The Many Aspects of Dermal Exposure Research

by Mark Boeniger

Editor's note: AIHce 2001 included two sessions dealing exclusively with "dermal" or skin exposure in the workplace that were sponsored by the Biological Monitoring Committee. The following is a summary of the two sessions.

Interest in assessing dermal exposure continues to increase because of growing awareness of the extent of the problem. Exposures to chemicals in the workplace continue to rank as a leading cause of illness and death in the United States, resulting in an estimated 60,000 deaths and more than 800,000 illnesses each year.[1] Since the first recommendations of Threshold Limit Values in the mid-1930s, and later with the legally enforceable Permissible Exposure Values, emphasis in occupational hygiene has been primarily on measuring and controlling airborne exposures to chemicals.

However, many chemicals in the workplace are primarily present as surface contaminants, coming in contact with the worker through transfer to the skin. As inhalation exposures come under better control in the workplace, the relative contribution from skin exposures becomes increasingly important. In addition to the potential of skin contamination and risk of systemic illness, occupational dermatitis remains the single most common illness resulting from chemical exposures. Yet there remains a relatively poor understanding of how to evaluate skin exposures, how to estimate risk and, most important, how to prevent exposures.

Fortunately, there is growing support both nationally and internationally in regard to occupational skin exposure assessment and prevention. In the United States, the National Institute for Occupational Safety and Health has recently provided multiyear funding of a Dermal Exposure Research Program, and the Occupational Safety and Health Administration has posted much skin exposure assessment guidance information on its website and has targeted inspections for determining the extent of occupational dermal exposure. In Europe, the recently formed multinational "RISKOFDERM" program has begun research in dermal exposure and much useful information should be forthcoming from each of these activities.

Joop van Hemmen, head of the Department of Chemical Exposure Assessment at TNO, The Netherlands, and head of the RISKOFDERM program, said this research program includes 15 European partners in 10 countries and comprises four interrelated parts:

- A qualitative survey to obtain an overview of relevant tasks, processes and determinants relevant for dermal exposure;
- A quantitative survey to obtain detailed data on dermal exposure and determinants;
- Exposure model building to create a predictive dermal exposure model using all relevant variables; and
- Development of a risk assessment and management toolkit based on relevant data on hazard, absorption into the body, dermal exposure potential and effectiveness of control measures. This toolkit is primarily meant to be used by small- and medium-sized establishments.

All parts of this project are scheduled for completion in 2003.

Dermal Risk Assessment

A long-standing problem has been the poor understanding of the relationship between surface concentration and transfer to skin under different conditions. This is particularly relevant to the interpretation of surface wipe sampling results. According to Martin Roff, Health and Safety Laboratory, Sheffield, United Kingdom, detailed laboratory research investigated whether transfer of contaminants from different common surfaces is task or surface dependent using a fluorescent dye (to measure contact skin surface area under UV light) and ionic strontium chloride (to measure mass transferred from surface to skin). He clearly demonstrated that the amount of mass transferred to the hands depended strongly on surface loading, hand pressure, skin moisture and contact time. Transferred mass to the skin from different surface materials was highest for hard surfaces and followed the same rank order as for transfer from surfaces by wipe sampling, but the transfer efficiency to the skin was 3- to 8-fold lower, depending on the contact surface.

Derk Brouwer, TNO Chemistry, Zeist, The Netherlands, reported that his group's laboratory experiments included repeated consecutive skin contacts (1-12) as a variable. Using a fluorescent dye as its study agent, which was dispersed into an oily skin cream matrix, it found that the area of skin surface contact more than doubled with a 2-fold increase in hand contact pressure, and it also increased slightly with an increasing number of contacts. Adherence amounts increased almost 6-fold with 12 low-pressure contacts compared to the amounts with a single contact. There was a linear increase with each consecutive contact if low pressure was applied, but with high pressure a greater adherence and probable saturation of skin loading capacity became apparent, resulting in a more log-normal pattern of increase.

A log-normal increase had also been reported in an earlier study using a dry, powdery contaminant. The stickier form of the contaminant resulted in about a 9.5-fold higher transfer efficiency compared to the powder form of the contaminant. These two studies provide needed information to better understand surface-to-skin transfer behavior that could potentially be used to model skin exposure.

Rob Aitken, director of research development, Institute of Occupational Medicine, Edinburgh, United Kingdom, compared actual exposure sampling data to the Health and Safety Executive's predictive model for Estimation and Assessment of Substance Exposure. The sampling data collected was for zinc in several industries using wipe samples from the forehead, neck, hands and arms. The actual measured exposures were about one order of magnitude lower than that predicted by EASE, indicating that additional work is needed to refine this tool and improve its predictive accuracy. EASE is a knowledge-based expert system that can be used for inhalation and/or dermal exposure estimation. Information including contact level, pattern of use and pattern of control are needed.

In a practical approach to dermal risk assessment, several problems face the health and safety professional including lack of exposure assessment methods, inadequate toxicological data for skin

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The suggested approach requires continuous improvement of the EL process, so that the long-range goal of protecting the largest number of people can be achieved. The steps would include:

- improving the PEL process within the existing OSHA legal framework. This is best accomplished by building a collaborative process and using current rules and existing data to address hundreds of chemicals per year;
- identifying opportunities for linkages and cooperation among current programs. Task groups of interested stakeholders could be formed to research current programs and agencies to determine where resources or overlap may exist;
- developing a strategy to involve the largest scope of exposures possible. This strategy must rely on existing agencies and programs to address the broad range of agents in use today, recognizing that "out of the box" views of responsibility and stewardship may provide important contributions; and
- pursuing legislative or regulatory changes. Some new legislation or regulation would likely be required to implement the strategy. Consensus among industry, labor and government would be needed to ensure success.

U.K. Health and Safety

Paul Oldershaw, U.K. health and safety executive, added an international perspective to the discussion of OELs with a presentation of a risk-banding scheme and a step-by-step process for setting generic control limits known as the Control of Substances Hazardous to Health Essentials. While these generic control limits are not subjected to the same judicial/legal constraints as PELs in the United States, he noted, they do provide guidance to a changing industrial base in Europe by describing a generic approach for classifying chemicals and determining appropriate exposure ranges and controls. The approach involves:

- allocation of substances to hazard bands (five in all) with risk phrases based on their toxicity and known health hazards;
- evaluation of exposure potential and workplace exposure characteristics (e.g., potential to become airborne) and scale of use;
- conducting a generic risk assessment considering health hazard data and exposure potential factors; and
- determining a control approach (i.e., general ventilation, engineering changes, containment, special considerations) to ensure that acceptable levels of exposure are achieved.

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Ultimately, the approach provides a set of criteria especially useful to small- and medium-sized businesses for classifying chemicals into discrete categories for which detailed information is provided regarding exposure control methods and risk management strategies.

The program has been widely accepted by affected businesses, suppliers and OS&H professionals, according to Oldershaw. "It is not a guarantee of safety," he said, "but a way to keep a simple approach for determining risk and controlling hazards for many other substances that do not have documented OELs."

NIOSH RELs

Marie Haring Sweeney, NIOSH, described the mission of NIOSH to develop and establish recommended exposure limits, many of which provide the basis for PELs promulgated by OSHA and the Mine Safety and Health Administation. Since its establishment under the Occupational Safety and Health Act of 1970, NIOSH has developed 695 RELs. The bases for the NIOSH RELs are found in criteria documents, current intelligence bulletins, alerts, hazard reviews and legal testimony. Each REL contained in a criteria document is accompanied by comprehensive guidance for addressing worker training and hazard communication, exposure monitoring strategies, sampling and analytical methods, engineering controls, personal protective equipment, medical screening and surveillance and recordkeeping.

Sweeney described the process of developing RELs, which includes prioritization and selection of topics, extensive review and documentation of scientific literature, rigorous internal and external review and discussions and dissemination through publications and the NIOSH website. Emphasizing a theme of challenges for developing NIOSH RELs in the 21st century, Sweeney noted that there are thousands of existing chemicals with no OELs and limited exposure and toxicity data, with many more new chemicals being developed yearly.

"Updating RELs as new scientific data become available, addressing mixed exposures and evaluating substituted compounds also create challenges for setting appropriate health-based exposure limits," said Sweeney. "Partnering is one promising approach to addressing these challenges—involving a shared responsibility for setting priorities and an open exchange of data and literature for review, but conducting independent analyses of data and risk either for validation or to reach possibly differing conclusions as to appropriate exposure limits."

Lentz is with NIOSH, Cincinnati, Ohio.