequently use a certain pest control product under relatively less favorable circumstances. For example, when using an aerosol can, basic assumptions are: relatively frequent use, application of a relatively large amount in a small room with a low ventilation rate, and a relatively long stay in that room. Every scenario is based on a realistic situation, in which exposure and uptake are substantial.

For all calculations of exposure and/or uptake the 75th or 25th percentile is used. Multiplication of two 75th -percentile parameter values will result in a 93.75th percentile, whereas multiplication of three 75th -percentile parameter values will result in a 98.5th percentile.

For the calculations using CONSEXPO not all parameter values are multiplied, on the other hand, parameter values may influence each other.

Since for all parameter values a 75/25th -percentile is calculated or estimated, the resulting outcome in the calculation is a higher exposure and/or uptake. Given the number of parameters and the relationship between the parameters, it is expected that the calculated values for exposure and uptake will result in a 99-percentile.

The end result is a reasonable worst-case' estimate for consumers who use relatively large amounts of pest control products under less favorable circumstances. In the General fact sheet (Bremmer and Van Veen, 2000)¹⁾, the boundary conditions under which the defaults are arrived at are dealt with in more depth.

1.3.3 Reliability of the data

The problem is that a number of parameters are difficult to estimate based on the literature sources and unpublished research. A value must still be chosen for these parameters, otherwise it is not possible to carry out any quantitative exposure estimates. This is why a quality factor (Q-factor) is introduced ¹⁾, which is in fact a grading system for the value of the estimate of the exposure parameter. Low Q-factors indicate that the default value is based on insufficient (or no) data. If such default is used in an exposure analysis, it should be looked at and, if possible, adapted. If applicants or producers supply representative data, it can replace the default values. High Q-factors indicate that the defaults are based on sufficient (or more..) data. These defaults generally require less attention. It is possible that they will need to be adapted if the exposure scenarios require it. For example, an exposure estimate might be carried out for a room of a particular size; the well-founded default room size would then need to be replaced by the required value. A Q-factor is given to all

parameter values in the fact sheets, indicating the reliability of the estimate of the default value. The quality factor can have a value of between 1 and 9. Table 1 shows a summary of the meaning of the values of the quality factor. In the General fact sheet (Bremmer and Van Veen, 2000)¹⁾, the value of the quality factor is dealt with in more depth.

Table 1: Value of quality factor Q

Q	Value
9	Ample and good quality data
8	good quality data
7	quality and number of studies satisfactory
6	useable, but open to improvement
5	little data, parameter value is usable as default value
4	single data source supplemented with expert judgment, parameter value doubtful as default value
3	single data source supplemented with expert judgment, parameter value not reliable as default value
2	educated guess from similarities with other products
1	educated guess, no data

1.4 Definition and classification of pest control products

Pest control products are divided into agricultural pesticides and non-agricultural pesticides, or biocides. Biocides form an extremely diverse group of products, which are used both by professionals and non-professionals (consumers) to control or prevent damage by undesired organisms, such as microbial organisms, fungi, flying and crawling insects, small mammals such as mice and rats, but also mosses, algae and weeds. Wood preservatives and disinfectants also fall into the biocides category. Some of the biocides are available to consumers for private use; other products are only available for professional use.

For the professional use of pest control products, like controlling plagues in larger locations, such as storage areas, office and factory buildings, warehouses, supermarkets and public areas. The products are used professionally by specially qualified companies and personnel. The products and equipment used are often not the same as those available to the consumer. Much more of the substance (active ingredient) is used than during private use, so that the person using the product can be exposed to much higher amounts before, during and after the application, than is the case during private use. Personal protection measures often need to be taken and, immediately after the application, special regimes often need to be put in place with regard to entering the treated areas.

The pattern of use by consumers is very diverse: the users are not specially trained in their task and protective measures are usually not taken. The products are often used in and around the house, whereby exposure can still take place long after application, and children, in particular, can have a relatively high exposure. This fact sheet describes the exposure and uptake for products that are available to the consumer for private use.

The following sections show the Dutch (§ 1.4.1) and the international situation (§ 1.4.2) with regard to the classification of biocides. Pest control products for the private user correspond with household agents in the Dutch classification and with 'pest control products' in the European Union's Biocides guideline.

1.4.1 Biocides, the Dutch situation

In the Netherlands, the Dutch Board for the Authorization of Pesticides (CTB) classifies biocides as follows:

Household agents (H-products), both for private use (ant and wasp dusting powders, pesticide sprayers, baits) and for professional use; both ready-to-use products and 'mixing and loading' (preparing it for use yourself).

Veterinary products (V-products), pest control products which are used by the private individual and by the professional user to control insects and the like, and to treat stables and animal quarters.

Wood preservatives (C-products) are used to protect wood from damage caused by fungi and insects. The anti-fouling products also fall within this group, used in paints to protect ships' hulls against the growth of algae and shellfish.

Disinfectants (D-products), mainly for professional use.

Household agents (H):

This includes products to control rats, mice and insects, for use in and around the home, as well as for professional use in storage, business and accommodation areas. Pest control-using gasses are mainly used in empty storage areas, shipyards, factories and silos; fumigants are commonly used for quarantine treatment and for merchandise. Baits and mothballs are also used. 'Household agents' include pest control products used in private gardens.

The sub-groups that are used in the Netherlands are:

- H1: outdoors
- H2: outdoors on surfaces
- H3: indoors as evaporator
- H4: indoors as air space spray
- H5: mosquito repellent
- H6: moth-resistant substances on textiles
- H7: stock protection products
- H8: rodenticides

In order to get an impression of the different products types, a CTB-summary from early 1994 was used. It showed that 265 H-products were authorized. The products were divided into the product types given below:

liquid:	59
powder:	35
bait:	48
aerosol:	65
gel:	2
gas:	12
stick:	8
powder spray:	6
strip:	4
evaporation products:	6
paste:	2
tablet:	3
atomizer:	3
paper:	1
tube:	1

1.4.2 Biocides, the international situation

The biocide directive (98/8/EC) came into force in the European Union in 1998. This deals with the authorization of active ingredients required for biocides which can occur within 23 categories, summarized as disinfectants, preservatives, pest control products and other (see: table 2).

Table 2: EU classification of Biocide Substances

1. Disinfectants and general biocidal products
01: Human hygiene biocidal products
02: Private area and public health area disinfectant and other biocidal products
03: Veterinary hygiene biocidal products
04: Food and feed area disinfectants
05: Drinking water disinfectants
2. Preservatives
06: In-can preservatives
07: Film preservatives
08: Wood Preservatives
09: Fiber, leather, rubber and polymerized materials preservatives
10: Masonry preservatives
11: Preservatives for liquid-cooling and processing systems
12: Slimicides
13: Metal working fluids
3. Pest control
14: Rodenticides
15: Avicides
16: Molluscicides
17: Piscicides
18: Insecticides, acaricides and products to control other arthropods
19: Repellents and attractants
4. Other biocidal products
20: Preservatives for food or feedstock
21: Antifouling products
22: Embalming and taxidermist fluids
23: Control of other vertebrates

More information on the biocide directive is available on the website of the European Chemicals Bureau (<http://ecb.ei.jrc.it/biocides/>). The pest control products (EU category 14-19) are important for this Pest control products fact sheet. The guidelines currently available for the biocide directive are strongly toxicologically determined. Guidelines for exposure aspects are in preparation; other guidance documents are referred to, such as for labeling and classification.

The United States does not make any principal differentiation between agricultural pesticides and biocides. They use the term biocides almost exclusively for anti microbials. In the US, biocides are therefore not divided into a number of categories of use. The Food Quality Protection Act is the chosen route in the US (FQPA; see <http://www.epa.gov/oppfead1/fqpa/index.html> for the official US-EPA site, also refer to <http://www.epa.gov/pesticides/> for the site of the US-EPA Office of Pesticide Programs). In the US, it is mainly the risk due to the intake of pest control products via foodstuffs that is regulated, and the FQPA requires that the combined intake (including the uptake not via the diet) does not exceed a certain limit. The US-EPA also groups together active ingredients with a similar working mechanism, and the effects of these compounds are cumulated in the risk analysis. The private use of biocides is therefore included in the total risk estimate of the active substance.

1.4.3 Classification into product categories

For this fact sheet, pest control products are classified into product categories, which are drawn up according to the type of use and exposure. The aim is to reduce the large number of individual products and applications to a limited number. The method of exposure within each category is very similar, so that one default exposure estimate can be drawn up for all products which fall into that category.

The following categories are defined for pest control products, based on the registration applications at the CTB, and according to the principle that a similar exposure takes place within a category:

1. Sprays
 - a. Targeted spot-application
 - b. Crack and crevice application
 - c. General surface application
 - d. Air space application
2. Evaporation from strips and cassettes
3. Electric evaporation
4. Insect repellents
5. Baits
6. Dusting powders
7. Textile biocides
8. Foggers

Each of these categories is covered in a separate section (sections 2 to 9) in the remainder of this fact sheet.

1.5 Principles behind the exposure estimate

During the assessment of the risk for private users and/or by-standers, an estimate of the potential exposure is made using the (concept) WG/GA (Statutory operating instructions/directions for use). A preference is given to the use of existing product data and measured exposure values. If this data is not available, the computer model CONSEXPO is used. The most relevant models are chosen from CONSEXPO for each relevant route (inhalatory, dermal and/or oral). The parameters needed for the models are then entered.

In this fact sheet, default models and default parameter values are proposed for every product category. If additional data is available for a particular application, this is taken into consideration. For example, if the amount of product to be applied per surface is given in the WG/GA, or if the producer of an aerosol can supplies the droplet size, these values are used.

The WG/GA is not always complied with exactly in the assessment. This is the case if we assume that some of the users will not follow the instructions. For example, if the use of gloves is advised, the exposure estimate will nevertheless assume that application without gloves will occur.

This fact sheet is principally aimed at exposure to the formulation (i.e., the whole product) and, as such, is independent of the active ingredient. This means that information about the active ingredient has to be added. This is mainly information about the concentration and the physical-chemical properties of the active ingredient.

2. Spray applications

2.1 Introduction

Pest control products to be sprayed are available on the Dutch market in many shapes and sizes. During a small shopping trip to make an inventory of the products, it was found that garden centers and Do It Yourself stores have ample choice in brands and product types, such as ready-to-use aerosol cans, liquids and powders. The two supermarkets visited had both set up a separate stand with anti-insect products during the summer months. The target organisms for these pest control products are invertebrates, mainly insects such as aphids, mosquitoes or fleas.

Straetmans (2000)³⁾ has put together a detailed literature overview about the exposure of the consumer to biocides during and after a spray application. Straetmans' data is used as a starting point for this chapter.

During use, sprays produce an aerosol cloud of very small to small droplets. The speed with which the droplets fall depends on the size of the droplet. Smaller droplets stay in the air for longer. The aerosol generation also means that few volatile ingredients remain in the air for any time. Llewellyn et al. (1996)⁴⁾ show that a much higher exposure occurs in a situation where spraying is carried out above the head than when it is aimed at the floor. This can be attributed to the contact with the aerosol cloud.

There are two main aspects when characterizing the exposure of spray applications, that is, whether the formulation still needs to be processed before application (mixing and loading) and the target of the application. With regard to mixing and loading, there is a distinction between:

Liquid concentrate, that is diluted and sprayed in a plant sprayer and whereby, during the dilution, evaporation can occur,

Powders and granules, which are dissolved in water and are sprayed in a plant sprayer; the powder can disperse during dissolving.

With regard to the target, one can distinguish between the following four types of application.

Targeted spot application refers to the spraying of hiding places of crawling insects and ant tunnels. It often concerns a relatively small surface to be sprayed, which is sometimes difficult to reach both for the user and for the non-user. For example, behind the refrigerator or a radiator, or in/under kitchen cabinets. When considering the method and extent of exposure, the spraying of plants against red spider mite and such like can be compared with the spot application.

Crack and crevice application concerns the spraying of cracks and crevices to control silver fish, cockroaches and so forth, for example, on baseboards in living and accommodation areas, and in cracks and holes in wooden floors.

General surface application is the spraying of large surfaces such as a carpet or couch to control dust mites or fleas, for example.

Air space application is the spraying of living, working or accommodation areas against flying insects, whereby the user stands in the middle of the room and sprays all four of its upper corners.

These spray applications differ from each other in the manner and extent to which the user and the by-standers are exposed. For example, a difference is expected in exposure during crack and crevice application and during a general surface spray, due to the longer application time of the latter treatment. A difference in the exposure during application can also occur due to the height at which the spraying takes place; above the head, as is usual during an air space application, or aimed at the floor, such as during a general surface spray. After application of these sprays, there is a difference in the size of the wipeable surface, amongst other things. Worst case, it is assumed that the entire sprayed surface of all types of spray are within the reach of crawling children. The default-scenarios for exposure after application are drawn up for this target group.

In the remainder of this chapter, we first concentrate on a number of parameters that are important for several spray applications, such as the frequency of use, the droplet size and the respirable fraction. We then describe the exposure during mixing and loading of a plant sprayer, for both liquid concentrates and powders/granules. The exposure during and after application is then described for the four spray applications mentioned above.

2.2 General parameters for the spraying process

Table 3 shows all of the models used in this chapter to describe the mixing and loading and to describe the different types of spray applications.

Table 3: Overview of the models used for spray applications

Situation		Route of exposure			
		contact	inhalatory	dermal	oral
before application	Dilution of liquid Dissolving a powder or granules	contact	evaporation from mixture	contact rate	
		contact	constant concentration	contact rate	
during application	targeted spot	contact	spray cloud	contact rate	spray cloud
	crack and crevice	contact	spray cloud	contact rate	spray cloud
	general surface	contact	spray cloud	contact rate	spray cloud
	air space	contact	spray cloud	contact rate	spray cloud
after application (aimed at children)	targeted spot	contact		transfer coefficient	hand-mouth
	crack and crevice	contact		transfer coefficient	hand-mouth
	general surface	contact		transfer coefficient	hand-mouth
	air space	contact		transfer coefficient	hand-mouth

The models that describe the spray applications are the same for the four different methods of spraying (targeted spot, crack and crevice, general surface and air space). In this section, we concentrate on parameters that are important for several spraying methods. These parameters are grouped together into the models in which they are applied. The models themselves and the meaning of the parameters are not considered here; these are described in detail in 'CONSEXPO 3.0, consumer exposure and uptake models' (Van Veen, 2001)²⁾.

2.2.1 Parameters for the contact scenario

Frequency of Use

Up to now, there has been little insight into the extent to which consumers use pest control products. The only references that were found were Weegels (1997)⁵⁾ and Baas and Van Veen (in preparation)⁶⁾. Weegels carried out a survey using a questionnaire and by asking a limited number of users (out of a total of 30 people on the panel) to keep a diary about the extent and the method of their use of consumer products, including biocides. Baas and Van Veen report on observational research and interviews with users of biocide sprays.

In general, the use of pest control products will be limited to the actual control of any plague, that is, the product will not be used if there are no pests. Therefore it is expected that the use of pest control products mainly to take place in the summer, since it is usually in this period that invertebrates (insects, arachnids, slugs, snails and such like) appear. In the 3 weeks during which Weegels carried out her diary survey, 11 people (from the panel of 30) actually used biocides. These 11 people were selected on the grounds that they had used biocides in the month prior to the research. During a period of 3 weeks, these 11 people used a spray a total of 11 times, whereby repeated sprayings during one course of treatment, as is often recommended on the packaging, were each counted separately. These values can be used to calculate a yearly frequency if one assumes that over a six month period, mainly in the summertime, biocides are used with a frequency equal to that in the 3 weeks during which the diary survey was carried out, and that no biocides were used in the other six months of the year. It should be remembered that people are considered who actually use biocides, and therefore do not represent the general public. This is consistent with the goal of the study: to find out about the exposure and risk of those who use sprays.

Based on these assumptions, the frequency of spray applications is calculated to be 9 times per person per year. Of the 11 times that a spray was used in van Weegels' survey, it was used 8 times after mixing and loading of a liquid, but there not one single case of spraying after mixing and loading of a powder or granules. The frequency of mixing and loading, related to the frequency of spraying (9 times/person/year), is calculated at 6 times per person per year.

Baas and Van Veen (in preparation)⁶⁾ report the results of interviews coupled with the observations of spraying behavior. Just as with Weegels' survey, they used people who had indicated that they use pest control products; organic products were also included. Table 4 shows the frequencies of use found. The air space application concerns ready-to-use products, where no mixing and loading is required.

Table 4: Frequency of use⁶⁾

Application	number of people	frequency per year [mean SD]
Targeted spot	14	3.7 2.9
Air space	2	84 8.5
Crack and crevice	1	12
General surface	3	2.3 0.6

The limited data given above is used to derive default values and quality factors for the frequency of use of sprays; these are shown in table 5.

Default values

Table 5: Frequency of use default values

Application	Frequency [times per year]	Q
Mixing and loading, liquid	6	5
Mixing and loading, powder or granules	3	5
Spraying, targeted spot	9	5
Spraying, air space	90 ¹⁾	5
Spraying, crack and crevice	9	5
Spraying, general surface	9	5

1) daily use over a period of 3 months

It should be remembered that for the default values, it is endeavored to estimate the 75th percentile and not averages. For the relatively high value of the air space application, it should be remembered that the product is used at locations where there is a continual problem due to mosquitoes or flies during the 'fly season'. This is confirmed by the Dutch Animal Plague Knowledge and Advice center, which states that in areas with many mosquitoes (near moorland, for example) such products are used several times a week (KAD, 2001³⁷). A daily use over a 3-month period is assumed, based on a 'heavy' user.

2.2.2 Density

In various models and scenarios that describe the spraying process, the density of the product is an important parameter. We assume that the active ingredient in liquid concentrates is normally dissolved in volatile organic solvents. The density of these solvents is around 0.7 g/cm³; this value is used as the default value for the density of liquid concentrates. If it turns out that water is the main constituent of a liquid concentrate, a density of 1 g/cm³ is used. In ready-to-use aerosols, the active ingredient is diluted in an organic solvent; the default value for the density is here also taken to be 0.7 g/cm³. Products that are sprayed using a plant sprayer are dissolved in water. The density of the ready-to-use formulation is set at 1 g/cm³.

Default values

Density of the solvents:

- main ingredient volatile organic solvents; 0.7 g/cm³ (quality factor Q: 7)
- main ingredient water; 1 g/cm³ (quality factor Q: 7)

2.2.3 Parameters for the 'spray cloud' model

To calculate the inhalatory exposure for the user, the 'spray: cloud model' from CONSEXPO is used for all spray applications.

Droplet size

Pest control products can be sprayed using a ready-to-use aerosol can or a plant

sprayer. The droplet size is an important parameter when estimating the exposure. Smaller drops fall at a lower speed and stay in the air for longer. The large droplets will quickly disappear from the air after being formed. As an indication: the falling time of droplets with a diameter of 100 μm from a height of 3 meters is calculated at 11 sec, and for droplets of 10 μm it is calculated at 17 min (Biocides Steering Group, 1998)⁷⁾. If a larger droplet is sprayed, part of the aerosol cloud will consist of finer droplets which stay in the air for longer, as a result of edge effects around the nozzle and the bounce back effect due to spraying onto a surface. There is hardly any measurement data available for the droplet size.

‘Assessment of human exposure to biocides’ from the Biocides Steering Group (1998)⁷⁾ gives a WHO classification with regard to the droplet size of sprays (see: table 6).

*Table 6: Classification of aerosol droplets*⁷⁾

droplet diameter [μm] ^{a)}	classification
< 15	mist
< 25	aerosol, fine
25-50	aerosol, coarse
51-100	mist
101-200	spray, fine
210-400	spray, medium
>400	spray, coarse

a): the median diameter; half of the particles are larger, half are smaller

In the same study, a classification is also given for the droplet size for various types of agricultural use (see table 7).

*Table 7: Droplet size for different types of agricultural use*⁷⁾

Aim of use	droplet diameter [μm]
flying insects	10-50
insects on plants	30-50
precipitation on surface	40-100
application on the ground	250-500

The Dutch Aerosol Association (1995)⁸⁾ distinguishes between aerosol sprays in aerosol cans with very fine atomized dry sprays (such as asthma sprays and insecticides) and fine atomized wet sprays (such as hair sprays and paint sprays). Matoba et al. (1993)⁹⁾ measured the droplet size of an aerosol can with a spray for air space applications. The average droplet size was 30 μm with a range of 1-120 μm . Based on the measurements, Matoba et al. classified the droplets into three groups: 10 % of the particles have a droplet size of 60 μm , 80 % have a droplet size of 20 μm and 10 % of the particles have a droplet size of 5 μm . A spray for air space applications generally has a smaller droplet diameter than a spray for surface applications.

Based on the data above, an average droplet size for aerosol cans for air space spraying is taken to be 5 μm , and for aerosol cans for surface applications it is taken to be 15 μm . The default value for the droplet size for a plant sprayer is given as 30 μm (see table 8).

The default values for the droplet size in CONSEXPO concern the average diameter of the aerosol particles. Given the small amount of data a relatively small average droplet size is used, resulting in a (possible too) high exposure. Given this uncertainty, the quality factor is set at 5.

For the risk assessment of new pest control products, applied using an aerosol can, the applicant or producer is obliged to supply data regarding the droplet size to the Dutch Board for the Authorization of Pesticides (CTB).

Respirable fraction

In the 'droplet size' section above, an average particle size for various spray applications is assumed of 5, 15 and 30 μm , respectively. In the Biocides Steering Group's report (1998)⁷⁾, they indicate that for an aerosol cloud with particles having an average aerodynamic diameter of 5, 10 and 10 μm , respectively, the respirable part of the breathed in particles is 34.4, 1.7 and 0.1 %, respectively .

The droplet size is obviously a distribution. Mainly based on the measurements by Matoba et al.(1993)⁹⁾, it is assumed that, worst case, 10 % of the particles with an average particle size of 15 μm will be smaller than 5 μm . Based on the data from the Biocides Steering Group, it is assumed that, of the droplets smaller than 5 μm , half are respirable.

Based on these assumptions ('of particles with an average particle size of 15 μm , 10 % is smaller than 5 μm ' and 'of the particles smaller than 5 μm , half are respirable') it is calculated that, of the particles with an average particle size of 15 μm , 5 % of the particles are respirable. In CONSEXPO it is assumed that the other 95 % precipitate in the upper airways and are then taken in orally. Using the same reasoning, one would expect 4 % of the particles with an average particle size of 30 μm to be smaller than 5 μm and, therefore, 2 % of the particles is expected to be respirable.

Table 8: Default values for particle size and respirable fraction

Spray application	particle diameter (average) [μm]	respirable fraction ^{a)} [%]	Q
Aerosol can air space	5	34.4	5
targeted spot; crack and crevice; general surface	15	5	5
plant sprayer targeted spot; crack and crevice; general surface	30	2	5

a) CONSEXPO assumes that the other part is taken in via the oral route

Airborne fraction

Sprays for a surface application (such as targeted spot, crack and crevice and general surface sprays) produce a coarser droplet, designed to end up on the sprayed surface.

Part of the aerosol cloud will actually consist of finer droplets which stay in the air for longer and can be inhaled. No references were found with relation to the percentage of the aerosol cloud that becomes airborne. The default value will initially be set at 15%.

Sprays for air space spraying applications are meant to produce a very fine mist, which stays in the air for a longer period of time. The value of this parameter can therefore be set at 100% for air space spray applications: all of the active ingredient is present in the air after spraying.

Radius aerosol cloud

To get an idea of the diameter of the aerosol cloud, Straetmans (2000)³⁾ sprayed various types of sprays, from a distance of 50 cm, onto kitchen towel, after which the diameter of the wet patch was measured. The different equipment (ready-to use sprays and a plant sprayer) appeared to consistently produce aerosol clouds of ± 20 cm in diameter (variation of ± 18 to 21 cm). The default value for this parameter has therefore been set at 20 cm for all spray applications.

2.2.4 Parameters for the ‘contact rate’ model

The ‘contact rate’ model from CONSEXPO is used to calculate the dermal exposure of the user during application, for all spray applications.

Contact rate formulation

During professional use of surface sprays, at a pressure of 1-3 bar, a value of 53.7 mg formulation/min was found as the 75th percentile for the dermal exposure (Biocides Steering Group (1998)⁷⁾). Thompson and Roff (1996)²⁴⁾ report a total amount of 0.006 – 0.35 ml formulation ending up on the skin when using a spray. The application time was 8 min and 23 sec, that is, a contact rate of 42 μ l/min for 0.35 ml. Since Thompson and Roff’s data is based on consumer use, it is taken as the default value. For a density of 0.7 g/cm³, 42 μ l/min is equivalent to a value of 29 mg/min. This value is used for targeted spot, crack and crevice and general surface applications.

For targeted spot, crack and crevice and general surface applications, the emission speed, during actual spraying, is 1.3 g/sec. For air space applications, an emission speed of 0.7 g/sec is assumed. The contact rate is related to the emission speed, the amount of formulation that leaves the aerosol can per minute. For air space sprays, a contact rate formulation is calculated that is proportionally lower than the emission speed, that is, a 0.7/1.3 part of the contact rate formulation of the other three spray applications. The contact rate formulation is calculated to be 23 μ l/min ($0.7 / 1.3 * 42 \mu\text{l}/\text{min}$), which is equal to 16 mg/min.

2.2.5 Parameters for the ‘transfer coefficient’ model

The ‘transfer coefficient’ model from CONSEXPO is used for the exposure of children after application of the product, for all four of the spray applications. The parameter values for the four applications are similar, and are therefore discussed here.

Dislodgeable fraction formulation

In an HSL Pilot study on aerosols (cited in the Biocides Steering Group’s report, 1998⁷⁾) 10 % is given as the value for the ‘dislodgeable residue from treated carpet’

parameter. The concept SOPs of the US-EPA ²⁵⁾ assume that 50 % of the amount of the active ingredient gets on to the surface and can be brushed off. Based on this data, the default value for the dislodgeable fraction is set at 30% .

Transfer coefficient

The ‘transfer coefficient’ is the surface that is wiped per unit time due to skin contact. The concept-SOPs from the EPA (1997)²⁵⁾ give a value of 2.3 m² /day, whereby it is assumed that there is activity for 4 hours a day, which means a transfer coefficient of 0.6 m² /hr.

2.2.6 Parameters for hand-mouth contact

If dermal exposure of children occurs after the application of a pest control product, those children can also be exposed orally due to hand–mouth contact. The parameter that describes hand- mouth contact is the ‘intake rate formulation’ parameter.

Intake rate formulation

Dermal exposure of children can take place on any uncovered skin, that is, on the head, the arms and hands, and on the legs and feet. It is assumed that all of the product that ends up on the hands is taken in orally due to hand-mouth contact. The hands form about 10 % of the total uncovered skin (see Bremmer and Van Veen, concept)⁴⁰⁾. It is therefore assumed that 10 % of the amount of the product that ends up on the skin of a child is taken in orally by hand-mouth contact. The intake rate formulation can be calculated based on this assumption.

2.3 Exposure to liquid concentrate during mixing and loading

The exposure to the active ingredient, which the user experiences during the dilution or dissolving of the active substance with/in water and during the loading in a plant sprayer, depends on the factors listed below, but will be independent of the final method of application of the spray. This is why the exposure during mixing and loading for the four different application areas is bundled together and is handled as ‘exposure before application’.

When determining the defaults, a distinction is made between ‘diluting a liquid’ and ‘dissolving a powder’. These product forms influence the dermal and inhalatory exposure of the user during mixing and loading. In all literature references, the powder or liquid was dissolved in water (including Roff and Baldwin, 1997¹⁰⁾; Weegels, 1997⁵⁾; Leidy et al, 1996¹¹⁾; Fenske et al., 1990)¹²⁾.

Use duration and total duration

Smith (1984)¹³⁾ gives the length of time measured for mixing and loading pesticides, which were used outside for the spraying of crops. Considering the amounts used, this data cannot be compared with the mixing and loading of biocides for use in a plant sprayer indoors. Weegels (1997)⁵⁾ gives an average total time (for two people) of 80 sec, for mixing and loading a liquid in a plant sprayer.

Dermal exposure: contact rate

Dermal exposure during mixing and loading of biocides for indoor use will almost

always be restricted to the hands (Van Hemmen, 1992)¹⁴⁾. Smith (1984)¹³⁾ gives an indication of the amount of formulation that ends up on the skin during mixing and loading per unit time, measured using so-called 'wrist pads'. Van Hemmen does not include any data collected using such pads in his inventory of measurement data during professional exposure, since a considerable amount of formulation will get onto the palm of the hand and the fingers without being detected by the pads.

Contact rate formulation

The results of Van Hemmen's inventory (1992)¹⁴⁾ give an indicative value for dermal exposure (in mg/hr) during mixing and loading. This value is the 90th-percentile of the measured exposure: 0.3 ml formulation (liquid concentrate)/hr by the dilution of 25 kg of the formulation. Van Hemmen indicates that there is a strong correlation between the level of the exposure and the amount of pesticide that is used. For consumer exposure, the values mentioned would have to be extrapolated to predict the amounts that are used by the consumer. In Weegels (1997)⁵⁾ and Roff and Baldwin (1997)¹⁰⁾ a final concentration of 0.1% active ingredient in the diluted formulation is given for mixing and loading by consumers. Roff and Baldwin mixed 200 ml of concentrate in 2.3 liters of water. For a plant sprayer with a capacity of 2 liters, this is equivalent to 174 ml. 25 kg of liquid concentrate is equivalent to 35.7 liters (density: ± 0.7 g/ml for organic solvents). This data is used to calculate a *contact rate* of 0.025 $\mu\text{l}/\text{min}$ for the consumer. Roff and Baldwin's own data for 'spilling' (<10 μl total concentrate on the skin), cannot be used to calculate a *contact rate*, as no duration is given for mixing and loading. Van Hemmen's indicative value for professional application is extrapolated to the consumer application. A quality factor of 3 is therefore assigned.

Inhalatory exposure: evaporation from mixture

During mixing and loading, inhalatory exposure to volatile chemical substances which evaporate from the concentrate can occur. This exposure can be described using the evaporation model 'evaporation from mixture'.

Release area

No data was found for this parameter. It is assumed that evaporation takes place from a bottle with a not-too-small circular opening with a 5-cm. diameter.

Room volume

'Room volume' is interpreted here as 'personal volume': a small area around the user of 1 m³. For the short time in which the treatment takes place, a small area around the user is relevant for the inhalatory exposure of the user, to be able to describe the evaporation of the active ingredient from the concentrate. Since no data were found with regard to the size of the room, a quality factor of $Q = 4$ is assigned.

Ventilation

The ventilation rate that Bremmer and Van Veen (2000)¹⁾ give for a non-specified room is taken as a default value; namely 0.6 hr⁻¹

Default values

Default values for mixing and loading: dilution of a liquid.

model	parameter	default value	Q	references, comments
Contact	frequency	6 year ⁻¹	5	see § 2.2.1
	use duration	80 sec	6	see above
	total duration	80 sec	6	see above
	start exposure	0	9	direct exposure
Dermal exposure				
Contact rate	contact rate formulation	0.025 µl/min	3	see above
	density formulation	0.7 g/cm ³	7	see § 2.2.2
Inhalatory exposure				
Evaporation from mixture	release area	20 cm ²	4	see above
	room volume	1 m ³	4	see above
	temperature	20 °C	8	room temperature
	ventilation	0.6 hr ⁻¹	8	see above
	mol. weight matrix	3000 g/mol	4	see Bremmer and Van Veen (2000a) ⁴⁹⁾

2.4 Exposure to powder and granules during mixing and loading

There are several differences with regard to the exposure to powder and granules during mixing and loading compared to the dilution of a liquid concentrate:

- powders can disperse (as can the dust around granules, to a lesser extent),
- with regard to the dermal exposure, specific measurement data about the worker's exposure is known.

A number of parameters (use duration, total duration, room volume) have the same value as for the dilution of a liquid. Only the parameters with a different value are mentioned below.

Dermal exposure: contact rate

Contact rate formulation

Van Hemmen (1992)¹⁴⁾ gives 2 g formulation/hr as the indicative value for dermal exposure to solids during the mixing and loading of 25 kg of formulation. Converting this for consumer exposure, and assuming the use of 0.4 g in 2 liters (based on the directions for use on the packaging), this gives a *contact rate* of 0.53 µg formulation/min. Van Hemmen's indicative value for professional application is extrapolated to the consumer application. A quality factor of 3 is therefore assigned.

Inhalatory exposure: constant concentration

Room volume

'Room volume' is interpreted here as 'personal volume': a small area of 1 m³ around the user. A small area around the user is relevant for the inhalatory exposure of the

user, for the short time in which the treatment takes place, as it enables the evaporation of the active ingredient from the concentrate to be described. Since no data with regard to the size of the room were found, a quality factor of $Q = 4$ is assigned.

Amount released

Van Hemmen (1992)¹⁴⁾ gives an indicative value of 15 mg formulation/hr for the inhalatory exposure during the professional use of solid substances during mixing and loading, based on the use of 25 kg of formulation. For consumer exposure when using 0.4 g of solid substance, this is equivalent to an inhalatory exposure of $4 \cdot 10^{-3}$ μg formulation per min.

Van Hemmen's indicative value for professional application is extrapolated to the consumer application. A quality factor of 3 is therefore assigned.

The quality of granules, particularly the degree of powder forming, determines how much lower the exposure will be for granules. For the time being, it is assumed that for granules a maximum of 10% is present in the form of powder. The inhalatory exposure is therefore expected to be 10-fold lower than with powders, and is set at $4 \cdot 10^{-4}$ μg formulation per min.

Default values

Default values for mixing and loading, dissolving a powder/granules

model	parameter	default value	Q	references, comments
Contact	frequency	3 year ⁻¹	5	see § 2.2.1
	use duration	80 sec	6	see § 2.3
	total duration	80 sec	6	see § 2.3
	start exposure	0	9	direct exposure
Dermal exposure				
Contact rate	contact rate formulation	0.53 $\mu\text{g}/\text{min}$	3	see above
Inhalatory exposure				
Constant concentration	room volume	1 m ³	4	see § 2.3
	amount released powder	$4 \cdot 10^{-3}$ $\mu\text{g}/\text{min}$	3	see above
	granules	$4 \cdot 10^{-4}$ $\mu\text{g}/\text{min}$	3	see above

2.5 Targeted spot application

Scenario

This scenario is based on a private user who sprays an object from close by. It is also assumed that the spraying is carried out indoors. Targeted spot treatment can take place anywhere in the house, per target. This will often involve plants on the window sill in the living room, but treating the cat in the kitchen or spraying an ant trail along a window or behind the refrigerator also falls into this category. Using the realistic worst case-scenario setting, a relatively small room is assumed, which will result in a higher exposure. The inhalatory exposure 'spray: cloud' model and the dermal exposure model 'contact rate' from CONSEXPO 3.0 are used to describe this scenario. The oral exposure is handled in the inhalatory exposure model. CONSEXPO

assumes that the non-respirable fraction is taken in orally.

The largest part of the formulation will end up on the object being sprayed, but some will also end up on the surface around it. The exposure after application concentrates on the exposure of crawling children, if they come into contact with these surfaces. It is assumed that a child (default 10.5 months) crawls over this surface for 1 hour a day during a 14-day period. Exposure after application is described using the dermal exposure model 'transfer coefficient' and the oral exposure model 'hand-mouth contact'.

Exposure during application

Contact

Use duration

Baas and Van Veen (in preparation)⁶⁾ report a use duration of between 8 and 185 seconds (average of 76 ± 58 sec) based on observations of aerosol can use. Weegels (1997)⁵⁾ reports a spraying period of between 30 and 56 seconds, again based on observations. In diaries kept by volunteers, a period of between 4 and 40 minutes was recorded. This latter time period is more likely to represent the total duration of the job than the active spraying time. Based on this data, a default value of 90 sec was assumed as the period of time during which spraying actually occurs, and a use duration, the time during which the spraying takes place, of 6 minutes.

Total duration

Using the 'spray: cloud' model from CONSEXPO, the average exposure during the duration of exposure was calculated (mean event concentration) as the parameter for the inhalatory exposure. The inhalatory exposure during the spraying process will be at a maximum some time after spraying, and with then decrease. A total time of 4 hours is taken as the default value for the inhalatory exposure during the application. It is assumed that the user leaves the treated room 4 hours after the application.

Inhalatory exposure 'spray: cloud' model

Emission rate formulation

To determine the amount of formulation that leaves the sprayer per unit of time, the use up of an 'aerosol type sprayer' was calculated (mostly in older literature such as Wright and Jackson, 1975¹⁶⁾ and Wright and Jackson, 1976¹⁷⁾; Wright and Leidy 1978²³⁾). If the data from the various types of sprayers is compared, 'aerosol type sprayers' seem to be at the bottom of the range of use per time unit (± 0.35 g/sec). The 'compressed air sprayers' are somewhat higher (± 1 g/sec; Wright & Jackson, 1975¹⁶⁾; Wright and Leidy, 1978²³⁾), while the commercially available 'aerosol spray cans' generate the most formulation per second (1.6 g/sec, on average; Thompson and Roff, 1996²⁴⁾). For the plant sprayer in Weegels (1997⁵⁾), a *generation rate* of 1.4 g/sec was calculated.

Based on the literature, no distinction could be made between the use of ready-to-use aerosol cans and plant sprayers. For the default value, the use of the different spray equipment is assumed to be the same, and is estimated at 1.3 g formulation/sec. As it is assumed that spraying actually occurred for a period of 90 sec during a time span of

6 minutes, the default value for the emission rate formulation is 0.33 g formulation/sec.

Release height

The places to be sprayed will mainly be in the area from ground level up to windowsill height, but the directions for use also indicate that lampshades can be treated. As the products are usually plant sprays, and the plants will be treated at window sill or work top height, unless a specific value is given in the WG/GA, a default value for the spraying height is set at 100 cm.

Room volume and ventilation rate

Treatment can take place anywhere in the house. Using the 'realistic worst case'-scenario setting, a relatively small room with no extra ventilation is assumed. Standard values from the 'General Fact sheet' (Bremmer and Van Veen, 2000)¹⁾ were used, where the room, which is not further specified, has a volume of 20 m³ and a ventilation rate of 0.6 h⁻¹.

Surface

No data is available for this parameter. The scenario assumes that individual houseplants are treated. A default value of 2 m² was chosen for the treated surface.

Exposure after application

Contact

Use duration, total duration

When estimating the total duration of exposure, it is important to know whether the application takes place inside or outside. During their observational research, Baas and Van Veen (in preparation)⁶⁾ only came across use of these products outside. House plants and pets are treated outside. We would expect the residues to disappear quickly outside, but no specific research has been found.

Products can also be used indoors. From the literature it is known that measurable residues are still present in the treated room long after the treatment with a pesticide (Leidy et al., 1987²⁶⁾; Wright et al., 1994²¹⁾; Koehler and Moye, 1995²²⁾; Leidy et al., 1996¹¹⁾). The total duration of the contact with the active ingredient can, in principle, be stretched out over a period of months. As the user and the by-stander are usually occupants of the house in which the formulation is used, this entire period should be included. Simulations of the exposure show that the tail end of the exposure contributes little to the exposure as a whole. When defining the total contact time of the user, only the start of the period after use is looked at, which is quantified as 14 days after the treatment. This value is used for children who are exposed orally and dermally after application.

Dermal exposure: transfer coefficient*Dislodgeable fraction formulation*

By multiplying the emission rate formulation and the use duration, the total amount of sprayed formulation can be calculated ($0.33 \text{ g/sec} \times 360 \text{ sec} = 118.8 \text{ g}$). The scenario assumes that some of the formulation ends up on the object being sprayed, and some ends up on the surfaces around it. Section § 2.2.3 shows that the airborne fraction is taken to be 15 %. It is assumed that this amount (15 % of the total amount sprayed $118.8 \text{ g} = 17.8 \text{ g}$) ends up on the floor next to the object that is being sprayed. Section § 2.2.5 shows that of the amount on the floor surface, 30 % is dislodgeable/wipeable (i.e., 5.3 g). The floor surface is 2 m^2 (see *surface* below). The dislodgeable fraction formulation is therefore calculated as 2.7 g/m^2 .

Surface

The scenario assumes that some of the formulation ends up on the object being sprayed, and some ends up on the surfaces around it. A default value of 2 m^2 was chosen for the surface on which the formulation lands around the treated object.

Default values*Default values for exposure during targeted spot application with an aerosol can*

model	parameter	default value	Q	references, comments
Contact	frequency	9 year ⁻¹	5	see § 2.2.1
	use duration	6 min	6	see above
	total duration	4 hr	6	see above
	start exposure	0	9	direct exposure
Inhalatory exposure				
Spray: cloud model	emission rate formulation ^{a)}	0.33 g/sec	6	see above
	density formulation	0.7 g/cm ³	7	see § 2.2.2
	airborne fraction	15 %	4	see § 2.2.3
	droplet size	15 µm	5	see § 2.2.3
	release height	100 cm	6	see above
	radius aerosol cloud	20 cm	6	see § 2.2.3
	room volume	20 m ³	8	see above
	ventilation rate	0.6 hr ⁻¹	8	see above
	surface	2 m ²	4	see above
	respirable fraction	5 %	5	see § 2.2.3
Dermal exposure				
Contact rate	contact rate formulation	42 µl/min	5	see § 2.2.4

a) calculated parameter, see text

Default values of exposure after targeted spot application

Model	parameter	default value	Q	references, comments
Contact	frequency	9 year ⁻¹	5	see § 2.2.1
	use duration	14 x 1 hr	6	see above
	total duration	14 days	6	see above
	start exposure	0	9	direct exposure
Dermal exposure				
Transfer coefficient	dislodgeable fraction formulation ^{a)}	2.7 g/m ²	6	see above
	transfer coefficient	0.6 m ² /hr	6	see § 2.2.5
	surface	2 m ²	4	see above
oral exposure				
Hand-mouth contact	intake rate formulation		5	see § 2.2.6

a) calculated parameter, see text

In the scenario it is indicated that the default values are for spraying with an aerosol can. If the spraying is carried out using a plant sprayer, water is the main ingredient of the sprayed liquid instead of an organic solvent. As a consequence, the density becomes 1 g/cm³ (see § 2.2.2). One must also take into account a different droplet size (30 µm instead of 15 µm) and therefore also a different respirable fraction (2 % instead of 5 %) (see § 2.2.3).

2.6 Crack and crevice application

Scenario

This scenario is based on a private user who is controlling crawling insects on the ceiling. It is assumed that the application is to be carried out on individual target areas, whereby one quarter of the ceiling is treated using an aerosol can. The user is assumed to stay in the treated room for 4 hours after the application.

To calculate the exposure of the user during the crack and crevice application, the 'spray: cloud model' is used for the inhalatory exposure and the 'contact rate' model is used for the dermal exposure.

The exposure after application is described for crawling children who are present in the room after a crack and crevice treatment has been carried out. It is assumed that a child (default 10.5 months) crawls over the treated surface for 1 hour a day during a 14 days period. Exposure after application is described using the dermal exposure model 'transfer factor' and the oral exposure model 'hand-mouth contact'.

Exposure during application

Contact

Use duration

In the literature, the following times are reported for the use duration: Leidy et al., 1982¹⁵⁾: 8 – 11 min.; Wright and Jackson, 1975¹⁶⁾: 6.1 – 8.1 min.; Wright and Jackson, 1976¹⁷⁾: 10.3 – 11.9 min. Observational research by Baas and Van Veen (in preparation)⁶⁾ shows that the actual spraying time is much shorter. For a duration of

use of the aerosol can of between 40 and 160 seconds, the period of active spraying was between 10 and 26 seconds. This might be explained by assuming that the previously mentioned references include the entire job, while Baas and Van Veen (in preparation)⁶⁾ only measure the duration of spraying. On this basis, the default value for the time during which spraying actually takes place is set at 60 sec (this duration is important when calculating the emission rate, among other things; see below). It is assumed that the time during which the spraying takes place, the use duration, is 4 minutes.

Total duration

In Leidy et al.(1996)¹¹⁾, the concentration of the used active ingredient (chlorpyrifos) in the air 1 week after a crack and crevice treatment is 50% of the concentration straight after spraying. Over an 84 days period, the measured concentrations are in some cases equal and in all cases are measurable, even in adjacent untreated rooms. Leidy et al. (1984)¹⁸⁾ show that during crack and crevice treatment (of diazinon), where spraying was carried out under increased (air) pressure, more than 10% of the original concentration, measured straight after the treatment, was still evident at various heights above the sprayed surface 5 weeks after spraying. Davis and Ahmed (1998)¹⁹⁾ report a few instances of surface treatment using chlorpyrifos where, two weeks after application, the product still formed a gas with the resulting deposits. Eight to nine days after a crack and crevice treatment (chlorpyrifos) with a 4.5 liter pressure sprayer, Byrne et al. (1998)²⁰⁾ still measured concentrations at different heights from 20 up to >50% of the concentrations immediately after spraying. The concentrations of the active ingredients in the air or as a residue on a surface, are of course related to factors such as the type of treatment, the type of equipment, the amounts used for the treatment, the treatment time, etc. This is why the above-mentioned data cannot simply be used to compare a treatment with a ready-to-use spray or a plant sprayer.

For the inhalatory exposure, the *average* exposure per application is calculated using the spray cloud model from CONSEXPO. A total time of 4 hours is taken as the default value for the inhalatory exposure. It is assumed that the user stays in the treated room for 4 hours after the application.

Inhalatory exposure: spray: cloud model

Emission rate formulation

The use of the spray per unit time will depend, among other things, on the type of equipment and not on the application. Considering the fact that commercially available aerosol cans often propose a combined 'targeted spot' and 'crack and crevice' treatment in their directions for use (often using the same equipment), the same value for the emission rate of 1.3 g/sec is kept to for the actual spraying using these sprays.

The use duration indicates that in the duration of use of 4 minutes, the period of active spraying was 60 sec. The average emission rate of the formulation during the 4 minutes is 0.33 g/sec.

Release height

'Crack and crevice' sprays are designed to spray baseboards, cracks and crevices, i.e., long splits on the floor with a minimal spray width. The directions for use for this type of spray sometimes state that it is not meant to be used as an air space spray. Baas and Van Veen (in preparation)⁶⁾ and Llewellyn et al. (1996)¹¹⁾ show that there are also applications on the ceiling. Following the worst case principle, the spraying height is adjusted for these ceiling applications, and is set at 220 cm.

Room volume and ventilation rate

If no room is specified, the default value for the treated area is derived from Bremmer and Van Veen (2000)¹⁾: a room with a surface area of 8 m², a volume of 20 m³ and a ventilation rate of 0.6 hr⁻¹.

Surface treated area

From two articles of Wright and Jackson (1975; 1976)^{16,17)}, it can be deduced that if the crack and crevice treatment is carried out using a small tube on the spray nozzle, the size of the treated surface is 3.4 % and 14.2 % of the total floor surface respectively. It is assumed that the 'width' of the sprayed surface is 5 cm.

Byrne et al. (1998)²⁰⁾ indicate that when treating without the tube, the treatment area is 30 cm 'wide', that is, a factor 6 larger than with the tube. Based on this factor, and using the data from Wright and Jackson, it is calculated that the treated surface during treatment without the small tube on the spray nozzle is between 21% and 85% of the total floor surface (6x3.4=21 and 6x14.2=85). For the default, 25% of the surface is taken to be the treated surface; for the room mentioned above (surface 8 m²), this is equivalent to 2 m².

Exposure after application

Contact

Use duration; total duration

Based on the data in 'total duration' for exposure during application, and the considerations in section 2.5 under 'total duration', it is expected that with regard to the exposure after application, a playing child will crawl over the treated area for 1 hour a day during a 14 day period.

Dermal exposure: transfer coefficient

Dislodgeable fraction formulation

By multiplying the emission rate formulation and the use duration, the total amount of sprayed formulation can be calculated (240 sec x 0.33 g/sec = 79.2 g). The scenario assumes that this amount is sprayed on the ceiling. The airborne fraction is 15 %. It is assumed that this amount (15 % of the total amount sprayed, or 11.88g) ends up on the floor surface. Section 2.2.5 shows that, of this amount, 30 % is dislodgeable, i.e., it can be brushed away (0.3 x 11.88=3.56g). The surface is 2 m² (see *surface* below). The dislodgeable fraction formulation is calculated at 3.56/2 = 1.8 g/m².

Surface

In the above calculation, 2 m² of ceiling is treated. It is assumed that some of this ends

up on the floor, on 2 m² of the floor surface.

Default values

Default values for exposure during crack and crevice application with an aerosol can

model	parameter	Default value	Q	references, comments
Contact	frequency	9 year ⁻¹	5	see § 2.2.1
	use duration	4 min	6	see above
	total duration	4 hr	6	see above
	start exposure	0	9	direct exposure
Inhalatory exposure				
Spray: cloud model	emission rate formulation ^{a)}	0.33 g/sec	6	see above
	density formulation	0.7 g/ml	7	see § 2.2.2
	airborne fraction	15 %	4	see § 2.2.3
	droplet size	15 µm	5	see § 2.2.3
	release height	220 cm	6	see above
	radius aerosol cloud	20 cm	6	see § 2.2.3
	room volume	20 m ³	8	see above
	ventilation rate	0.6 hr ⁻¹	8	see above
	surface	2 m ²	6	see above
	respirable fraction	5 %	5	see § 2.2.3
Dermal exposure				
Contact rate	contact rate formulation	42 µl/min	5	see § 2.2.4

a) calculated parameter, see text

Default values exposure after application of crack and crevice spray

model	parameter	default value	Q	references, comments
Contact	frequency	9 year ⁻¹	5	see § 2.2.1
	use duration	14 x 1 hr	6	see above
	total duration	14 days	6	see above
	start exposure	0	9	direct exposure
Dermal exposure				
Transfer coefficient	dislodgeable fraction formulation ^{a)}	1.8 g/m ²	6	see above
	transfer coefficient	0.6 m ² /hr	6	see §2.2.5
	surface	2 m ²	6	see above
oral exposure				
Hand-mouth contact	intake rate formulation		5	see §2.2.6

a) calculated parameter, see text

The scenario indicates that the default values are given for spraying with an aerosol can. If spraying is carried out using a plant sprayer, water is the main ingredient of the sprayed liquid instead of an organic solvent. The consequences for the density are that it becomes 1 g/cm³ (see § 2.2.2). One should also take into account a different droplet size (30 µm instead of 15 µm) and therefore also a different respirable fraction (2 % instead of 5 %) (see § 2.2.3).

2.7 General surface application

Scenario

This scenario is based on a private user spraying the floor surface of a living room with an aerosol can. To calculate the exposure of the user during the application, the 'spray: cloud model' is used for the inhalatory exposure and the 'contact rate' model is used for the dermal exposure. The oral exposure is handled in the inhalatory exposure model. CONSEXPO assumes that the non-respirable fraction is taken in orally.

The exposure after application is described for crawling children present in the room after the treatment has been carried out. It is assumed that a child (default 10.5 months) crawls over the treated surface for 1 hour a day during a 14-day period. Exposure after application is described using the dermal exposure model 'transfer factor' and the oral exposure model 'hand-mouth contact'.

Exposure during application

Use duration

Baas and Van Veen (in preparation)⁶⁾ describe a number of general surface applications, where the use duration varies between 44 and 350 seconds. The period of active spraying was shorter: between 31 and 278 seconds. Five minutes (300 sec) is used as the default value for the active spraying time. Ten minutes is used as the value for the use duration, the time during which the spraying takes place.

Total duration

For the total duration, the same values are used as for the crack and crevice application (see section 2.6). For the exposure during application, a total duration of 4 hours is assigned, assuming that the user stays in the treated room for 4 hours after application. With regard to the exposure after application, it is assumed that a playing child crawls over the treated area for 1 hour a day during a 14-day period.

Inhalatory exposure: 'spray: cloud' model

Emission rate formulation

There are aerosol cans for sale that, according to the directions for use, can be used to treat large surface areas. It is not obvious whether these are other types of sprays than those sold for 'targeted spot' and 'crack and crevice' applications. Although it is expected that the spraying nozzle, in particular, is different on these sprays (and therefore their use), there is no specific data available. For this reason, the value used for the other sprays, calculated as 1.3 g/sec during active spraying, will be used as the default. The use duration indicates that during a time span of 10 minutes, the period of active spraying was 5 minutes. Consequently, 0.65 g formulation/sec is used as the default value for the emission rate formulation.

Release height

'General surface' sprays will mainly be used on floor coverings, although it is also possible to use such a spray to treat a couch for fleas. Baas and Van Veen (in preparation)⁶⁾ indicate that during a general surface application the spray is directed towards the floor or the ground. The default spraying height is set at 25 cm.

Room volume and ventilation rate

A larger room means a larger floor surface. Spraying is therefore carried out for longer in a larger room, and more of the product is applied. A relatively large room has been chosen as the default value, as it is expected that the exposure, particularly the exposure after application, will yield the highest value in such a room. The values for a living room from the 'General fact sheet' (Bremmer and van Veen, 2000)¹⁾ are used as the default values for the room and the ventilation rate. The volume of the living room is 58 m³, the ventilation rate is 0.5 hr⁻¹.

Surface of treated area

The surface area of the living room, the treated surface in the scenario, is 22 m².

Exposure after application***Dermal exposure: transfer coefficient****Dislodgeable fraction formulation*

By multiplying the emission rate formulation and the use duration, the total amount of sprayed formulation can be calculated (0.65 g/sec x 600 sec = 390 g). It is assumed that this amount ends up on the floor surface of the living room, so that the amount of formulation per surface unit can be calculated (390 g on 22 m², or 17.7 g/m²). Section 2.2.5 shows that, of this amount, 30 % is dislodgeable. The dislodgeable fraction formulation is calculated at 5.3 g/m².

Default values*Default values for exposure during general surface application with an aerosol can*

model	parameter	default value	Q	references, comments
Contact	frequency	9 year ⁻¹	5	see § 2.2.1
	use duration	10 min	6	see above
	total duration	4 hr	6	see above
	start exposure	0	9	direct exposure
Inhalatory exposure				
Spray: cloud model	emission rate formulation ^{a)}	0.65 g/sec	6	see above
	density formulation	0.7 g/ml	7	see § 2.2.2
	airborne fraction	15 %	4	see § 2.2.3
	droplet size	15 µm	5	see § 2.2.3
	release height	25 cm	6	see above
	radius aerosol cloud	20 cm	6	see § 2.2.3
	room volume	58 m ³	9	see above
	ventilation rate	0.5 hr ⁻¹	8	see above
	surface	22 m ²	9	see above
	respirable fraction	5 %	5	see § 2.2.3
Dermal exposure				
Contact rate	contact rate formulation	42 µl/min	5	see § 2.2.4

a) calculated parameter, see text

Default values for exposure after application of general surface spray

model	parameter	default value	Q	references, comments
Contact	frequency	9 year ⁻¹	5	see § 2.2.1
	use duration	14 x 1 hr	6	see above
	total duration	14 days	6	see above
	start exposure	0	9	direct exposure
Dermal exposure				
Transfer coefficient	dislodgeable fraction formulation ^{a)}	5.3 g/m ²	6	see above
	transfer coefficient	0.6 m ² /hr	6	see § 2.2.5
	surface	22 m ²	9	see above
oral exposure				
hand-mouth contact	intake rate formulation		5	see § 2.2.6

a) calculated parameter, see text

The scenario indicates that the default values are drawn up for spraying with an aerosol can. If the spraying is carried out using a plant sprayer, water is the main ingredient of the sprayed liquid instead of an organic solvent. The consequences for the density are that it becomes 1 g/cm³ (see § 2.2.2). A different droplet size (30 µm instead of 15 µm) should also be taken into account, and therefore also a different respirable fraction (2 % instead of 5 %) (see § 2.2.3).

2.8 Air space application

Scenario

This scenario is based on a private user who sprays an aerosol can in the living room to control flies or mosquitoes. Spraying is carried out from the middle of the room in the direction of the four upper corners. A daily use during a 3-month period is assumed. To calculate the exposure of the user during the application, the ‘spray: cloud model’ is used for the inhalatory exposure and the ‘contact rate’ model is used for the dermal exposure. The oral exposure is handled in the inhalatory exposure model; in CONSEXPO it is assumed that the non-respirable fraction is taken in orally.

The exposure after application is described for crawling children present in the room after the treatment has been carried out. It is assumed that a child (default 10.5 months) crawls over the floor of the treated room for 1 hour a day during a 7 day period. Exposure after application is described using the dermal exposure model ‘transfer factor’ and the oral exposure model ‘hand-mouth contact’.

Exposure during application

Contact

Use duration

According to the directions for use on an air space spray, you should spray for 1 sec per 10 m³. For a living room, chosen as the default room (see below), with a volume of 58 m³, this means spraying for 5.8 sec. The manufacturer of a different air space spray indicates 10 sec spraying per 20 m² floor surface. The above-mentioned room

has a floor surface of 22 m², which means spraying for 11 sec. Observations by Baas and Van Veen (in preparation)⁶⁾ indicate that the two volunteers who used the air space applications only used them for 1 second.

The default value for the active spraying time with an air space spray is set at 10 seconds; this higher value is mainly based on the directions for use. The use duration, the time during which the spraying takes place, is assumed to be twice as long and is therefore set at 20 seconds.

Total duration

For the total duration, the same values are used as for the crack and crevice application (see section 2.6). A total time of 4 hours is taken as the exposure during the application. It is assumed that the user stays in the treated room for 4 hours after the application.

Inhalatory exposure: spray: cloud model

Emission rate formulation

Using data from Matoba et al. (1993)⁹⁾ the use of an air space spray is calculated at 0.7 g/sec. This is half the value used for other application areas. An explanation may lie in the fact that an air space spray has a spraying nozzle which atomizes the product extremely finely, whereby the use per time unit is smaller than for other types of sprays.

Roff and Baldwin (1997)¹⁰⁾ also found a much lower use for air space sprays than for 'general surface sprays' (1- 4 to 5 ml/m³ versus 10 - 50 ml/m², respectively). For this reason, 0.7 g/sec is used as the default value when using air space sprays. The use duration, the time during which the spraying takes place, is twice as long as the actual spraying time. The emission rate formulation is therefore 0.35g/sec.

Release height

Based on the directions for use, the spraying height of an air space spray will be the default height of a Dutch man/woman, plus a small part of the hand/arm length, when the spray is aimed upwards into the four corners of the room. The default for the spraying height is set at 180 cm.

Room volume, surface area, ventilation rate

The control of flying insects takes place in various rooms of the house, such as in the living room and in bedrooms. As there is a direct relationship between the size of the room and the duration of the spraying, a higher exposure is expected when treating a larger room. As a worst case, therefore the living room is chosen as the default room. The default values for a living room are given in the 'General fact sheet' (Bremmer and Van Veen, 2000)¹⁾: volume of the living room 58 m³, surface area 22 m² and ventilation rate 0.5 hr⁻¹.

Exposure after application

The exposure after application is described for crawling children present in the room after application. It is assumed that the spray is distributed evenly over the floor surface after spraying. Since air space sprays are used daily, residues can accumulate

on the floor (see Matoba et al. (1998)⁴⁷). It is assumed that a child (default 10.5 months) crawls over the floor of the treated room for 1 hour a day, and that the residues are cleaned off the floor once a week (as a result of walking, crawling, brushing, vacuuming, mopping etc). This means implicitly that the potential exposure to residues on the floor after 7 days is considered to be zero again. It is assumed that the accumulation of the residues during these 7 days is linear. In other words, on the day of application the amount of residue is R, on day two it is 2R..... and on day seven the amount of residue is 7 R. The average exposure during these 7 days is 4 times as high as the exposure on the day of application.

Dermal exposure: transfer coefficient

Dislodgeable fraction formulation

By multiplying the emission rate formulation and the use duration, the total amount of sprayed formulation can be calculated ($0.35 \text{ g/sec} \times 20 \text{ sec} = 7.8 \text{ g}$). It is assumed that this amount ends up on the floor surface of the living room (22 m^2), so that the amount of formulation per unit surface can be calculated (318 mg/m^2). Section 2.2.5 shows that, of this amount, 30 % is dislodgeable. The dislodgeable fraction formulation is therefore 30 % of the amount of formulation per unit surface. The dislodgeable fraction formulation, on the day of application, is calculated as 95 mg/m^2 . By accumulation (see above) the average exposure during the application time is 4 times as high as the exposure on the day of application. The average dislodgeable fraction formulation during the entire application is calculated as 380 mg/m^2 .

Default values*Default values for exposure during air space spray application*

model	parameter	default value	Q	references, comments
Contact	frequency	90 year ^{-1 a)}	5	see § 2.2.1
	use duration	20 sec	6	see above
	total duration	4 hr	6	see above
	start exposure	0	9	direct exposure
Inhalatory exposure				
Spray: cloud model	emission rate formulation ^{b)}	0.35 g/sec	6	see above
	density formulation	0.7 g/cm ³	7	see § 2.2.2
	airborne fraction	100 %	6	see § 2.2.3
	droplet size	5 µm	5	see § 2.2.3
	release height	180 cm	6	estimation
	radius aerosol cloud	20 cm	6	see § 2.2.3
	room volume	58 m ³	9	see above
	ventilation rate	0.5 hr ⁻¹	8	see above
	surface	22 m ²	9	see above
	respirable fraction	34.4 %	5	see § 2.2.3
Dermal exposure				
Contact rate	contact rate formulation	23 µl/min	5	see § 2.2.4

a) daily use over a 3 month period

b) calculated parameter, see text

Default values for exposure after application of air space spray

model	parameter	default value	Q	references, comments
Contact	frequency	90 year ^{-1 a)}	5	see § 2.2.1
	use duration	7 x 1hr	6	see above
	total duration	7 days	6	see above
	start exposure	0	9	direct exposure
Dermal exposure				
Transfer coefficient	dislodgeable fraction formulation ^{b)}	380 mg/m ²	6	see above
	transfer coefficient	0.6 m ² /hr	6	see § 2.2.5
	surface	22 m ²	9	see above
oral exposure				
hand-mouth contact	intake rate formulation		5	see § 2.2.6

a) daily use over a 3 month period

b) calculated parameter, see text

3. Evaporation from strips and cassettes

Pest control products that evaporate from strips and cassettes are mainly used in the Netherlands to control moths, carpet beetle larvae and flying insects. The active substances are trapped in a solid matrix, paper or plastic strips, or are present in cassettes. In all cases, the evaporation of the active substances takes place during the application.

3.1 Use and composition

Pest control products that evaporate from strips and cassettes are split into two groups, depending on the exposure.

- Products for use in a small 'sealed' area (closet/trunk/suitcase).
This mainly concerns products to control moths and carpet beetle larvae (fur beetles). The products are hung or spread out in closets, blanket boxes, suitcases with clothes etc. The insecticide evaporates slowly and spreads throughout the small area.
- Products for use in a room.
This mainly concerns products to control flying insects, used in a room. In all cases, the products are sealed until the moment of use; evaporation of the product only starts when the product is opened.

In the first application group, the two subcategories listed below can be distinguished with regard to the exposure.

- Moth paper supplied in the form of individual sheets. In general, these sheets are sufficient for an area of approximately 1 m³, and must be cut into pieces for smaller areas such as a closet or suitcase.
- Strips pieces of paper or plastic strips that are ready-to-use and supplied in an (aluminum) cassette from which you can take as much as you need. There are also cassettes that should be hung in the closet after opening, in their entirety.

The exposure takes place during mixing and loading and otherwise only incidentally during the application. The duration of the dermal contact is different for the two subcategories.

The second application is in the form of strips or cassettes, both of which are used in a room to control flying insects. When used against flying insects, the product is hung in a room and the insecticide is supposed to get into the air in the whole room. In this way, all people present in the room are continuously exposed. The contact duration then depends on what the room in question is used for (kitchen or bedroom).

Oral exposure can also be expected. From the literature, it seems that when PVC strips with dichlorvos are used, the air concentration is equivalent to the concentration in food during the normal preparation of a meal (Elgar et al. 1972)²⁷⁾, (Collins and DeVries 1973)²⁸⁾.

From the CTB-Pesticide database (CTB, 1998)⁴⁶⁾ it seems that organophosphates and pyrethroids are used as active ingredients (a.i.). These substances seem to be applied mainly in a solid plastic matrix, in cassettes or in impregnated paper.

The use of dichlorvos in PVC strips is mainly described in the older literature (Leary, 1974²⁹⁾; Elgar et al., 1972²⁷⁾; Elgar and Steer, 1972³¹⁾; Weiss et al., 1998³⁰⁾).

Table 9 shows the above-mentioned methods of exposure by evaporation from strips and cassettes.

Table 9: Ways of exposure due to evaporation from strips and cassettes

exposure	small area (closet/trunk/suitcase)		room
	paper strips	strips/cassette	cassettes
Mixing and loading			
Dermal	contact duration = time of folding, cutting, positioning	short (hanging up the strip)	not applicable
Inhalatory	evaporation in preparatory stage	evaporation in preparatory stage	
Application			
Dermal	not applicable		not applicable
Inhalatory	- the saturated air in small sealed areas results in a brief high concentration. - leakage from the sealed area		for use in rooms there is long term contact, depending on the use of the room
Oral	not applicable		food
After application			
	not applicable		not applicable

3.2 Exposure to products in sealed areas

Mixing and loading

Contact

Frequency

The frequency is determined by the number of times that a consumer cuts up strips of paper to put in closets. When determining this frequency, a consumer is assumed who chooses this type of pest control, and not the average consumer. No literature references were found. From the directions for use, the average period of effectiveness is set at 4 months; a frequency of 3 times a year is assigned on this basis.

Use duration, total duration

It is assumed that the consumer prepares several strips at a time when cutting up the paper. No literature references are known about these times. For the time being, it is assumed that 10 minutes is needed to cut and/or fold a piece of anti-moth paper and then to distribute it among the clothes.

Inhalatory exposure: evaporation from pure substance

The exposure during mixing and loading is determined by the concentration that occurs during cutting. An inhalatory exposure due to evaporation and a dermal exposure due to handling the strip is anticipated. The 'evaporation from pure substance' model is used for the inhalatory exposure, whereby the surface is corrected for the weight fraction of the active ingredient. The 'evaporation from mixture' model is not applicable, since, based on Raoult's law, it assumes an ideal liquid. A plastic or

paper matrix is not an ideal liquid. In the 'evaporation from pure substance' model, it is assumed that only the pure substance, i.e., the active ingredient, is present. The model does not take into account the fact that the active ingredient is caught in a solid matrix. The evaporating surface is adapted to the percentage of active ingredient in the matrix. Using the 'evaporation from pure substance' model, an overestimate of the exposure will be calculated. There is currently no model which better describes the exposure.

Release area

It is assumed that a strip is cut with a surface area of 120 cm². The effective surface is the surface as if the active ingredient were present in its pure form. The effective surface is calculated by multiplying the surface by the fraction of active ingredient. If the weight fraction of the active ingredient in the above-mentioned strip of 120 cm² is 0.25, for example, the effective surface is 120 x 0.25 = 30 cm².

Room volume

The initial area in which the substance evaporates is presumed to be 1 m³ around the user.

Ventilation rate

The ventilation rate is taken to be the same as a standard ventilated room: 0.6 hr⁻¹ from the 'General fact sheet' (Bremmer and Van Veen, 2000)¹.

Application

Contact

Frequency.

A more general effect on the exposure is the consumer use of anti-moth products: does the consumer always hang them up in the closet, or are they only used for long-term storage, since the storage place will then rarely be opened. When used to control moths, it is possible that the product is used all year round, and that exposure only actually takes place a few times a year. As a worst case, it is assumed that the anti-moth products are used in the every-day closet, and that there is therefore the potential for daily contact. The frequency is set at 365 times per year.

Duration of use and total duration

Inhalatory exposure will mainly occur briefly when opening the closet/trunk/ suitcase. There are no observations on this matter. It is not known how much leakage there is from the sealed area into the room, whereby inhalatory exposure at a low concentration is expected.

In the model to calculate the inhalatory exposure, it is assumed 'worst case' that the user has his/her nose in the closet throughout the period of application. This is a 'worst case' assumption, since, when opening the closet/trunk/suitcase, the active ingredient will spread around the area, whereby the concentration will decrease. There is currently no model which better describes the inhalatory exposure.

For the default values for the use duration and the total duration, an estimate is made of the time during which exposure to the concentration of the active ingredient in the closet takes place; this time is estimated to be 5 minutes.

Inhalatory exposure: evaporation from pure substance

The application phase actually covers the entire lifetime of the product. This definition means that the phase after application becomes unimportant. Exposure takes place by the evaporation of the active ingredient. The 'evaporation from pure substance' model is used here, whereby the surface is corrected for the weight fraction of the active ingredient (see mixing and loading). Just as for 'mixing and loading' an overestimate of the exposure will be calculated.

Room volume

The area is taken to be a closet with a volume of 1.5 m³.

Ventilation rate

Based on the background data from the 'General fact sheet'(Bremmer and Van Veen, 2000)¹⁾, the ventilation rate in a closet that is opened once a day is estimated to be 0.3 hr⁻¹

Default values; products in a sealed room, mixing and loading

Model	parameter	default value	Q	references, comments
Contact	frequency	3 year ⁻¹	5	see above
	use duration	10 min	3	see above
	total duration	10 min	3	see above
	start	0		direct exposure
Inhalatory exposure				
Evaporation from pure substance	release area ^{a)}			see above
	temperature	20 °C	9	room temperature
	room volume	1 m ³	5	see above
	ventilation rate	0.6 hr ⁻¹	8	see above
Dermal exposure				
Contact rate	contact rate	1 mg/min	2	estimation
	density	1 g/cm ³	5	estimation

a) calculated parameter, see text

Default values; products in sealed area, during application

Model	parameter	default value	Q	references, comments
Contact	frequency	1 day ⁻¹	3	see above
	use duration	5 min	3	see above
	total duration	5 min	3	see above
	start	0		direct exposure
Inhalatory exposure				
Evaporation from pure substance	release area ^{a)}			see above
	temperature	20 °C	9	room temperature
	room volume	1.5 m ³	5	see above
	ventilation rate	0.3 hr ⁻¹	4	see above

a) calculated parameter, see text

3.3 Exposure to products in living areas

Application

Contact

Frequency, duration of use and total duration

It is assumed that the products are used in the summertime, from mid-May to mid-September. The total duration is 5 months. During these 5 months, exposure can occur daily. The frequency is therefore daily for 5 months per year. It is assumed that the products are used in a living area in which people are present for 8 hours a day.

Inhalatory exposure: evaporation from pure substance

The ‘evaporation from pure substance’ model is used. The reasoning given for the application of products in sealed areas (§3.2) is also applicable here.

Release area

The surface area of PVC strips is between 200 and 220 cm² (28); 29); 31). The effective surface is the surface as if the active ingredient were present in its pure form. The effective surface is calculated by multiplying the surface area (220 cm²) by the fraction of the active ingredient.

Room volume and ventilation rate

This is based on the standard values from the ‘General Fact sheet’ (Bremmer and Van Veen)¹⁾: a room of 58m³ and a ventilation rate of 0.5 hr⁻¹.

Default values; products in living areas during application

Model	parameter	default value	Q	references, comments
Contact	frequency	1 day ^{-1 a)}	6	see above
	use duration	8 hr/day	6	see above
	total duration	8 hr/day	6	see above
	start	0	8	direct exposure
Inhalatory exposure				
Evaporation from pure substance	release area ^{b)}			see above
	temperature	20 °C	9	room temperature
	room volume	58 m ³	8	see above
	ventilation rate	0.5 hr ⁻¹	8	see above

a) daily use over a period of 3 months, or 150 times a year

b) calculated parameter, see text

4. Electrical evaporators

4.1 Introduction

Electrical evaporators are used to kill insects, in particular flies and mosquitoes. An electrical evaporator is plugged into an electrical socket; the solvent and active ingredients are heated, resulting in evaporation. Once in the colder air of the room, the solvent condenses and the active ingredient almost immediately and completely turns into droplets, which rise to the ceiling due to the warmer air.

Use and composition

The exposure to active ingredients from electrical evaporators is modeled in detail by Matoba et al. (1994)³²⁾. This model seems to adequately predict both the behavior of the active ingredient and the aerosol in a room as a concentration of the active ingredient, although only one validation experiment was carried out. However, the model is too complex to implement in scope of these fact sheets. From a model point of view, the working mechanism of the electrical evaporator is comparable to that of an air space spray. With an electrical evaporator, just as with an air space spray, small droplets are generated which float in the air. The question is whether the generated droplets give rise to exposure by staying in the air for a certain period of time, or whether it is only the exposure due to evaporation that is important. Matoba et al. (1994)³²⁾ indicate that 98% of a synthetic pyrethroid (mol. weight: 302.41; vapor pressure: 1.68×10^{-2} Pa) condenses and that the droplet with the active ingredient formed in this way is in the air for 49.3 seconds.

For this fact sheet, the well-mixed spray model will be used as a simplified approach of the Matoba-model. The assumption here is that active ingredients used in an electrical evaporator at room temperature are negligibly volatile. This will normally be the case, as the used active ingredients will only be evaporated slowly due to heating.

The insects against which the evaporator is used, in particular flies and mosquitoes, mainly come out at dusk. This means that the equipment is mainly used in the evening in living areas and bedrooms. In bedrooms, exposure can take place all night long.

Electrical mosquito evaporators have a cartridge of 45 to 50 ml containing a solvent and the active ingredient. Matoba et al. (1994)³²⁾ mention n-paraffins (especially a mixture of n-tetradecane: 70%; n-pentadecane: 24%) as solvents.

4.2 Exposure

Scenario

This scenario is based on the application of an electrical evaporator in a bedroom, for 8 hours a day for 5 months a year. With regard to the exposure after application, a child (default 10.5 months) is assumed who crawls over the floor for 1 hour a day during the 5-month application period.

Exposure during application

Contact

Use duration, total duration

There are two types of evaporators with regard to the working time. There are evaporators with an on/off switch that operate continuously once switched on. There are also evaporators with a built-in time switch that have their own on/off rhythm. It is assumed that electrical evaporators are used in the evening in living areas and bedrooms, and that those in the living room are turned off at bedtime. If the apparatus is used in the bedroom, the exposure takes place during the entire period that the people are asleep. A default value for the use duration when used in a bedroom is set at 8 hours. This value is also used for a child's bedroom, assuming that the electrical evaporator is functioning there for 8 hours a day.

There is no data known about the frequency of use. It will be used most intensively in areas with lots of mosquitoes. Mosquitoes can appear from April to November, with a peak in the late summer and fall. The Dutch Animal Plague Knowledge and Advice center states that in areas with many mosquitoes (near moorland, for example) aerosol sprays are used to control those mosquitoes several times a week (KAD, 2001)³⁷⁾. Based on this data, the default value assumes a use of 5 months per year.

Inhalatory exposure: spray-well mixed model

Generation rate formulation

The emission rate of the active ingredient was measured by Matoba et al. (1994)³²⁾, who found a rate of 7.36×10^{-7} g/sec. The value is converted to the emission rate of the formulation, which is 1.3 mg formulation/min.

Airborne fraction

All evaporated substances enter the air and form small droplets. The airborne fraction is therefore 100 %.

Density

The density will depend on the solvent. When organic solvents with a relatively high boiling point are used (including n-tetradecane and n-pentadecane), the density will normally be in the region of 0.8 g/cm^3 .

Droplet size, respirable fraction.

Matoba et al.(1994)³²⁾ indicate that the droplets are initially $3.5 \mu\text{m}$. Due to condensation and evaporation, the droplet sizes vary between 3.5 and $15 \mu\text{m}$. The default value for the average droplet size of the particles is taken to be $5 \mu\text{m}$. Section § 2.2.3 shows that a respirable fraction of 34.4 % for the particles with a diameter of $5 \mu\text{m}$ is expected.

Room volume, ventilation rate

We assume the room to be the smallest bedroom from the 'General fact sheet' (Bremmer and Van Veen, 2000)¹⁾ of 7 m^2 with a volume of 16 m^3 . In this report, the default value for the ventilation rate of a bedroom is given as 1 hr^{-1} .

Exposure after application

The active ingredient is expected to not only rise to the ceiling, but also to spread around the room. The first reason is that extensive monitoring of a sprayed chlorpyrifos application shows that the chlorpyrifos spreads itself around a room (Gurunathan et al., 1998)³³). Some of the chlorpyrifos was also found on toys on which it had not landed initially. The second reason is that when using an electrical evaporator, the active ingredient has also been found on the walls and floor (Matoba, 1994)³²). Based on measurements whereby an electrical evaporator with the above-mentioned synthetic pyrethroid (mol. weight: 302.41; vapor pressure 1.68×10^{-2} Pa) was used for 6 hours in a room of 23.3 m³ with a ventilation rate of 0.58 hr⁻¹, Matoba et al. (1994)³²) calculated that the amount of the pyrethroid on the floor and on the walls was comparable. They calculated that 12 hours after the start of the application, the amount of pyrethroid on the floor and on the walls was approximately 0.01 % of the amount that was present on the ceiling, and was approximately 1 % of the amount in the air.

Based on the above, it is assumed that some of the active ingredient will end up on the floor and some will become attached to other materials such as toys and bed linen. Children crawling over the floor can be exposed dermally; oral exposure can also occur due to hand-mouth contact. Oral exposure can also take place when young children mouth toys and/or bed linen.

The scenario assumes that the electrical evaporator is used daily during a 5 month period. The extent of the exposure will depend on the properties of the applied active ingredient, the vapor pressure, and the speed of degradation of the substance, but also on the absorption and re-absorption properties of the substance and the sort of materials present in the room. External factors such as the ventilation rate will also have an influence.

Based on the available data, it is not possible to make a reliable estimate of the amounts of the product that may be present on bed linen, toys and on the floor. To make a sound estimate of the exposure after application, a good possibility is to empirically determine the amount of product on the floor. Based on these measurements, the transfer coefficient model can be used to calculate the dermal exposure, and the hand-mouth contact scenario to calculate the oral exposure. The calculation of the dermal and oral exposure is comparable to the calculation of the exposure after application of a spray, as shown in chapter 2.

Dermal exposure: transfer coefficient

Dislodgeable fraction formulation

It was previously stated that no reliable estimate can be made of the amount of product present on the floor. If this amount is known from measurements, the dislodgeable fraction formulation can be calculated. Section § 2.2.5 shows that of the amount on the floor surface, 30 % is dislodgeable.

4.3 Default values

Default values during application of electrical evaporator

Model	parameter	default value	Q	references, comments
Contact	frequency	1 day ^{-1 a)}	5	see above
	use duration	8 hr	5	see above
	total duration	8 hr	5	see above
	start	0	9	direct exposure
Inhalatory exposure				
Spray-well mixed model	generation rate formulation	1.3 mg/min	6	see above
	airborne fraction	100 %	6	see above
	density	0.8 g/cm ³	6	see above
	droplet size	5 µm	5	see above
	release height	110 cm	7	height socket
	room volume	16 m ³	9	see above
	ventilation rate	1 hr ⁻¹	7	see above
	respirable fraction	34.4 %	5	see above

a) daily use over a period of 3 months, or 150 times a year

Default values after application of electrical evaporator

Model	parameter	default value	Q	references, comments
Contact	frequency	1 day ^{-1 a)}	5	see above
	use duration	150 x 1 hr	6	see above
	total duration	150 days	6	see above
	start exposure	0	9	direct exposure
Dermal exposure				
Transfer coefficient	dislodgeable fraction formulation	30 %	6	see above
	transfer coefficient	0.6 m ² /hr	6	see § 2.2.5
	surface	7 m ²	9	floor surface
oral exposure				
hand-mouth contact	intake rate formulation		5	see § 2.2.6

a) daily use over a period of 3 months, or 150 times a year

5. Insect repellents

5.1 Use and composition

Insect repellents aim to repel bloodsucking insects, fleas or ticks. In moderate climates these are mosquitoes (Culicidae), sand flies (Phlebotomidae), biting midges or black flies (Ceratopogonidae, Simuliidae) and horse flies (Tabanidae), which are not only troublesome but also act as carriers of disease (Haupt and Haupt, 1998)³⁴. In the tropics the tsetse fly (*Glossina*) should be added as the carrier of sleeping sickness. The mechanism of action the active ingredients in insect repellents is not revealed yet, (see Fradin, 1998)³⁵, their effectiveness is determined experimentally.

The products are supplied as a liquid (milk, gel, lotion) in a plastic bottle, as impregnated cloths, as sticks or as a spray. All of these products are ready to use. They must be applied to the skin and should prevent insects from landing on the skin. They are normally applied to the uncovered parts of the skin. Users sometimes apply the products to their clothes to prevent insects such as ticks from getting into the clothes, or to prevent mosquitoes from biting through the clothes. Exposure occurs when these products are applied to the skin. This obviously results in dermal exposure. Oral exposure can also occur as a result of hand-mouth contact, since the product is applied using the hands and the product is also applied to the hands. With the sprays, inhalatory contact with aerosols is possible.

The active ingredients in insect repellents are described below.

- DEET (N, N-diethyl-3-methylbenzamide) is the most important active ingredient in insect repellents. There is a broad spectrum of repellents that are effective against mosquitoes, black flies, fleas and ticks. DEET is the most effective and the best-studied repellent. It is used worldwide, whereby human poisoning occurs now and then due to misuse and specific over-sensitivity. Various sources summarize these cases of poisoning (Fradin, 1998³⁵; Osimitz and Murphy, 1997³⁶; Veltri et al., 1994³⁸). These references mainly concern children, where cases with the highest doses occur. For adults, poisoning occurs as a result of too high a dosage or due to increased skin penetration.
- Citronella oil. Citronella is the active ingredient in most 'natural' or 'vegetable-based' insect repellents. It is registered by the US-EPA as an insect repellent. Citronella oil smells like lemon and used to be extracted from the grass *Cymbopogon nardus*. There is little data comparing the efficiency of products based on citronella and products based on DEET. In a study by Wright (1975, cited in Fradin, 1998³⁵) 0.01 µmol DEET per liter of air was enough to prevent 90% of the mosquitoes from landing on the skin; a concentration of citronellol (one of the active ingredients in citronella oil) of one thousand times higher was required to achieve the same effect.
- Bite Blocker is a vegetable-based repellent that has been available for a long time in Europe and since 1997 in the US. Bite Blocker seems to use soya oil, geranium oil and coconut oil as active ingredients in its formulation. Studies at the University of Guelph, Ontario, Canada (Lindsay et al., 1996, cited in Fradin, 1998³⁵), show that 97 % protection against *Aedes*-mosquito bites was achieved under field conditions, even up to 3.5 hours after application. At the same time, a spray of 6.65% DEET gave 86% protection, and a citronella-repellent only gave

40% protection.

5.2 Exposure

Scenario

Repellents are applied on the uncovered skin: on the head, hands, arms, legs and feet. Exposure takes place dermally and orally. The inhalatory route is excluded due to the use outdoors, and because use indoors only takes place in the summer in situations where there is a high ventilation rate. On these grounds, the inhalatory exposure to aerosol sprays is also considered to be negligible.

Insect repellents are also applied on the hands. If the product is supplied in the form of a liquid or cream, it is applied using the hands. Hand-mouth contact can occur, leading to the ingestion of some of the repellent. Exposure due to hand-mouth contact will mainly be important for children. The exposure is described for adults and children of 10.5 months.

Contact

Frequency

The US-EPA (1998)⁴⁸⁾ reports an average frequency of 15 applications per year of DEET for the entire population of the US, and 19 applications per year for the male population. An average frequency of 12 applications per year is given for children. The US-EPA report does not indicate standard deviations of these figures. Research by Weegels and Van Veen (2001)³⁹⁾ indicates that for a product used by consumers, the coefficient of variation quickly approaches the region of 1. If this coefficient of variation is taken as being applicable, a reasonably high frequency of use for men is 27 days per year (when assuming a log normal distribution, the 75th percentile of the frequency). For children, a reasonably high use is 21 days per year (when assuming a log normal distribution, the 75th percentile of the frequency). The default value for the frequency of use is set at 27 days per year, where a use of twice a day is assumed (see use duration).

The frequencies are calculated based on the frequency of use from the American DEET data and the variation in Dutch consumer products. Data from the US is not necessarily applicable to the Dutch situation (different climate, different habits). The calculation is also carried out using parameters between which there is little or no relationship. The quality factor Q for the frequency of use is therefore set at 4.

Use duration, total duration

The duration of protection and the related number of applications per day varies according to the active ingredient and the parasite that has to be repelled. The duration of protection was investigated for the active ingredient DEET, and proved to depend on the concentration of DEET and the sort of parasite (see Fradin, 1998)³⁵⁾. In general, products that have no special matrix have a duration of protection of between 2 and 4 hours for a concentration of the active ingredient of 10-12.5%, and 6 to 8 hours for a concentration of 20-50% a.i. A duration of protection of 1.9 hours is given for a 5 % solution of citronella oil (Spero, 1993, cited in Fradin, 1998³⁵⁾). Another product based on citronella gave a protection duration of 2 hours, whereby the best protection occurred within 40 minutes. A duration of protection of around 3.3 hours is given for

Bite-Blocker (Lindsay et al., 1996, cited in Fradin, 1998³⁵).

The duration of protection indicates that exposure for less effective products (citronella, bite blocker, DEET<10%) will be maximally 3 hours, while the exposure for effective products (DEET>20%) will be 6 hours. It can also be assumed that less effective products are used more frequently. For two applications, there is a total duration of exposure of 6 hours, equal to the duration of a single application of the effective substance. As the default two applications per day with a duration of exposure of 3 hours per application are assumed.

Dermal exposure: fixed volume model

Amount of product on the skin

Data is available about the repellents themselves and comparable data about suntan creams and body lotions, allowing the amount applied to the skin per application to be estimated.

- The US-EPA assessment of DEET (US-EPA, 1998)⁴⁸) assumes an average of between 1.0 and 1.3 grams of active ingredient per application. Children and adults fall within this range. Unfortunately, the concentration of DEET contained in the formulation is not stated. If we assume concentrations of 60 and 20% DEET in the formulation, the amount of product applied on the skin is approximately 1.9 and 5.8 grams, respectively.
- The default values for amounts of suntan creams and body lotion applied, given in the 'Cosmetics fact sheet' are 10 g and 8 g per application (Bremmer et al., in preparation)⁴¹). For both products, almost all of the skin is treated. Insect repellents are applied on the uncovered skin: on the head, hands, arms, legs and feet. The surface of these body parts is 64 % of the total body surface (Bremmer and Van Veen, 2000)¹). If the use of repellents is comparable to that of suntan creams and body lotions, 5 to 6 g is used per application. Based on the above, the default value and the amount of repellent per application is set at 6 g.
- The default value for the total body surface of children of 10.5 months is 0.437 m². The total body surface of an adult is 1.75 m² (Bremmer and Van Veen, 2000)¹). If it is assumed that there is a linear relationship between the body surface and the amount of repellent used, the amount of repellent used for a child of 10.5 months would be 1.5 grams per application.

Oral exposure: hand-mouth contact

Intake rate

Children exhibit a great deal of hand-mouth contact; for adults the contact is mainly between the fingers and the mouth. As the applied products are expected to be rubbed over the skin by adults using their bare hands, the oral route will also be important for adults. It is expected that children will take in the amount that is rubbed into the hands orally, and that adults will take in the amount on the fingers.

For children of 10.5 months, the fraction of the surface formed by the hands is approximately 10 % of the total treated body surface (head, hands, arms, legs and feet) (Bremmer and Van Veen, in preparation)⁴⁰). For adults, the fraction of the surface formed by the fingers is approximately 4 % of the total treated body surface (Bremmer and Van Veen, 2000)¹). For adults, this means that 4 % of 6 g (240 mg) is taken in by hand-mouth contact in 3 hours. The intake rate is calculated at 80 mg/hr.

For a child of 10.5 months, it is calculated that 10 % of 1.5 g (150 mg) is ingested in 3 hours, or 50 mg/hr.

5.3 Default values

Default values for the application of insect repellents

Model	parameter	default value	Q	references, comments	
Contact	frequency	54 year ^{-1 a)}	4	see above	
	use duration	3 hr	6	see above	
	total duration	3 hr	6	see above	
	start	0	9	direct exposure	
Dermal exposure					
Fixed volume model	dilution	1	8	instructions for use	
	weight of product	adult	6 g	5	see above
		child (10.5 months)	1.5 g	5	
	density formulation	0.9 g/cm ³	7	estimation	

Oral exposure				
Hand-mouth contact	intake rate			see above
	formulation			
	adult	80 mg / hr ^{b)}	4	
child (10.5 months)	50 mg / hr ^{b)}	4		

a) 27 days, application 2 times per day

b) calculated parameter, see text

6. Baits

Baits are used to kill mice, rats, ants and cockroaches. The products are placed at the appropriate places, the animals eat some of the products and die. The products against rats and mice are mainly grains to which the active ingredient has been added. It is always compulsory to dye the product in such cases.

In addition to the above-mentioned products, there are also baits to control flies in cattle and poultry sheds. These products are exclusively for professional use, and are not discussed in the present scope.

For the baits to control rats and mice there is a definite division between products for professional use and for consumer use. For consumer use, the net contents of a single packet may not be higher than 200g, and bait stations must be included. For professional use, the net content of a single package is minimally 800g. For use in rooms, the bait must be put out in feeding boxes that are closed on the top; for outdoor use, it must be put out in specially designed feeding stations, in such a way that the bait is not within the reach of children, cattle, pets or birds. The data above was obtained from the Pesticide Database from the Dutch Board for the Authorization of Pesticides (CTB, 2000^a)⁴⁵⁾.

Ant and cockroach bait stations

Ant and cockroach bait stations are all entirely closed boxes (made of metal or plastic) in which the user only has to make a small hole to be able to use it. The bait stations are positioned in places where the ant or cockroaches walk.

The ants take the product out of the box and back to their nest, so that they die in the nest. It takes several days before the whole nest is wiped out. This is why the bait stations should remain in the same place for at least one week. One bait station is enough for a small room. The bait will cease to be effective after about 1 month, due to the contents being removed by the ants and by it drying out. One type of ant bait station contains approximately 12 g of product.

To control German cockroaches, depending on the numbers, between 1 and 5 bait stations (with 1.2 to 1.5 g per station) are advised per 10 m². The bait in the bait stations will work well for approximately 3 months. To control the larger types of cockroach, such as the Oriental, the Australian and American cockroaches, the use of between 1 and 3 bait stations (of 7.5 g) per 10 m² is advised (CTB, 2000^a)⁴⁵⁾.

Cockroach bait stations are intended for indoor use. Ant bait stations can be used both indoors (e.g. in kitchens) and outdoors (e.g. on balconies and patios). The active ingredient in ant bait stations are trichlorfon and foxim; in cockroach bait stations: fenitrothion and hydramethylnon (CTB, 2000^a)⁴⁵⁾.

Mouse and rat baits

The baits for mice consist of grain to which the active substances have been added. These products must be dyed. For consumer use, the net contents of a single packet may not be higher than 200 g of product. The packaging includes specially designed feeding stations, closed on top. The mouse pellets are sometimes pre-packed in a sealed bag that has to be put into the bait station. In a number of cases, the pellets themselves need to be placed in the bait station. This bait can only be used indoors.

The dosage is 25 to 50 g (usually 40 g) per 10 to 15 m² surface. A good quantity of the product should be present for several days. This should be checked daily or every other day. If necessary, the bait should be topped up until no more is eaten. Products that are moldy or contaminated must be replaced. When the activity is stopped, the remains of the product must be collected and packed in plastic. This should be disposed of as small chemical waste or as household garbage (CTB, 2000^a)⁴⁵.

Only a few baits were found for consumers to control brown rats. These were ready-to-use rings that should be placed somewhere that is frequented by the rats, such as in or near an entrance to a burrow or hiding place, on paths, or places where they collect or eat food. Sewers, under the floors of buildings where it is very damp, and waterfronts are explicitly mentioned. The active ingredient in mouse poison is bromadiolon, difethialon, or difenacum; in rat poison it is warfarin (CTB, 2000^a)⁴⁵.

6.1 Exposure

The vapor pressure of the above mentioned active substances is very low. Evaporation of these substances will be so small that the inhalatory exposure is considered to be negligible.

Ant and cockroach bait stations

Some dermal exposure could occur when making the hole in the bait station. In addition, an extremely small, mainly dermal exposure could occur by ants or cockroaches taking the substance out of the bait station, after which people come into contact with it. For the time being, the exposure due to the use of ant and cockroach bait stations is considered to be negligible. Accidents (swallowing, children who open bait stations) do not form a part of a standard assessment.

Mice and rat baits

This mainly concerns ready-to-use products, which are often pre-packed and then only have to be placed into a bait station. It must take into account that some of the users will anyhow open the packets. In such a case, a small amount of dermal exposure will occur.

Dermal exposure can once again occur when topping up and tidying up the baits. It should be remembered that the bait stations can be made of thin cardboard. The exposure when topping up and tidying up the bait stations could be higher than that when setting up the bait stations.

Scenario

The use of baits against mice is described as the default. It is assumed that two bait stations are positioned, 4 times a year, with 40g bait per bait station. In the scenario, the topping up of a bait station is regarded as positioning a new bait station. Exposure can occur during 'mixing and loading' and when tidying up the bait station, which falls into the 'after application' category. The exposure during application is considered to be negligible. The exposure concerned is dermal exposure of a part of the hands. No data about the dermal exposure have been found.

The method of exposure during 'mixing and loading' and 'after application' is the same. As no data was found, the exposure is not split into 'mixing and loading' and

‘after application’, but an estimate of the total exposure is made. For the time being, it is assumed that the total dermal exposure per bait station with 40 g of bait will be maximally 0.5 % of the applied amount of product (0.5 % of 40 g = 0.2 g). For mathematical reasons, the model assumes that the entire exposure takes place during mixing and loading.

6.2 Default values for bait stations to control mice

Model	parameter	default value	Q	references, comments
Contact	frequency	8 x/ year	4	see above
	use duration	5 min	5	estimation
	total duration	5 min	5	estimation
	start exposure	0	5	direct exposure
Dermal exposure fixed volume model				
	weight of product	0.2 g	2	estimation
	density	1.5 g/cm ³	5	estimation

7. Dusting powders

This chapter deals with fine dusting powders. Dusting powders are used to control ants, wasps, flees and crawling insects. In addition, but mainly for professional use, there are also powders that have to be dissolved or suspended in water prior to spraying. This type of product is covered in chapter 2 Spray applications.

7.1 Use and composition

Ant dusting powder

Powders to control ants are exclusively permitted for application outdoors. The dusting of a small amount of powder at the entrance to the ant nest, i.e., in crevices and between tiles and the like is preferred. If the user cannot find the nest entrance, a small amount of powder should be dusted on paths and/or along doorsteps and window frames and other places where the ants enter the house. The following is stated in one set of instructions for dusting a product: 'Cut a corner off the inner packet using scissors, so that the contents can easily be scattered'. The active substances for ant dusting powders are deltamethrin, foxim and permethrin.

Wasp powder

Wasp powders for non-professional use are only permitted for the control of wasps outdoors. To control wasps, a small amount of powder should be put at the opening of the nest, preferably in the evening when the wasps are already in the nest. Active substances are deltamethrin and permethrin

Cat and dog fleas

To control fleas and their larvae around dogs and cats, the places where the dog and/or cat sleeps or lies down should be treated with powder. Cracks, crevices and surfaces can be treated with the insect powder. Up until April 1995 a flea powder was permitted which was sprinkled over the animals' fur and rubbed into the skin. The current thinking is: For the effective control of fleas it is necessary to treat both the area around your cat or dog and the animal itself with a registered product designed for this purpose. Active substances in dusting powders to control fleas and their larvae are deltamethrin, permethrin and propoxur.

Crawling insects

To control crawling insects (house cricket, firebrats, carpet beetles, lice, fleas, wood lice and earwigs) in living and accommodation areas, dusting powders are permitted with permethrin and propoxur as the active substances. The directions for use indicate: "Use in cracks and crevices, treat the places where insects can hide; lightly dust the areas to be treated; do not use on people or pets!"

Dust mite

The directions for use indicate: 'Sprinkle the powder over the carpet, distribute it equally over the carpet and brush the carpet with a broom, vacuum it up when it is completely dry'. The drying time is 1-3 hours; the carpet must not be walked on while it is drying. The recommendation is to check regularly, for example every 3 months in

the first year and then once a year, to see whether a repeat treatment is necessary. The dosage given is: 1 packet of 750 g for 12 m² low pile, 10 m² middle pile and 7.5 m² deep pile carpet. The active substance is benzylbenzoate.

Germination inhibiting products on potatoes

Germination inhibitors can be used to discourage potatoes from germinating. Germination inhibitors in powder form are permitted for non-professional users. To discourage germination, stored potatoes are dusted with the powder in the fall, before they have produced shoots. Chloroprofam is usually used as the germination inhibitor. The dosage is 500 grams per 250 kg of potatoes. It is used exclusively for potatoes for the retail market, with the understanding that the treated batches may not be consumed within 2 months after treatment.

The above-mentioned products are mainly H-products. A few powders to control fleas in the area around cats and dogs are listed under the H-products, in addition to a powder for this use listed under the V-products. The powders to control fleas in the area around cats and dogs, which fall under the H-products category, are all permitted for another application, for example the control of ants. The products that inhibit the germination of potatoes fall into the L-products category. Several of the above-mentioned products are permitted for more than one of the mentioned applications. The information about the use and composition was obtained from the Pesticide Database of the CTB (CTB, 2000^a)⁴⁵.

7.2 Exposure

Dusting powders can be split up into four categories:

- powders that are scattered outdoors (to control ants and wasps);
- powders used indoors to lightly dust the area to be treated. The area to be treated is the floor and/or the area where a dog or cat sleeps or lies down (to combat dog and cat fleas and against crawling insects);
- substances that have to be brushed into the carpet (against dust mite);
- germination inhibitors for potatoes.

Inhalatory exposure due to evaporation

The active substances in dusting powders are all substances with an extremely low vapor pressure, and are therefore not very volatile. The inhalatory exposure due to evaporation is therefore considered to be negligible. All products are fine powders that need to be scattered (for the control of ants and wasps), or with which the surface to be treated must be dusted (such as for fleas and crawling insects).

Mixing and loading

A large number of the dusting powders are supplied in a shaker, similar to an icing sugar shaker. The preparation usually involves pricking through the holes in the shaker to be able to sprinkle the contents. There are also powders that are supplied in a plastic bag, where the corner has to be cut off before the powder can be sprinkled. For the time being, it is assumed that there are no products for which the powder has to be taken out of the bag and put into a shaker. On these grounds, the exposure during mixing and loading is considered to be negligible.

Dusted surfaces and amounts used

The amount of powder that is used when controlling dust mite, according to the directions for use, is 60 to 100 g per m² (see § 7.1). Based on this data, 2200 g is taken as the default value for the amount of powder dusted in a living room of 22 m² (Bremmer and Van Veen, 2000)¹⁾.

The calculation of the amount of germination inhibitor on potatoes is based on the winter storage of 125 kg of potatoes. According to the directions for use, 250 g of germination inhibitor should be used. It is assumed that the storage of 125 kg of potatoes covers an area of 3 m².

No data were found on the size of the dusted surface and the amount of dusted powder for the other applications. The dusted surfaces given in the table are estimates. It is assumed that 60 g per m² is the amount of powder dusted per unit surface for these applications. This value is estimated based on the powder used when controlling dust mites.

Default values for dusted surfaces and amounts used

type of powder	Use	dusted surface [m ²]	Q	amount of powder dusted [g]	Q
Wasp powder	Outside	0.25	4	15	4
ant powder	Outside	1	4	60	4
flea powder	Inside	1	4	60	4
Crawling insects	Inside	1	4	60	4
dust mite	Inside	22	8	2200	8
Germination inhibitor	Inside	3	6	250	7

Scenario

This scenario is based on a non-professional user who is controlling crawling insects indoors with the help of a dusting powder. For the room in which the treatment takes place, we assume the default room given in the 'General fact sheet' (Bremmer and Van Veen, 2000)¹⁾ of 20 m³, 8 m², and a ventilation rate of 0.6 hr⁻¹. It is assumed that 60 g of powder is dusted onto 1 m².

After application, dermal exposure can take place by a child crawling over the treated area. Oral exposure can then take place by hand-mouth contact. As the default, a child of 10.5 months who crawls over the treated area is assumed. For application indoors, it is assumed that a child is in contact with the treated area for 1 hour a day during the 14 days after application.

Exposure outdoors

A number of models have been developed in CONSEXPO to describe the inhalatory exposure in a room. The 'spray cloud' model describes the inhalatory exposure due to spraying aerosols indoors, for example, and the 'evaporation from mixture' model describes the exposure due to the evaporation of a substance in a room. These models can all be applied to calculate the inhalatory exposure in a room. These models cannot be applied to calculate the inhalatory exposure outdoors.

The dermal and the oral exposure after application outdoors can be described with the

help of CONSEXPO (using the 'transfer coefficient' and the 'hand-mouth contact' model, respectively). For application outdoors, where there is influence of sunlight, wind and rain, it is assumed that exposure occurs over a 7-day period. For outdoor application it still is assumed that the child is in contact with the treated area, for 1 hour a day.

Exposure during application

Inhalatory/oral exposure: spray cloud model

During the dusting of the surface under treatment, the dusted particles can be breathed in and oral and/or inhalatory exposure can occur. In the section above it is assumed that the evaporation of the active substance is negligible; here is mainly referred to the inhalatory/oral exposure to dusted particles. When using dusting powders, the surface being treated is almost always on the ground (outdoors; ant control on the patio), the floor (indoors; fleas and crawling insects), or objects on the floor (cat or dog baskets, potatoes). An exception is the control of wasps (nests).

The parameter which has the most influence with regard to the dispersion of particles, and therefore the exposure, is the particle size of the powder particles. In addition to the amount dusted and the duration, the sprinkling height is also of importance. The force of the wind also has to be taken into account when outdoors. Extremely fine particles can disperse with the slightest wind, and will not immediately reach the ground.

No special model, developed for the application, is available for the use of dusting powders. The use of dusting powders can be described with the help of the 'spray cloud model', which was developed for the spraying of aerosols. The definitions for a number of parameters do have to be somewhat altered. The spray cloud model describes the behavior of a cloud of aerosol particles, but it can also describe a cloud of solid particles, that is, a dusted powder. The model shows the situation whereby the user's head ends up in the cloud of dispersed powder. This is not always the case. A situation is therefore described whereby an overestimate of the exposure is calculated.

Emission rate formulation

The emission rate formulation is calculated by dividing the amount of powder dusted by the duration of use. If 60 g of dusting powder is dusted in 5 minutes, the emission rate formulation is $60/5 = 12$ g/min.

Radius aerosol cloud

The 'radius aerosol cloud' from the spray cloud model concerns the initial radius of the aerosol cloud, before deposition occurs. For the use of a dusting powder, the default value for 'radius aerosol cloud' is first calculated as the radius of a circle with, as its surface, half of the surface over which the powder is scattered. For a dusted surface of 1 m^2 , the default value for the 'radius aerosol cloud' is taken to be the radius of a circle with a surface of 0.5 m^2 ; this is calculated as 40 cm.

Release height

A sprinkling or dusting height of 50 cm is taken as the default.

Droplet size, airborne fraction.

The average diameter of the dusted particles should be filled in as the droplet size. The diameter of the particles is important for the time that the particles remain in the air. Smaller droplets fall more slowly. With regard to the number of particles in the air, in addition to the 'particle size', the 'airborne fraction' is also important. The airborne fraction is defined as the fraction of the particles that is dispersed in the air.

As a guideline for the size of the particles, the particle size distribution of agricultural lime is assumed. For lime marl, the legal requirement is that 99 % of the lime particles are smaller than 1000 µm and 90 % are smaller than 150 µm. Based on this data, it is provisionally defined that most of the particles will have a diameter of between 50 and 150 µm. For the smallest 5% of the particles, the average particle size is set at 25 µm. It is assumed that this 5 % disperses itself in the air, that is, the "airborne fraction" is set at 5 %.

Respirable fraction

The Biocides Steering Group (1998)⁷⁾ indicates that 0.1 % of particles with a diameter of 15 µm are respirable, and that particles of 18 µm and larger are not respirable. CONSEXPO assumes that inhaled particles which are not respirable are taken in orally. For the time being, all particles that are dusted are assumed to be larger than 18 µm. This means that the respirable fraction is 0; no inhalatory exposure occurs. It is assumed that all of the inhaled particles are taken in orally.

Dermal exposure: contact rate

Contact rate formulation

When sprinkling/dusting the surface to be treated, dermal exposure can occur, particularly of the hands. This is definitely the case for products to control dust mites, which have to be brushed into the carpet. The dermal exposure is described using the contact rate model.

No data on the amount of the product that ends up on the hands have been found. Van Hemmen (1992)¹⁴⁾ gives 2 g formulation /hr as the indicative value for dermal exposure to solids during the mixing and loading of 25 kg of formulation (see §2.4). This can be converted into a contact rate formulation of 1.3 µg/min per gram of dusted powder.

If 60 g of dusting powder is dusted, the contact rate formulation is $60 \times 1.3 = 78 \mu\text{g}/\text{min}$. This value is used as the default value for the contact rate formulation. Van Hemmen's indicative value for professional application during mixing and loading is extrapolated to a consumer application for the scattering of powder. A quality factor of 3 is therefore assigned.

Exposure after application

Dermal exposure: 'transfer coefficient' model

Transfer-coefficient

Data about the transfer coefficient (the factor that indicates what surface is rubbed off by the skin per unit time, and is therefore transferred from the floor to the skin) is given by the EPA (1997)²⁵⁾. For children from 6 to 18 months who crawl over the

treated carpet, a factor of 0.6 m²/hr is given, where the EPA assumes a maximum of 4 hours of activity per day.

Dislodgeable fraction formulation

In an HSL Pilot study on aerosols (cited in the Biocides Steering Group's report, 1998⁷⁾) 10 % is given as the value for the parameter 'dislodgeable residue from treated carpet'. The concept-SOPs of the US-EPA²⁵⁾ assume that 50 % of the amount of the active ingredient gets on to the surface. Based on this data, the default value for the dislodgeable fraction is set at 30%. If 60g of flea powder is sprinkled onto 1 m², the dislodgeable fraction formulation is therefore 60 x 0.3 = 18 g/m².

Oral exposure: hand-mouth contact

Intake rate formulation

For the oral exposure due to hand-mouth contact, it is assumed that 10 % of the amount of a product that gets onto a child's skin is taken in orally by hand-mouth contact (see § 2.2.6). The intake rate formulation can be calculated based on this assumption.

Default values for the application of dusting powder against crawling insects, indoors

Model	parameter	default value	Q	references, comments
Contact	frequency	5 year ⁻¹	5	in summer, once a month
	use duration	5 min	4	estimation
	total duration	5 min	4	estimation
	start	0	9	direct exposure
Inhalatory exposure spray – cloud model				
	emission rate formulation	12 µg/min ^{a)}	4	see above
	density formulation	1.5 g/cm ³	5	estimation
	airborne fraction	0.05 g/g	3	see above
	droplet size	25 µm	3	see above
	release height	50 cm	5	see above
	radius aerosol cloud	40 cm ^{a)}	3	see above
	room volume	20 m ³	8	see above
	ventilation rate	0.6 h ⁻¹	8	see above
	surface	1 m ²	5	see above
	respirable fraction	0	5	see above
Dermal exposure contact rate				
	contact rate formulation	4.8 mg/min ^{a)}	3	see above

a) calculated parameter, see text

Default values after the application of dusting powder against crawling insects, indoors

Model	parameter	default value	Q	references, comments
Contact	frequency	5 year ⁻¹	5	in summer once a month
	use duration	14 x 1 hr	6	see above
	total duration	14 days	6	see above
	start	0	9	direct exposure
Dermal exposure transfer factor				
	dislodgeable fraction formulation	18 g/m ² a)	3	see above
	transfer coefficient	0.6 m ² /hr	6	see above
	surface	1 m ²	5	see above
Oral exposure hand-mouth contact				
	intake rate formulation	-- mg/ min ^{a)}	3	see above

a) calculated parameter, see text

8. Textile biocides, gasses and foggers

8.1 Textile biocides

This concerns moth, decay and fungus-resistant products in textiles. One could think here of products such as carpets, awnings and tents. One could also think of mosquito nets which are impregnated with insecticide.

In the H-products category (see § 1.4.1), only two products were found that are permitted in wool-processing factories to control insects that damage wool and silk. These products are added to wool, silk, wool mixtures, and textile threads made up from them (CTB, 2000^a)⁴⁵). The active substance in both cases was permethrin. In 'Textile finishing companies and carpet factories' (VROM, 1992)⁴²) chlorophenyl and ammonia fluorosilicates are also named as moth, decay and fungus-resistant products. In the Netherlands, there are currently no permitted products with which to impregnate cotton (tents, awnings) with moth, decay and fungus resistant products (CTB, 2000)⁴³).

Textile biocides are applied to the textile during the production process. They are not used by consumers and are therefore not elaborated on in this study. Exposure by consumers to textile biocides can therefore only occur by using the treated products. The estimate of the exposure can be carried out in a similar way as the risk assessment for AZO dyes in clothes (Zeilmaker et al., 1999⁴⁴).

8.2 Gasses and foggers

A number of pest control products is applied as gasses or a gas is formed during use. There are also pest control products that are applied in an atomized form.

The gas methylbromide is used as a pest control product for professional use in storage, business and accommodation areas. Examples of gas forming products are aluminum phosphide (AlP) and magnesium phosphide (Mg₂P₂). If these phosphides come into contact with moisture, the extremely poisonous gas phosphine (PH₃) is produced. The products mentioned above are permitted as supply protection products, to control animal organisms (mites and insects). The products or goods that can be gassed with phosphine include grains, grain products, seeds, nuts, spices, tea, tobacco, cotton and wool, in addition to furniture and empty buildings. The products may not be applied in living and accommodation areas or to control wood-attacking insects in buildings. Methylbromide is also allowed to control rats on board ships, since they cannot be controlled with anything else. The products may only be used by experts, under stringent conditions.

The soil in green houses used to be disinfected by gassing with methylbromide. This application has not been permitted for some time. In the past, to control wood-attacking insects in buildings, the building in question was packed in and gassed; prussic acid (hydrocyanic acid) was used as the active substance. The data above was obtained from the Pesticide Database of the Dutch Board for the Authorization of Pesticides (CTB, 2000^a)⁴⁵).

To prevent potatoes from germinating, they are gassed with a germination inhibitor (usually chlorprofam). Germination inhibitors are introduced into the internal air stream of the stored potatoes using a jet engine spray (fog). This type of product may only be used by professional users. The products fall into the crop protection products category.

All the above-mentioned applications for the use of gasses, gas-forming products and foggers are only permitted for professionals, and not for non-professional users. Exposure of consumers due to the use of these products will therefore not occur.

9. Uncertainties and limitations

This report records a number of default parameters which can be used in the exposure assessment of the non-professional user of pest control products, with the help of CONSEXPO. The model approach for estimating the exposure has huge advantages. There is little quantitative data about consumer exposure to pest control products. The model approach makes it possible to extrapolate the relatively sparse data for certain products to other products and other scenarios, for which there is no specific data. The determination of default values for the various model parameters also ensures that a high degree of consistency can be achieved in the assessments.

One should realize that the exposure estimates from a model depend on the quality and the reliability of the input-data. It is therefore recommended that one is alert in the choice of parameter values and the determination and improvement of default values. This last point is mainly true for scenarios and the related parameters which can have a major influence on the final exposure estimate.

The scenario of the dermal exposure of crawling children is based on a number of assumptions which must be substantiated further in the future. The quantitative estimate of the so-called hand-to-mouth route should also be further investigated.

It should also be noted that the model-modules used in CONSEXPO are developed for particular purposes (e.g., the spray-cloud model was developed for an aerosol can or trigger spray). When there are no adequate alternatives, one is forced to use some modules for derived scenarios. Until better models are available, the models suggested in the text are the best alternative. When drawing up an exposure calculation, the limitations of the used model must be stated.

Some examples are given below (already mentioned previously in the text): For dusting powders the calculations are carried out using the 'spray-cloud model'. This model assumes that the user has his/her nose in the aerosol cloud, which is a realistic assumption for a number of spray-applications. When scattering an ant powder, however, it can be assumed that there is some exposure to the powder, but not that the user has his/her nose in the powder cloud.

Another example of a (too) worst case assumption concerns the inhalatory exposure due to evaporation of the active ingredient from strips and cassettes. For the inhalatory exposure the 'evaporation from pure substance' model is used. In the 'evaporation from pure substance' model, it is assumed that only the pure substance, i.e., the active ingredient, is present. The model does not take into account the fact that the active ingredient is caught in a solid matrix. The evaporating surface is adapted to the percentage of active ingredient in the matrix, however. Using the 'evaporation from pure substance' model, an overestimate of the exposure will be calculated. There is currently no model which better describes the exposure.

In the next versions of CONSEXPO and/or in the update of this report (if more data is available) these aspects will be further elaborated on. Depending on what is needed, further adapting exposure modules of certain scenarios can be considered or developing new modules, for example.

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Appendix 1, mailing list

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- 6-10 Hoofdinspecteur voor de Gezondheidsbescherming
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- 13 dr. W.H. van Eck, VWS/afd. Gezondheidsbescherming
- 14 drs. J.W. Dornseiffen, VWS/afd. Gezondheidsbescherming
- 15 dr. ir. J.M. de Stoppelaar, VWS/afd. Gezondheidsbescherming
- 16 prof. dr. J.J. Sixma, Gezondheidsraad
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- 20 dr. S. Bosman- Hoefakker, CTB Wageningen
- 21 dr H.E.Falke, CTB Wageningen
- 22 dr. C.E. Goewie, CTB Wageningen
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- 41 dr. M Michaux, CEFIC, Brussel
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- 50 ir. G.J. Schefferlie, CSR
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