Risk assessment method for the implementation of materials divided up to the nanometric scale

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Abstract. A new approach of assessing the risks inherent in the implementation of powders, including nanomaterials has been developed. This tool is based on the method of the OHB (Occupational Hazard Band) widely spread in the chemical industry. The European classification and CLP scales of toxicity have not been modified; only the control of exposure has been worked at. The method applies essentially to the prevention of the exposures by airborne materials, whatever their particle size. The skin exposure is not treated there specifically for the time being. The method considers exposure based on seven parameters to take into account the characteristics of the materials used, their emission potential, the conditions of use, as well as classic parameters of the characterization of the exposure as the duration and the frequency. The method stresses on a pragmatic exploitation of the current knowledge and of the available data, bearing in mind that a lot of them are not easily accessible to plant operators. The product of the reflection is then positioned on a hazard x exposure matrix from which 3 levels of priority of action are defined, as in the classical OHB method applied to pure chemical risk. This approach fills in a gap in term of risk assessment and avoids jeopardizing all that had been set up for years, while introducing new elements of reflection accessible to all operators.

1. Introduction
The evaluation of risks at the workplace is a must in the process of occupational risk control. It must be conducted under the responsibility of the employer. The fact that nanomaterials show more unknowns than givens enhances the importance of assessing the risks in order to better prevent their occurrence. There are many risk assessment methods, mainly associated to the chemical risk. Given their reactivity and their physical characters, the nanomaterials make necessary the adaption of
existing tools to the new context in term of health and industrial hygiene. The main challenge is to provide professionals with appropriate information and tools so that they can better exchange with their partners when building an exposure case, and better prioritize the preventive actions to be taken. It is important that the method is dedicated to operational workers so that they can take active part to their own safety rather than being spectator. The safety and hygiene staff provides support and guidance, and insures the quality of the process of risk assessment in a continuous improvement approach. The following risk assessment method leans upon « control banding » in use in the industry for long, and easily accessible to operators. It combines toxicology data with the conclusions of exposure scenarios. However, given the current level of uncertainty of toxicological data of nanomaterials, the toxicity scale was deliberately kept unchanged.

2. Risk assessment method

2.1. Objectives and scope of the method
The present risk assessment method tackles the handling of solid materials, of powders, of solid aerosols, and beyond of solids divided up to the nanometric scale. This method is based on « control banding » which consists in distributing on several levels the toxicological hazard of materials on one side, and the potential exposure to these materials on the other side. With respect to hazard, this method leans upon the OHB (Occupational Hazard Band) toxicology scale commonly used in chemical risk management (1, 2). The assessment of exposure takes into account the conditions of use of materials, their characters, the quantities used, as well as their frequency and duration of use.

The risk assessment process can be summarized as follows:

![Figure 1: Risk assessment process scheme.](image-url)
The application of this method results in a semi quantitative quotation of risks which must have its follow-up in the appropriate sizing of risk control measures. This risk assessment process has to be usefully supplemented with specific measurements of exposure at the workplace using appropriate techniques which will enable to check the adequacy of risk control means recommended with actual working situations.

This risk assessment tool can also be used to provide information in the risk assessment studies preliminary to operations like maintenance and cleaning, or even in the preparation of specific procedures intended to manage accidents. The PPE’s (Personal Protective Equipment) are not considered in this risk assessment method. As a matter of fact, the risk has to be assessed in the absence of the PPE’s that must be used as the last protection means, only once the collective preventive actions and the collective corrective actions have been taken to reduce the initial risk.

2.2. **Control banding**

The toxicology scale used in the present risk assessment method is the OHB scale, very commonly used in the industry, which encompasses 5 levels. This classification scale has been recently revised in 2010, in order to match the requirements of CLP. This toxicology scale is slightly different from most scales commonly used at this moment that tend to consider the CMR 1A & 1B materials in the higher toxicity band, but that are leaving at the same time the acute toxic 1 and 2 at a lower concern.

The CLP toxicology scale has not been adjusted for the specific risks inherent to nanomaterials for the following reasons. The transition period between the old labeling and the new one is not yet finished and it is preferable to let the industry finalize the implementation of CLP before moving to a new classification, even though a slight adjustment. Another reason is that the toxicological data related to nanomaterials are not yet finalized for most of them. Since the occupational exposure limits are currently missing, it is recommended to lean upon the data issued by the suppliers and to get as much information as possible before implementing any process, or before using any new material.

In the total absence of toxicological properties, nanomaterials shall be rated at OHB 4, which is a rule that applies for any unknown chemical. It is recommended that the materials that show most concerns like the bio persistent fibbers are rated at OHB 5 by application of the principle of precaution. However, from a practical stand point, rating at OHB 4 or 5 does not make a lot of difference to the extent that both OHB categories can result in similar recommendations of safety at the workplace.

2.3. **Exposure levels**

The exposure levels are calculated as follows:

\[ I_e = H \times S \times E \times C \times Q \times F \times D \]

The parameters H, S, E, C, Q, F, D are based on a pragmatic approach of assessing risks in labs and plants. The hermetism parameter H takes into account that a lot of implementations are performed with a physical barrier between the material and the operator, hence with no contact at all during the whole task being analyzed which enables to put into practice the principle that no exposure means no risk in normal operating conditions.

The properties of the powders implemented and their behavior within the process applied are integrated in the characters of the solid S and the emission potential E. The expression of these parameters is very much impregnated with the observation of industrial processes within the cosmetics.

A novelty compared to the other risk assessment methods is the air containment C that is taken into account as an essential parameter that drives or prevents the exposure to airborne materials. Based on the current state of the art, a dynamic barrier like a top-down air flow generated at the ceiling combined with a specific extraction that enables a slight depression at the workplace is amongst the best ways to protect operators from the exposure by inhalation to materials. Given all the different
configurations that may be encountered in an occupational environment, it is reasonable to let operators to assess the risks associated to their tasks while taking into account the characters of their collective protection equipment.

As with other control banding methods, quantity Q, frequency F and duration D are used to qualify the exposure to materials during the task being observed. The quantity Q covers all scales from research up to manufacturing, while frequency F and duration D take into consideration classical job description parameters.

**Evaluation of risk**
The calculation of the exposure level Ie of a given task is next reported in a OHB vs exposure matrix that allows highlighting the levels of risk on 3 levels (high, medium and low) and their corresponding priorities of action.

2.4. **Residual risk**
For every task identified in the examined process, a level of priority of action must be concluded. All the tasks result in an action plan that must be taken and finalized before the process is started.

The risk assessment has to cover all the phases of implementation, in particular the reception, the weighing, the handling, the quality controls, the elimination of waste and of the effluents, the maintenance of equipments including the equipments of collective protection, as well as the cleaning of the workplace.

The actions of protection and/or prevention which ensue from evaluations of risks are decided by the employer and confirmed by operational staff in charge of applying them in logic of continuous improvement. These actions cover ideally:

- Keeping the operators away of the danger zones where they have nothing to do, or even the replacement of certain materials when it is possible
- The collective protection equipments
- The personal protection equipments (PPE) which must be taken as the last solution to be implemented only after having finalized all the possible actions of collective protection
- Detailed procedures, drafted in a practical and practicable language so that they are easily practiced
- Training, information and authorization of the staff, as specific and preliminary requisites in the process to be operated
- A possible medical follow-up in the situations requiring it

The EHS staff, as an expert of the risk assessment method and as the support of the operational staff realizing their evaluation of risks, has to validate the actions decided before their implementation in logic of continuous improvement.

Once the evaluation has been finalized, the EHS staff has to assist the operational staff in the quotation of the residual risk, resulting from the application of protective and/or preventive measures decided, so that no unwanted situation continue during the implementation of the processes that have been examined.

2.5. **Documenting**
The documentation of all the reflections of evaluation of the risks and the actions which ensued from it for all the examined processes is ideally managed by the site Management in due time by the regulations, or in defect during at least all the duration of implementation of the above mentioned processes.

Also, the traceability of the implementation of materials and of their maintenance as well as of processes must be kept by the site Management in the conditions and deadlines determined by the local regulations.
References
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