Safety Science 88 (2016) 1–15

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Using very toxic or especially hazardous chemical substances in a research and teaching institution

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ARTICLE INFO

Article history:
Received 27 November 2015
Received in revised form 24 March 2016
Accepted 20 April 2016

Keywords:
Authorization
Chemicals
Safety
Handling
Storage
Disposal

ABSTRACT

Wrong manipulation, storage or disposal of chemicals can cause great damage whether it occurs on industrial plants, in academia or at home. Amongst the numerous reasons, lack of knowledge and haste are the most common ones. Except for a few substances subject to international agreements, the academic world benefits from a great latitude in the use of chemicals. To make colleagues aware of the hazards and risks associated to chemicals, and protect them accordingly, the Occupational Safety and Health service of the School of Basic Sciences (SB-SST) has decided to submit to authorization the purchase and manipulation of very hazardous chemicals. The process starts by a thoughtful discussion with the requester about the substance and whether a less hazardous alternative could be used instead. If the request is validated, the work procedure is analyzed and the protective measures for safe manipulation of the chemical checked. Consequently the SB-SST authorizes or not the personnel to order the compound. This innovative participative risk-management concept is illustrated herein with osmium tetroxide, as an example of a lethal compound used in chemistry, biology and electronic microscopy. The data resulting from the authorization process is recorded in a database and the need to review the associated procedure and/or the authorization itself is performed twice a year during safety audits of the workplaces.

1. Introduction

Chemicals are wonderful tools which can improve people's life by, for example, generating better tyres, more efficient dye-sensitised solar cells and healing people. However chemicals are often considered as been too risky because they are believed to be reactive, very reactive. Actually this is true if they are not used in a controlled manner; intrinsically chemicals can be hazardous *per se* and, to lower the risk, operating conditions must be set up accordingly. Thus, because of some mistrust, fear, lack of knowledge, people might feel uncomfortable when confronted to a chemical. On the other hand, chemicals might be used unconsciously to impress pupils. Some might also believe adding several chemicals will benefit from a sort of *add-on effect* and get rid of some resistant dirt and/or disinfect more efficiently. Thus it is crucial that people required to use chemicals are informed thoroughly about the hazards and the way the substances must be used to keep the risk as low as possible.

Thanks to Sax (Lewis, 2012) and Bretherick's (Urben and Bretherick, 2006) investigations, compilations of precious information about how hazardous substances should be handled exist since the 1950s. Many other sources provide additional advises (Picot and Grenouillet, 1994; Lunn and Sansone, 2012). All of them constitute essential readings in this manner. Whatever the level of education and the work environment, safety should be taught and reconsidered on a continuous basis as it evolves, but also because crucial behaviors to adopt in case of emergency might have been forgotten.

To make people aware of hazards and risks associated to chemicals an approach has been set up by the Dangerous Substances Directive (EC, 1967), one of the main European Union laws concerning chemical safety. It regulates the classification and labelling of chemicals in Europe. However as a compound may have been classified differently from one country to another, this directive had to be reinforced. This is the purpose of the implementation of the Globally Harmonized System of classification and labelling of chemicals (GHS, 2003). With the GHS, all countries worldwide have to classify their chemical substances according to the same regulation. This homogeneous classification will also facilitate international import and export of chemicals. With the GHS, new thresholds for classifying and labelling chemicals have been set.

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http://dx.doi.org/10.1016/j.ssci.2016.04.019
0925-7535/

As a result more pictograms, signal words and fully written hazard and precautionary statements can be read on the label. Moreover the European Community Regulation on chemicals and their safe use (REACH, 2006) established complementary obligations. For example, it specifies the availability and set-up of the Safety Data Sheet (SDS). Thus these regulations classify chemicals according to their hazards, define their labelling, packaging and the safety information made available to the customer *via* the SDS. Reading the latter document is essential as it contains precious information about how the substance shall be handled from its storage, to its use and disposal. Precious intervention measures for first aid, fire-fighting and accidental release are also listed in chapters 4, 5 and 6, respectively.

This available information, as well as corrective actions following accidents or near misses, helps developing preventive and protective technologies to avoid chemical exposure risk. After analyzing injuries occurring in the industry over a 15-year period (1992–2006), Mannan et al. (2009) report injuries due to chemicals are decreasing more rapidly than injuries in general. However the number of illnesses and casualties related to chemical exposure is still too high. For example, Leigh et al. (1997) estimate that workplace related exposures lead to several thousand of cases annually in the United States of America alone. Mannan et al. (2009) worked out 94% of injuries due to chemicals are from single exposure. Whether the workplace related injuries/illnesses due to exposure to chemicals are the result of ignorance, carelessness of the employee or employer is subject to debate. This is even more difficult, there is a trend to underreport workplace injuries/illnesses (Miller, 2008). Long term (chronic) diseases may also come from lifestyle-related factors and environmental agents (Irigaray et al., 2007). Foreseeing this type of toxicities will always remain the ultimate challenge because the technology might not be that accurate yet. As a result, it might cause difficulties when trying to rank molecules of high concern and, without clear criteria, lead to serious implications for the regulations (Santillo and Johnston, 2006). Scientific studies should be encouraged in order to assess these possible undesirable health impairments, find alternatives and help authorities to continue on legislating further restrictions (Christensen et al., 2011; Hass, 2006). In this way the Organisation for Economic Co-operation and Development (OECD) has approved experimental studies proving neurotoxicity of some chemicals and, thereof, has published a guideline for the testing of chemicals (OECD, 2007). The European trade unions have also analyzed the benefits of REACH for workers' health (Pickvance et al., 2005). The study shows that the regulation could save Europe 50,000 cases of work-related respiratory diseases and 40,000 cases of work-related skin diseases each year. In other words, reforming policies has health and economic benefits. Finally, to improve and promote worldwide chemical exposure-risk assessments, the World Health Organization has recently launched a new chemical risk assessment network (WHO, 2014). Amongst others, it aims at developing scientific and technical exchange, and assist in the identification of emerging risks to human health from chemicals.

At the School of Basic Sciences (FSB), over 2000 researchers from over 100 different nationalities are working in more than 850 laboratories. Chemicals, for example, are used all over the campus as starting material to synthesise molecules, as tools to analyze, transform other chemicals, materials and objects. Hence they can be used in different activities, by persons having different qualifications, often without education in chemistry, and on various scales. Moreover, constantly new procedures, processes and techniques are created, implemented, tested and eventually developed. Projects evolve quickly and the turnover of staff is also very important (3 years on average). Together with tight deadlines, unawareness of regulations, occupational exposure limits and other constraints, these factors could contribute to underestimate hazards and risks associated to the tools (chemicals, lasers, electromagnetic fields, *etc.*) used in these laboratories. Consequently it is very likely that no risk assessment to identify appropriate measures will, or could, be done.

The mission of the FSB's Occupational Safety and Health service (SB-SST) is to implement rational solutions to preserve human's integrity by preventing health impairments. With this in mind, the SB-SST has set up required activities and organized them as a (MICE) program. The latter is composed of the following four categories: Management, Information, Control and Emergency (Marendaz et al., 2011; Meyer, 2012; SB-SST website).

To avoid learning safety by accident, an important effort is put on making collaborators aware of safety policies as soon as possible. When an employee starts in our institution she/he has to attend a mandatory introductory course on occupational safety and health instructions. If the employee will be involved in laboratory-based-activities, a complementary basic laboratory safety course is also organized (SB-SST website). At this point, the importance of risk management when handling chemicals is taught to the employee, regardless of the person's background. Taking into consideration the fast evolution of projects and the necessity to intervene correctly in case of an event, it is crucial people understand why and how to react. As previously reported by Carney (2003), "Training differs from education in that it seeks to impart a set of established facts and skills and to obtain a uniform predictable behavior from the trainees without the necessity of their understanding why they should act in the prescribed manner." This is why participative trainings and accompanying support, rather than just *telling what has to be done* courses, are organized by the SB-SST. Thus Meyer (2012) encourages every employee to follow additional courses to broaden their knowledge in chemistry, physics, biology and risk management in these fields. The purpose is making users responsible, in order to protect themselves and their colleagues whilst they manipulate chemical substances, for example. Moreover to actively help the students and the research groups to carry out their activities safely, our institution has decided to go a step further by developing a tool restricting the use of especially hazardous compounds. More than just a list of substances with very high concern, this authorization concept is intended making sure a detailed risk assessment will be performed. Indeed, because of the above mentioned *stress* factors, the work force needs to be informed and trained accordingly. This is done best by involving and accompanying them straight from the beginning. To our knowledge, this approach is innovative in terms of collaborative support and risk assessment it offers to a campus comprising teaching and research activities. The strength of this concept is also the consideration of the entire lifecycle of the substance and that the authorizations are challenged again once in use.

To sustain this management, achieve adequate training and control, it is important to implement a simple and practical system. Therefore the following quality system has been set up to keep a good track-record of chemicals at the FSB. As shown in Fig. 1, the management of chemicals at the FSB considers the chemical's whole lifetime cycle (zones A to C) and proceeds as follows:

The procedure steps shown in Fig. 1 are:

- chemical's evaluation (zone A):
  (1) Account of the chemical substance's nature ①. To make sure that colleagues are aware of the risks associated to the chemical and will follow the recommendations, especially hazardous substances cannot be ordered without an *authorization* ②. The interested person needs to obtain it from the SB-SST. This has been also established to encourage users to find less hazardous tools for their needs whenever possible. The same task can be often achieved using a less hazardous