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A Structured Strategy for Assessing Chemical Risks, Suitable for Small and Medium-sized Enterprises

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Background: A previous study carried out in 20 Belgian companies, especially small and medium-sized enterprises (SMEs), showed that prevention advisors did not use any structured approaches to assess chemical risk. They used their personal judgement and the information contained in manufacturers' Safety Data Sheets to assess the risk.

Objective and method: The purpose of the Regetox network is to provide companies with a global approach for assessing chemical health risks. The structured approach proposed consists of two successive steps of increasing complexity. For the first step, we chose a method developed by the INRS (France), the 'ranking of potential risk', which allows the safety officer or staff member to identify hazards and to set priorities among all the supplied products used in the workplace. For the second step, we applied the COSHH method and EASE model established by the UK Health & Safety Executive for assessing 'chemical risk by reference to occupational exposure limits'. The INRS and COSHH Essentials methods were chosen because they define hazards using R-phrases of the European classification system and assess the exposure by using simple information that is easy to collect in the workplace and toxicological databases. A feasibility study conducted in two enterprises shows the usefulness of this approach. In addition to the intrinsic limitations of the methods, the approach showed some limitations related to the inaccuracy of the manufactured safety data sheets and to the collection of the basic information needed for ranking potential risks.

Conclusion: The use of the Regetox approach needs training of prevention advisors and a strategy involving employers, staff members and workers in collecting basic information and managing chemical risks. Under these conditions, Regetox seems to be a useful tool for chemical risk assessment in SMEs.

Keywords: control banding; Regetox; SMEs

INTRODUCTION

The European Chemical Agents Directive (EU, 1998) compels companies to assess chemical risks in the workplace and implement a specific prevention policy. Nevertheless, few companies seem prepared to meet this new obligation. Indeed, a scientific investigation held in Belgium in 1999 in some 20 companies in the Walloon region (French-speaking part) of the country, showed that the assessment of chemical risks rested mostly on the experience and personal judgement of prevention advisers (Balsat *et al.*, 2001). The sources of information that are most often used are those mentioned in the manufacturers' Safety Data Sheets (MSDSs), while the toxicological data are rarely consulted. These observations corroborate the conclusions of a scientific investigation held in the UK (Topping *et al.*, 1998), suggesting that companies lack the appropriate tools to make a thorough evaluation of chemical risks.

Indeed, the accurate measurement of chemical risk through atmospheric monitoring requires many samples in order to take into account within- and between-worker sources of variability (Kromhout, 2002; Rappaport *et al.*, 2002). The cost and practical difficulties associated with atmospheric monitoring represent an often insurmountable obstacle for companies. This is why the American Industrial Hygiene Association proposed a strategy (Hawkins *et al.*, 1991; Mulhausen and Damiano, 1998) based on an approach in successive stages that can reduce costs

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(Stewart and Stenzel, 2000; Dunham *et al.*, 2001). Nevertheless, the expertise of suitably trained and experienced industrial hygienists proves that it is necessary to use and assess the results provided by the ranking methods used in the first stages of this strategy (Popendorf, 1984; Taith, 1993; Stewart and Stenzel, 2000). Nevertheless, the conclusions of our investigation show that many small and medium-sized enterprises (SMEs) cannot normally have access to such a level of expertise.

With this observation in mind, different prevention organizations or professional associations have, in the last decade, developed methods aimed at making the analysis of chemical risks more accessible to companies. These methods claim to be simple and use the R-phrases of the European classifications for the identification of hazards. They can be divided into four categories, each dedicated to a particular level of risk analysis: classification of the products in hierarchical order (1), classification of the operations in hierarchical order (2), evaluation of the acceptability of the risk (3), and semi-quantitative risk assessment (4). Table 1 recapitulates some of the proposed methods.

The first level of analysis consists of organizing manufactured products in order of priority so as to help the employer to define priorities in terms of prevention policy. Based on basic information available in the company, the methods used are very easy to implement and require only minimal expertise. At level 2, the hierarchical system of operations also allows the employer to define priorities. Nevertheless, this necessitates a higher level of expertise. Indeed, to guarantee its feasibility, this approach must be led by prevention advisers. The methods of evaluation of the acceptability of the chemical risk (level 3) call for a lot of data and provide concrete information to improve prevention. However, their use takes time and requires the expertise of prevention advisers. They do not assess the risk semi-quantitatively. In addition, the method developed by the INRA (1999) is mainly dedicated to laboratory activities. Finally, COSHH Essentials (level 4), because of its simplicity of use, is accessible to companies. It makes the semi-quantitative risk assessment possible, in reference to occupational exposure limits, and proposes corrective measures. It can also evaluate the risk before the implementation of new strategies or the use of new products.

Considering that prevention advisers are seldom available, especially in SMEs, a survey was made in order to propose a structured approach through successive steps, so as to use at each stage the means and skills that are just necessary to lead to the risk assessment and identify control measures.

This survey was devoted to the implementation of certain methods of Table 1; the feasibility of this approach was then tested in two companies.

METHODOLOGY

Creation of the strategy

We propose a strategy comprising of at least two successive stages. The first stage requires a minimal level of expertise but must supply the basic elements to start the second, more complex stage, which has to be led by prevention advisers.

For the first stage, the calculation method of the potential risk (Vincent *et al.*, 2000) developed by the INRS was chosen. In this method, the recovery of basic data (inventory of products, annual quantities used and the frequency of use) can be done by workers and staff members. The role of the prevention advisers is restricted to organizing this data collection and retrieving the MSDSs to extract some R-phrases. For each product, the method calculates a level of priority—high, medium or low—from a hazard score in accordance with the nature of R-phrases allocated by the manufacturer and an exposure score in terms of the annual quantity used and the frequency of use. A list of products classified in decreasing

Table 1. Levels of risk analysis and corresponding methods

Level	Danger parameters	Exposure parameters	Results	Validation	References
1	R-phrases	Annual quantities used and frequency of use	Classification of products by order of priority	Consensus of experts	Vincent *et al.* (2000)
2	R-phrases	Control strategy levels	Classification of operations by order of priority	Consensus of experts	Marcenac *et al.* (1999), UIC (1999)
3	R-phrases, OEL, toxicological data	Control strategy levels, dilution, volatility, duration of exposure	Acceptable risk, (three unacceptable levels, ranked by order of priority)	Consensus of experts	INRA (1999)
	R-phrases	Numerous risk determinants, including administrative data	Acceptable risk (four unacceptable levels, ranked by order of priority)	Consensus of experts	AUVA (1999)
4	R-phrases	All the risk determinants, excluding administrative data	Semi-quantitative risk assessment	Hazard validated in reference to OEL; exposure validated by monitoring data	COSHH (1999)

order of priority is thus obtained and can then be submitted to the employer. It therefore constitutes the starting point of the actual evaluation of the risks.

For the second stage, the chosen method must ensure that occupational exposure limits are respected, not only for existing situations but also for new work procedures, and provide information about the necessary prevention measures. Methods aiming at estimating the acceptability of the risk do not meet these criteria and their use requires that numerous data be taken into consideration, some of which have to be evaluated by experts. This is the reason why the COSHH method (Brooke, 1998; Maidment, 1998; Russel *et al.*, 1998) was selected. To reduce the time devoted to its implementation, the risk assessment will be limited to those products that have been defined by the first stage as being of medium and high priority.

Because the COSHH Essentials model of exposure (Maidment, 1998) is calculated for pure substances, it appears desirable, when mixtures are being used, to evaluate the risks associated with each of the harmful substances present, according to their weight percentage. This means that, for each of them, the R-phrases allocated by the European system of classification and the boiling temperature in the case of liquids should be known. These data have to be retrieved from certain databases. The other information necessary for the use of the method can be retrieved at the workplace: the quantity used during each operation, the physical dustiness state for solids, the temperature of the process for liquids and the control strategy level.

The results obtained by the COSHH Essentials method were interpreted by taking into account the occupational exposure limits (OELs), when these were available, and the time of exposure. Results of the atmospheric monitoring carried out during a partial validation study have shown that the 95th percentile of the distribution of data for different operations fitted within the predicted exposure ranges, and may even have been less (Tischer, 2001). The maximal atmospheric concentration predicted by the exposure model was compared with the OEL when this value was available. The duration and the frequency of the daily exposure were also taken into account for the calculation of the results.

Feasibility study

The feasibility of the proposed strategy has been tested within two companies: a company of 80 workers manufacturing plastic foam, and a larger company (950 workers) providing mechanical maintenance. The strategy was used in three workshops of the foam manufacturer—the preparation of plasticizing mix, weighing and the manufacture of a prepolymer of polyurethane—and in the paint workshop of the maintenance company. Table 2 describes the nature of the operations carried out. In the three workshops of the plastic company, it covers manual filling operations. For the workshops of the maintenance company, it covers the painting operations. In each company, workers undertake the same activities and can be considered as belonging to similar exposure groups. Unlike the paint workshop, all the operations of the plastic company are undertaken daily and use different products except for three of them.

The efficiency of local exhaust ventilation systems was measured with an anemometer. If the exhaust speed was <0.5 m/s at the point of emission, the general ventilation was taken into account for the calculation of the risk.

The protocol of the feasibility study recommended that the following tasks be executed:

- After some brief information given by the prevention adviser, workers, helped by the foreman, were given the task of making an inventory of the products used at each workplace.
- The internal adviser had to retrieve the contents of the labelling of each product.

Table 2. Nature of the operations carried out in the workshops

Company	Workshop	Operation	Physical state
Foam manufacturer	Preparation of mix	Filling	Liquid and dust
	Weighing	Filling	Liquid and dust
	Manufacturing of foam	Manual and automatic filling (reactor)	Liquid and dust
Maintenance	Painting	Preparation of paint	Liquid and solid in liquid
		Drying	Liquid and solid in liquid
		Painting with rolls	Liquid and solid in liquid
		Stripping	Liquid
		Cleaning of paint guns	Liquid
		Painting of small parts	Aerosols
		Painting of vehicles	Aerosols

Table 3. Protocol of tasks

Tasks	Who?	Company	
		Foam manufacturer	Maintenance
Product inventory	Workers	Not done	Not done
Collecting information on labels	Safety officer	OK	Not done
Retrieving MSDSs in MSDS file	Safety officer	OK	OK
Retrieving quantities used and frequency of use	Safety officer	OK	Not done
Retrieving missing information in the MSDSs	Occupational physician	Not done	Not done

- The internal adviser had to verify this inventory and retrieve the MSDSs and the basic information for the calculation of the potential risk.
- The occupational physician had to ask the manufacturer for the missing information (composition of the product) on the condition of medical secrecy.
- A visit to the workplaces was organized in the presence of the occupational physician, the internal prevention adviser and a representative of the management to collect the different necessary data for the semi-quantitative risk assessment (COSHH).

The role of the researcher had to limit itself solely to the actions relative to the control and expertise aspects in the framework of the development of the strategy. In particular, the research team was given the task of verifying the MSDSs file, the reliability of the labelling and the MSDSs, and the different data with a view to using the methods.

After recovery of the necessary data, the chosen methods were tested separately. Finally, the results of the semi-quantitative risk assessment were compared with those obtained when this assessment is limited to products of medium and high priority as determined by the calculation of the potential risk.

The COSHH Essentials approach does not allow for the risk assessment linked to the aerosols produced during the painting operations with guns. These operations are undertaken either in two small open paint booths, with air extraction, or in large closed but ventilated booths reserved for bigger parts. In these cases, the EASE (1997) model was used to estimate the exposure.

RESULTS

The proposed protocol was only partially completed (Table 3). Internal advisers did not meet the workers, probably because of problems linked to the organization of the work (work in shifts, planning) or cultural aspects (unusual approach). In addition, the workload of the internal advisers and the diary of the occupational physician posed some difficulties. Thus, the research team had to take part in the inventory of the products and estimation of the quantities for the maintenance company. Finally, the occupational physicians did not contribute to the strategy.

Table 4. Situation of the files of the MSDSs available in the companies

	Foam manufacturer		Maintenance company	
	n	%	*n*	%
Number of products	39	100	42	100
Missing MSDSs	0	0	11	26
Insufficient MSDSs	4	10	12	29

During the visit of the workshops and the observation of the tasks necessary for the data collection required by COSHH Essentials, the research team was able to meet the workers. The latter showed a lot of interest by asking very relevant questions about the hazards of the products and the possible effects on their health.

Basic data

The keeping of the MSDS files and the content of the MSDSs showed various inadequacies: missing MSDSs, MSDS that had not been updated or were incomplete, or MSDSs that did not correspond with the product, or gave incoherent information.

Table 4 shows the situation of the files of available MSDSs in both companies, concerning the products used in the workshops studies: a certain number of existing MSDSs could not be used because they were incomplete or because they showed inconsistencies.

As for the accuracy of labelling and MSDSs with respect to the allocation of R-phrases, the labelling appears less reliable than the MSDSs. Similarly, the information contained in MSDSs evaluates the hazard correctly or over-estimates it in 93 and 62%, respectively, of the products used in each company (Table 5). This difference can be explained by the poor level of expertise of one of the suppliers of the maintenance company.

For seven products, the danger could not be determined with accuracy (impossible conclusion). For three of them, no MSDS was available despite the many letters sent to the manufacturers. For the four others, it has not been possible to verify the hazard, either because the substance was mentioned under a form different from the international denomination in the absence of a CAS number, or because its concentration was not mentioned in the composition.

Table 5. Reliability of regular labelling and of the MSDSs for the allocation of R-phrases

	Evaluation of hazards			Impossible conclusion
	Exact	Over-evaluation	Under-evaluation	
Foam manufacturer				
Label				
n[a]	30	3	6	
%	77	8	15	
MSDSs	33	3	3	
%	85	8	8	
Maintenance company				
MSDSs				
n	20	6	9	7
%	48	14	21	17

[a]Number of products.

Potential risk hierarchical system

The calculation of the potential risk is easy and takes only a little time. Products are listed by decreasing order of priority. As an example, Table 6 gives the results obtained in the workshop for the preparation of plasticizing mixtures (for the foam-manufacturing company).

In this example, a medium or high priority is attributed to eight products out of 24. The highest priority levels are attributed to the most hazardous products, as the factors relative to the used quantities and to the frequency of use have less impact on the calculation of the potential risk.

Semi-quantitative evaluation of the risk (COSHH, EASE)

Table 7 shows the global results of the semi-quantitative risk assessment for all operations made in each company.

Table 6. Potential risk hierarchical system for the workshop that prepares the plasticizing mix

Code[a]	Product	Q (kg)[b]	FU[c]	R-phrases	P[d]	C[e]
1906104	Catalyst	5130	2	R 22 R 43	3	5
1905100	Inflating agent	37200	1	R 42	3	5
1909100	Additive	10140	3	R 23/25 R 36	3	5
1907100	Weight	8000	1	R 40 Carc. Cat. 3	2	9
1908100	Additive	1410.5	3	R 36/38 R 43	2	9
Z	Charge	418348	2		2	17
1902130	Plasticizer	272959	3		2	17
1902310	Plasticizer	79469	3		2	17
1904200	Amorphous SiO_2	3560	1	TLV	1	19
1904213	Additive	1950	1	R 36	1	19
1903300	Plasticizer	18000	3		1	20
1902312	Plasticizer	24472	2		1	20
1910130	Pigment	9225	3		1	20
1906100	Catalyst	4400	3		1	20
1902311	Plasticizer	10750	2		1	20
1904110	Charge	72500	1		1	20
1904214	Additive	25	1	R 36/38	1	21
1907410	Charge	500	1		1	23
1904100	Charge	27500	1		1	23
1908800	Additive	1820	3		1	23
1910210	Pigment	651	3		1	23
1910320	Pigment	2220	3		1	23
1910400	Pigment	25	3		1	24
1904210	Additive	0.47	1		1	25

[a]Code of the product alllocated by the company in the MSDS file.
[b]Annual quantity of use.
[c]Frequency of use.
[d]Level of priority: 1 = low priority; 2 = medium priority; 3 = high priority.
[e]Position in ranking from 1 to 25 in decreasing order of priority.

Table 7. Global results of the semi quantitative evaluation of risks for the studied workshops

	Foam manufacturer	Maintenance company
Situations complying with the regulations	32	41
Situations to correct: local exhaust ventilation	11	6
Continuation of the evaluation	3	18
Total	46	65

The majority of operations complied with the regulations. Only six and 11 operations, respectively, had to be improved by the installation of local exhaust ventilation. For the foam-manufacturing company, the three work situations for which it was necessary to continue the risk assessment concerned the use of methylene diisocyanate (MDI). The OEL if MDI is 5 p.p.b., i.e. a band not considered by COSHH Essentials. In this case, atmospheric monitoring is necessary.

For the maintenance company, the 18 operations for which the risk assessment must be continued all correspond to spray painting in large booths. The exposure that is expected by the EASE model for a daily duration of 3 h is within a concentration range of 187–300 p.p.m., i.e. values higher than the OELs of most solvents present in the paints used (Table 8). In this case, no improvement is possible except for wearing respiratory protective equipment. This is all the more justified as lead chromates, 1,6-hexamethylene diisocyanate (<0.1%) (TLV 5 p.p.b.) and 2,6-diisopropylphenyl isocyanate (<1%) are found in some paints. Finally, some distillates of the oil referred to could also contain >0.1% of benzene.

The TWA8 was estimated for each solvent present in the paints by adding the maximum concentrations provided by the EASE and COSHH Essentials models for the different operations undertaken on one day of use during the spray-painting operations in the large booth (Table 8). Values are very similar because the exposure results are from spray-painting operations. They largely exceed half of the OEL. From the annual use frequency of each product, the number of days when this value was exceeded has been estimated for each solvent. This information is likely to define priorities concerning the atmospheric monitoring and the medical supervision.

The evaluation of risks was not possible for three products that were used because no MSDSs were available.

Combined use of both methods

The Regetox strategy proposes to limit the semi-quantitative risk assessment to products of high potential risk (priority 3 and 2) as determined by the INRS method. For each company, the conclusions reached by applying the COSHH and EASE methods for all the products used (strategy 1) have been compared to those obtained by limiting the semi-quantitative risk assessment to products of high potential risk (strategy 2). For the foam-manufacturing company, 24 products out of 39 have a high priority but the conclusions provided by the two strategies remain unchanged. For the maintenance company, 22 products out of 35 have a high priority; in this case, strategy 2 did not allow us to identify one work situation that needed improving. Nevertheless, a simple examination of the working conditions would have allowed us to consider that this operation should have been subjected to a semi-quantitative risk assessment. This suggests that the strategy aimed at limiting the semi-quantitative risk assessment to the products of medium and high potential risk makes it possible to identify in a more economic way the most harmful work situations that require technical adjustments.

Table 8. Solvents present in the paints (maintenance company)

Solvent	TWA8[a]	No. of days[b]	TLV[c]	STEL[d]
2-Ethoxyethyl acetate	304	139	5	
1-Methoxy-2-propanol acetate	302	166	50	100
Xylene	302	178	100	150
1,2,4-Trimethylbenzene	302	8	25	
n-Butyl acetate	302	38	150	200
n-Butyl alcohol	302	12	50	
Methyl isobutyl ketone	302	6	50	75
Toluene	302	6	50	
Isobutanol	302	6	50	
Ethyl benzene	302	6	100	125
Stoddart solvent	302	16	100	
Ethyl acetate	302	18	400	
1-Methoxy-2-acetoxypropane	302	8		
1-Methoxy-2-propanol	302	12		

[a]Time-weighted average 8 h.
[b]Number of days when half of the value limits of each solvent has been exceeded.
[c]Threshold limit value: the ACGIH (2003) OEL for a TWA of 8 h.
[d]Short time exposure limit.

DISCUSSION

The feasibility study was only carried out on two companies of very different sizes. In addition, these companies show important differences as to the nature of the activities and the type of organization. These elements are likely to explain the differences that were shown in the results. The size and the 'company culture' of the foam-manufacturing company favour communication; the internal adviser is warned of the use of every new product and can regularly update the MSDS file. This mode of dynamic organization of relationships is not found within the maintenance company, whose company culture has not yet integrated safety aspects.

Concerning the reliability of MSDSs, the differences that were noticed between the two companies seem linked to the fact that some suppliers are clearly incapable of writing MSDSs, as the poor quality of their documents suggests. Finally, the nature of the activities developed in each company could explain the differences observed, in terms of product inventory and quantities. Indeed, the foam-manufacturing company undertakes production activities. For quality control reasons, the inventory of the products and the quantities used are immediately available and reliable. For the maintenance company, these data do not exist for the workshop studied; they were estimated from the internal order book. However, purchase orders do not reflect the reality, as some orders date back to the year before the product was actually used. It was therefore necessary to tally this information with that held by the foreman and the workers.

The feasibility study also revealed two particular elements. For instance, the study protocol was not respected by the participating members of the company, and workers expressed needs in terms of information on toxicological effects. These elements are important insofar as they may be an obstacle to the use of the strategy by companies.

To reduce the time devoted to the use of the tools, the strategy proposes to limit the semi-quantitative risk assessment to those products whose potential risk has been calculated as medium or high. In this way, some necessary corrective measures might not be identified. However, in the observations made, this aspect seems minimal, especially if the results of the potential risk are interpreted by the prevention advisers in the light of their knowledge of the working conditions.

The methods used in the strategy have advantages and intrinsic limitations. The use of R-phrases makes the identification of the danger for a large number of products possible, while OELs have been made for only ~650 substances. Nevertheless, the accuracy of the information contained in MSDSs is extremely variable (Douwen, 1996) and depends on the expertise of the supplier or the manufacturer. The methods used do not suit either gases or products that have no R-phrases (drugs, welding and rubber fumes, wood and silica dusts, reaction products, etc.) (Russel *et al.*, 1998; Vincent *et al.*, 2000). The COSHH Essentials method overestimates the danger in certain cases (Brooke, 1998); taking OELs into consideration when these are available partly makes up for this. The exposure model of the COSHH Essentials method has been validated for pure substances. As we use it for each in a given mixture, the exposure is overestimated in a certain number of cases: aqueous solutions (hydrochloric acid, hydrofluoric acid, etc.) and mixtures of solvents (Raoult's and Henry's laws) (Harris *et al.*, 1994). The strategy does not assess the risk incurred by the worker except in some particular cases. Thus, in the maintenance company the same solvents are present in many products and operations. If workers of this workshop can be considered as belonging to a similar exposure group, the risk is not assessed for each solvent used. Nevertheless, the necessary data for the use of the COSHH Essentials and EASE model can be exploited to estimate the TWA8 and the number of days when half of the OELs has been exceeded. This information allows the employer and prevention advisers to define priorities concerning atmospheric monitoring and medical supervision. Finally, the semi-quantitative evaluation of the risk by the COSHH Essentials or EASE model does not suit substances having a STEL or a ceiling value, because of the important variability of the exposure during operations.

The strategy has identified improvements to make in the workshops studied and provided information for the continuation of the risk assessment and medical supervision. It also provides workers with targeted information likely to favour their adherence to the policy of prevention (in respect of the procedures and wearing personal protective equipment). Using a structured and exhaustive approach avoids founding the risk assessment on an empirical approach and on the personal judgement of prevention advisers. It is particularly suited to levels of expertise to which companies, particularly SMEs, have access. Finally, the specificity of each company is likely to influence the feasibility of the strategy and the quality of the results. The strategy comprises the collection of data. Their processing by both methods is only possible with the help of software accessible to company partners via the Internet. It also makes possible the publication of a report that is required by law.

CONCLUSION

The Chemical Agents Directive (EU, 1998) compels companies to assess chemical risks in the workplace and to implement a specific prevention policy. Nevertheless, companies do not seem prepared to meet this new obligation. Indeed, the chemical risk assessment most often rests on the experience and the professional judgement of the prevention adviser. This study proposes a structured strategy for chemical risk assessment, adapted to the needs and difficulties of companies, particularly SMEs. It identifies mainly collective measures of prevention to implement and also supplies information necessary for the continuation of the evaluation and the medical supervision.

Tested in two companies, which are very different in size, in the nature of their activities, in their culture and modes of organization, the strategy has shown that its feasibility strongly depends on the above-mentioned parameters. Similarly, the lack of the prevention advisers' adherence to the feasibility study suggests that these elements have to be taken into consideration to allow companies to apply the proposed strategy. Studies are still necessary to assess these needs.

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