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"Stoffenmanager, a web-based control banding tool using an exposure process model

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Summary

In the scope of a Dutch programme to reinforce the working conditions policy on hazardous substances, an internet based tool was developed to help small and medium sized companies to handle hazardous substances with more care. The heart of this tool, called the Stoffenmanager, is a risk banding scheme for inhalation exposure. It combines a hazard banding scheme similar to that of COSHH Essentials and an exposure banding scheme based on an exposure model originally presented by Cherrie *et al.* (1996) and further developed by Cherrie and Schneider (1999). The exposure model has been modified to allow non-expert users to understand and use the model. Exposure scores are calculated based on categorisation of determinants of emission, transmission and immission. These exposure scores are assigned to exposure bands. The combination of exposure bands and hazard bands leads to a risk band or priority band. Following the evaluation of the priority of tasks done with products, generic exposure control measures can be evaluated for their potential to lower the risks. Relevant control measures can be put into an action.

The current version of Stoffenmanager is partly bilingual (English and Dutch for the modules on risk banding and control measures). Stoffenmanager also contains a risk banding module for dermal exposure and several other functionalities regarding registration and storage of products. This publication however is focussed on the exposure model for inhalation.

The use of the Stoffenmanager is growing steadily in The Netherlands. Several branch-specific versions of the tool have been developed; most of them will be operational end of 2007. This branch-specific development originates from the desire to make better use of branch-specific information on processes and exposure control and because of the inherent limitations of generic tools. A number of other developments are also made to further increase the usefulness of this tool.

Contents

1 Introduction and Background

The rules for assessing and managing risks of dangerous substances in the workplace have been laid down in several European Directives, such as the Framework Directive (Council Directive 89/391), the Carcinogens Directive (Council Directive 90/394/EEC) and the Chemical Agents Directive (Council Directive 98/24/EC). However, keeping these rules is not easy, as several authors from different EU member states have stressed (Maidment, 1998, Nieminen, 1998, Tijssen and Links, 2002, Balsat *et al.*, 2003). Further research on Chemical Risk Factors and Risk Management in SMEs are among the top priorities in Europe in relation to occupational safety and health (European Agency for Safety and Health at Work, 2000). The Dutch Ministry of Social Affairs and Employment has established a four year programme to assist SMEs in reinforcing the working conditions policy on hazardous substances, the so-called "VASt-programme" (http://vast.szw.nl, Hollander, 2003). Industry sectors, product chains and companies could obtain financial support for action plans aimed at implementation of improvements through this programme. Furthermore, a set of projects has been carried out to provide the industry with effective tools to assess and control exposure to dangerous substances.

The control banding tool for inhalation exposure was developed to help companies without specific expertise in chemical risk assessment to prioritize their potential risks of chemicals and to indicate the types of exposure controls that could lower these risks. The development of the tool started with an inventory of available approaches in Europe. A number of approaches were studied, including COSHH Essentials (Russel *et al.*, 1998), a "safety check" developed by the German BIA (Kittel *et al.*, 1996), a "support making decision tool" in development in France (Vincent and Bonthoux, 2000) and a method for "Chemische Arbeitsstoffe" by the Austrian AUVA (AUVA, date unknown).
The instruments were all evaluated against the following criteria:

- directed at hazardous substances;
- directed at the SME employer;
- part of a larger improvement process;
- relevant for risk assessment and control.

All instruments appeared to offer useful elements. However, it was decided that a new instrument would best fit the needs of SMEs in The Netherlands. Therefore, instead of "simply" translating one of the foreign instruments, a new instrument was built, based on previous work published by other groups. In this way, it represents a combination of useful elements from different sources.
Briefly, the "hazard banding" part of the tool is based on COSHH Essentials (Brooke, 1998), the exposure model on an approach published by Cherrie *et al.* (1996) and Cherrie and Schneider (1999) and the "risk banding" part is made by combining hazard bands with exposure bands resulting from the exposure model. The structure of the Stoffenmanager was derived from a software tool (ChemAudit) which assists SMEs in controlling risks due to exposure to hazardous substances (Heussen *et al.*, 2002).

In this publication the Stoffenmanager will be briefly described. The focus of the publication is on the inhalation exposure model, because this is the more innovative part of the tool. The version that will be described is the improved version that will be available from October 2007. This version is evaluated using a large scale validation study (Tielemans *et al*. 2007a). Also, some (future) developments of this tool will be indicated.

As mentioned Stoffenmanager also contains a risk banding module for dermal exposure. The core of this module is the RISKOFDERM Toolkit (Goede *et al.*, 2003, Oppl *et al.*, 2003, Schumacher-Wolz *et al.*, 2003, Warren *et al.*, 2003), which is incorporated in Stoffenmanager with some modifications to facilitate use by non-experts in SMEs. This feature will be presented separately in a future publication.

2 General framework of the Stoffenmanager

The basic element of the Stoffenmanager is risk banding. However, some other useful elements are included as well. The Stoffenmanager is a web-based tool. (www.stoffenmanager.nl). The user enters data in web-based forms. Data are kept confidential and can only be accessed and used by the user by logging in with his user name and password. Use of the Stoffenmanager is free of charge.
The general structure of the tool is presented in figure 1.

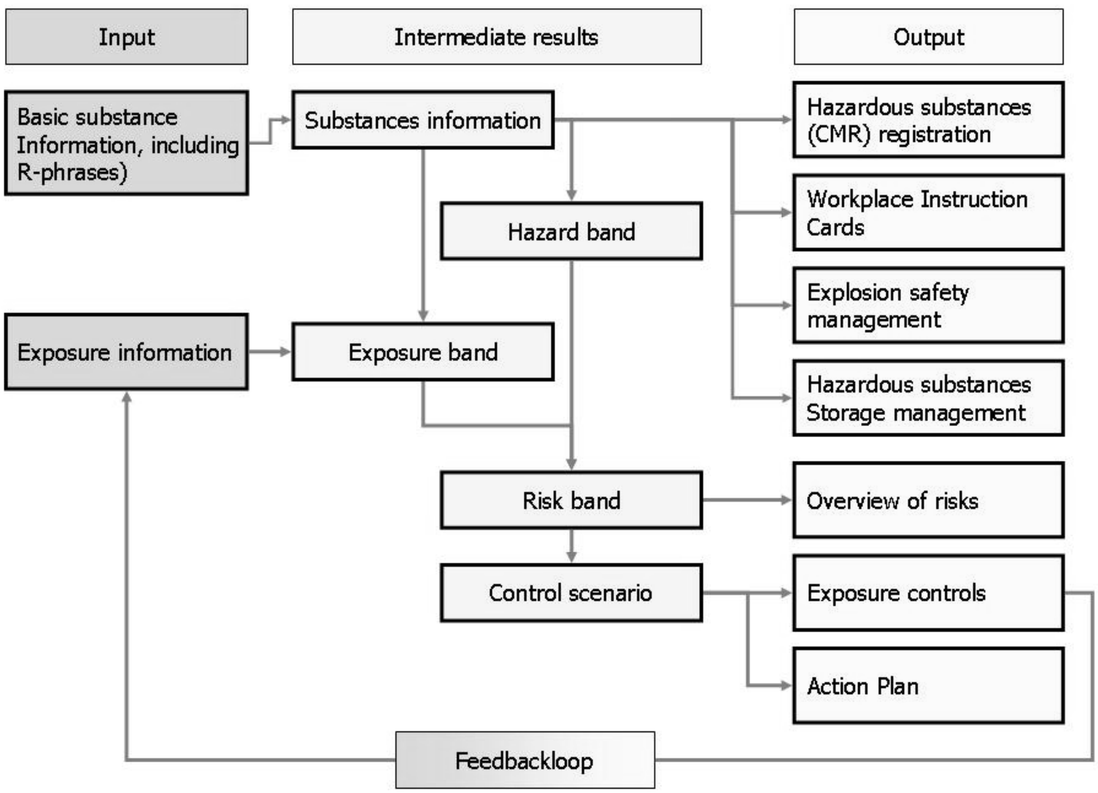

Figure 1. Overview of Stoffenmanager, including risk banding and some other important elements

2.1 Input of basic data

The Stoffenmanager prioritizes exposure to products. These may be preparations (e.g. a paint), but can also be pure substances. Basic data on the products can be entered manually or (largely) from a database with product information, using a standard exchange format. The following information has to be entered:

- Name of the product
- Publication date of the SDS
- Whether the substance is a solid or a liquid
    - For a solid: the dustiness

    - For a liquid, the vapour pressure
- Supplier of the product
- Departments in which the product is used
- Composition of the product, according to the SDS
- Hazard categories (*i.e.* symbols according to the SDS)
- Personal protective equipment and ventilation needed (according to the SDS)
- Risk and Safety phrases (R/S phrases for the product [*i.e.* not for the individual components], according to the SDS)

The vapour pressure for products (i.e. not pure substances) as mentioned on the SDS is used, when available. When no vapour pressure is mentioned for the substance as a whole, but a vapour pressure for a main ingredient is given, that value can be entered. If no vapour pressure is available at all, the option "unknown" has to be chosen. In that case the vapour pressure of water at 20 ºC is chosen as default value.
A choice of "dustiness" of the product has to be made by the user of the Stoffenmanager to allow the exposure model to take account of this parameter in establishing the exposure band (see later).
The input of the departments where the substance is used is needed to prepare the output of specific registration information for carcinogens, mutagens and reprotoxic agents.

2.2 Hazard banding

The hazard band of each substance is based on the R-phrases entered. For this purpose, the division of R-phrases in hazard bands of COSHH Essentials is used. The original hazard bands are described by Brooke (1998). A few modifications have been made since that publication to accommodate changes in the European Directives.
An overview of the hazard bands is presented in Table 1.

Table 1. Overview of hazard bands in the Stoffenmanager (from "Summary of the Technical Basis for COSHH Essentials"[1])

R-phrases	**Hazard Band in the Stoffenmanager**[2)]
R36, R38, R65, R67 and all R phrases not otherwise listed	A
R20, R21, R22, R68/20/21/22[3)]	B
R23, R24, R25, R34, R35, R37, R41, R43, R48/20/21/22, R39/23/24/25	C
R26, R27, R28, R40 (Carcinogen category 3) , R60, R61, R62, R63, R64, R48/23/24/25, R39/26/27/28	D
R68 (Mutagen category 3; formerly R40 Muta cat 3)[4)], R42, R45, R46, R49	E

1) www.coshh-essentials.org.uk/assets/live/CETB.pdf

2) A combination of R-phrases is classified in the same hazard band as the single R-phrase with the highest hazard band in the combination, unless indicated otherwise.

3) This refers to the combination of R68 with any one of R20, R21 or R22, where R68 is not intended to represent "substances classified as mutagenic category 3".

4) This only refers to the use of R68 to indicate "substances classified as mutagenic category 3".

2.3 Exposure banding

The exposure model used for exposure banding in the Stoffenmanager is based on the ideas published by Cherrie *et al.* (1996) and further developed by Cherrie and Schneider (1999). These ideas are used and adapted in several ways. The resulting model used in the Stoffenmanager is discussed in the next part of this publication. The exposure model leads to a classification in one of four exposure bands.

2.4 Risk banding

The results from the hazard and exposure banding steps are combined in the Stoffenmanager to risk bands. The Stoffenmanager only provides a relative ranking of risks. No quantitative comparison between exposure levels and hazard levels is made, because in the present version both exposure and hazards are only classified in relative bands. The result of the risk banding is therefore a "priority band". In future versions it will be possible to generate quantitative exposure estimates, based on relations between exposure scores and quantitative exposure from the evaluation study (Tielemans *et al.*, 2007a). The combination of hazard and exposure into priority or risk bands in the Stoffenmanager is presented in figure 2.

Hazard band / **Exposure band**	A	B	C	D	E
1	**3**	**3**	**3**	**2**	**1**
2	**3**	**3**	**2**	**2**	**1**
3	**3**	**2**	**2**	**1**	**1**
4	**2**	**1**	**1**	**1**	**1**

Figure 2. Priority bands in the Stoffenmanager;
Hazard: A = lowest hazard, E = highest hazard
Exposure: 1 = lowest exposure, 4 = highest exposure
Overall result: 1 = highest priority, 3 = lowest priority

Based on the bands of hazard and exposure, the risk band is determined. Risk bands resulting from (relatively) low exposure bands and (relatively) low hazard bands are of low priority, risk bands combining (relatively) high exposure bands with (relatively) high hazard bands are of high priority and the remainder of combinations is of medium priority. Substances that are mutagenic or carcinogenic or that lead to respiratory sensitization are considered to be so hazardous that they always lead to the highest priority, independent of their exposure. The intention is to ensure that these substances and their use and control are always considered specifically and in more detail by the user and to encourage the substition by less dangerous substances.

When all situations within a company with exposure to substances have been assessed, the total overview of the risk banding for all these substances and situations provides a semi-quantitative risk assessment for the whole company.

2.5 Control scenario

When a situation is evaluated and a priority band is assigned, Stoffenmanager enables the user to design a risk reduction scenario or control scenario. This option leads to a list of possible control measures that can be taken. The measures are presented in a number of groups. The following (generic) control measures can be chosen in the system in the order as indicated:

- control measures at the source
  - removal of the hazardous product from the task
  - removal of the task from the process
  - modification of the product form, e.g. use a paste instead of a powder
  - modification of the task, e.g. instead of "frequent handling" the task can be modified to "handling in closed systems"
  - replacement of the product by another product with another composition, changing the hazard and possibly also the exposure
  - automation of the process, leading to a whole new exposure assessment
  - changing the order of tasks, e.g. adding powder to liquid instead of the other way around
- control measures in an area directly around the source
  - placing the source in a ventilated containment in the room (full enclosure)
  - adding local exhaust ventilation to emission sources
  - combination of local exhaust ventilation and full enclosure
  - limiting the emission of a product (e.g. moisturizing powder)
- modifying controls in the wider work area of the worker
  - creating and ensuring natural ventilation
  - installing a (mechanical) area ventilation system
  - use of a spray cabin
- control of the situation of the worker
  - use of work cabins (with or without ventilation with clean air supply)
  - use of personal protective equipment

Depending on the choice of control measure, some of the inputs need to be re-evaluated to adopt the hazard or exposure bands for the chosen control measures. The new priority band is then calculated based on the modified inputs. The modified inputs can be saved as a control scenario that can be used in the action plan.
Because the exposure model leads to a classification into exposure bands, it is possible that a control measure that will lead to a reduction in exposure will not lead to a lower exposure band (and related priority band). In such cases this is reported in the results of the control scenario and the user is recommended to consider implementing the control measure, even if it may not lead to a lower priority band.

2.6 Action plan

The control scenarios and control measures for different tasks can be presented in the form of an action plan. There is an option to download the information into a document including elements to be filled in locally, e.g. who is responsible for the action, the estimated costs and the deadline for finalizing the action.

2.7 Workplace instruction cards

For all products Stoffenmanager can generate so-called workplace instruction cards.This is a better readable and more user friendly version of the information taken over from the Safety Data Sheet. In addition the user has to specify the personal protective equipment, storage instructions and control measures in the case of accidental spillage.

2.8 Registration of carcinogenic, mutagenic and reprotoxic substances

There are specific legal requirements in The Netherlands for registering the carcinogenic, mutagenic and reprotoxic substances used in the workplace. This includes: the number of workers exposed, the amount of the substance available in the workplace and the type of activities done with the substance. When a carcinogenic, mutagenic or reprotoxic substance is entered into the Stoffenmanager, the user can add this information in his dataset to build up a registry of such substances. The user is also asked to indicate the control measures used to control exposure and the reasons why this substance cannot be substituted or removed from the process. This registry can be used to have a quick overview of the situation regarding these substances and to show to the authorities when required.

2.9 Information for the storage of dangerous substances

Information and guidance regarding the storage of dangerous substances in accordance to the guidelines in The Netherlands can also be entered and evaluated through the Stoffenmanager. This will not be discussed further in the present publication.

2.10 Explosion safety

Stoffenmanager also enables the user to assess explosion risks in the workplace (according to the European ATEX guidelines) and to choose control measures which can be transferred to an action plan. This module will not be discussed further in the present publication either.

3 Exposure model in the Stoffenmanager

The exposure model used for the classification into exposure bands is based on a model presented for sources close to the worker by Cherrie and Schneider (1999), which was based on earlier work by Cherrie *et al.* (1996).
Cherrie *et al.* (1996) have made categories, running from 'none' to 'very high' for each parameter and given these categories a score on a logarithmic scale, running from 0 through 0.03, 0.1, 0.3, 1 and 3 to 10. A logarithmic scale for categories leads to a reasonable dispersion of resulting exposure levels or scores over the categories, in accordance with the logarithmic distribution that exposure levels often are found to have.

The model presented by Cherrie and Schneider (1999) has been modified on a few points to build a model that is suitable for use by SME employers, who are non-experts in occupational hygiene.
A source of emission can be in the breathing zone of the worker, but also outside of the breathing zone. In the first case, this is called 'near-field' emission, while the latter situation is called 'far-field' emission. Cherrie and Schneider (1999) also present an equation for the 'far-field' sources. They define the breathing zone as a cube around the head of the worker with dimensions of 2 by 2 by 2 meter. A source is inside the breathing zone according to the Stoffenmanager if it is within a distance of 1 meter from the head of the worker. This defines the breathing zone as a sphere instead of a cube. Because the main purpose of the Stoffenmanager is to rank situations relative to their risk, an additional factor was added for frequency of the task.

The modified model as used in the new version of the Stoffenmanager is represented by the following equations.

$$B = C \cdot t_h \cdot f_h \qquad (1)$$

$$C = (C_{ds} + C_{nf} + C_{ff}) \cdot \eta_{imm} \qquad (2)$$

$$C_{ds} = E \cdot a \qquad (3)$$

$$C_{nf} = E \cdot H \cdot \eta_{lc\_nf} \cdot \eta_{gv\_nf} \qquad (4)$$

$$C_{ff} = E \cdot H \cdot \eta_{lc\_ff} \cdot \eta_{gv\_ff} \qquad (5)$$

The final equation of the exposure model of Stoffenmanager is:

$$B = \{[H \cdot \eta_{lc\_nf} \cdot \eta_{gv\_nf}] + [H \cdot \eta_{lc\_ff} \cdot \eta_{gv\_ff}] + [a]\} \cdot E \cdot \eta_{imm} \cdot t_h \cdot f_h \qquad (6)$$

where: B = exposure score
C = total concentration (score)
t_h = duration of the handling score

f_h	= frequency of the handling score
C_{ds}	= background concentration (score) due to diffusive sources
C_{nf}	= concentration (score) due to near field sources
C_{ff}	= concentration (score) due to far field sources
η_{imm}	= multiplier for the reduction of exposure due to control measures at the worker
E	= intrinsic emission score
a	= multiplier for the relative influence of background sources
H	= handling (or task) score
η_{lc_nf}	= multiplier for the effect of local control measures at near field sources
η_{gv_nf}	= multiplier for the effect of general ventilation in relation to the room size on the exposure due to near field sources
η_{lc_ff}	= multiplier for the effect of local control measures at far field sources
η_{gv_ff}	= multiplier for the effect of general ventilation in relation to the room size on the exposure due to far field sources

Of course, SME employers are not able to use the equations presented above. Therefore, each of the parameters was specified in relatively simple parameters to create a useful model.
The steps that are taken to establish the scores for the parameters of the exposure model are presented in figure 3.

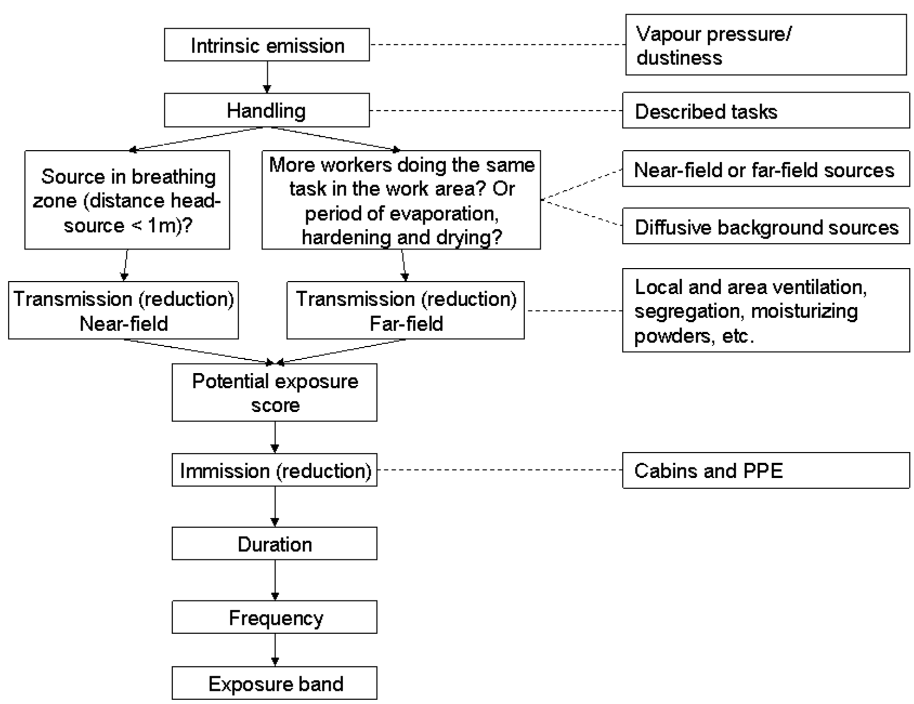

Figure 3. Steps taken in the exposure model of the Stoffenmanager. These steps are briefly explained in the text of the publication.

3.1 Intrinsic emission

Intrinsic emission (‘E’ in equations (3) to (6)) is a substance related parameter in the exposure model of the Stoffenmanager. It relates to the vapour pressure of liquids and the dustiness of powders.

For liquids E is directly related to the vapour pressure. This factor is chosen to be the same as the evaporation factor used in the “AWARE” code: E = P / 30,000 (Krop and van Broekhuizen, 2006). This code has been developed in The Netherlands in the scope of the so-called “VASt-programme” to assist companies in choosing products with lower risks. In this factor all substances with a vapour pressure of 10 Pa or lower are given the score 10/30,000. Between 10 Pa and 30,000 Pa the score increases linearly with the vapour pressure. All substances with a vapour pressure at or above 30,000 Pa are given the score 1 (30,000/30,000).

The vapour pressure of a product can be derived in different ways. If available, e.g. on the Safety Data Sheet, the vapour pressure of the product itself can be used. If the liquid part of a product largely consists of one substance, the vapour pressure of that substance can be used. This could e.g. be done for a paint product where the only hazardous substance mentioned on the Safety Data Sheet is a mineral spirit with a weight percentage of 20-50% in the paint. The vapour pressure of this substance can be used as such (approximately 350 Pa) to calculate the relevant emission factor. If a product contains two or three volatiles that make up large parts of the product, one could derive a vapour pressure of the product according to equation (7).

$$P_{product} = P_1 \cdot f_1 + P_2 \cdot f_2 + P_3 \cdot f_3 \qquad (7)$$

Where: P_i = the vapour pressure of substance i
f_i = the fraction of substance i in the product

For a product with mineral spirits with a vapour pressure of 350 Pa in a concentration of 15% and naphtha with a vapour pressure of 690 Pa in a concentration of 30% the calculated product vapour pressure to enter into Stoffenmanager would be 350 · 0.15 + 690 · 0.3 = 259.5 Pa.

Finally, if the above presented methods are not possible or not practicable, the vapour pressure can be presented as “unknown” in which case the value for water at 20 ºC (2300 Pa) will be used. This default is chosen from a conservative point of view, since it is unlikely that the vapour pressure of the critical compound in the mixture will be higher than the vapour pressure of water.

When the Stoffenmanager is used to prioritise exposures for single components from products, the intrinsic emission for the single substance can be calculated as:

$$E_i = P_i / 30{,}000 * F_i \qquad (8)$$

where: E_i = the intrinsic emission for a specific component in the product;
F_i = the fraction of the specific component in the product;
P_i = the vapour pressure of the specific component (Pa), with 10 as a minimum (substances with vapour pressure $\leq$10 Pa) and 30,000 as a maximum (substances with vapour pressure $\geq$ 30,000 Pa).

For dustiness of solids (powders) no direct relation with physical parameters is at hand. In analogy to the Cherrie model a table with weighing factors for different descriptions of dusts was developed. The user will have to determine this parameter himself by comparing the observed dustiness with the descriptions of the categories of dusts in the Stoffenmanager. The scores for intrinsic emission of solid substances are presented in Table 2.

Table 2. Scores for intrinsic emission of solids

Score	Intrinsic emission parameter	Explanation
0	Solid objects	Solid forms of substances or products, such as blocks, kegs or slabs
0.01	Firm granules or flakes	E.g. firm polymer granules, granules covered with a layer of wax, bound fibers, such as in cotton. No dust emission without intentional breakage of the product
0.03	Granules or flakes	Granules of flakes that may fall apart and crumble. E.g. washing powder, sugar or fertilizer
0.1	Coarse dust	A dust cloud is formed, but settles quickly due to gravity. E.g. sand, coarse carbon black, calcium stearate, unbound fibres
0.3	Fine dust	A dust cloud is formed that is clearly visible for some time. E.g. talcum powder, flour
1	Extremely dusty products	A visible dust cloud remains airborne for a long time

3.2 Handling

The scores for handling ('H' in equations (4) to (6)) are related to a number of processes that may influence emission. These processes can be described in physico-chemical terms, such as evaporation, frictional forces, etc. In a specific model for a specific set of tasks, e.g. in a branch-specific Stoffenmanager, the handling can be described in detail in a language understandable to SME employers. This is much more difficult in a generic model. Descriptions and discriminating categories, that are expected to be understandable to the user of the model, were made to capture these exposure processes. The scores for handling are described in Table 3a for liquids and in Table 3b for solids.

Table 3a. Scores for handling of liquids

Description	Examples	Score
Handling of liquids in tightly closed containers	○ Transport/shifting of closed containers.	0
Handling of liquids where only small amounts of product may be released.	○ Measuring doses using a dose-measuring device ○ Handling of small quantities in laboratory situations, like using pipettes.	0.1
Handling of liquids at small surfaces or incidental handling of liquids.	○ Gluing of stickers and labels ○ Cleaning of small objects like knives, ○ Cementing ○ (Un)coupling of tank lorries or (dis)connecting of production lines.	0.3
Handling of liquids using low pressure, low speed and on medium-sized surfaces.	○ Mixing/diluting of liquids by stirring ○ Manually drawing off or pouring of product ○ Painting of casings using a roller or brush	1

Description	Examples	Score
	o Gluing pieces together o Degreasing or cleaning small machines/tools/work pieces/tanks, etc. o Immersion of small objects in bucket with cleaning agent.	
Handling of liquids on large surfaces or large work pieces.	o Painting of walls or ships with a roller or brush o Degreasing of large machinery o Glueing or cleaning of floors o Handling of heavily contaminated tools/objects or packages o Handling of immersed objects, handling of painted objects. o Mechanically immersing of large objects in an immersion baths for example for cleaning purposes	3
Handling of liquids (using low pressure but high speed) without creating a mist or spray/haze	o Spraying of liquid using low pressure. o Foaming a product for cleaning or coating purposes o Mixing of products under high velocity using a mixer o Uncontrolled pouring of a liquid from a large altitude, for example pouring of production flows o Use of metalworking fluids like lubricants during cutting, sanding or drilling activities.	3
Handling of liquids at high pressure resulting in substantial generation of mist or spray/haze.	o Spraying of product (using high-pressure or spray painting) o Fogging a product producing a visible mist o Opening a (pressurized) production line for taking samples, or opening a closed cleaning device to remove cleaned objects. o Opening of a closed system where products are treated/present at high temperature or pressure. o Activities in the direct vicinity of open baths (high process temperature, cooking liquid).	10

Table 3b. Scores for handling of solids

Description	Examples	Score
Handling of products in closed containers.	o Transport/shifting of barrels or plastic bags.	0
Handling of product in very small amounts or in situations where release is highly unlikely.	o Shifting of packages of which the seams aren't dustproof. o Weighing a few grams of product. o Preparing medication.	0.1
Handling of product in small amounts or in situations where only low quantities of product can be released.	o Moving of polluted/dirty packages. o Weighing a several hundreds of grams of product. o Shifting of cement bags or sackcloth bags with product with a fork-lift truck.	0.3
Handling of product with low speed or with little force in medium quantities.	o Producing cement wet mortar using a chip. Producing cement manually with a shovel. o Kneading of paste. o Handling small or light materials externally contaminated with a substance (for example collecting and piling up of cement bags). o Weighing of products for recipes (for example in the animal feeds or textile industries)	1
Handling of products with a relatively high speed/force which may lead to some dispersion of dust	o Manual dumping o Manually scattering/strewing of the product. o Sweeping of product. o Mixing of product with a mixer o Dumping of powder with a pipe. o Manually scooping of products (high control level) o Manually handling of treated or contaminated products/materials (for example rubber parts are treated with anti-stick powder).	3

Description	Examples	Score
Handling of products, where due to high pressure, speed or high force, large quantities of dust are generated and dispersed.	○ Spraying of powders (powder coating) ○ Dumping of product from big bags. ○ Bagging of product. ○ Dumping of bags. ○ Cleaning of contaminated machines or object with compressed air.	10

3.3 Near-field and far-field sources

A source is considered to be in the near-field ('nf' in equations (2), (4) and (6)) if it is within 1 meter of the head of the worker. This is a pragmatic definition of "breathing zone". A far-field source ('ff' in equations (2), (5) and (6)) is made recognizable to users by asking whether other workers in the room are doing the same task or whether there is a period of evaporation, hardening or drying of products on a surface (after application) that is left in the work area of the worker. To simplify the model, it is assumed that the same handling is conducted in the far field as in the near field. In addition, no distinction is made between one or multiple co-workers in the far field or continuous presence of co-workers versus presence during only part of the time.

3.4 Reduction of transmission

Reduction of transmission from the source towards the worker is possible in several ways. In the Stoffenmanager this is split into two factors: local control measures (η_{lc} in equations (4) to (6)) and general ventilation (η_{gv} in equations (4) to (6)). Both can have different options for near-field and far-field sources, as indicated by $\eta_{lc.nf}$ versus $\eta_{lc.ff}$ in equations (4) to (6). However, to simplify the model, it is assumed that the same local controls are used for near-field and for far-field sources. The scores for local controls used for near-field and far-field sources are presented in Table 4.

Table 4. Scores for local controls

Criteria	Explanation	Score
Containment of the source with local exhaust ventilation	Containment of the source in combination with local exhaust ventilation, e.g. a fume cupboard	0.03
Containment of the source	The source is fully contained, however no local exhaust ventilation is used within the containment	0.3
Local exhaust ventilation	Removal of air at the source of the emission. The dangerous substances are captured by an air stream leading them into a hood and ductsystem	0.3
Use of a product that limits the emission	E.g. wetting a powder, spraying of water	0.3
No control measures at the source		1

The scores for general ventilation are different for near-field and far-field sources. These scores are related to the room volume and are based on simulations conducted by Cherrie (1999). They are presented in Tables 5a and 5b.

Table 5a. Scores for reduction by general ventilation for near-field sources, dependent on room size

Room size (volume)	No general ventilation	Mechanical/natural ventilation	Spraying booth
Volume < 100 m^3	10	3	0.1
Volume 100-1000 m^3	3	1	0.3
Volume >1000 m^3	1	1	1
Work is done outside	-	1	-

Table 5b. Scores for reduction by general ventilation for far-field sources, dependent on room size

	No general ventilation	Mechanical/natural ventilation	Spraying booth[1)]
Volume < 100 m^3	10	3	0
Volume 100-1000 m^3	1	0.3	0
Volume >1000 m^3	0.3	0.1	0
Work is done outside	-	0.1	-

[1)] When tasks are performed inside spray cabins it was decided that this does not lead to far-field exposure of workers outside of the spray cabin

3.5 Background emissions

The far-field sources can be distinguished by the answers to the questions in the Stoffenmanager. However, there can also be sources dispersed through the work area that are not covered by these questions. Such sources can be leaking machinery, contaminated rags lying around the room, spills that have not been cleaned up, etc. In the evaluation study it became apparent that situations with very low direct emissions may still lead to measurable exposures because of such sources. Therefore, an additional factor was added for background emissions in the model (C_{ds} in equations (2) and (3)). In the model it is a basic assumption that the exposure (and the background sources) has to be related to the intrinsic emission of the product. Therefore, it was decided to use a factor directly related to the intrinsic emission factor (a in equation (3)). In this way, the background emission of high volatile substances would be higher than that of low volatile substances. A (small) factor is made, dependent on the regularity of inspection of machines and on the cleaning procedures in the work area. The scores are presented in Table 6. By using the background emissions through a small additional emission factor, its influence is insignificant for activities with high direct emissions, but becomes apparent when there are hardly any direct emissions as seen from the handling scores. As the impact of diffusive sources on exposure level is extremely difficult to predict we decided to keep this part of the equation as simple as possible. Therefore a general ventilation parameter was not incorporated in the diffusive source component.

Table 6. Scores for the multiplier for the relative influence of background sources

	No daily cleaning	**Daily cleaning**
No regular inspections and maintenance of machines and equipment	0.03	0.01
Regular inspections and maintenance of machines and equipment	0.01	0

3.6 Calculation of the potential exposure score

The potential exposure score is calculated by multiplying all the scores for the different parameters evaluated up until this point in the model. This is done separately for near-field and far-field sources (where relevant).
An example of the calculation is given in figure 4.

Example of calculation of potential exposure score
Exposure to a car washing product that is diluted before use. The product has an unknown vapour pressure. It is spread onto a large surface area and another worker is doing the same task on another car in the same hall. The hall is 800 m^3 in volume and there is no ventilation system. Thorough cleaning and tidying up of the work area is done every day. The following scores are used to calculate the potential exposure score:

- Intrinsic emission: unknown vapour pressure → 'Ei' = 2300/30,000 ≈ 0.077
- Working with liquids on large surfaces or large objects → 'H' = 3
- No local control → '$\eta_{lc.nf}$' and '$\eta_{lc.ff}$' = 1
- Room 100 - 1000 ^{3} with no general ventilation → '$\eta_{gv.nf}$' = 3
  → '$\eta_{gv.ff}$' = 1
- machine inspected monthly **and** everyday cleaning → a = 0 → C_{ds} = 0

➔ potential exposure score = {(3 x 1 x 3) + (3 x 1 x 1) + 0} * 0.077 = 0.924

Figure 4. Example of the calculation of a potential exposure score

3.7 Modification of the potential exposure score for reduction of immission and duration and frequency of the task

The potential exposure score is corrected for the reduction of immission ('η_{imm}' in equations (2) and (6)). The reduction of immission in this model can be accomplished by means of segregating the worker from the source or by using personal protective equipment (PPE). The first measure is slightly different from separating the source from the worker. Instead of putting a source in a specific room, the workers are put in a specific room (e.g. a control room) for most of their working day. They only enter the area where the real production takes place for specific activities. The worker can also be placed in a closed cabin (e.g. in a tractor cabin while spraying pesticides). The scores for reduction of immission are presented in Table 7.

Table 7. Scores for reduction of immission

Score	Reduction of immission parameter	Explanation
0.03	The worker is in a separated (control) room with independent clean air supply	The workplace of the worker is in a (control) room that is equipped with an air supply independent of the air in the room where the source is
0.1	The worker works in an open or closed cabin without specific ventilation system	For example in a cabin of a tractor or truck, a cabin not equipped with filters, overpressure system etc. or behind a screen.
1	The worker does not work in a cabin	The employee is not protected from the source by using a cabin.

Another option to limit immission is the use of personal protective equipment (PPE). For this purpose the assigned protection factors as presented in a document of the Dutch Occupational Hygiene Society on selection and use of respiratory protection were used as a basis (NVvA, 2001). The scores, which include an additional safety factor, are presented in Table 8.

Table 8. Scores for protection by PPE

score	Type
1.00	none
	Dusts
0.40	Filter mask P2 (FFP2)
0.20	Filter mask P3 (FFP3)
0.40	Half mask respirator with filter, type P2L
0.20	Half mask respirator with filter, type P3L
0.20	Full face respirator with filter, type P2L
0.10	Full face respirator with filter, type P3L
0.20	Half/full face powered air respirator TMP1 (particulate cartridge)
0.10	Half/full face powered air respirator TMP2 (particulate cartridge)
0.10	Half/full face powered air respirator TMP3 (particulate cartridge)
0.05	Full face powered air respirator TMP3 (particulate cartridge)
0.20	Hood or helmet with supplied air system TH1
0.10	Hood or helmet with supplied air system TH2
0.05	Hood or helmet with supplied air system TH3
	Gases/Vapours
0.40	Half mask respirator with filter/cartridge (gas cartridge)
0.20	Full face respirator with filter/cartridge (gas cartridge)
0.20	Half/full face powered air respirator TM1 (gas cartridge)
0.10	Half/full face powered air respirator TMP2 or 3 (gas cartridge)
0.20	Hood or helmet with supplied air system TH1
0.10	Hood or helmet with supplied air system TH2
0.05	Hood or helmet with supplied air system TH3

In the model there is one lookup-table with both the options for reduction of immission in Table 7 and the options for PPR in Table 8. It is not possible to combine options from both tables, e.g. a worker working in a control room and using a filter mask, because this is considered to be a highly unlikely situation.

The Stoffenmanager prioritizes separate tasks with products, based on the exposure related to the product and the task and the hazards related to the products. Some tasks may occur only a part of the work shift. This is accounted for by modification of the exposure score based on duration of the task during a working day and frequency of the task (year-based). The calculated exposure score is based on the assumption that a task is being performed during 8 hours a day with a frequency of 5 days per week (totally 40 hours per week). In this situation the factor "duration times frequency of task" is 1. If a task is being performed during fewer hours per day and/or in a lower frequency than 5 days per week, a linearly proportional reduction of the factor "duration times frequency of task" is used.
The scores for duration and frequency of exposure are presented in Tables 9 and 10.

Table 9. Scores for duration of exposure

Score[1)]	**Parameter**
0.06	1 to 30 minutes a day
0.25	0.5 to 2 hours a day
0.50	2 to 4 hours a day
1.00	4 to 8 hours a day

Table 10. Scores for frequency of exposure

Score[1)]	**Parameter**
0.01	1 day a year
0.05	1 day a month
0.10	1 day per 2 weeks
0.20	1 day a week
0.60	2-3 days a week
1.00	4-5 days a week

[1)] a combination of unrealistic combinations of duration and frequency, e.g. "more than 4 hours per day" combined with "Two to four times per day" will be noted by the tool and the user will be asked to specifically confirm that this is indeed the combination that needs to be used.

3.8 Calculation of final exposure score and exposure band

The final exposure score of the substance and situation is calculated by multiplying the potential exposure score with the factors for reduction of immission, duration and frequency. In the web-based prioritization tool, the options for PPE are included in the score for reduction of immission. In the (quantitative) spreadsheet form of the exposure model the options for PPE are not included in the final exposure score. An example is presented in figure 5

Example of calculation of final exposure score (as in the web-based tool)

The car washing task used as example for the potential exposure score is further elaborated here. It is assumed that the workers do not work in a specific control room or cabine. Car washing is done up to 4 hours per day, almost every day of the week. This leads to the following scores used for calculating the final exposure score:

- Potential exposure score (see earlier example, figure 4) = 0.924
- No cabin or control room, no PPE → 'η_{imm}' = 1
- Duration up to 4 hours per day → 't_h' = 0.50
- Frequency is more or less daily (five days per week) → 'f_h' = 1.00

➔ Final exposure score = 0.924 x 1 x 0.5 x 1 ≈ 0.46

Figure 5. Example of the calculation of a final exposure score

The exposure scores are not exposure levels. Also, there are several sources of uncertainty in the scoring system, such as the model itself, the chosen boundaries between categories and the weight given to the categories. Therefore, the tool does not use these scores directly, but they have been assigned to exposure bands according to Table 11.

Table 11. Assignment of exposure scores to exposure bands

Exposure band	Minimum exposure score	Maximum exposure score
1	0	0.00002
2	0.00002	0.002
3	0.002	0.2
4	0.2	20

4 Further developments of the Stoffenmanager

4.1 Branch-specific versions

The present Stoffenmanager is a generic tool for use in all kinds of companies. It is therefore not tailored to specific needs of specific branches. In such a specific branch the tasks and processes are often rather similar and can be described by branch-specific terminology. This has been recognized and, stimulated by the VASt programme, several branches, including artists, surface treatment (metal), cleaning, metal fabrication and engineering industry, construction industry (subsectors plastering and tiling), dentistry, textile and carpet manufacture, flooring and carpet laying industry have started to develop their own version of the Stoffenmanager. Other branches are in the process of deciding on such a development. These branch-specific tools will be made available only to companies in the branch. The branch-specific tools are generally based on the previous version of Stoffenmanager and can have specific modifications. Such modifications include:

- using default tasks to choose from for the parameter ‘handling’;
- providing a list of default control measures (“good practices”) for specific tasks;
- adding known reduction factors of control measures to enable the user to evaluate the effectiveness of taking certain control measures;
- quantification of exposure levels for certain tasks for which there is sufficient information;
- an integrated product-database to allow easy choice of products and input of basic product data;
- adding sector specific hazard bands for toxic substances released during a process;
- a specific risk banding system for skin exposure.

A general feature of the branch-specific versions is that the language of the tool is tailored to the terminology of the branch. This is specifically important in the description of tasks and exposure control measures. It is unclear at present whether the branch-specific tools will also modify the exposure model to bring it into accordance with the improved version presented in this publication.

4.2 Other developments

A number of other developments of the tool are already incorporated or planned for the (near) future.

A better advice on risk management measures is provided by the inclusion of fact sheets and PIMEX (Picture Mix Exposure) videos on exposure control measures (generic or branch-specific).

In the Stoffenmanager important data about products, their use and the control measures are gathered. A preliminary functionality has been developed to allow the user to extract such data to be used as (part of) exposure scenarios under REACH (http://ecb.jrc.it/). Options to combine information from Stoffenmanager from different companies within one branch, e.g. to assist in deriving exposure scenarios under REACH, are feasible, but have not yet been developed.

Finally, the exposure model of the Stoffenmanager (old version and this version) has been evaluated using an extensive set of dedicated measurements together with existing exposure data gathered from several sources (Tielemans, *et al.*, 2007a). The results of this study will also be used to make a quantified version of the exposure model in the Stoffenmanager that can be used in exposure assessments for REACH. Because this quantification is done on the basis of the large scale evaluation study, a new validation study of the quantified model will be done with independent, newly gathered exposure data. A web-based database is under development to collate exposure data in order to calibrate and improve the Stoffenmanager exposure model in the future (STEAMbase: SToffenmanager Exposure And Modelling database).

5 Discussion and conclusions

The Stoffenmanager is an easy to use tool that plays an important role in the Dutch 'VASt'-programme. There are now almost 6000 registered users of the Stoffenmanager. After implementation of the branchespecific Stoffenmanagers this number is expected to increase rapidly. This tool apparently fills a need in The Netherlands as is also shown by the development of several specific Stoffenmanagers for industry branches.
The Stoffenmanager is not the answer to all questions regarding risks of dangerous substances in SMEs. Presently, it is limited to prioritizing risks in a rather generic way, coupled with advice on general risk management measures and some other useful elements. It cannot fully fill all the needs of the rules for risk assessment at the workplace (e.g. the so-called "Chemical Agents Directive 98/24/EC). The usefulness of the tool depends on its validity, its outputs, as well as on its user-friendliness. The hazard banding part of the Stoffenmanager is largely the same as that of the widely accepted COSHH Essentials tool. The exposure model is different. It is based on published approaches, including an evaluation of the processes from source emissions to exposures. The model has been evaluated with a rather large set of measured data and was shown to perform quite well (Tielemans *et al.*, 2007a).

Several of the boundaries between categories had to be chosen in a rather arbitrary manner, because of a lack of information on the relation between the parameters and exposure levels. While some boundaries are clear-cut (e.g. room volumes), others are described only qualitatively (dustiness index) to allow non-expert users to use the tool with information that they have available. It is not possible to evaluate every boundary and every choice within such a tool in-depth based on real exposure data. An evaluation was done of final Stoffenmanager scores in comparison with real exposure data in a relatively large evaluation study.

An important wish of users of the Stoffenmanager is to enable its use for comparison of (quantitative) exposure levels with occupational exposure limits. When the next version of the Stoffenmanager is a quantified version such comparisons of predicted exposure levels with quantitative occupational exposure limits will be possible. A further extansion may be to directly improve the model estimates with measured exposure levels for the situation under study through a Bayesian method. Such a new modelling approach has been proposed by Creely *et al.* (2005). We are currently investigating the possibilities of this approach, both for a large scale "advanced exposure model" (Tielemans *et al.*, 2007b) with a built-in exposure database as well as for a small scale option for users to fill in a few own measurement results to improve on their own assessment..

Both the Ministry of Social Affairs and Employment and the industry invest a substantial amount of money and/or time in the development of the 'VASt'-programme and the development of the Stoffenmanager, showing that the industry in The Netherlands is willing to improve the working conditions on dangerous substances, especially when this can be done in a pragmatic manner, leading to useful tools. Due to its central position within the 'VASt'-programme,

Stoffenmanager functions as a crystallization point for several other developments. In the future, other tools can be integrated in, or linked to the Stoffenmanager (or its specific versions).
The development of several specific variants of the Stoffenmanager raises the question whether in the future all these variants can still be called “Stoffenmanager”. Their internal engine may still be largely similar, but their outside skin and several specific elements may lead to very different tools. This is not a real problem, as long as the quality of the tools is ensured. Whether or not a tool is still a version of the Stoffenmanager is not a real issue; much more important is the fact that the development of the Stoffenmanager has facilitated a whole range of further developments of useful tools for SMEs.

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8 Signature

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