Improved Use of Workplace Exposure Data in the Regulatory Risk Assessment of Chemicals within Europe

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The process of risk assessment for human health demands the availability of soundly based effects and exposure information. However, many of the available data, particularly those which seek to describe human exposures to chemicals, are of varying quality and scope. Changing public and regulatory expectations increasingly demand that the outcomes of risk assessments are seen to have duly accounted for these data, in order that their conclusions can be viewed as valid. The challenge for risk assessors, therefore, is how the different grades of data should be integrated within the overall process. A series of core values are identified that govern the relationships and the influence that different types of exposure data have within European Union (EU) regulatory risk assessment for chemicals. Building on these values, an approach is presented for evaluating workplace exposure information in the context of how such data might be used within the EU process for assessing the risks to human health of new and existing substances. The implications of adopting the approach for regulatory risk assessment within the EU and its consequent impact on current occupational hygiene practice are discussed.

Keywords: exposure data; data quality; data evaluation; risk assessment

BACKGROUND

Within the European Union (EU) the regulation of new and existing substances includes a process of risk assessment (EEC, 1967, 1993a). The process addresses the risks to both human health and the environment presented by the production and use of chemicals. In order that there is a consistent approach to the risk assessment of different chemicals, the basis for the overall process is laid down in regulations (EEC, 1993b; EC, 1994). A detailed description of the considerations that need to be included is contained within the Technical Guidance Documents (European Commission, 1996).

The availability of exposure information is fundamental if soundly based risk assessments are to be developed and progressed. Such information helps determine where risks might be considered to reside, their relative importance and what political priorities they should subsequently receive if they are considered to be unacceptable. Indeed, because of the importance that exposure data have in both the assessment and management of risk, some commentators have suggested that it may be even more important for the risk assessment process than comprehensive hazard information.

However, whilst recent initiatives have focused on ensuring the availability of comprehensive, high quality information on a substance’s hazardous properties (ICCA, 1998; EPA, 2000), an equivalent emphasis has not formally been placed on the need for exposure information to achieve similar data standards. Although attempts have been made to try to ensure that the information placed in workplace exposure databases is in a form suitable for subsequent retrospective exposure assessment (ACGIH, 1995; Rajan et al., 1996), these initiatives have not addressed the utility to which that information is applicable in the wider chemicals regulation setting. The consequence of this overall lack of historical focus and imperative is twofold. First, the information that is available and which seeks to describe and/or quantify workplace exposures is of hugely
varying quality (Northage and Marquat, 2001). Moreover, the quality of the information does not appear to be necessarily related to either the size or complexity of the organization in which the information originates. Secondly, little continues to be known about exposures within many small and medium sized companies (SMEs). And this picture is generally accepted as worsening the further a chemical progresses down the supply chain (Money, 2001).

The challenge that industry and regulators therefore face is how can suitably reliable and robust exposure assessments be developed, recognizing the potential shortcomings presented by the current situation? As the industry representatives on the EU Working Group which reviews the human exposure portion of the Technical Guidance Document (European Commission, 1996), the authors developed this approach with the aim of stimulating discussion on the extent to which such a scheme can be justified at both the scientific and regulatory levels. Government representatives from the UK, the Netherlands, Germany and Spain comprised the other members of the EU group.

CORE PRINCIPLES FOR A SUGGESTED APPROACH

Despite the fact that the quality and quantity of available exposure information varies immensely and that relatively little is available for some downstream uses of chemicals, exposure information does exist. Exposure assessors must therefore assimilate and synthesize what is available in a manner that enables it to be appropriately evaluated and utilized in the exposure assessment process. Furthermore, in order that any method used to develop exposure assessments remains credible for stakeholders, it needs to be transparent and scientifically robust, as well as ensuring consistency between different substances. Thus, in order to begin to develop a basis for a structure capable of accommodating the current differences in exposure information, a series of core assumptions needs to be developed which should be applicable to all such information:

All exposure information is relevant for exposure assessment

A starting point in any scientific process is to decide upon the criteria against which information is accepted or rejected. In the context of regulatory risk assessments, all available exposure information should be considered as being potentially admissible and useful. This is because risk assessment is not an entirely scientific process. The basis of the conclusion of a risk assessment is influenced by the confidence that can be invested in the exposure estimates, both in relation to how representative these are likely to be of the exposures experienced by the target population and how they, in turn, determine the choice of any safety factors which may need to be applied within the risk assessment. Risk assessments are used to identify whether risks are considered acceptable or not. In the regulatory context, this demands societal, as well as scientific considerations. Therefore, in order that a risk assessor is able to arrive at robust conclusions, it should be a prerequisite that all forms of exposure information should be capable of being evaluated within the process. However, how the different types and qualities of exposure information may be used is a different question altogether.

Exposure information of different quality has a different weight in the exposure assessment process

Dependent upon the confidence that can be invested in the ability of the available information to reliably describe or predict exposure, then differing weights can be placed on that information concerning its relative roles in estimating and characterizing exposure. The more information that is available, the higher will be the confidence that the ultimate exposure assessment is fully representative of the scenario it is intended to describe. A similar analysis is applicable when information of better quality becomes available.

There is a preferred hierarchy of exposure information

Information that is available and which describes the nature of an individual’s exposure to the substance (for example that obtained via personal exposure or biological monitoring) should play a more significant role in exposure assessment than data that may be available from similar substances or activities (often described as surrogate or analogous information). In turn, surrogate or analogous sources are likely to be more representative of personal exposures to a substance than those which have been estimated empirically or derived from models. Such an approach to the segregation of information, in a manner which reflects the ability of the data to more accurately describe the exposure experiences of an individual or group, is frequently encountered within occupational hygiene practice. A similar exposure data hierarchy also exists within the EU (European Commission, 1996).

The greater the confidence in the exposure estimate, the greater the confidence generated in the resultant risk assessment outcomes

The exposure assessment process is not undertaken in isolation. It is undertaken to support risk assessments that, in turn, result in appropriate risk management outcomes and actions. The more that is known about exposure, the greater will be the confidence
that the exposure assessment will be fully representative. And the more representative the exposure assessment, the greater the likelihood that subsequent risk management choices will be both correct and cost effective (Jantunen, 1998). Such an approach is again consistent with aspects of occupational hygiene practice typically used to evaluate workplace health risks. It also reflects the role that scientific knowledge has in determining the extent to which cautionary approaches to the assessment and management of health risks need to be recognized (European Commission, 2001).

DESCRIPTION OF APPROACH

Table 1 describes an approach for handling the different types of workplace exposure information that are generally available and the subsequent role that this information should play within the context of the current EU risk assessment process for new and existing substances. Put simply, the EU process utilizes exposure information for the following.

1. To provide a quantitative estimate of the exposure experienced by key groups within a population. In the context of workplace exposures, the estimate is chosen to reflect those experienced by some upper boundary of that group (and is generally referred to as the ‘reasonable worst case’).

2. To help interpret the relevance of available health effects information, for example by providing information on the relevance that any effect elicited within animal studies has in the context of actual exposure levels within industry.

3. To better inform the basis on which margins of safety (MOS) are chosen and applied within the overall risk assessment process. Based upon whether the chosen MOS is considered acceptable, when compared with the estimated exposure of different groups, then conclusions can be drawn concerning whether the risks to health are regarded as acceptable (Conclusion 2), unacceptable (Conclusion 3) or requiring further information before any conclusion can be reliably reached (Conclusion 1).

4. When it is concluded that risks are unacceptable and need to be reduced (Conclusion 3), then the estimated exposure will affect the severity and urgency of any consequent risk reduction measures. Moreover, in the specific case where exposure to substances with no threshold of effect occurs, e.g. genotoxic carcinogens, then exposure information will help inform the basis by which existing exposures are deemed acceptable when seen in the context of the related risks.

Table 1 contains the following key elements:

1. Available information is categorized according to the reliability that can be placed on the information to adequately describe the exposures to a chemical substance by an individual or group of workers. If the confidence that can be invested is high, then the caution which might need to be exercised in the interpretation of health effects data at the risk characterization stage will consequently be less. For example, when data have been obtained using recognized protocols and are supported by core information describing key exposure determinants (Rajan et al., 1996), then this will provide a high level of confidence.

In such cases, the MOS chosen for a particular health effect should be lower than one allocated when data confidence is poor. In this latter respect, the acceptable MOS cannot be quantified as such. It will change under different combinations of effect, target population and data confidence. For example, a MOS considered appropriate for an irritant effect is likely to be different to that for a more serious health endpoint such as carcinogenicity or reprotoxicity.

2. Similarly, where the confidence in the exposure estimate is high, a lower MOS may still be applicable if exposures are low, even though there may not be a correspondingly high level of confidence in the available hazard information.

3. The quality of exposure information will also influence the nature of the resultant conclusions in the EU risk assessment process. Where exposure data quality is high, then it is unlikely that further information on workplace exposures will be sought in order to refine the basis for any risk management decisions. This situation may not, however, apply in cases where data confidence is low.

4. Provided similar standards of data quality prevail, information on exposure obtained from valid biological monitoring is treated as an equivalent to that available from airborne sampling in terms of its ability to characterize likely risks.

5. The quality and reliability of the available exposure estimates should positively influence the nature of the final conclusions of the risk assessment process. Where data confidence is low, then more circumspection will need to be exercised in interpretation of the data. This is likely to be reflected in conclusions that either further information should be sought, in order to better characterize the true nature of the risk (Conclusion 1), or that a risk is likely to exist irrespective of the shortcomings in the data (Conclusion 3). However, when data confidence is high, then it will be possible to readily arrive
Table 1. Categorization of exposure data quality and relevance

<table>
<thead>
<tr>
<th>Category</th>
<th>Data characteristics</th>
<th>Comments regarding role in the EU risk assessment process</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>Actual data</strong> of high quality, e.g. personal exposure data (including that obtained by biological monitoring) that are representative of the scenario being described; which have been collected and analysed according to recognized (e.g. CEN or equivalent) protocols; and that are available as sets of raw data supported by information of key exposure determinants.</td>
<td>This form of data is likely to enable either Conclusion 2 or 3 dependent on the MOS. Unless key activities are not covered by data of this type, then Conclusion 1 is unlikely to be necessary. Data confidence is high and this should impact the interpretation of the MOS at the RC stage of the RA. For example, a low MOS may be acceptable when exposures are low even though extensive hazard data may not be available.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Analogous (or surrogate) data</strong> of a similar quality to the above and which describes exposures that derive either from: other substances having similar exposure characteristics (e.g. volatility, dustiness); and/or other comparable activities considered likely to provide a reliable estimate of exposure for the scenario in question. <strong>Actual data</strong> of intermediate quality, e.g. data that have been consolidated and where only basic statistics are available to support them; where data have been obtained using non-standard protocols; where data cannot be described as being fully representative of the scenario; obtained from static sampling which can be shown to reasonably represent personal exposures, etc.</td>
<td>This form of data is likely to enable either a Conclusion 2 or 3 dependent on the MOS. However Conclusion 1 may be more appropriate when the MOS is low. Data confidence is good and this should positively affect the interpretation of the MOS at the RC stage. Because of the nature of these data, a reduced MOS may be acceptable when exposures are low, even when extensive hazard data are unavailable or thresholds for significant health endpoints are uncertain.</td>
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<tr>
<td>3</td>
<td><strong>Predicted exposures</strong> derived from suitably validated models and using input criteria/values that are relevant for the scenario and are derived from accepted EU sources. <strong>Actual data</strong> of intermediate quality, e.g. where data are only available from compliance monitoring or static sampling; where limited information on key exposure determinants are available. <strong>Analogous/surrogate data</strong> of intermediate quality, e.g. conforming to the definition for actual data contained in above, but where only basic statistics are available to support them or where data points may be insufficient to suggest representativeness.</td>
<td>To reflect the increased uncertainty of data, should yield Conclusion 2 if associated MOS are correspondingly higher. Conclusion 3 may be appropriate when the MOS is low. Where moderate MOS are present, then Conclusion 1 is likely to be more appropriate. Data confidence remains acceptable, particularly when the exposure assessment is derived from an extensive range of sources. The certainty of the data should still enable low MOS to be considered particularly when health endpoints are of a low significance. Exposure data derived from compliance monitoring are often biased towards reflecting high end exposures. This in-built MOS should be accounted for at the RC stage.</td>
</tr>
<tr>
<td>4</td>
<td>Exposure data arising from sources not addressed in any of the above classes. For example, this may include data obtained from static sampling; circumstances when input data for models are inadequately defined; or where exposure models have not been adequately validated.</td>
<td>Cannot be used to reach Conclusion 2. Conclusion 1 is the preferred default. Conclusion 3 may be indicated only in exceptional circumstances. Data confidence is questionable and these data alone cannot usefully be used to describe risk. However, such data can be useful in helping to interpret those scenarios where some exposure data may be deficient and in guiding decisions on the nature of gap filling.</td>
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</table>

Conclusion 1, need for further (workplace exposure) information (or testing); Conclusion 2, no need for further (workplace exposure) information, testing or risk reduction measures; Conclusion 3, risk reduction measures required; MOS, margin of safety; RA, risk assessment; RC, risk characterization, the stage of the RA process when a conclusion is drawn. This is achieved by comparing the estimated exposures with the effect levels for critical health end-points and evaluating whether the resultant MOS is considered acceptable for the effect and target population in question.

at categorical conclusions that risks either do or do not exist (Conclusion 3 or 2, respectively).

**DISCUSSION**
The regulatory risk assessment of chemicals products and substances within the EU is likely to increase over the coming years and is likely to have a more direct impact on the nature of workplace health risks than has been the case in the past. In part, this is because regulatory authorities are likely to play a more proactive role in determining which chemicals or chemical products can reliably be used within SMEs, because these companies seem unable to effectively understand and manage workplace health...
risks (Topping et al., 1998). Risk assessments will continue to be undertaken in the workplace, for example those required under EU health and safety legislation (EC, 1998). However, a parallel activity that aims to ensure the management of workplace health risks at the market level will increasingly be used to support the existing workplace obligations.

In order that regulatory risk assessments for different chemicals can be undertaken in a consistent manner, there is a need to standardize the way in which available exposure information is assimilated within the process as a whole. Because regulatory risk assessments have real impacts on the ability of industry to manufacture and market chemical substances, the basis for any approach needs to be both soundly based and pragmatic. The approach described in Table 1 represents one solution. It applies to exposure information that is intended to describe exposure by inhalation. It should be stated that because of the inherent difficulties at the present time of collecting and interpreting data on dermal exposures to chemicals, this type of exposure information is not currently considered suitable for use in the risk assessment process.

The central thesis to the proposed approach is that it acknowledges that the quality and quantity of currently available exposure information varies immensely. However, rather than responding to this fact by discounting the information as having little relevance for the risk assessment process, the approach develops a framework that allows, in a manner that is workable, transparent and scientifically driven, all available information to be incorporated into the process. In part, this is a reflection of the quality of exposure information that should be obtained in order to meet the expectations established by external bodies and other key stakeholders within the regulatory process extends beyond that traditionally considered necessary to demonstrate compliance with occupational exposure limits, for example. The environment in which chemical policy is being developed and promulgated within Europe (European Commission, 2001) is establishing expectations on data transparency, quality and currentness that transcend those which have historically been considered acceptable within the framework of much European health and safety legislation. Occupational hygienists and other health professionals should be aware of these changing expectations that, in turn, will undoubtedly have a bearing on accepted practices in the workplace. Not only must exposure information be available that is sufficient to demonstrate that risks to health are satisfactorily managed within the framework of relevant health and safety legislation (EEC, 1989), but it ought also to reflect the expectations that are now associated with the ability to sell chemical products that are being produced within a workplace. These sets of expectations are complementary, but not identical.

The approach outlined in Table 1 provides a structure against which occupational hygienists can assess the adequacy of exposure information that is intended to support the regulatory risk assessment of chemicals. It is also of relevance in helping to define how exposure information might need to be collected in order to support the wider responsibilities related to the manufacture and supply of chemicals. For the chemical industry these aspirations are consistent with those outlined within the Responsible Care initiative.

Exposures derived from the use of models which are either inadequately validated or which rely upon inputs which cannot readily be ascribed as representative of the chosen scenario are often of little practical relevance. Inappropriate models (or input data) will not provide sufficient confidence to conclude, in the context of regulatory risk assessments, that risks are either actually present or, conversely, adequately managed. More likely, they will help identify where further exposure information is required in order to arrive at conclusions similar to those obtained using Category 2 information alone.

A further advantage of the scheme presented in Table 1 is that the categorization of exposure information in the manner outlined provides the basis for developing data collection strategies within industry. Occupational hygienists should be aware that the processes of workplace risk assessment under European legislation for health and safety and product regulation are different, yet complementary. For
those workplaces which produce chemical substances and products, this demands an evaluation of how workplace exposure data is collected and evaluated, so that the site’s licence to operate also provides a sound foundation for the continued ‘licence to sell’ its products.

Based upon the above and the analysis in Table 1, it is suggested that successful exposure assessments would result from adoption of the following approach:

- collect all available exposure data for the substance, including those for suitable surrogate substances and/or activities;
- assess the data quality according to the criteria identified in Table 1;
- grade the data into the categories listed in Table 1;
- accounting for the relative relevance and weight of the available data, develop estimates of exposure for the different workplace scenarios of interest.

Whilst the concepts contained in Table 1 represent the basis for a workable and pragmatic approach, the choice of what constitutes an acceptable regulatory approach is determined by both scientific and political considerations. In some instances these may dictate that any approach is further simplified in order that it is accessible and understandable by all parts of industry. In other instances, a desire to demonstrate caution may indicate the need for less flexibility in the analysis and interpretation of available knowledge. Within the process for the revision of the Technical Guidance Documents within the EU, the final choice will be a synthesis of these considerations and represent a working consensus across government, industry and other stakeholders.

CONCLUSIONS

At least over the short and medium term, it is not realistic to expect that the nature of human exposures will be thoroughly understood and described in all workplaces. However, the need to deliver improved mechanisms for transparently and consistently evaluating the risks presented from the production, use and disposal of chemicals will remain and perhaps even grow further. Robust and pragmatic approaches to exposure assessment within the context of regulatory risk assessment therefore need to be developed in the interim. These will need to utilize an understanding of the theoretical basis by which exposure arises, as well as other information on exposure that may be available, in order that the final outcomes of the risk assessment process remain both scientifically valid and practically relevant.

An approach is presented that categorizes available exposure information according to the confidence that can be invested in it for regulatory risk assessment purposes. The approach enables assessments of exposure to be consistently carried out between chemical substances. It gives preference to information of greater reliability, whilst accounting for the existence of other qualities of data. In the context of the scientific and political demands of regulatory risk assessments, such a broad-based approach maximizes the likelihood that the resulting conclusions will be scientifically valid and capable of being implemented.

REFERENCES


