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Pest Control Products Fact Sheet

To assess the risks for the consumer
Updated version for ConsExpo 4

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Abstract

Exposure to compounds in pest control products

Exposure to compounds in consumer products can be assessed using the computer program ConsExpo (Consumer Exposure). Given the huge number of consumer products, it is not possible to calculate the exposure for each separate product, so a limited number of groups containing similar products are defined. The information for each group of products is described in a fact sheet. Paint, cosmetics, children's toys and cleaning products are examples fact sheets which have been published already. This fact sheet covers the use of pest control products by consumers. In the factsheet eight product categories are described, including sprays, dusting powders, repellents, electrical evaporators and baits. To assess exposure of compounds in the pest control products default values for all eight product categories have been determined.

Key words: pest control products, biocides, exposure, consumer, risk, compounds

Rapport in het kort

Blootstelling aan stoffen ongediertebestrijdingsmiddelen

Voor de conversie van het computerprogramma ConsExpo 3.0 naar 4.0 is de factsheet ongediertebestrijdingsmiddelen aangepast en herzien.

ConsExpo 4.0 is een computerprogramma, dat gebruikt kan worden om de blootstelling van mensen aan stoffen in consumentenproducten uit te rekenen. Hierbij wordt rekening gehouden met verschillende blootstellingsroutes (dus via de huid, via inhalatie en via orale opname).
Bij het ConsExpo programma hoort ook een database, waarin standaardwaarden voor vele producttypen en voor een groot aantal blootstellingsscenarios worden aangeboden. De beschrijving van deze achtergrondinformatie bij deze standaardwaarden wordt gerapporteerd in zogenoemde ‘factsheets’.
In dit rapport, factsheet ongediertebestrijdingsmiddelen, is de meest recente informatie bijeengebracht om de blootstelling aan stoffen uit ongediertebestrijdingsmiddelen te berekenen. De verschillende typen ongediertebestrijdingsmiddelen zijn verdeeld in 8 categorieën, bijvoorbeeld poeders, spuitbussen en crèmes.
Voor iedere categorie wordt de samenstelling en gebruik van producten uit die categorie beschreven. Daarnaast wordt aangegeven welk model of modellen van ConsExpo het meest geschikt is om de blootstelling uit te rekenen en worden voor alle gegevens die nodig zijn voor de berekening standaardwaarden ingevuld. Naast deze factsheet ongediertebestrijdingsmiddelen zijn er ook factsheets voor cosmetica, verf, reinigingsmiddelen en desinfectantia.

Trefwoorden: ongediertebestrijdingsmiddelen, biociden, blootstelling, consument, risico, stoffen

Contents

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. Paint, cosmetics, children’s toys and cleaning products are examples of fact sheets which have been published already. This fact sheet covers the use of pest control products by consumers for eight product categories including sprays, dusting powders, repellents, electrical evaporators 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. Voor elke hoofdcategorie wordt de informatie in een factsheet weergegeven. Verf, reinigingsmiddelen, kinderspeelgoed en cosmetica zijn voorbeelden van factsheets die al gereed zijn. 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, strooipoeders, 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.

1 Introduction

1.1 General

Descriptive models have been developed within National Institute for Public Health and Environment (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 computer program called ConsExpo 4.0. 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.

Because of the large number of consumer products currently on the market, it is not possible to assign exposure models and parameter values to each individual product. Therefore, a limited number of main categories of similar products have been defined. Examples of the main categories are paint, cosmetics, children's toys, cleaning products and pest control products. 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 substance 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 type of exposure, whereby differences can occur in the exposure phase (mixing and loading, during or after exposure) and the route of exposure (inhalation, 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 are 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 via a database. Using these data, standardized exposure calculations for consumers resulting from the use of pest control products can be performed.

1.2 ConsExpo

ConsExpo is a software tool for Consumer Exposure assessment. ConsExpo is a set of coherent, general models that can be used to calculate the exposure to substances from consumer products and their uptake by humans. It is used 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. Furthermore, ConsExpo is also one of the models that is used to assess the consumer exposure to biocides. (Technical Notes for Guidance (TNsG): Human Exposure to Biocidal Products – Guidance on Exposure Estimation[50)] (http://ecb.jrc.it))

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. ConsExpo 4.0, the most recent ConsExpo version, is described in detail in Delmaar et al. (2005)[2)].

ConsExpo 4.0 can be used for a screening assessment or for an advanced (higher tier) assessment. Per exposure route i.e. inhalation, dermal and oral route, different models are offered for calculating external exposure. ConsExpo also integrates the exposure via the different routes resulting in a systemic dose. Different dose measures can be calculated (acute, daily, chronic exposure). ConsExpo can also run calculations using distributed input parameters and sensitivity analysis can be performed.

The computer model is publicly available. Default data are available via the database which is an integral part of ConsExpo. The software, the user manual and the various fact sheets (see section 1.3) can be downloaded via the website of the Institute for Public Health and the Environment in the Netherlands (www.rivm.nl/consexpo)

1.3 Fact sheets

This report is one of a series of fact sheets that describes a main category of consumer products, such as paint, cosmetics, children's 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'[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 facts sheets, information about exposure to chemical substances is collected into certain product categories. These categories are chosen so that products with similar exposures are grouped. On the one hand, the fact sheet gives general background information; while on the other hand, it quantifies exposure parameters which, together with one or more of the ConsExpo exposure models, produce a quantitative estimate of the exposure.

The fact sheets are dynamic documents. As new research becomes available or as perceptions change, the parameter default values may need to be changed. Additional models can also be developed within ConsExpo; this too will require adaptations. The fact sheets are linked with ConsExpo since the fact sheets define the default values for the parameters used in the different ConsExpo models. Alterations in either the default values or the parameters influence both the fact sheets and (data base of) ConsExpo. 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 substance. This means that the information about the active substance must be added separately. This mainly concerns information about the concentration and the physico-chemical properties of the active substance.

1.3.1 Definition of the consumer

Non-professional use only

The default values in the fact sheets have been collected for consumers (private or non-professional users). They are not aimed at describing exposure for people who professionally work with pest control products, 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.

Groups to consider

Two groups can be distinguished in the exposure assessment for consumers: the group experiencing the highest exposure during use (in most cases the user) and the group exposed after application (e.g. children). The person applying the product (the user) is the one actually using the formulation and, if necessary, diluting it to the required concentration (‘mixing and loading’). It is expected that the user will be exposed to high levels during mixing and loading and during application.

In the post-application phase, for relevant scenarios, young children can be relatively high exposed, due to their specific time-activity pattern (crawling on treated surfaces,

hand-to-mouth contact, relatively low body weight).
In the present fact sheet, if relevant, the exposure calculations are based on children between 10 and 11 months, since this group demonstrates the most crawling and hand-mouth contact, combined with a relatively low body weight. More information on specific exposure scenarios for children is provided in Van Engelen and Prud'homme de Lodder (2004)[55)].

1.3.2 'Reasonable worst case' estimate

The basis for the calculation and/or estimation of the default parameter values is a realistic worst-case scenario, and considers consumers who frequently use a certain pest control product under relatively less favourable circumstances. For example, when using a pest control product, 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.

The parameter values in the fact sheets are aimed at (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 (or estimated) for each parameter. The 75th percentile is used for parameters which 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.

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. Since for all parameter values a 75th /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 in general the calculated values for exposure and uptake will result in a 99th percentile.
The result is a 'reasonable worst-case' estimate for consumers who use relatively large amounts of pest control products under less favourable circumstances.

1.3.3 Reliability of the data

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 assessments. 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 a default is used in an exposure analysis, it should be carefully considered and, if possible, adapted. If representative data is supplied by applicants or producers, 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 according to the exposure scenarios. For example, an exposure estimate might be carried out for a room of a particular size; the well-established default room size should then be replaced by the actual 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 range has been adapted and it can have a value of between 1 and 4.

In previous fact sheets, the quality factor ranged from 1 to 9. Table 1 shows the meaning of the values of the quality factor.

Table 1: Value of quality factor Q

Q	Value
4	Good quality relevant data, parameter value reliable
3	Number and quality of the data satisfactory, parameter value usable as default value
2	Parameter value based on single data source supplemented with personal judgement
1	Educated guess, no relevant data available, parameter value only based on personal judgement

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 by specially qualified companies and personnel. The products and equipment used, and therefore exposure circumstances, are often not the same as those available to the consumer. On the one hand, professionals use more active substances than private users. Subsequently, a professional user of the product can be exposed to much higher amounts before, during and after the application than a private user. On the other hand, professionals may use special personal protection measures and, immediately after the application, special regimes 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.

1.4.1 Classification of biocides

In this section the classification of biocides in the European Union and the United States is described.

The biocide directive (98/8/EC) came into force in the European Union in 1998. This deals with the authorization of active substances required for biocides which can occur within 23 categories, summarized as disinfectants, preservatives, pest control products and other biocidal products (see: Table 2). The pest control products (EU category 14-19) are important for this pest control products fact sheet.
More information on the biocides directive is available on the website of the European Chemicals Bureau (http://ecb.ei.jrc.it/biocides/). Guidelines for exposure aspects can be found in the Technical Notes for Guidance[50)].

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: Fibre, 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

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 substances 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.

1.4.2 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 belong to that category.
The following categories are defined for pest control products, based on the registration applications at the Board for the Authorisation of Pesticides in the Netherlands (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, gasses and foggers

Each of these categories is covered in a separate section (sections 2 to 8) in the remainder of this fact sheet.

1.5 Principles behind the exposure estimate

For the exposure assessment for private users and/or bystanders, an estimate of the potential exposure is based on the (concept) 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 (and this is usually the case), a consumer exposure model like ConsExpo can be used. For the product under study, the most relevant models are chosen from ConsExpo for each relevant route (inhalation, dermal and/or oral) and the parameters needed for the models are then collected.

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 should be taken into consideration. For example, if the amount of product to be applied per surface is given in the directions for use, or if the producer of an aerosol can supply the droplet size distribution, these values are used.

The directions for use are not always complied with exactly in the assessment when it can be assumed 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, independent of the active substance.

1.6 Uncertainties and limitations

This fact sheet presents a number of default parameters which can be used in the exposure assessment of the non-professional user of pest control products, when using ConsExpo. 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. Scenarios and the related parameters can have a major influence on the final exposure estimate. For example, 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 models used in ConsExpo are developed for particular purposes. In the absence of specific models, one is forced to use a model developed for another purpose. For example, for dusting powders the exposure is calculated using the spray model which is developed for an aerosol can or trigger spray.

Another example of a (too) worst case assumption concerns the inhalation exposure due to evaporation of the active substance from strips and cassettes. For the inhalation exposure the 'exposure to vapour: evaporation' model is used.
It is assumed that only the pure compound, i.e., the active substance, is present. The fact that the active substance is caught in a solid matrix is not taken into account. The evaporating surface is adapted to the percentage of active substance in the matrix, however. Using the 'exposure to vapour: evaporation' 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 models for certain scenarios can be considered or developing new models, for example.

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 centres 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 three main aspects when characterizing the exposure of spray applications, that is:
- the type of spraying device (spray can or trigger spray);
- whether the formulation still needs to be processed before application (mixing and loading);
- the target of the application.

2.1.1 Type of spraying device

To spray pest control products two types of spraying devices are available: aerosol spray cans and trigger sprays. Aerosol spray cans are pressure resistant containers from which a liquid is discharged under the pressure of a propellant; these cans are ready-to-use spray products.
Trigger sprays are dispensers turning a liquid into a (fine) spray. There are ready-for-use pest control product trigger sprays and formulations, which should be mixed and loaded in a plant sprayer. By turning around the nozzle of the plant sprayer the spray distribution can be adjusted which results in a spray with fine or coarse droplets.

2.1.2 Mixing and loading

With regard to mixing and loading, there is a distinction between:
- **liquid concentrate,** that is diluted and sprayed using a plant sprayer and whereby, during the dilution, evaporation can occur
- **powders and granules,** which are dissolved in water and are sprayed using a plant sprayer; the powder can produce dust during dissolving

2.1.3 The target of the application

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 bystanders 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 wipe able surface, amongst other things. Worst case, it is assumed that the entire sprayed surface of all types of spray is 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 initial particle distribution and inhalation cut-off diameter. 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 types of spray applications mentioned above. Sprays for a surface application (such as targeted spot, crack and crevice and general surface sprays) are available as aerosol spray cans as well as trigger sprays. Both spray devices are discussed in the sections concerned. Air sprays are only available as aerosol spray cans; therefore, only the application of aerosol cans is described.

2.2 General parameters for the spraying process

Table 3 shows all the models to describe the mixing and loading, the exposure during and after spray application.

Table 3: Overview of the models used for spray applications

Situation		Spray type	Route of exposure		
			Inhalation	**Dermal**	**Oral**
Mixing and loading	Dilution of liquid Dissolving a powder/ granules		Evaporation	Instant application Constant rate	
During application	Targeted spot Crack and crevice General surface Air space	Spray can/ trigger spray Spray can/ trigger spray Spray can/ trigger spray Spray can	Spray Spray Spray Spray	Constant rate Constant rate Constant rate Constant rate	Spray Spray Spray Spray
After application (post-application exposure of children)	Targeted spot Crack and crevice General surface Air space			Rubbing off Rubbing off Rubbing off Rubbing off	Hand-mouth Hand-mouth Hand-mouth 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 focus 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 the help file and user manual of ConsExpo 4.0 (Delmaar et al., 2005)[2)].

2.2.1 Parameters for use frequency

- *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 (2000) [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 reports 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 (2000)[6)] reports the results of interviews coupled with the observations of spraying behaviour. 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 use [6)]

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: Default values for use frequency

Application	Frequency [times per year]	Q
Mixing and loading, liquid	6	2
Mixing and loading, powder or granules	3	2
Spraying, targeted spot	9	2
Spraying, air space	90[a)]	3
Spraying, crack and crevice	9	2
Spraying, general surface	9	2

[a)] daily use over a period of 3 months

It should be remembered that for the default values, it is endeavoured 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 Centre, which states

that in areas with many mosquitoes (near moor land, for example) such products are used several times a week (personal communication J. de Jong, 2001).
A daily use over a 3-month period is assumed, based on a 'heavy' user.

2.2.2 Density

In the spray model the density of the non-volatile fraction is one of the parameters. The active substance in liquid concentrates can be dissolved in volatile organic solvents. The density of these solvents is around 0.7 g/cm^3; 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/cm^3 is used.
Products that are sprayed using a plant sprayer are dissolved in water.

Many active substances in pest control products are made of large organic compounds with densities usually between 1.0 and 1.5 g/cm^3. For a complex mixture of (especially organic) compounds, the density is set at 1.8 g/cm^3. The density of salts generally varies between 1.5 and 3.0 g/cm^3 (see Table 6).

Table 6: Default values for density

Type	**Main ingredient**	**Density** [g/cm^3]	**Q**
Solvents	Volatile organic solvents	0.7	3
	Water	1	4
Non-volatile compounds	Large organic compounds	1.5	3
	Salts	3.0	3
	Complex mixture of compounds, especially organic compounds	1.8	3

2.2.3 Parameters for the spray model

To calculate the inhalation exposure for the user, the spray model from ConsExpo is used for all spray applications.
Pest control products can be sprayed using a ready-to-use aerosol can or a trigger spray. A trigger spray can be a ready-for-use spray or a plant spray in which the formulation should be mixed and loaded.

The spray model is developed on the basis of the results of experimental work and describes the indoor inhalation exposure to slightly evaporating or non-volatile compounds in droplets that are released from a spray can or trigger spray. (Delmaar et al.) [2, 56)]. For volatile substances, the evaporation model is more appropriate. If the spray model is used for volatile substances the inhalation exposure will be underestimated, because exposure to vapour is not considered in the spray model.
Volatile is defined as compounds with vapour pressure > 0.1 Pa,
non volatile < 0.01 Pa and slightly volatile between 0.01and 0.1 Pa[37)].

- *Initial particle distribution*

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.
'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 7).

Table 7: Classification of aerosol droplets [7)]

Droplet diameter [μm] [a)]	Classification
< 15	fog
< 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 8).

Table 8: 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.

TNO-PML[53)] has investigated the initial particle size distributions from aerosols spray cans and trigger sprays. Among other types of spray pest control products were studied. The investigated spraying devices were aerosol spray cans, ready-to-use trigger sprays and plant sprayers with an adjustable nozzle to produce a spray with droplets as small as possible or a spray with coarse droplets. The percentiles of different spraying devices are given in Table 9. The 10, 50, and 90 percentiles for the volume distributions of the spray cans are given as d_p (V, 0.10), d_p (V, 0.50) and d_p (V, 0.90), which means that 10%, 50% or 90% of the product mass is below the mentioned size.

Table 9: Percentiles of the initial volume distribution of spray cans and trigger sprays[53)]

Application	**Spraying device**	**Content**	**Percentiles of the initial particle distribution [µm]**		
			D_p (0.10)	**D_p (0.50)**	**D_p (0.90)**
Air space spraying, aerosol cans					
Air space (against flies & mosquitoes)		Full Nearly empty	25 17	125 49	414 101
Air space (against flies)		Full Nearly empty	7 6.6	23 23	109 45
Surface spraying, aerosol cans					
Targeted spot on plants (affecting insects)		Full Nearly empty	55 20	97 68	232 152
Crack & Crevice/ Surface (against fleas)		Full Nearly empty	9.4 9.8	30 27	142 97
Wood preservative		Full Nearly empty	15 20	40 52	106 92
Surface spraying , trigger sprays					
Targeted spot on plants (affecting insects)	Plant spray [a)] (fine [b)])	Full Nearly empty	33 27	88 69	191 171
Targeted spot on plants (affecting insects)	Plant spray [a)] (coarse [b)])	Full Nearly empty	39 36	127 123	512 420
Crack & Crevice/ Surface (against crawling insects)	Trigger spray (ready-to-use)	Full Nearly empty	29 31	63 65	200 157

a) the user has to mix and load the formulation in a plant sprayer
b) the nozzle can be adjusted so that the plant sprayer generates a fine spray with droplets as small as possible or a spray with coarse droplets

Air space sprays

For aerosol spray cans the default initial particle distribution is based on data generated by TNO-PML[53)] and on (confidential) data from exposure assessments. Default: lognormal distribution with median 20 µm and a coefficient of variation (C.V.) 0.4. (see Figure 1).

Surface spraying

- Aerosol spray cans
  The default initial particle distribution is based on above-mentioned data generated by TNO-PML and on (confidential) data from exposure assessments.
  Default: lognormal distribution with median 25 µm, coefficient of variation 0.4. (see Figure 2)
- Trigger sprays
  The default initial particle distribution is based on data generated by TNO-PML.
  Default: lognormal distribution with median 50 µm, coefficient of variation 0.6. (see Figure 3)

The default values for the initial particle distributions are given in Table 10.

Table 10: Default values initial particle distribution

Pest control sprays	**Distribution**	**Median** [µm]	**C.V.**[a)]	**Q**
Aerosol spray can				
air space	Lognormal	20	0.4	3
targeted spot; crack and crevice; general surface	Lognormal	25	0.4	3
Trigger spray				
targeted spot; crack and crevice; general surface	Lognormal	50	0.6	3

a) C.V.: Coefficient of Variation

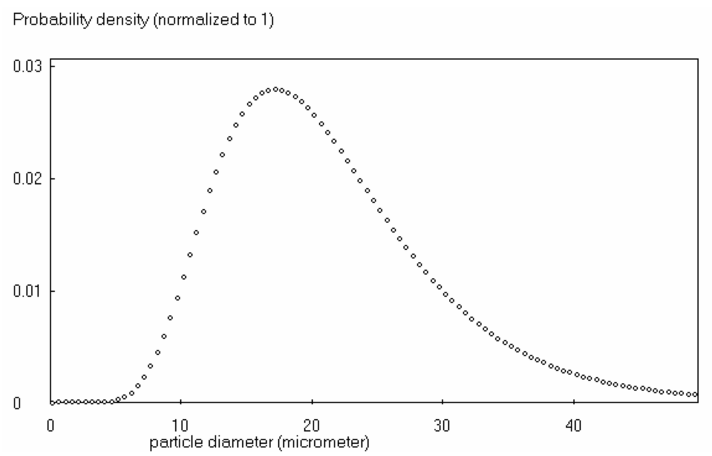

Figure 1: Default initial particle distribution for air space sprays i.e. a lognormal distribution with median 20 µm (C.V. 0.4)

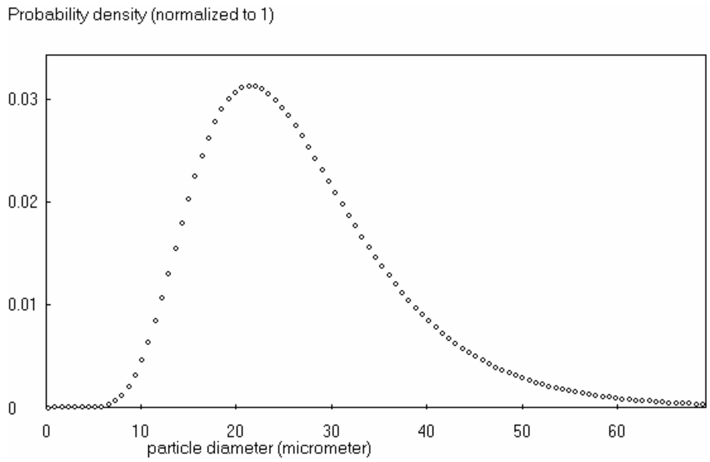

Figure 2: Default initial particle distribution for surface spray cans i.e. a lognormal distribution with median 25 µm (C.V. 0.4)

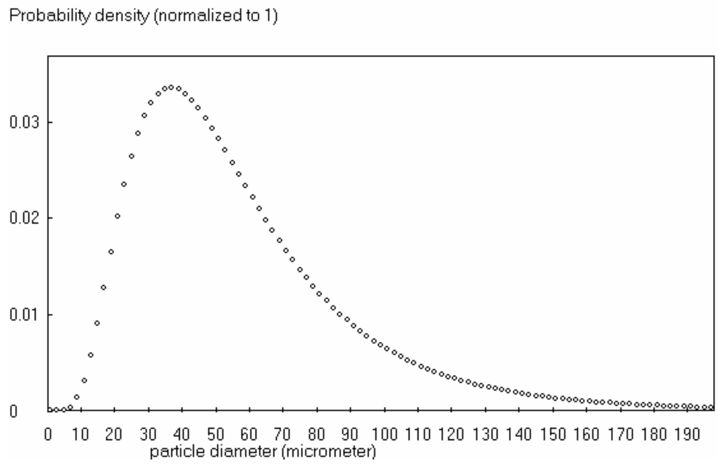

Figure 3: Default initial particle distribution for surface trigger sprays i.e. a lognormal distribution with median 50 µm (C.V. 0.6)

- *Inhalation cut-off diameter*

The inhalation cut-off diameter is the measure for the diameter of the spray droplets that can be inhaled and reach the lower areas of the lungs (alveoli, bronchioles, bronchia). Particles that are above this diameter deposit in the higher parts of the respiratory tract and will be cleared via the gastro-intestinal tract, leading to oral exposure. The inhalation cut-off diameter is only an approximation of the complicated process of deposition of particles in the lung. In general its value will be around 10-15 micrometer. The default value is set at 15 µm.

- *Airborne fraction*

The airborne fraction is the fraction of non-volatile material that becomes airborne in the form of droplets. The 'airborne fraction' combines the fraction non-volatile material that ends up in the smaller droplets and the fraction of droplets that becomes airborne. The latter is closely connected to the type of spray and the way it is used, i.e. spraying on a surface (paint, wood preservative) or spraying in the air (spraying against flies), and on the droplet size distribution that has been specified.
Airborne fractions have been determined experimentally for different sprays. The airborne fraction is derived from the TNO-PML[53)] survey on the exposure from spray cans and trigger sprays (Delmaar et al., in prep.)[56)]. In Table 11 the airborne fractions

for the investigated spray cans and trigger sprays are presented. Based on these values, default values are set (see Table 12).

Table 11: Airborne fractions of investigated spray cans and trigger sprays

Application	**Percentiles of the initial particle distribution [µm]**			**Main solvents**	**Airborne fraction [%]**
	D_p (0.10)	**D_p (0.50)**	**D_p (0.90)**		
Spray cans					
Air space, against flies & mosquitoes	25	125	414	water	60
Air space, against flies	7	23	109	Isoparafine/ isopropanol	60
deodorant	7.6	22	41	ethanol	100
Hair spray	17	39	69	Dimethyl ether / ethanol	100
Flea spray	9.4	30	142	Benzine/ aceton	50
Plant spray Affecting insects	55	97	232	water	10
Trigger sprays					
Plant spray fine [a], affecting insects	33	88	191	water	20
Plant spray coarse [a], affecting insects	39	127	512	water	20
Spray against crawling insects	29	63	200	water	10
All purpose cleaner	46	133	391	water	10

a) the nozzle can be adjusted so that the plant sprayer generates a fine spray with droplets as small as possible or a spray with coarse droplets

Table12: Default values for the airborne fraction

	Airborne fraction	**Q**
Air space sprays	1	2
Surface sprays; median of the initial particle distribution < 50 µm	1	2
Surface sprays; median of the initial particle distribution ≥ 50 µm	0.2	2

2.2.4 General composition spray cans and trigger sprays

Air space sprays

For air space spray cans, the weight fraction of the propellant is set at 60%. The weight fraction of non-volatile compounds is anyhow the active substance. When pyrethrum insecticides are used, another non-volatile compound can be the synergist (1-2%).

Surface spraying

- Aerosol spray cans
  The weight fraction of the propellant is set at 50%; for non-volatile compounds, the weight fraction is anyhow the active substance.
- Trigger sprays
  The weight fraction of the non-volatile compounds is anyhow the active substance.

This information is derived from 'Guide to spray cans' of the Dutch Aerosol Association[8)], the TNO-PML investigation on spray cans and trigger sprays[53)] and on (confidential) data from exposure assessments.

2.2.5 Parameters for the 'constant rate' model

To calculate the dermal exposure of the user during application the 'constant rate' model from ConsExpo is used for all spray applications.
The TNsG[50)] provides data for consumer spraying, for air space spraying and surface spraying with pre-pressurized aerosol spray cans and hand-held trigger sprays. The measured data for dermal exposure have a wide range. For consumer spraying these data are used as default values for contact rate (see Table 13).

In the former version of this report other default values were proposed, the TNsG data were not available at that time

Air space spraying

- *Contact rate aerosol spray cans*

In the TNsG's[50)] 'Consumer product spraying and dusting' an air space spraying model is stated in which the consumer uses a pre-pressurized aerosol spray can to spray into the air of a small sealed room. The dermal exposure on hands and forearms ranges from 21.6 to 432 mg/min with a 75th percentile of 156 mg/min. The dermal contact rate for legs, feet and face ranges from 24.5 to 233 mg/min with a 75th percentile of 113 mg/min. Using these data, the default value for contact rate is set at 269 mg/min.

Surface spraying

- *Contact rate aerosol spray cans*

In the TNsG's[50)] 'Consumer product spraying and dusting' a surface spraying model is stated in which the consumer uses an pre-pressurized aerosol spray can for spraying surfaces i.e. skirting board, dining chairs, a sofa and carpet. The dermal exposure on hands and forearms ranges from 1.7 to 156 mg/min with a 75th percentile of 64.7 mg/min. The dermal contact rate for legs, feet and face ranges from 17 to 45.2 mg/min with a 75th percentile of 35.7 mg/min.
Using these data, the default value for contact rate is set at 100 mg/min.

- *Contact rate trigger sprays*

In the TNsG's[50)] 'Consumer product spraying and dusting' a surface spraying model is stated in which the consumer uses a hand-held trigger spray for spraying surfaces i.e. skirting, shelves and horizontal and vertical laminate. The dermal exposure on hands and forearms ranges from 3 to 68.2 mg/min with a 75th percentile of 36.1 mg/min. The dermal contact rate for legs, feet and face ranges from 1.9 to 2.4 mg/min with a 75th percentile of 9.7 mg/min. Using these data, the default value for contact rate is set at 46 mg/min.

Table 13: Default values contact rate for spray cans and trigger sprays

	Contact rate [mg/min]	**Q**
Spray can		
air space	269	3
targeted spot; crack and crevice; general surface	100	3
Trigger spray		
targeted spot; crack and crevice; general surface	46	3

2.2.6 Parameters for the 'rubbing off' model

The 'rubbing off' model from ConsExpo is used for the exposure of children after application of the product, for all four types of spray applications. The parameter values for the four types of applications are similar, and are therefore discussed here.

- *Dislodgeable amount*

The TNsG[50)] gives an overview of transfer efficiency for different types of surfaces, the dislodgeable amount ranges from 1% to 60%. A HSL Pilot study on aerosols (cited in the Biocides Steering Group's report, 1998[7)]) gives 10% 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 substance gets on to the surface and can be brushed off. Based on this data, the default value for the dislodgeable amount 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 m^2 /day, whereby it is assumed that there is activity for 4 hours a day, which means a transfer coefficient of 0.6 m^2 /hr.

2.2.7 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. 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. The hands form about 20% of the total uncovered skin. It is assumed that 50% of the product that ends up on the hands is taken in orally due to hand-mouth contact. This means that via hand-mouth contact 10% of the external dermal exposure is ingested.
The ingestion rate can be calculated based on the assumption that from the total dermal exposure 10% is taken in orally due to hand-mouth contact.

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 types of spray applications 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, 1997[10)]; Weegels, 1997[5)]; Leidy et al., 1996[11)]; Fenske et al., 1990) [12)].

Inhalatory exposure during mixing and loading can occur due to evaporation from the bottle with the formulation. Dermal exposure can occur, due to liquid spills.

Scenario
A private user mixes and loads liquid into a plant sprayer filled with water to produce 2 litres of ready-for-use product. The active substance evaporates from the bottle with the formulation, a one-litre bottle with a not-too-small circular opening with a 5-cm diameter, resulting in a surface area of 20 cm^2. During mixing and loading the user stays in the vicinity of the evaporating compound and it is therefore assumed that the user is present in a 'personal volume' instead of a room volume. Further, there could be dermal exposure due to spillage. To calculate the exposure of the user during mixing and loading liquid, the 'evaporation model' is used for inhalation exposure and the 'instant application' model is used for dermal exposure.

Inhalation exposure: evaporation from a constant surface

- *Exposure duration and application 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 1.33 minutes, for mixing and loading a liquid in a plant sprayer. After mixing and loading the user closes the bottle; consequently, the exposure duration equals the application duration. The duration of 1.33 minutes is set as default value for both exposure duration and application duration.

- *Product amount*

This parameter is for limiting the evaporated amount of active substance from the product. It is not the *used* product amount but half of the bottle content. For a one-litre bottle the averaged amount liquid in the bottle is estimated at 500 g (density 1 g/cm^3), which is set as default value.

- *Room volume*

'Room volume' is interpreted here as 'personal volume': a small area of 1 m^3 around the user. A small area around the user is relevant for the inhalation exposure of the user, for the short use duration in which the treatment takes place, as it enables the evaporation of the active substance from the concentrate to be described. Since no data with regard to the personal volume were found, a quality factor Q of 1 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}.
To what extent this value is applicable to the 'personal volume' of 1 m^3 around the user is unknown, therefore the quality factor Q is set at 1.

- *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 which gives a release area of 20 cm^2.

- *Molecular weight matrix*

The parameter 'molecular weight matrix' is the molecular weight of the 'other' components in the product. In Paint Fact Sheet[49)] this parameter is extensively discussed. The 'molecular weight matrix' is roughly given by M_w / fraction solvents. If the value for molecular weight matrix lacks, the molecular weight matrix is set at 3000 g/mol, which is a worst-case assumption. In this case, it is assumed that the fraction solvent is small; therefore, the partial vapour pressure will not be lowered by the solvent matrix.

Dermal exposure: instant application

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.

- *Product amount*

For dermal exposure of professionals, the inventory performed by Van Hemmen[14)] results in an indicative value during mixing and loading of liquid pesticides. The indicative 90th percentile value of dermal exposure is 0.3 ml formulation/hr [14)], which is considered applicable for about 25 kg active substance applied per day. It is assumed that for consumers the quantity of active substance applied per day is 1000 times lower than for professionals; thus, the amount applied per day is circa 25 grams of active substance.
The above-mentioned *indicative value for professional application* is extrapolated to consumer application. The dermal exposure for consumers is estimated at 0.3 µl/hr, this is 0.3 mg/hr or 5 µg/min (density 1 g/cm^3). With an application duration of 1.33 minutes, the dermal exposure is 6.5 µg per operation.

Dermal exposure of consumers is described in the TNsG [50)] for dispersing a concentrate from a one-litre can and diluting with water in a small vessel (200 ml concentrate plus 2.3 L water). The dermal exposure of hands results in a range from 0 to 3.2 mg (n=10). The non-zero values varied from 0.33 to 3.2 mg (n=8).

For dermal exposure of amateurs, the UK POEM model [51)] describes the pouring of fluid from a container into a receiving vessel. The 75th percentiles for dermal exposure during mixing and loading are given for 1 litre and 2 litre containers i.e. 0.01 ml per operation. Containers of 5 litres with narrow closures or with 45/63 mm closures give a dermal exposure of 0.2 ml and 0.01 ml per operation, respectively (see Table 14).

Table 14: Hand contamination per operation of mixing and loading[51)]

Container [litre]	Type of closure	Contamination [ml/ operation]
1	Any closure	0.01
2	Any closure	0.01
5	Narrow closure	0.20
5	45 or 63 mm closure	0.01

For dermal exposure, the extrapolated value from professionals is rather low compared to the other two data of consumer exposure. Therefore, only the reported dermal exposures for consumers are taken into account. Using these data for mixing and loading, the default value for dermal exposure is set at 0.01 ml or 10 mg (density 1 g/cm^3) per operation. For comparison, one small drop liquid is about 0.02 ml i.e. 20 mg.

Defaults

Default values for mixing and loading: dilution of a liquid

	Default value	Q	References, comments
General			
Frequency	6 year^{-1}	2	See § 2.2.1
Inhalation			
Evaporation from a constant surface			
Exposure duration	1.33 min	3	See above
Product amount	500 g	3	See above
Room volume	1 m^3	1	See above
Ventilation rate	0.6 hr^{-1}	1	Unspecified room[1)]
Release area	0.002 m^2	2	See above
Application duration	1.33 min	3	See above
Mass transfer rate	Langmuir		See help file ConsExpo
Mol. weight matrix	3000 g/ mol	2	Worst-case; see above
Dermal			
Exposure, instant application			
Product amount	0.01 g	3	See above
Contact time	1.33 min	3	I.e. application duration

2.4 Exposure to powder and granules during mixing and loading

The main difference with regard to the exposure to powder and granules during mixing and loading compared to the dilution of a liquid concentrate is that powders, and granules, to a lesser extent, can disperse.
This section describes the exposure of the user during mixing and loading of powders and granules.

Scenario
A private user loads powder / granules into a plant sprayer and then adds water to produce 2 litres of ready-for-use product. The dust of the formulation disperses, resulting in inhalation and dermal exposure.

Models
For calculating the inhalation exposure to powder with ConsExpo, the spray model is applicable. However, product parameters such as mass generation rate, airborne fraction, and particle size distribution should be known.
If these data are available, the inhalation exposure could be estimated with ConsExpo's spray model. If these parameter values are lacking, the below-mentioned data, derived from van Hemmen, can be used to calculate the inhalation exposure.
To calculate the dermal exposure of the user during mixing and loading the 'constant rate' model can be used for dermal exposure.

Inhalation exposure: default values for spray model
- *'Spray' duration and exposure duration*

No data were found for the duration of mixing and loading a powder. It is assumed that the 'spray' duration and exposure duration have the same value as for mixing and loading liquids i.e. 1.33 minutes.

- *Room volume, room height and ventilation rate*

'Room volume' is interpreted here as 'personal volume': a small area of 1 m^3 around the user with a height of one meter. A small area around the user is relevant for the inhalation exposure of the user, for the short use duration in which the treatment takes place. The ventilation rate of an unspecified room is used i.e. 0.6 hr^{-1} [(1)].

- *Weight fraction*

The weight fraction for non-volatile is set at one.

- *Density*

If data concerning the density is lacking, the default for density non-volatile is set at 1.8 g/cm^3 (see § 2.2.2).

Inhalation exposure: other models
For inhalation exposure of professionals, the inventory performed by Van Hemmen[14)] results in an indicative value during mixing and loading of solid pesticides (wettable powder). The indicative 90th percentile value of the inhalation exposure is 15 mg formulation/hr, which is considered applicable for about 25 kg active substance applied per day.
It is assumed that for consumers the quantity of active substance applied per day is

1000 times lower than for professionals; thus, the amount applied per day is circa 25 grams of active substance.
The above-mentioned *indicative value for professional application* is extrapolated to the consumer application. The inhalation exposure for consumers is estimated at 15 µg/hr or 0.25 µg/min.
With an exposure duration of 1.33 minutes (see above), the inhalation exposure is 0.3 µg.
Dust of washing powder is given by Van de Plassche et al.[54)]: a cup containing 200 gram of washing powder can generate 0.27 µg dust. The term dust was not defined and the used method for determining the amount of dust was not described. Nevertheless, this value has the same order of magnitude as the extrapolated value for consumers.

The quality of granules, particularly the degree of powder forming, determines how much lower the exposure will be for granules compared to powders. Van Golstein Brouwers et al.[52)] estimated that for granules a maximum of 10% is present in the form of powder. The inhalation exposure is therefore expected to be 10-fold lower than with powders, and is set at 0.025 µg/min.
With an application duration of 1.33 minutes (see above) the inhalation exposure is 0.03 µg.

Dermal exposure: constant rate

- *Contact rate*

For dermal exposure of professionals, the inventory performed by Van Hemmen[14)] gives an *indicative* value during mixing and loading of solid pesticides (wettable powder). The indicative 90th percentile value of dermal exposure is 2000 mg formulation/hr, which is considered applicable for about 25 kg active substance applied per day. It is assumed that for consumers, the quantity of active substance applied per day is 1000 times lower than for professionals; thus, the amount applied per day is circa 25 grams of active substance.
The above-mentioned *indicative value for professional application* is extrapolated to the consumer application. The dermal exposure for consumers is estimated at 2 mg/hr, i.e. 0.033 mg/ min. A quality factor Q = 2 is assigned.

- *Release duration*

It is assumed that the release duration has the same value as for application duration during mixing and loading liquids i.e. 1.33 minutes.

Default values

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

	Default value	**Q**	**References, comments**
General			
Frequency	3 year^{-1}	2	See § 2.2.1
Dermal			
Exposure, constant rate			
Contact rate	0.033 mg/ min	2	See above
Release duration	1.33 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 private user sprays with either an aerosol spray can or a trigger spray.
The inhalation exposure 'spray' model and the dermal exposure model 'constant rate' from ConsExpo 4.0 are used to describe this scenario. The oral exposure is handled in the inhalation exposure model. ConsExpo assumes that the non-respirable fraction is taken in orally (see inhalation cut-off diameter in section 2.2.3)

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 targets 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 'rubbing off' and the oral exposure, due to hand-mouth contact, with the 'constant rate' model.

Exposure during application

Inhalation exposure: spray model

- *Spray duration*

Baas (2000) [6)] reports 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 spray duration, the time during which the spraying takes place, of 6 minutes.

- *Exposure duration*

Using the 'spray' model from ConsExpo, the average exposure during the duration of exposure was calculated (mean event concentration) as the parameter for the inhalation exposure. The inhalation 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 inhalation exposure during the application. It is assumed that the user leaves the treated room 4 hours after the application.

- *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 m^3 and a ventilation rate of 0.6 h^{-1}.

- *Mass generation rate*

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, 1975[16)] and Wright and Jackson, 1976 [17)]; Wright and Leidy 1978[23)]). 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 and Jackson, 1975[16)]; Wright and Leidy, 1978[23)]), while the commercially available 'aerosol spray cans' generate the most formulation per second (1.6 g/sec, on average; Thompson and Roff, 1996[24)]). For the plant sprayer in Weegels (1997 [5)]), 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.

TNO-PML (2005)[53)] has investigated the mass generation rate of 23 aerosols spray cans and trigger sprays, including 8 pesticides. The mass generation rate of full and of nearly empty cans was measured.
The median of all full spray cans and trigger sprays was 1.0 g/sec, the 75th percentile 1.5 g/sec.
No distinction could be made between the aerosol cans and trigger sprays, the 75th percentile of the full trigger sprays was 1.5 g/sec, the 75th percentile of the full spray cans 1.6 g/sec.
The mass generation rate of the nearly empty spray can was in some cases 80-90% of the full can, in some other cases only 30% of the full can.
If only the eight spray cans and trigger sprays with pesticides are taken into account a median of 1.5 g/sec and a 75th percentile of 1.9 g/sec was found.

Based on the literature and the TNO-PML investigation it is concluded that no distinction can be made between spray cans and trigger sprays and also not between sprays used for a specific application.
For all spray cans and trigger sprays, for all applications the mass generation rate is set at 1.5 g /sec.

As it is assumed that targeted spot spraying actually occurred for a period of 90 seconds during a time span of 6 minutes, the default value for the mass generation rate is 0.38 g formulation/sec.

Exposure after application

General

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 (2000)[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., 1987 [26]; Wright et al., 1994[21]; Koehler and Moye, 1995[22]; Leidy et al., 1996[11]). The total duration of the contact with the active substance can, in principle, be stretched out over a period of months. As the user and the bystander 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 after application the period directly after use is of importance, which in this case is defined as 14 days after the treatment. This value is used for children who are exposed orally and dermally after application.

- *Frequency*

The default value of the use frequency is 9 $year^{-1}$ (see § 2.2.1); the default value for the frequency that children are exposed after the treatment is set at
14 x 9 $year^{-1}$ = 126 $year^{-1}$.

Dermal exposure: rubbing off

- *Dislodgeable amount*

By multiplying the mass generation rate and the spray duration, the total amount of sprayed formulation can be calculated (0.38 g/sec x 360 sec = 136.8 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. It is assumed that 15% of the total amount sprayed (0.15 x 136.8 g = 20.5 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., 6.2 g). The floor surface is 2 m^2 (see *rubbed surface* below). The dislodgeable amount is therefore calculated as 3.1 g/m^2.

- *Contact time*

Based on the data in ‘exposure duration’ for exposure during application, and the considerations under ‘frequency’, 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.

- *Rubbed 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.

Defaults

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

	Default value	Q	References, comments
General			
Frequency	9 $year^{-1}$	2	See § 2.2.1
Inhalation			
Exposure, spray model			
Spray duration	6 min	3	See above
Exposure duration	240 min	3	See above
Room volume	20 m^3	3	See above
Room height	2.5 m	4	Standard room height
Ventilation rate	0.6 hr^{-1}	3	See above
Mass generation rate	0.38 g/s	3	See above
Airborne fraction	1 g/g	2	See § 2.2.3
Weight fraction non-volatile			See § 2.2.4
Density non-volatile	1.8 g/g	3	See § 2.2.2
Initial particle distribution			
Median (C.V.)	25 µm (0.4)	3	See § 2.2.3
Inhalation cut-off diameter	15 µm		See § 2.2.3
Dermal			
Exposure, constant rate			
Contact rate	100 mg/min	3	See § 2.2.5
Release duration	6 min	3	I.e. spray duration

Default values for exposure during targeted spot application with a trigger spray

	Default value	Q	References, comments
General			
Frequency	9 $year^{-1}$	2	See § 2.2.1
Inhalation			
Exposure, spray model			
Spray duration	6 min	3	See above
Exposure duration	240 min	3	See above
Room volume	20 m^3	3	See above
Room height	2.5 m	4	Standard room height
Ventilation rate	0.6 hr^{-1}	3	See above
Mass generation rate	0.38 g/s	3	See above
Airborne fraction	0.2 g/g	2	See § 2.2.3
Weight fraction non-volatile			See § 2.2.4
Density non-volatile	1.8 g/g	3	See § 2.2.2
Initial particle distribution			
Median (C.V.)	50 µm (0.6)	3	See § 2.2.3
Inhalation cut-off diameter	15 µm		See § 2.2.3
Dermal			
Exposure, constant rate			
Contact rate	46 mg/min	3	See § 2.2.5
Release duration	6 min	3	I.e. spray duration

Default values of exposure after targeted spot application

	Default value	Q	References, comments
General			
Frequency	126 $year^{-1}$	2	See above
Body weight	8.69 kg	4	Child 10.5 months[1)]
Dermal			
Exposure, rubbing off			
Transfer coefficient	0.6 m^2 / hr	2	See § 2.2.6
Dislodgeable amount	3.1 g/ m^2	2	Calculated; see above
Contact time	60 min	2	See above
Rubbed surface	2 m^2	3	See above
Oral			
Exposure, constant rate			
Ingestion rate	--		Calculated, see § 2.2.7
Exposure time	60 min	2	I.e. contact time

2.6 Crack and crevice application

Scenario

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

To calculate the exposure of the user during the crack and crevice application, the ‘spray’ model’ is used for the inhalatory exposure and the ‘constant rate’ model is used for the dermal exposure. The oral exposure is handled in the ‘spray’ model. ConsExpo assumes that the non-respirable fraction is taken in orally.

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 ‘rubbing off’ and the oral exposure model ‘constant rate’.

Exposure during application

Inhalation exposure: spray model

- *Spray duration*

In the literature, the following times are reported for the spray duration: Leidy et al., 1982 [15)]: 8 – 11 min.; Wright and Jackson, 1975[16)]: 6.1 – 8.1 min.; Wright and Jackson, 1976[17)]: 10.3 – 11.9 min. Observational research by Baas (2000)[6)] shows that the actual spraying time is much shorter. For a use duration 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 (2000)[6] only measures the duration of spraying. On this basis, the default value for the time during which spraying *actually* takes place is set at 60 seconds (this duration is important when calculating the mass generation rate, among other things; see below). It is assumed that the time during which the spraying takes place, the spray duration, is 4 minutes.

- *Exposure duration*

In Leidy et al. (1996)[11], the concentration of the used active substance (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 litre 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 substances 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 model from ConsExpo. A total time of 4 hours is taken as the default value for the inhalation exposure. It is assumed that the user stays in the treated room for 4 hours after the application.

- *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 m^2, a volume of 20 m^3 and a ventilation rate of 0.6 hr^{-1}.

- *Mass generation rate*

In section 2.5 (targeted spot application) is described that for all spray cans and trigger sprays, for all applications the mass generation rate is set at 1.5 g /sec.

The spray duration, the time during which the spraying takes place, is set at 4 minutes, the period of active spraying at 1 minute (see spray duration). The average mass generation rate of the formulation during the 4 minutes is 0.38 g/sec.

Exposure after application

Dermal exposure: rubbing off

- *Dislodgeable amount*

By multiplying the mass generation rate and the spray duration, the total amount of sprayed formulation can be calculated (240 sec x 0.38 g/sec = 91.2 g). The scenario assumes that this amount is sprayed on the floor. It is assumed that 85% of the total amount sprayed (0.85 x 91.2 = 77.52 g) ends up on the floor surface. Section 2.2.6 shows that, of this amount, 30% is dislodgeable, i.e., it can be brushed away (0.3 x 77.52 = 23.26 g). The surface is 2 m^2 (see *rubbed surface* below). The dislodgeable amount is calculated at 23.26/2 = 11.6 g/m^2.

- *Rubbed surface*

According to the scenario 25% of the floor area is taken to be the treated surface; for the room mentioned above (surface 8 m^2), this is equivalent to 2 m^2.

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 (6 x 3.4 = 21 and 6 x 14.2 = 85).

Default values

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

	Default value	Q	References, comments
General			
Frequency	9 $year^{-1}$	2	See § 2.2.1
Inhalation			
Exposure, spray model			
Spray duration	4 min	3	See above
Exposure duration	240 min	3	See above
Room volume	20 m^3	3	See above
Room height	2.5 m	4	Standard room height
Ventilation rate	0.6 hr^{-1}	3	See above
Mass generation rate	0.38 g/s	3	See above
Airborne fraction	1 g/g	2	See § 2.2.3
Weight fraction non-volatile			See § 2.2.4
Density non-volatile	1.8 g/g	3	See § 2.2.2
Initial particle distribution			
Median (C.V.)	25 µm (0.4)	3	See § 2.2.3
Inhalation cut-off diameter	15 µm		See § 2.2.3
Dermal			
Exposure, constant rate			
Contact rate	100 mg/min	3	See § 2.2.5
Release duration	4 min	3	I.e. spray duration

Default values for exposure during crack and crevice application with a trigger spray

	Default value	Q	References, comments
General			
Frequency	9 $year^{-1}$	2	See § 2.2.1
Inhalation			
Exposure, spray model			
Spray duration	4 min	3	See above
Exposure duration	240 min	3	See above
Room volume	20 m^3	3	See above
Room height	2.5 m	4	Standard room height
Ventilation rate	0.6 hr^{-1}	3	See above
Mass generation rate	0.38 g/s	3	See above
Airborne fraction	0.2 g/g	2	See § 2.2.3
Weight fraction non-volatile			See § 2.2.4
Density non-volatile	1.8 g/g	3	See § 2.2.2
Initial particle distribution			
Median (C.V.)	50 µm (0.6)	3	See § 2.2.3
Inhalation cut-off diameter	15 µm		See § 2.2.3
Dermal			
Exposure, constant rate			
Contact rate	46 mg/min	3	See § 2.2.5
Release duration	4 min	3	I.e. spray duration

Default values exposure after application of crack and crevice spray

	Default value	Q	References, comments
General			
Frequency	126 $year^{-1}$	2	See § 2.5
Body weight	8.69 kg	4	Child 10.5 months[1)]
Dermal			
Exposure, rubbing off			
Transfer coefficient	0.6 m^2 / hr	2	See § 2.2.6
Dislodgeable amount	11.6 g/ m^2	2	Calculated; see above
Contact time	60 min	2	See § 2.5
Rubbed surface	2 m^2	3	See above
Oral			
Exposure, constant rate			
Ingestion rate	--		Calculated, see § 2.2.7
Exposure time	60 min	2	I.e. contact time

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. The user is assumed to stay in the treated room for 4 hours after the application. The private user sprays with either an aerosol spray can or a trigger spray.
To calculate the exposure of the user during the application, the 'spray' model is used for the inhalatory exposure and the 'constant rate' model is used for the dermal exposure. The oral exposure is handled in the 'spray' 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 'rubbing off' and the oral exposure model 'constant rate'.

Exposure during application

Inhalation exposure: spray model

- *Spray duration*

Baas (2000)[6)] describes 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 spray duration, the time during which the spraying takes place.

- *Exposure duration*

For the exposure duration, the same values are used as for the crack and crevice application (see section 2.6). For the exposure duration, a total duration of 4 hours is assigned, assuming that the user stays in the treated room for 4 hours after application.

- *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. For a living room the values 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 m^3; the ventilation rate is 0.5 hr^{-1}.

- *Mass generation rate*

In section 2.5 (targeted spot application) is described that for all spray cans and trigger sprays, for all applications the mass generation rate is set at 1.5 g /sec.

The spray duration indicates that during a time span of 10 minutes, the period of active spraying was 5 minutes. Consequently, 0.75 g formulation/sec is used as the default value for the mass generation rate.

Exposure after application

Dermal exposure: rubbing off

- *Dislodgeable amount*

By multiplying the mass generation rate and the spray duration, the total amount of sprayed formulation can be calculated (0.75 g/sec x 600 sec = 450 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 (450 g on 22 m^2, or 20.45 g/m^2). Section 2.2.6 shows that, of this amount, 30 % is dislodgeable. The dislodgeable amount is calculated at 6.1 g/m^2.

- *Rubbed surface*

The surface area of the living room, the treated surface in the scenario, is 22 m^2.

Default values

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

	Default value	Q	References, comments
General			
Frequency	9 $year^{-1}$	2	See § 2.2.1
Inhalation			
Exposure, spray model			
Spray duration	10 min	3	See above
Exposure duration	240 min	3	See above
Room volume	58 m^3	4	See above
Room height	2.5 m	4	Standard room height
Ventilation rate	0.5 hr^{-1}	3	See above
Mass generation rate	0.75 g/s	3	See above
Airborne fraction	1 g/g	2	See § 2.2.3
Weight fraction non-volatile			See § 2.2.4
Density non-volatile	1.8 g/g	3	See § 2.2.2
Initial particle distribution			
Median (C.V.)	25 µm (0.4)	3	See § 2.2.3
Inhalation cut-off diameter	15 µm		See § 2.2.3
Dermal			
Exposure, constant rate			
Contact rate	100 mg/min	3	See § 2.2.5
Release duration	10 min	3	I.e. spray duration

Default values for exposure during general surface application with a trigger spray

	Default value	Q	References, comments
General			
Frequency	9 $year^{-1}$	2	See § 2.2.1
Inhalation			
Exposure, spray model			
Spray duration	10 min	3	See above
Exposure duration	240 min	3	See above
Room volume	58 m^3	4	See above
Room height	2.5 m	4	Standard room height
Ventilation rate	0.5 hr^{-1}	3	See above
Mass generation rate	0.75 g/s	3	See above
Airborne fraction	0.2 g/g	2	See § 2.2.3
Weight fraction non-volatile			See § 2.2.4
Density non-volatile	1.8 g/g	3	See § 2.2.2
Initial particle distribution			
Median (C.V.)	50 µm (0.6)	3	See § 2.2.3
Inhalation cut-off diameter	15 µm		See § 2.2.3
Dermal			
Exposure, constant rate			
Contact rate	46 mg/min	3	See § 2.2.5
Release duration	10 min	3	I.e. spray duration

Default values for exposure after application of general surface spray

	Default value	Q	References, comments
General			
Frequency	126 $year^{-1}$	2	See § 2.5
Body weight	8.69 kg	4	Child 10.5 months[1)]
Dermal			
Exposure, rubbing off			
Transfer coefficient	0.6 m^2 / hr	2	See § 2.2.6
Dislodgeable amount	6.1 g/ m^2	2	Calculated; see above
Contact time	60 min	2	See § 2.5
Rubbed surface	22 m^2	4	See above
Oral			
Exposure, constant rate			
Ingestion rate	--		Calculated, see § 2.2.7
Exposure time	60 min	2	I.e. contact time

2.8 Air space application

Scenario

This scenario is based on a private user who sprays with 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' model is used for the inhalation exposure and the 'constant rate' model is used for the dermal exposure. The oral exposure is handled in the inhalation 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 'rubbing off' and the oral exposure model 'constant rate'.

Exposure during application

Inhalation exposure: spray model

- *Spray duration*

According to the directions for use on an air space spray, you should spray for 1 sec per 10 m^3. For a living room, chosen as the default room (see below), with a volume of 58 m^3, this means spraying for 5.8 sec. The manufacturer of a different air space spray indicates 10 sec spraying per 20 m^2 floor surface. The above-mentioned room has a floor surface of 22 m^2, which means spraying for 11 sec. Observations by Baas (2000)[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 spray duration, the time during which the spraying takes place, is assumed to be twice as long and is therefore set at 20 seconds.

- *Exposure duration*

For the exposure 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 duration. It is assumed that the user stays in the treated room for 4 hours after the application.

- *Room volume and 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 m^3 and ventilation rate 0.5 hr^{-1}.

- *Mass generation rate*

Using data from Matoba et al. (1993)[9)] the use of an air space spray is calculated at 0.7 g/sec.
TNO-PML (2005)[53)] has investigated the mass generation rate of 2 air space sprays, a spray against flies and mosquitoes and a spray to control flies. The mass generation rate of the full cans was respectively 2.15 and 0.53 g/sec.
The mass generation rate of air space sprays does not appear to be deviating from the other types of spray.
In section 2.5 (targeted spot application) is described that for all spray cans and trigger sprays, for all applications the mass generation rate is set at 1.5 g/sec. Therefore the default value used for the other sprays, 1.5 g/sec during active spraying will be used as the default for air space spraying too.
The spray duration, the time during which the spraying takes place, is twice as long as the actual spraying time. The mass generation rate is therefore 0.75 g/sec.

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: rubbing off

- *Dislodgeable amount*

The total amount of sprayed formulation is 15.0 g (0.75 g/sec [mass generation rate] x 20 sec [spray duration] = 15.0 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 (0.682 g/m^2). Section 2.2.6 shows that, of this amount, 30% is dislodgeable. The dislodgeable amount is therefore 30% of the amount of formulation per unit surface. The dislodgeable amount, on the day of application, is calculated as 0.205 g/m^2. Due to accumulation (see above) the average exposure during the after application time is 4 times as high as the exposure on the day of application. The average dislodgeable amount during the entire period of after application is calculated as 0.82 g/m^2.

- *Rubbed surface*

The default value for rubbed surface is the surface area of the living room i.e. 22 m^2 [1)].

Default values

Default values air space application with an aerosol can

	Default value	Q	References, comments
General			
Frequency	90 $year^{-1}$	3	See § 2.2.1
Inhalation			
Exposure, spray model			
Spray duration	0.33 min	3	See above
Exposure duration	240 min	3	See above
Room volume	58 m^3	4	See above
Room height	2.5 m	4	Standard room height
Ventilation rate	0.5 hr^{-1}	3	See above
Mass generation rate	0.75 g/s	3	See above
Airborne fraction	1 g/g	3	See § 2.2.3
Weight fraction non-volatile			See § 2.2.4
Density non-volatile	1.8 g/g	3	See § 2.2.2
Initial particle distribution			
Median (C.V.)	20 µm (0.4)	3	See § 2.2.3
Inhalation cut-off diameter	15 µm		See § 2.2.3
Dermal			
Exposure, constant rate			
Contact rate	269 mg/min	3	See § 2.2.5
Release duration	0.33 min	3	I.e. spray duration

Default values for exposure after application of air space spray

	Default value	Q	References, comments
General			
Frequency	90 $year^{-1}$	3	See § 2.2.1; daily use over a period of 3 months
Body weight	8.69 kg	4	Child 10.5 months[1)]
Dermal			
Exposure, rubbing off			
Transfer coefficient	0.6 m^2 / hr	2	See § 2.2.6
Dislodgeable amount	0.82 g/ m^2	2	Calculated; see above
Contact time	60 min	2	See § 2.5
Rubbed surface	22 m^2	4	See above
Oral			
Exposure, constant rate			
Ingestion rate	--		Calculated, see § 2.2.7
Exposure time	60 min	2	I.e. contact time

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 m^3, 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 (aluminium) 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 De Vries, 1973)[28)].

From the CTB-Pesticide database (CTB, 1998)[46)] it seems that organophosphates and pyrethroids are used as active substances (a.s.). 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, 1974[29]; Elgar et al., 1972[27]; Elgar and Steer, 1972[31]; Weiss et al., 1998[30]).

Table 15 shows the above-mentioned methods of exposure by evaporation from strips and cassettes.

Table 15: 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
Inhalation	evaporation in preparatory stage	evaporation in preparatory stage	
Application			
Dermal	not applicable		not applicable
Inhalation	- the saturated air in small sealed areas results in a shortly 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

Exposure during mixing and loading

The exposure during mixing and loading is determined by the concentration that occurs during cutting. An inhalation exposure due to evaporation and a dermal exposure due to handling the strip are anticipated. For the latter the ‘constant rate’ model is used.
The evaporation model (constant surface, compound in pure form) is used for the inhalation exposure, whereby the surface is corrected for the weight fraction of the active substance. The evaporation model which is generally used 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 compound’ model, it is assumed that only the pure substance, i.e., the active substance, is present. The model does not take into account the fact that the active substance is caught in a solid matrix. The evaporating surface is adapted to the percentage of active substance in the matrix. Using the ‘evaporation from pure compound’ model, an overestimate of the exposure will be calculated. There is currently no model which better describes the exposure.

General

- *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 actually 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.

Inhalation exposure: evaporation from constant surface, compound in pure form

- *Exposure duration and application 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. For both the exposure duration and the application duration the default value is set at 10 minutes.

- *Product amount*

It is assumed that individual sheets of moth paper have a size of an A4 sheet with a weight of 20 grams; further, it is assumed that a strip is cut with a surface area of 30 cm x 4 cm. This strip of moth paper is approximately 1/5 part of an A4 sheet; consequently, a strip weights about 4 grams.

- *Room volume*

The initial area in which the substance evaporates is presumed to be 1 m^3 around the user. Since no data with regard to the personal volume were found, a quality factor Q of 1 is assigned.

- *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)].
To what extent this value is applicable to the 'personal volume'of 1 m^3 around the user is unknown, therefore the quality factor Q is set at 1.

- *Release area*

It is assumed that a strip is cut with a surface area of 120 cm^2 (see product amount). The effective surface is the surface as if the active substance were present in its pure form. The effective surface is calculated by multiplying the surface by the fraction of active substance. If the weight fraction of the active substance in the above-mentioned strip of 120 cm^2 is 0.25, for example, the effective surface is 120 x 0.25 = 30 cm^2.

- *Mass transfer rate*

The mass transfer rate is determined by the rate at which the compound is transported away from the evaporation surface. In general this transport will depend on rate of diffusion of the compound through air, and the rate of air movement above the product-air surface.

Langmuir's method effectively assumes that diffusion of the compound is infinitely fast. It will as a rule highly overestimate the evaporation rate and predict higher peak concentrations than the more conservative Thibodeaux approximation. Thibodeaux' method is a simple approximation of the more elaborate Liss-Slater two-layer model describing the evaporation of a substance from water. The latter is not applicable for the evaporation from a solid matrix; therefore, the Langmuir's method is chosen for mass transfer rate. For further information, see help file ConsExpo 4.0.

Exposure during application

The evaporation (constant surface, pure compound) model is used here, whereby the surface is corrected for the weight fraction of the active substance (see mixing and loading). Just as for ‘mixing and loading’ an overestimate of the exposure will be calculated.

Inhalation exposure: evaporation from constant surface, compound in pure form

- *Frequency.*

Exposure will be largely affected by the way the consumer uses anti-moth products: does the consumer places them 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.

- *Exposure duration and application duration*

Inhalation exposure will mainly occur shortly 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 inhalation exposure at a low concentration is expected.

In the model to calculate the inhalation 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 substance will spread around the area, whereby the concentration will decrease. There is currently no model which better describes the inhalation exposure.
For the default values for both the exposure duration and the application duration, an estimate is made of the time during which exposure to the concentration of the active substance in the closet takes place; this time is estimated to be 5 minutes.

- *Room volume*

The area is taken to be a closet with a volume of 1.5 m^3.

- *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

	Default value	Q	References, comments
General			
Frequency	3 $year^{-1}$	3	See above
Inhalation			
Exposure, evaporation from constant surface, pure compound			
Exposure duration	10 min	2	See above
Product amount	4 g	2	See above
Room volume	1 m^3	1	See above
Ventilation rate	0.6 hr^{-1}	1	See above
Release area			Calculated, see above
Application duration	10 min	2	See above
Mass transfer rate	Langmuir		See above
Dermal			
Exposure, constant rate			
Contact rate	1 mg/min	1	Estimate, based on § 2.4
Release duration	10 min	2	I.e. application duration

Default values; products in a sealed room, during application

	Default value	Q	References, comments
General			
Frequency	365 $year^{-1}$	3	See above
Inhalation			
Exposure, evaporation from constant surface, pure compound			
Exposure duration	5 min	1	See above
Product amount	4 g	2	See above
Room volume	1.5 m^3	3	See above
Ventilation rate	0.3 hr^{-1}	1	See above
Release area			Calculated, see above
Application duration	5 min	1	See above
Mass transfer rate	Langmuir		See above

3.3 Exposure to products in living areas

Exposure during application

General

- *Frequency*

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 i.e. 150 times per year.

Inhalation exposure: evaporation from constant surface, compound in pure form

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

- *Exposure duration and application duration*

It is assumed that the products are used in a living area in which people are present for 8 hours a day.

- *Product amount*

The size of a strip is estimated at 25 x 5 x 0.3 cm. With a density of 1 g/cm^3 the product amount is calculated at 30 g (Q = 2).

- *Room volume* and v*entilation rate*

This is based on the standard values from the ‘General Fact sheet’ (Bremmer and Van Veen)[1)]: a living room of 58 m^3 and a ventilation rate of 0.5 hr^{-1}.

- *Release area*

The surface area of PVC strips is between 200 and 220 cm^2 [(28; 29; 31)]. The effective surface is the surface as if the active substance were present in its pure form. The effective surface is calculated by multiplying the surface area (220 cm^2) by the fraction of the active substance.

Defaults

Default values; products in living areas during application

	Default value	**Q**	**References, comments**
General			
Frequency	150 $year^{-1}$	3	See above
Inhalation			
Exposure, evaporation from constant surface, pure compound			
Exposure duration	480 min	3	See above
Product amount	30 g	2	See above
Room volume	58 m^3	4	See above
Ventilation rate	0.5 hr^{-1}	3	See above
Release area			Calculated, see above
Application duration	480 min	3	See above
Mass transfer rate	Langmuir		See § 3.2

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 substances are heated, resulting in evaporation. Once in the colder air of the room, the solvent condenses and the active substance almost immediately and completely turns into droplets, which rise to the ceiling due to the warmer air.

Use and composition
The exposure to active substances from electrical evaporators is modelled in detail by Matoba et al. (1994)[32)]. This model seems to adequately predict both the behaviour of the active substance and the aerosol in a room as a concentration of the active substance, 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; vapour pressure: 1.68 $x10^{-2}$ Pa) condenses and that the droplet with the active substance formed in this way is in the air for 49.3 seconds.

For this fact sheet, the spray model will be used as a simplified approach of the Matoba-model. The assumption here is that active substances used in an electrical evaporator at room temperature are negligibly volatile. This will normally be the case, as the used active substances 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 substance. 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

General

- *Frequency*

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 Centre states that in areas with many mosquitoes (near moor land, for example) aerosol sprays are used to control those mosquitoes several times a week (personal communication J. de Jong, 2001). Based on this data, the default value assumes a daily use of 5 months per year i.e. 150 times per year.

Inhalation exposure: spray model

- *Spray duration and exposure 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 use 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 both the spray duration and the exposure 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.

- *Room volume and 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}.

- *Mass generation rate*

The generation rate of the active substance 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 mass generation rate of the formulation, which is 1.3 mg formulation/min (2.2×10^{-5} g/sec).

- *Airborne fraction*

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

- *Weight fraction non-volatile*

Matoba et al. (1994)[32] indicate that the droplets are initially 3.5 µm. Due to condensation and evaporation, the droplet sizes vary between 3.5 and 15 µm. Generally organic solvents with a relatively high boiling point will be used (including n-tetradecane and n-pentadecane).
Based on this data, it is assumed that the droplets only contain non-volatile compounds; thus, the weight fraction for non-volatile is set at 1 g/g.

- *Initial particle distribution*

Matoba et al. (1994)[32] indicate that the droplets are initially 3.5 µm. Due to condensation and evaporation, the droplet sizes vary between 3.5 and 15 µm. Based on this data, the default of the initial particle distribution is set at a lognormal distribution with a median of 8 µm and a coefficient of variation of 0.3.

Exposure after application

The active substance 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 substance 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; vapour pressure $1.68x10^{-2}$ Pa) was used for 6 hours in a room of 23.3 m^3 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 substance 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 substance, the vapour 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 of 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 ‘rubbing off’ model can be used to calculate the dermal exposure, and the ‘constant rate’ model 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: rubbing off

- *Dislodgeable amount*

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

	Default value	Q	References, comments
General			
Frequency	150 $year^{-1}$	3	See above
Inhalation			
Exposure, spray model			
Spray duration	480 min	3	See above
Exposure duration	480 min	3	See above
Room volume	16 m^3	4	See above
Room height	2.5 m	4	Standard room height
Ventilation rate	1 hr^{-1}	3	See above
Mass generation rate	$2.2 * 10^{-5}$ g/s	3	See above
Airborne fraction	1 g/g	2	See above
Weight fraction non-volatile	1 g/g	2	See above
Density non-volatile	1.5 g/cm^3	2	See § 2.2.2
Initial particle distribution	8 μm (0.3)	2	Median (CV); see above
Inhalation cut-off diameter	15 μm		See § 2.2.3

Default values after application of electrical evaporator

	Default value	Q	References, comments
General			
Frequency	150 $year^{-1}$	2	See above
Body weight	8.69 kg	4	Child 10.5 months[1)]
Dermal			
Exposure, rubbing off			
Transfer coefficient	0.6 m^2 / hr	2	See § 2.2.6
Dislodgeable amount	30%		See above
Contact time	60 min	2	See above
Rubbed surface	7 m^2	4	See above
Oral			
Exposure, constant rate			
Ingestion rate	--		Calculated, see § 2.2.7
Exposure time	60 min	2	I.e. contact time

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 substances 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, inhalation contact with aerosols is possible.

The active substances in insect repellents are described below.

- DEET (N, N-diethyl-3-methylbenzamide) is the most important active substance 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, 1998[35)]; Osimitz and Murphy, 1997[36)]; Veltri et al., 1994[38)]). 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 substance 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, 1998[35)]) 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 substances 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 substances in its formulation. Studies at the University of Guelph, Ontario, Canada (Lindsay et al., 1996, cited in Fradin, 1998[35]), 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 inhalation 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 inhalation 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.

General

- *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 duration of protection).

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 2.

- *Duration of protection*

The duration of protection and the related number of applications per day varies according to the active substance and the parasite that has to be repelled. The duration of protection was investigated for the active substance 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 substance 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, 1998[35]). 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, 1998[35)]).

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. This value for exposure time is used for oral exposure.

Dermal exposure: instant application model

- *Amount of product on the skin*

Data are 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 substance 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., 2002)[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 m^2.
    - The total body surface of an adult is 1.75 m^2 (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: constant rate

- *Ingestion 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, 2002)[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: adults

	Default value	Q	References, comments
General			
Frequency	54 $year^{-1}$	2	27 days, use 2 day^{-1}
Dermal			
Exposure, instant application			
Product amount	6 g	3	See above
Oral			
Exposure, constant rate			
Ingestion rate	80 mg/hr	2	Calculated, see above
Exposure time	180 min	3	See above

Default values for the application of insect repellents: children

	Default value	Q	References, comments
General			
Frequency	54 $year^{-1}$	2	27 days, use 2 day^{-1}
Body weight	8.69 kg	4	Child 10.5 months[1)]
Dermal			
Exposure, instant application			
Product amount	1.5 g	3	See above
Oral			
Exposure, constant rate			
Ingestion rate	50 mg/hr	2	Calculated, see above
Exposure time	180 min	3	See above

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 substance 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 200 g, 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 m^2. 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 m^2 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 substance 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 m^2 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 mouldy 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 substance in mouse poison is bromadiolon, difethialon, or difenacum; in rat poison it is warfarin (CTB, 2000[a])[45)].

6.1 Exposure

The vapour pressure of the above mentioned active substances is very low. Evaporation of these substances will be so small that the inhalation 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 40 g 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

Default values for bait stations to control mice

	Default value	**Q**	**References, comments**
General			
Frequency	8 $year^{-1}$	2	See above
Dermal			
Exposure, instant application			
Product amount	0.2 g	1	See above

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 m^2 low pile, 10 m^2 middle pile and 7.5 m^2 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.

Inhalation exposure due to evaporation
The active substances in dusting powders are all substances with an extremely low vapour pressure, and are therefore not very volatile. The inhalation 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 m^2 (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 m^2 (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 m^2.

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 m^2 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	2	15	2
Ant powder	Outside	1	2	60	2
Flea powder	Inside	1	2	60	2
Crawling insects	Inside	1	2	60	2
Dust mite	Inside	22	4	2200	4
Germination inhibitor	Inside	3	3	250	3

Scenario

The scenario describes 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 m^3, 8 m^2, and a ventilation rate of 0.6 hr^{-1}. It is assumed that 60 g of powder is dusted onto 1 m^2.

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 model describes the inhalation exposure due to spraying aerosols indoors, for example, and the 'evaporation' model describes the exposure due to the evaporation of a substance in a room. These models can all be applied to calculate the inhalation exposure in a room. These models cannot be applied to calculate the inhalation exposure outdoors.

The dermal and the oral exposure after application outdoors can be described with the help of ConsExpo (using the 'rubbing off' and the 'constant rate' 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

Inhalation/ oral exposure: spray model

During the dusting of the surface under treatment, the dusted particles can be breathed in and oral and/or inhalation 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 inhalation/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' model, which is developed for the spraying of aerosols. The definitions for a number of parameters do have to be somewhat changed. The spray model describes the behaviour of a cloud of aerosol particles, but it can also describe a cloud of solid particles, that is, a dusted powder.

- *'Spray' duration*

For dusting the application duration is the 'spray' duration. It is estimated that it takes 5 minutes for dusting 1 m^2.

- *Exposure duration*

A total time of 4 hours is set as the default value for the exposure duration It is assumed that the user leaves the treated room 4 hours after the application.

- *Mass generation rate*

The mass generation rate 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 mass generation rate is 60/5 = 12 g/min.

- *Initial particle distribution.*

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. It is provisionally defined that most of the particles will have a diameter of between 50 and 150 µm.

In the TNsG's[50)] a 'Consumer product spraying and dusting' model is stated in which the consumer uses a hand-held dusting applicator pack for crack and crevice powders against fleas and ants. The products were found to be particles of inert filler such as fine talc or chalk (median, 45% of dust less than 75 µm) [50)].

Based on this data, the default value for the initial partial distribution is a lognormal distribution with a median of 75 µm and a coefficient of variation of 0.6.

Dermal exposure: constant rate

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 constant rate model.

- *Contact rate*

In the above-mentioned dusting model (TNsG[50)]), the subjects in the study applied crack and crevice powders in a kitchen treating skirting boards, shelves and laminate surfaces. The dermal exposure on hands and forearms ranges from 0.4 to 4.18 mg/min with a 75th percentile of 2.83 mg/min. The dermal exposure for legs, feet and face ranges from 0.22 to 6.56 mg/min with a 75th percentile of 2.15 mg/min. Using these data, the default value for contact rate is set at 4.98 mg/min.

Exposure after application

Dermal exposure: 'rubbing off' 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 m^2/hr is given, where the EPA assumes a maximum of 4 hours of activity per day.

- *Dislodgeable amount*

The TNsG[50)] gives an overview of transfer efficiency for different types of surfaces, the dislodgeable amount ranges from 1% to 60%. In an HSL Pilot study on aerosols (cited in the Biocides Steering Group's report, 1998[7)]) 10 % is given as the value for the parameter 'dislodgeable residue from treated carpet'. The concept-SOPs of the US-EPA[25)] assume that 50% of the amount of the active substance gets on to the surface. Based on this data, the default value for the dislodgeable fraction is set at 30%. The airborne fraction is taken to be 15%, so 85% of 60 g of flea powder is sprinkled onto 1 m^2; the dislodgeable amount is therefore 0.85 x 60 x 0.3 =15.3 g/m^2.

Oral exposure: constant rate

- *Ingestion rate*

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 § 2.2.7). The ingestion rate can be calculated based on this assumption.

Defaults

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

	Default value	**Q**	**References, comments**
General			
Frequency	5 $year^{-1}$	3	In summer, once a month
Inhalation			
Exposure, spray model			
Spray duration	5 min	2	See above
Exposure duration	240 min	3	See above
Room volume	20 m^3	3	Unspecified room[1)]
Room height	2.5 m	4	Standard room height
Ventilation rate	0.6 hr^{-1}	3	See above
Mass generation rate	0.2 g/sec	3	Calculated, see above
Airborne fraction	0.2 g/g	1	See § 2.2.3
Weight fraction non-volatile	1 g/g	4	100% product
Density non-volatile	1.8 g/ cm^3	3	See § 2.2.2
Initial particle distribution	75 µm (0.6)	2	Median (CV); see above
Inhalation cut-off diameter	15 µm		See § 2.2.3
Dermal			
Exposure, constant rate			
Contact rate	4.98 mg/min	2	See above
Release duration	5 min	2	I.e. ‘spray’ duration

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

	Default value	Q	References, comments
General			
Frequency	70 $year^{-1}$	2	5 x 14 days per year
Body weight	8.69 kg	4	Child 10.5 months[1)]
Dermal			
Exposure, rubbing off			
Transfer coefficient	0.6 m^2 / hr	2	See § 2.2.6
Dislodgeable amount	15.3 g/ m^2	2	Calculated, see above
Contact time	60 min	2	See above
Rubbed surface	1 m^2	2	See above
Oral			
Exposure, constant rate			
Ingestion rate	--		Calculated, see above
Exposure time	60 min	2	I.e. contact time

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.

Within the category 'Pest Control Products' only two products were found that are permitted authorized to be used 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., 1999[44)].

8.2 Gasses and foggers

A number of pest control products are 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 (Mg_2P_2). If these phosphides come into contact with moisture, the extremely poisonous gas phosphine (PH_3) 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 chlorpropham). 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.

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