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Federal government regulation of occupational skin exposure in the USA

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Abstract There are at least 14 federal regulations and three agencies that are involved in the regulation of occupational skin exposures in the USA. The Environmental Protection Agency (EPA) requires the reporting of health effects information on chemicals, and such information is used to assess the risks of human and environmental exposure. The health effects information and any resulting risk assessments are generally available to the public. A fair amount of this information relates to skin irritation, sensitization, and dermal absorption. The EPA can require the submission of new data necessary for it to carry out its risk assessments, and has the authority to ban hazardous chemicals for certain uses. The Food and Drug Administration (FDA) regulates the correct labeling of cosmetics and requires safety and efficacy data on new products that are claimed to have preventive or health benefits. Commercial distribution of topical skin-care and protection products, therefore, can be potentially scrutinized by the FDA, which can control the use of hazardous chemicals in such products. The Occupational Safety and Health Administration (OSHA) has the most direct contact with workplaces through its field inspection compliance activity, which is directed at the reduction of workplace injuries and illnesses. Our analysis suggests that although considerable amounts of health effects information is generated and available, such information may not always be adequately conveyed to the end users of chemical products. In addition, the most effective and practical means of preventing exposure is often not apparent or generally known. Current regulations may have created a reliance on use of chemical protective equipment that may not always be the best approach to protecting workers. Lack of performance criteria that are measurable has hampered industry from objectively assessing skin exposures. This lack of performance criteria or guidance has also hindered the implementation of prevention strategies and a critical assessment of their effectiveness. Better guidance from regulatory agencies directed at performance-based control of occupational skin hazards is presently needed.

Keywords Federal regulations · Occupational · Skin · Control · Exposures

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Introduction

Occupational skin exposures can lead to a wide spectrum of occupational diseases, are a significant cause of economic loss, and can adversely affect an individual's capacity to perform in a chosen vocation. Costs associated with any type of occupational illness include lost or reduced productivity, medical diagnoses and treatment, administrative costs, and, when the worker is unable to work due to the illness, worker's compensation for lost wages. The Bureau of Labor Statistics (BLS) estimates that skin disease currently accounts for 13% of all reported occupational disease (BLS 1999). According to the BLS the rate of occupational skin diseases was 81 cases per 100,000 workers in 1997. The estimated annual cost may be upward of $1 billion (Mathias 1985). According to the latest available data, dermatitis is the third most common cause of compensable temporary total and partial disability and the sixth most common cause of permanent partial disability in the USA (Leigh and Miller 1998).

Causes of occupational dermatoses include (1) mechanical, caused by friction, pressure, and mechanical

disruption; (2) chemical; (3) physical, caused by extremes in temperature and radiation (principally ultraviolet); and (4) biological, caused by microbiological and parasitic organisms (Tucker and Key 1992; Harvey and Hogan 1995). Approximately 90–95% of all work-related dermatoses, excluding those that are caused by mechanical trauma, is attributable to occupational contact dermatitis (OCD; Lushniak 1995). OCD is typically characterized by inflammation and erythema (reddening), itching, and/or scaling, as a result of contact with external substances. OCD can be further divided into two etiological classes: allergic and irritant. Although both major causes of OCD are highly preventable through avoidance of exposure, the prognosis of untreated OCD is generally poor (Hogan 1994; Birmingham, 1986).

The extent to which skin absorption contributes to other possible causes of disability such as systemic poisoning, neurotoxic effects, and ill-defined conditions, is unknown. A full understanding of the health significance of skin exposure leading to systemic toxicity is far less clear, because of the difficulty in objectively determining the role of skin absorption to an adverse outcome, especially if the illness were the result of chronic exposures. If skin absorption contributed to a fraction of the estimated total annual 60,000 deaths and 860,000 occupational illnesses attributed to workplace exposures, it would be a substantial number (Leigh et al. 1997).

Several organizations have provided skin hazard designations as guidance to warn against the potential for increased risk of systemic toxicity due to skin permeation. These designations are assigned to certain compounds for which inhalation exposure limits have been established. The American Conference of Governmental Industrial Hygienists (ACGIH) lists more than 229 chemicals with a skin hazard designation that supplements the threshold limit values (TLVs) for inhalation concentration. The US Occupational Safety and Health Administration (OSHA) listed 147 skin notations on the 1989 permissible exposure limit (PEL) tables. An estimated 13.2 million workers in the USA are potentially exposed to chemicals with the OSHA skin notation (NIOSH 1988).

In light of the potential seriousness of adverse consequences from skin exposures, one might presume that there is significant regulatory control over the factors and agents that can contribute to this problem. The following describes those regulatory statutes that have a bearing on the protection of workers from occupational skin exposures in the USA.

Regulatory standards

The primary agencies that have regulatory authority that may include work establishments and workers are OSHA, which is organizationally within the Department of Labor, the EPA, which is an independent agency, and the FDA, which is organizationally within the Department of Health and Human Services. Of the three agencies, OSHA has been given the most direct oversight of national occupational health and safety protection, while the EPA and FDA with broader mandates indirectly play important roles. The regulations that are relevant to occupational skin exposure for each of these three regulatory agencies are summarized in Table 1.

Environmental Protection Agency

The EPA is an independent agency of the federal government and is mandated to control certain occupational exposure hazards by virtue of several Acts.

The Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) became effective in 1977 and requires manufacturers and distributors to provide certain production data and toxicity data to the EPA. The EPA issues rules for complying with TSCA in 40, Code of Federal Regulations (CFR), part 721. Through TSCA, Sect. 4, the US Congress established the Interagency Testing Committee (ITC) to select chemicals to be tested. These chemicals are nominated by members that represent several governmental organizations. Since its creation the ITC has reviewed over 50,000 chemicals for toxicological testing. Relevant to skin absorption, the ITC has published a proposed test rule for in vitro dermal absorption testing of 47 high-production-volume chemicals that were of interest to OSHA because of insufficient data (64 FR, no. 110, pp 31074–31090, 1999). This information was of interest to OSHA to support OSHA's development of skin designations. The proposal described an in vitro testing protocol for the calculation of steady-state permeation coefficients as well as a short-term absorption rate for when a chemical will damage the skin with prolonged contact. Public comments on the proposal were received, and, at present, the EPA is proceeding with the finalization of this testing as an enforceable rule.

The EPA maintains a chemical substance inventory of thousands of chemicals that are employed in commerce. Using TSCA, Sect. 8(a), EPA identified chemicals in commerce as of 1 January 1977 by compiling the TSCA inventory of chemical names and chemical abstract numbers, along with production and importation volume ranges, specific sites of production or importation. Presently, the TSCA inventory contains over 70,000 chemicals. With TSCA, Sect. 4, being used, approximately 540 chemicals have been the subject of testing actions within the Office of Pollution, Prevention, and Toxics (OPPT) Existing Chemicals Testing Program since 1979. After 1977, if a company wishes to introduce a new chemical into commerce, a pre-manufacturing notification (PMN) must be filed with the EPA. TSCA, Sect. 5(e), provides EPA with the authority to regulate new substances pending development of health and

Table 1 Key regulatory statutes affecting occupational skin exposures in the USA

Regulation	Administering office	Purpose
Toxic Substances Control Act (TSCA), 40 CFR, part 721	EPA, Office of Pesticides, Pollution and Toxic Substances	Defines types of production and health effects data to be reported to EPA
Worker Protection Standard (WPS), 40 CFR Part 170	EPA, Office of Pesticide Programs	Prescribes protective measures against pesticide exposures for agricultural workers
Federal Insecticide, Fungicide and Rodenticide Act	EPA, Office of Pesticide Programs	Requires submission of toxicological and exposure information necessary for risk/benefit assessments
Food, Drug, and Cosmetic Act	FDA, Center for Drug Evaluation and Research, Office of Compliance	Defines cosmetics labeling and requires safety and efficacy testing of new drugs
General Duty Clause of the OSHA Act (Section 5(a)(1)	OSHA Directorate of Compliance Programs	Employer provides a workplace free from serious recognized hazards
29 CFR 1910.1000, Table Z-1	OSHA Directorate of Compliance Programs	Skin notations alert employer of additional hazard from skin absorption
Personal Protective Equipment Standard, 29 CFR 1910.132–138	OSHA Directorate of Compliance Programs	To provide appropriate personal protective equipment, including protection of the skin
Recording and Reporting Occupational Injuries and Illnesses, 29 CFR 1904	OSHA Directorate of Compliance Programs	Requires employers to record and report occupational injuries and illness to OSHA and its workforce.
Hazardous Waste Operations and Emergency Response Standard, 29 CFR 1910.120, Subpart H, Appendix B	OSHA Directorate of Compliance Programs	Describes general description and discussion of the levels of protection and protective gear when personnel are working to remediate hazardous waste sites
General Industry Sanitation Standard 29 CFR 1910.141	OSHA Directorate of Compliance Programs	Employer shall provide adequate washing facilities for employees in industry
Construction Industry Sanitation Standard 29 CFR 1910.1926.51(f)	OSHA Directorate of Compliance Programs	Employer shall provide adequate washing facilities for employees in construction
Field Sanitation Standard 29 CFR 1928.110	OSHA Directorate of Compliance Programs	Employer shall provide adequate washing facilities in the field for hired farm workers
Substance Specific OSHA Standards, 29 CFR 1910.1001 through 1910.1050	OSHA Directorate of Compliance Programs	Substance-specific standards include general requirements for hygiene facilities, protective clothing, and medical surveillance
Hazard Communication Standard, 29 CFR 1900.1200	OSHA Directorate of Compliance Programs	To identify and communicate hazards to employees

environmental effects data based on either the potential risk presented by the substance or the potential for substantial production ($>100{,}000$ kg per year) and substantial or significant human exposure or environmental release. Since 1979, EPA action under TSCA, Sect. 5(e), has resulted in the generation of needed health and/or environmental effects data on over 1,000 new chemicals. As described in Sect. 5, and 26(c), of TSCA, the EPA established a process for the issuing of significant new use rules (SNURs) for certain previously approved chemical substances. Chemicals that qualify either have been issued orders under Sect. 5(e), of TSCA, or the substance may present hazards to human health or the environment if exposures or releases are significantly different from those described in a premanufacturing notice.

Under the SNUR guidelines, Sect. 40, CFR 721.63, Protection in the Workplace, provides reporting requirements relevant to skin exposure. Paragraph (a)(1) states that each person who is reasonably likely to be dermally exposed in the work area to the chemical substance through direct handling of the substance, or through contact with equipment on which the substance may exist, or because the substance becomes airborne in the form listed in paragraph (a)(6) of this section, is provided with, and is required to wear, personal protective equipment that provides a barrier to prevent dermal exposure to the substance in the specific work area where it is selected for use. Each such item of personal protective equipment must be selected and used in accordance with 29 CFR 1910.132 (general requirements) and 1910.133 (eye and face protection) (authors' note: 29 CFR 1910.138 is the section in the OSHA PPE standard that deals specifically with hand protection, but was not specifically mentioned in this guideline).

The employer is able to demonstrate that each item of chemical protective clothing that is selected, including gloves, provides an impervious barrier that prevents dermal exposure during normal and expected duration and conditions of exposure within the work area by any one or a combination of the following:

1. The testing of the material that is used to make the chemical protective clothing and the construction of the clothing to establish that the protective clothing will be impervious for the expected duration and conditions of exposure. The testing must subject the chemical protective clothing to the expected conditions of exposure, including the likely combinations of chemical substances to which the clothing may be exposed in the work area.
2. The evaluation of the specifications from the manufacturer or supplier of the chemical protective clothing, or of the material used in construction of the clothing, to establish that the chemical protective clothing will be impervious to the chemical substance alone and in likely combination with other chemical substances in the work area.

Furthermore, Sect. 40, CFR 721.72, hazard communications program, item 5 requires that the employer prescribe on the label, material safety data sheets (MSDSs), or alternative form of warning, the measures that are required to control worker exposure or environmental release which the employer determines will provide the greatest degree of protection.

Health and safety-related information is submitted to EPA under three sections of TSCA: Sect. 4, chemical testing results; Sect. 8(d), health and safety studies; Sect. 8(e), substantial risk of injury to health or the environment notices. Additionally, voluntary documents are submitted to EPA. There are presently over 89,000 studies on 7,500 unique chemical substances. Many of these studies include dermal toxicity evaluations. As examples of its relevance to the skin, presently about 270 records involve dermal absorption, and 1,700 records involve dermal sensitization. This information can be retrieved by the public through a database system called "TSCATS", which is available through the National Library of Medicine (National Technical Information Service (NTIS), Gaithersburg, Md., USA) or Chemical Information Systems (CIS, Towson, Md., USA). Both NTIS and CIS provide full-text studies on microfiche.

Pesticides

The EPA has long been mandated to control the use of pesticides and has recognized the relative importance of skin exposures as a route of entry. EPA's Worker Protection Standard (WPS), 40 CFR, part 170, is a regulation that is aimed at the reduction of the risk of pesticide poisonings and injuries among agricultural workers and pesticide handlers. The WPS offers protection to over 3.5 million people who work with pesticides at over 560,000 workplaces. The WPS contains requirements for pesticide safety training, notification of pesticide applications, use of personal protective equipment, restricted entry intervals (REIs) following pesticide application, decontamination supplies, and emergency medical assistance. This standard is administered by the Office of Pesticide Programs and is often carried out through state government programs. Among the training requirements that must be provided by the employer to new employees within 5 days of their being hired is information about: the hazards of pesticides and how to avoid pesticide exposures by not entering restricted entry fields that are posted; washing before eating, drinking, smoking, or using the toilet; wearing work clothing that is protective; showering after work; washing work clothing separately from other clothing; and washing immediately if pesticides are spilled or sprayed on the body. Employers must provide decontamination supplies to pesticide handlers, field maintenance, and harvesting workers. Decontamination supplies include water, soap, and paper towels, which must be made available to agricultural employees to enable them to wash off pesticides and pesticide residues routinely and after emergency exposures. The decontamination supplies must be made available to workers that enter treated areas, for 30 days after a pesticide is applied or a REI has been in effect. Low-toxicity pesticides with an REI of 4 h require only 7-day availability of decontamination supplies.

The WPS also defines and sets minimum standards for the types of personal protective equipment that must be used when pesticides are being handled. These standards must be displayed on the pesticide labels. Gloves are required when pesticides are being mixed, loaded and applied, and when workers re-enter pesticide-treated areas during the REI. Flock-lined gloves are prohibited from being used because they may act as reservoirs of contamination and are likely to be used for long periods. However, in a change to the WPS (federal register, Vol. 62, no. 174, proposed rules: pp 47543–47550), presently, absorbent liners made from lightweight material may be worn under chemical-resistant liners for up to 8 h but then must be discarded.

In order for any pesticide to be legally sold or distributed in the USA it must first be registered with the EPA. Required information for the registration include data on toxicological and ecological effects. Statutory authority that requires registration and submission of data on a pesticide's effects on humans and the environment is derived from the Federal Insecticide, Fungicide and Rodenticide Act (title 7, USC Act of 25 June 1947, Chap. 125).

Reporting requirements for risk/benefit information are explained in 40 CFR, part 159. Part 158 describes the data requirements for toxicological and exposure assessment. Through the Office of Prevention, Pesticides, and Toxic Substances (OPPTS), "Test Methods and Guidelines" are made available through their Internet site (http://www.epa.gov/epahome/research.htm). This site provides the OPPTS harmonized test guidelines that have been developed for pesticides and toxic substances to minimize variations in testing under TSCA and FIFRA. These methods adopt features of previous methods published by the OPPT and appeared in title 40, Chap. I, Subchap. R, of the CFR, the Office of Pesticide Programs (OPP), which appeared in publica-

tions of the NTIS and the guidelines published by the Organization for Economic Cooperation and Development (OECD). Included are standard methods for the testing of acute dermal toxicity (for the determination of initial potency of dermal exposure, e.g., LD_{50}), 21 to 28-day dermal toxicity (for use in the determination of the degree of percutaneous absorption, target organs affected, the possibilities of accumulation, and which can be of use in the selection of dose levels for longer-term studies and for the establishment of safety criteria for human exposure), 90-day dermal toxicity (for no observed effect level), skin sensitization, and dermal absorption. In addition there are standard methods for occupational and residential exposure-assessment guidelines.

Food and Drug Administration

Organizationally, the FDA is part of the Department of Health and Human Services. The FDA has the authority to regulate approximately $1 trillion's worth of products each year and is charged with the protection of American consumers by the enforcement of the Federal Food, Drug, and Cosmetic (FD&C) Act and several related public health laws. The combined market for skin products such as soaps, protective lotions, and disinfectants for industry, and the healthcare and food services businesses is probably over $10 billion per year. Several types of products that are used in the workplace on workers' skin merit mention, since they could have an impact on health. The distinction between a drug and a cosmetic is established by a number of ways, which include claims stated on the product label, in advertising, on the Internet, or in other promotional material. The distinction is important, because the rules that are used to regulate each of these types of products are quite different.

Cosmetics

The FD&C Act defines cosmetics as "articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body... for cleansing, beautifying, promoting attractiveness, or altering the appearance." Included in this definition are skin moisturizers (emollients). Skin cleansers that are derived from synthetic detergents are considered to be cosmetics, but true soap products that consist primarily of an alkali salt of a fatty acid and make no label claim other than for the cleaning of the human body are not considered to be cosmetics under the law. However, few products that are used in skin cleansers presently contain true soap, but rather synthetic surfactants, i.e., detergents.

The FD&C Act does not require pre-market clearance or approval of cosmetic products or their labeling. Further, there is no requirement that manufacturers of cosmetic products register their products with the FDA or submit data to substantiate the safety or efficacy of their products. In general, with the exception of color additives and those ingredients that are prohibited or restricted by regulation from use in cosmetics, a manufacturer may essentially use any ingredient in the formulation of a cosmetic product, provided that the ingredient and the finished product are safe, the product is properly labeled and the use of the specific substance does not otherwise cause the cosmetic to be adulterated or misbranded under the FD&C Act. If the safety of a cosmetic product or one or more of its ingredients has not been substantiated, 21 CFR 740.10 requires that the product's label conspicuously bear the statement "*Warning*: The safety of this product has not been determined" to avoid the product's being misbranded under the FD&C Act.

By regulation, at present, the FDA prohibits or restricts the use of nine chemicals or chemical classes in cosmetics, of which some might have been used in skin-care products (21 CFR, parts 250.250 and 700.11 through 700.23). The Cosmetic Ingredient Review (CIR) expert panel, with its headquarters in Washington, D.C., is an independent panel of scientific experts that was established in 1976 by the Cosmetic, Toiletry, and Fragrance Association, and which regularly assesses the safety of cosmetic ingredients and publishes its findings. The toxicological literature is reviewed and a conclusion of safety is provided in a compendium of reports and in published reviews in the Journal of the American College of Toxicology or the Journal of Environmental Pathology and Toxicology.

The FDA does not have the authority to require manufacturers to register their cosmetic establishments, file data on ingredients, or report cosmetic-related injuries. FDA maintains a voluntary registration program. Cosmetic manufacturers that wish to participate in the program register their finished products and ingredients with the FDA. The Office of Cosmetics and Colors also maintains a database on the cosmetic complaints that it receives in its Cosmetic Adverse Reaction Monitoring Program.

Drugs

The FD&C Act, Sect. 201(g), defines drugs as "articles intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease... and articles (other than food) intended to affect the structure or any function of the body of man or other animals". Over-the-counter (OTC) drugs are drugs that can be purchased without a doctor's prescription.

Skin-care products that claim to treat or prevent dermatitis or absorption of chemicals due to their barrier properties would seemingly fall under the FDA's definition of a drug. As such, a product may only be legally marketed if either (1) this type of product was marketed prior to 4 December 1975, and a monograph

or rule on the safety and efficacy of such products has been completed by an FDA OTC review, or (2) the product has been submitted and reviewed by the new drug approval (NDA) process. If a product does not meet the requirements of an applicable final rule or there is no final rule, it is considered a ''new drug''. Further, since the adequacy of the labeled direction for these ''barrier'' uses may not have been determined, the product may be considered to be misbranded under Sect. 502(f)(1) of the Act.

Companies that submit an application for approval of a new drug must provide evidence of both the safety and effectiveness of the use for which it is claimed to be of benefit. The FDA does not develop and promote specific protocols for the assessment of safety and effectiveness but allows, on the part of the NDA party that is submitting, flexibility in selecting appropriate tests and presentation of the data. Obtaining NDA approval can require substantial amounts of data.

At present, the FDA is in the process of reviewing alcohol-containing anti-microbial products for skin disinfection. Since FDA is not aware of any evidence that so-called barrier products are generally recognized as safe and effective, such products are considered to be new drugs as defined under Sect. 201(p) of the FD&C Act (FDA 2000). Recently, the FDA, Center for Drug Evaluation and Research, Office of Compliance issued warning letters to several companies who were marketing products with purported protective (barrier) properties and which had not substantiated their claims through the NDA process.

Labeling

Under the Fair Packaging and Labeling Act (15 U.S.C. 1451–1460) and FD&C Act (Sect. 602) all cosmetics and OTC drugs must be accurately labeled with regard to their net quantity of contents. Cosmetic ingredients must be named in descending order of predominance (21 CFR 701.3). Fragrances do not have to be specified. For OTC drug products, active ingredients must be listed in alphabetical order, separately from the inactive ingredients. A manufacturer may petition FDA to allow the listing of an ingredient as ''and other ingredients'' if it believes that the ingredient is a trade secret. The Office of Cosmetics and Colors has granted this status in only a handful of cases.

Occupational Safety and Health Administration

OSHA is a regulatory organization that was established by the Occupational Safety and Health Act of 1970 (PL 91–596), which addresses workplace safety and health issues only. OSHA has several regulations that are relevant to workplace skin exposures. Some regulations are general in nature, some address specific hazards, some offer guidance, and some have specific criteria. The most general of the OSHA requirements comes directly from the Occupational Safety and Health Act. Sect. 5(a)(1) states, under ''Duties'', that the employer ''(1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or likely to cause death or serious physical harm to his employees, and shall comply with occupational safety and health standards promulgated under this Act''. Although potentially a very powerful requirement, which OSHA field compliance officers may use to cite, this general duty clause requires that several criteria be met that are often difficult to be established. First, a hazard is considered to have been recognized if the employer's industry has acknowledged its existence, there is evidence that the employer previously had knowledge of its existence, or it should have been common sense to recognize the hazard. Furthermore, to establish a Sect. 5(a)(1) violation the agency must identify a method that is feasible, available, and likely to correct the hazard and to indicate that the recognized hazard is preventable. Sect. 5(a)(1) may not be used if there is a more specific standard that applies to the particular hazard involved (OSHA 2000a).

As for health protection, OSHA is probably best known for the control of inhalation hazards from specific toxic chemicals, through the1974 publication of the Air Contaminants Standard, 29 CFR 1910.1000, Tables Z-1, Z-2 and Z-3, which list PELs and ''skin'' notations. These PELs provide clear criteria of acceptable inhalation exposures. These values were adopted from the Walsh–Healy Public Contracts Act, and for the most part were based on the 1968 threshold limit values (TLVs) that were developed by the ACGIH. OSHA, although it includes a ''skin'' notation in the Z-1 Table, neither defines the notation nor requires any action associated with the notation. The skin notation was originally introduced by the ACGIH in 1961. At that time, the organization stated that ''This notation is to be interpreted simply as an indicator that skin absorption may contribute to the overall intake from exposure in addition to that from inhalation. It refers mainly to absorption from liquid contamination'' (Stockinger 1962). OSHA's intentions were likely similar.

On 19 January 1989, OSHA, in a single rulemaking, attempted to amend the PEL list and skin notation designations to reflect better the more recent toxicological and human health effects information (OSHA 1989). Skin notations were associated with 147 of the 567 chemicals in this list. Both industries and labor appealed against this ''Air Contaminants Update Project'' on various procedural and substantive grounds, and these updated values were revoked by the federal court (AFL v OSHA 1992). Even though the amended standard was revoked, it may still serve as a voluntary guideline.

By 1989 the ACGIH had expanded their definition of the skin notation to explain that it is intended to call attention to the need for ''appropriate measures for the prevention of cutaneous absorption so that the threshold limit is not invalidated. Thus, a skin notation warns

that exposure via the cutaneous route, including absorption through the eyes or mucous membranes by either airborne or direct contact, may contribute substantially to an employee's overall exposure and cause systemic toxicity'' (OSHA 1989). In the 1989 preamble to the final rule, OSHA proposed that an employee's skin exposure to materials listed in Table Z-1 with a skin notation shall be prevented or reduced to the extent possible through the use of gloves, coveralls, goggles, or other appropriate personal protective equipment (PPE), engineering controls or work practices. It went on to explain that ''OSHA is not requiring that engineering controls be used preferentially to protect against skin absorption; the Agency notes that this decision is consistent with 29 CFR 1910.132 and 1910.134 (Respiratory Protection Standard) which require the use of engineering controls and work practices in preference to personal protective equipment only when inhalation is the route of entry.'' This 1989 position with regard to hand protection is consistent with the current 29 CFR 1910.138 (a) ''Hand Protection'', which states that ''employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances.'' The general Air Contaminants Standard, 29 CFR 1910.1000, also specifies a hierarchy of controls, with engineering being the preferred option but specifically only with regard to the control of inhalation hazards. No recommendation for the use of approaches other than chemical protective clothing (CPC) to control skin exposures are indicated in any of the OSHA standards.

In addition to the Z tables OSHA has substance-specific rules for 29 substances in 29 CFR 1910.1001 through 1050. These regulations often include requirements for protective clothing and washing facilities. The regulations tend to be performance oriented and not recommend specific types of protective clothing, specific decontamination regimens, or methods of monitoring for potential dermal exposures.

Medical surveillance of skin effects is mentioned in several of these chemical-specific standards. For instance, dermal effects of trivalent arsenic compounds are noted in the medical appendix to the arsenic standard, and this standard does specify some exposure controls and housekeeping standards, but CPC is not specified nor are methods of measuring potential dermal exposure hazards (29 CFR 1910.1018, Appendix C). The skin is to be examined as part of the periodic medical examination. The skin is of concern because trivalent arsenic compounds are corrosive. Although the OSHA standard is based on minimization of the risk of death by lung cancer for workers who are exposed to inorganic arsenic, it should also minimize skin cancer from such exposures. Arsenic trioxide and pentoxide are also capable of producing skin sensitization and contact dermatitis. Arsenic may produce keratoses, especially of the palms and soles. Horizontal white lines (striations) on the fingernails and toenails are commonly seen in chronic arsenical poisoning and are considered to be a diagnostic accompaniment of arsenical polyneuritis. Some additional chemical-specific standards that mention skin effects in the medical surveillance section include acrylonitrile (1910.1045), 4,4′-methylenedianiline (1910.1050), methylene chloride (1910.1045), formaldehyde (1910.1048), and benzene (1910.1028).

The performance of biological monitoring for exposure to lead and cadmium is required but this was not intended because of concerns for skin absorption. Biological monitoring of benzene exposure that may include incidents of skin contact is required only if an employee is exposed to benzene in an emergency situation. ''The employer shall have the employee provide a urine sample at the end of the employee's shift and have a urinary phenol test performed on the sample within 72 h. The urine specific gravity shall be corrected to 1.024. If the result of the urinary phenol test is below 75 mg phenol/L of urine, no further testing is required. If the result of the urinary phenol test is equal to or greater than 75 mg phenol/L of urine, the employer shall provide the employee with a complete blood count including an erythrocyte count, leukocyte count with differential and thrombocyte count at monthly intervals for a duration of three (3) months following the emergency exposure.''

The record-keeping requirements for occupational injuries and illnesses are described in a mandatory standard entitled ''Recording and Reporting Occupational Injuries and Illnesses'' (29 CFR, part 1904) and such occurrences are recorded on a standard OSHA no. 200 form. Skin-related injuries and illnesses that are required to be recorded by the company include (1) all third degree burns (and first and second degree burns that require medical treatment beyond first aid, restricted work activity, days away from work, loss of consciousness or death), (2) skin disorders (that last beyond 48 h and include, but are not limited to, allergic or irritant contact dermatitis), and (3) lacerations (that require closure that includes, but is not limited to, the use of sutures, adhesive closures and staples). Such injuries and illness must be classified as resulting in (1) a fatality, (2) lost workday(s) or restricted workday(s), or (3) no loss of workday. Approximately 80% of the occupational skin diseases that are reported do not result in lost time away from work (BLS 1999). There may be some shorter-term skin disorders that might not meet the duration criteria for being reported, such as with contact urticaria. Also, workers may take time away from work or seek private medical treatment of skin disorders unbeknown to the employer. In most states, small employers with no more than ten employees at any time during the preceding year are not required to record and report injuries and illnesses, with the exception of fatalities (29 CFR 1904.1-5).

In 1994, OSHA published its final rule for a revised personal protective equipment standard for general industry that went into effect on 5 July of that year (OSHA 1994). Two goals of the revision were to make the new standard more performance-oriented to

encourage innovation in product development, and to reflect newer information since promulgation of its earlier standard. In the preamble to the published rule it was pointed out that neither OSHA nor such organizations as the American National Standards Institute (ANSI) currently have criteria for the selection of hand protection or chemical protective clothing. Rulemaking participants suggested that OSHA provide performance criteria and test methods for gloves and provide better guidance for the selection of gloves. They stated that in many instances gloves are not being worn, and when gloves are worn, they are often the wrong type of glove for the application involved. As a result of these comments, OSHA determined that employers need more explicit guidance to determine what hand protection their employees need.

The final revised PPE standard, Subpart 1, Sect. 1910.138 regarding hand protection contains the following general requirements:

(a) Employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations, severer abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes.

Regarding selection, the revised PPE standard states:

(b) Employers shall base the selection of the appropriate hand protection on an evaluation of the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards and potential hazards identified.

Also included in the standard is a non-mandatory, informational only Appendix B, titled "Compliance guidelines for hazard assessment and personal protective equipment selection." This appendix provides compliance assistance for employers in the implementation of requirements for a hazard assessment and the selection of PPE in general. With regard to the control of hazards, it states that PPE devices alone should not be relied on to provide protection against hazards, but should be used in conjunction with guards, engineering controls, and sound manufacturing practices. With regard to the selection and assessment of appropriate PPE, it states that it should be the responsibility of the safety officer to exercise common sense and appropriate expertise to accomplish these tasks. This appendix does provide some general suggestions on what should be included in a hazard assessment, including the conducting of a survey of each operation, identification of specific potential hazards, organization of the data, and the analyzing of the information, which should include a determination of the level of risk and seriousness of the potential injury from each hazard found in the area. It does not present specific recommendations on how these elements are to be accomplished or how the information is to be interpreted. With regard to the selection of appropriate PPE, it is recommended that the PPE be selected to ensure a level of protection greater than the minimum required to protect employees from the hazard. For skin-exposure hazards, recommendations for quantifiable allowable exposures are not available. A specific section was included to assist in the selection of hand protection (Sect. 11). It states that OSHA is unaware of any gloves that provide protection against *all* potential hand hazards, and commonly available glove materials provide only limited protection against many chemicals. Therefore, it is important for employers to select the most appropriate glove for a particular application and to determine how long it can be worn, and whether it can be reused. However, the authors are unaware of any approaches that are presently available for the practical performance of these evaluations or for the interpretation of the results, apart from some recently published proposals (Klingner and Boeniger 2002; Boeniger and Klingner 2002).

In addition to the PPE standard, another OSHA regulation is the Hazardous Waste Operations and Emergency Response standard, CFR 1910.120, subpart H, Appendix B, which gives a general description and discussion of the levels of protection and protective gear when one is working to remediate hazardous waste sites. This standard pertains only to clean-up operations that are required by a governmental body, whether federal, state, local or other, which involve hazardous substances and are conducted at uncontrolled hazardous waste sites. This standard acknowledges that the selection of appropriate PPE is a complex process that should take into consideration a variety of factors. Furthermore, the amount of protection provided by PPE is material-hazard specific. In many instances, protective equipment materials cannot be found which will provide continuous protection from the particular hazardous substance. In these cases, it is recommended that the breakthrough time of the protective material should exceed the work duration. Four levels of PPE are described, with level A being most protective, and level D the least protective. However, criteria for the rating of the level of risk of skin exposures are not provided, only that, for instance, if "substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible—level A protection should be used." However, what constitutes a "high degree of hazard" is not clearly described.

The OSHA Technical Manual, Sect. IV, Chap. 2, contains information on the control of occupational exposure to hazardous drugs. It recommends that all hazardous drugs be handled inside biological safety cabinet ventilated booths when they are being prepared for use. Chemical-resistant gloves are to be worn, preferably thick natural rubber latex or other gloves recommended by the manufacturers for a particular drug. Sect. , Chap. 1, contains general information on selection of chemical protective equipment. Subpart F, entitled "Field Selection of Chemical Protective Clothing", states:

1. Even when end users have gone through a very careful selection process, a number of situations will arise when no information is available to judge whether their protective clothing will provide adequate protection. These situations include: chemicals that have not been tested with the garment materials; mixtures of two or more different chemicals; chemicals that cannot be readily identified; extreme environmental conditions (hot temperatures); and lack of data in all clothing components (e.g. seams, visors).
2. Testing material specimens using newly developed field test kits may offer one means for making an on-site clothing selection. A portable test kit has been developed by the EPA using a simple weight loss method that allows field qualification of protective clothing materials within one hour. Use of this kit may overcome the absence of data and provide additional criteria for clothing selection.
3. Selection of chemical protective clothing is a complex task and should be performed by personnel with both extensive training and experience. Under all conditions, clothing should be selected by evaluating its performance characteristics against the requirements and limitations imposed by the application.

OSHA has also published several standards for employers that are conducive to the enhancement of employee personal hygiene. Each of these standards helps ensure the removal of contaminants from the skin and the prevention of transfer of contaminants from the hands to the mouth. The Standard for General Industry [CFR 1910.141 (d)(2)] directs that lavatories shall be provided with hot and cold running water, or tepid running water. Hand soap or similar cleansing agents shall be provided. Individual towels or sections thereof, of cloth or paper, warm-air blowers or clean individual sections of continuous cloth toweling, convenient to the lavatories, shall be provided. With regard to the construction industry, the Occupational Health and Environmental Controls Sanitation regulation CFR 1926.51(f) states that "the employer shall provide adequate washing facilities for employees engaged in the application of paints, coatings, herbicides, or insecticides, or in other operations where contamination may be harmful to the employees. Such facilities shall be in near proximity to the work site and shall be so equipped as to enable employees to remove such substances." Standard 1928.110, Field Sanitation, requires that sanitation facilities be available in the field for hired farm workers. This standard is applicable to any employer with 11 or more hired workers and requires that drinking water, toilet and hand washing facilities be made available. Employers are responsible for instructing workers on the importance of washing their hands both before and after using the toilet, and to wash their hands before eating and smoking.

The OSHA Hazard Communication Standard, CFR 1900.1200, was promulgated to ensure that potential hazards of all chemicals produced or imported are assessed, and that information concerning their hazards is transmitted to employers and employees (OSHA 1983). This goal is to be met in part through the proper labeling of containers and preparation of MSDSs. MSDSs can be useful to employers that are aiming to select the safest materials, or for the identification of potential hazards for which exposure prevention must be implemented, and for employees to check if there are questions about their potential risks of working with a product or the precautions to take to prevent exposure. The hazard assessment of products includes identification of those whole mixtures or components of formulated products that can either damage the skin (e.g., irritants, allergens, corrosives) or be absorbed through the skin and contribute to systemic toxicity. OSHA Instruction CPL 2-2.38C, Appendix D, provides a guide for one to review MSDS completeness. An MSDS must list all ingredients for mixtures tested as a whole that contribute to a known hazard. For mixtures not tested as a whole the MSDS must list all ingredients that have been determined (from secondary sources) to be potential health hazards if they are present at a concentration of 1% or greater, including carcinogens if present at 0.1% or greater. Chemical and common name(s) of all ingredients that are health hazards, and for which there is evidence that the product may present a risk to employees even though the ingredients are present in a mixture in concentrations of less than 1% (or less than 0.1% for carcinogens), must also be reported. This includes irritants and sensitizers that must be reported if there is evidence that the chemical causes a reversible inflammatory effect when tested on albino rabbits, or a substantial number of exposed people or animals have developed an allergic reaction. If a chemical manufacturer or importer does not test a formulated mixture as a whole, it may be assumed that the mixture presents the same hazards as its component parts. The formulator can choose to rely on upstream chemical manufacturers' hazard determinations for the component parts of the mixture.

For labeling and hazard-rating purposes, certain toxic endpoints related to the skin are defined. A corrosive is defined as a chemical that causes visible destruction of, or irreversible alteration to, living tissue at the site of contact. One common means for this to be tested is the use of the Draize test as described by the US Department of Transportation in Appendix A to 49 CFR, part 173. The chemical is applied to the intact skin of albino rabbits for 4 h. This regulation also addresses toxic and highly toxic chemicals for dermal exposures. Chemicals that are highly toxic by the cutaneous route are defined as having a median lethal dose (LD_{50}) of 200 mg or less per kg body weight when administered by continuous contact for 24 h or fewer if death occurs sooner. A toxic substance is one that has an LD_{50} by cutaneous application of greater than 200 mg/kg but not more than 1,000 mg/kg when administered by continuous contact for 24 h. An irritant can be tested on the intact skin of albino

rabbits by the methods of 16 CFR 1500.41, and if, after 4 h exposure, it results in an empirical score of 5 or more, it can be classified as such.

Finally, Sect. (g)(2)(ix) of the Hazard Communication standard requires that any generally applicable control measures that are known to the chemical manufacturer, importer or employer that is preparing the material safety data sheet, such as appropriate engineering controls, work practices, or personal protective equipment, be included in the MSDS.

Joint agency activities

The National Institutes of Health Revitalization Act (NIHRA) of 1993 (PL no. 103-43, Sect. 1301) prompted the creation of the Interagency Coordinating Committee on the Validation of Alternative Methods (ICCVAM), and in 1998 it created the National Toxicology Program (NTP) Interagency Center for the Evaluation of Alternative Toxicological Methods (NICEATM). ICCVAM is responsible for the coordination of the development and review of various alternative toxicological methods, one goal of which would reduce the need for use of animal testing.

For the testing of the corrosive action of chemicals on skin, a new commercial in vitro test named Corrositex 7 has become available. The test evaluates the dermal corrosive potential of chemicals and mixtures based on their ability to pass through an artificial bio-barrier by diffusion, destruction, or erosion and create a color change in an underlying liquid chemical detection system. US regulatory agencies that are involved with chemical safety participated in the NTP review of this method, which was subsequently accepted for the screening of chemicals that cause this effect (NTP 1999). The EPA, for example, accepts Corrositex as an approved test for characterization of the dermal corrosivity of solid waste (40 CFR, parts 260, 264, 265, and 266). Similarly, the murine local lymphocyte node assay (LLNA) was also approved as an alternative assay to reduce the number of animals used in the testing of the potency of allergenic compounds. The assay involves the measurement of the incorporation of ^{3}H-methyl thymidine into lymphocytes in draining lymph nodes of animals that are topically exposed to the test articles, as a measurement of sensitization.

Critique and conclusions

Presently, there are over 137 million working people in the USA (BLS, 2003 Current Population Survey). Dermatitis is the predominant disease resulting from chemical agent exposures (BLS 1999). In addition, it has been estimated that, annually, hundreds of thousands of job-related illnesses and tens of thousands of deaths result from workplace exposures to toxic substances (Leigh et al. 1997). It is unknown as to what proportion of the chemical exposures leading to these illnesses were due to absorption through the skin, but it is likely that some were contributed to by skin exposures. NIOSH estimated that approximately 42% of American workers may have skin exposure to potentially dangerous chemicals (NIOSH 1993). Inadequate means of measuring skin exposures and proving etiological connections have prevented better estimates being made of the significance of skin absorption in the workplace. Good epidemiological studies combined with exposure data, which use reliable approaches for measuring the contribution due to skin absorption, are urgently needed.

Regulation of occupational skin exposure in the USA occurs through a number of regulatory statutes. Standards such as TSCA and the Hazard Communication Standard stimulate the generation and reporting of health-hazard information. However, there is inadequate guidance on appropriate ways to control skin exposures in the workplace. Current regulations incorporate boilerplate references to ''use appropriate hand protection'' or ''clothing designed to protect an employee against contact with or exposure to...''. Appropriate means for the prevention of skin exposures should consider practical aspects of worker acceptance, costs, and effectiveness. Standards for acceptable performance of personal protective clothing in more quantitative terms are needed.

The present inclination in the USA to rely primarily on CPC for skin protection should be questioned, in view of its potential disadvantages and limitations of performance. For instance, improper use of even properly selected CPC may result in increasing exposure if it is worn over skin that is already contaminated. Therefore, care in adhering to good work practices is an ongoing necessity. Additionally, there are risks of potential irritant response from chronic occlusion and allergic response from chemicals that are used in the production of the CPC. Epidemiological surveys of occupational dermatitis often identify rubber-product chemicals and CPC as a predominant cause. These inherent risks from the use of CPC (along with worker discomfort, reduced productivity, donning and doffing time, generation of contaminated solid wastes, and costs of replacement) should be carefully considered before CPC is selected as the universal standard for the prevention of dermal exposure.

NIOSH believes that CPC should be considered as the last line of defense to protect against accidental contact, e.g., spills, splashes (Roder 1990). The use of engineering and work practice controls are the preferred methods to eliminate or minimize the possibility of contact with chemicals and should be implemented and assessed before one resorts to CPC. Likewise, a guide published by OSHA titled ''Assessing the need for personal protective equipment: A guide for small business employers'' states that the preferred way to protect employees from workplace hazards, including hazardous substances that can cause injury, is through engineering controls or work practice and administrative controls,

Table 2 Number of federal OSHA citations for recent 31-month period: 1910.138(a) and (b)

Statute	Total violations	Serious violations	Willful violations	Repeat violations	Other, non-serious
1910.138(a)	898	613	2	4	276
1910.138(b)	87	48	1	0	37

but when these controls are not feasible or do not provide sufficient protection, an alternative or supplementary method of protection is for employers to provide workers with personal protective equipment and to know how to use it properly (OSHA 1997). It is not clearly stated in this document whether OSHA was referring to CPC with regard to this hierarchy of controls to prevent skin contact, or if the guidance is more directed towards hearing protection, eye protection, etc. In the OSHA PPE standard regarding skin exposures, only mention of the use of appropriate CPC is specified as an acceptable option.

Demonstrated approaches to prevent occupational skin exposures effectively are critically needed. These approaches and their effectiveness should be critically and scientifically assessed. Alternative approaches to the use of CPC, such as engineering controls and administrative and work practices, should be investigated, and if CPC must be relied upon, selection guidelines, performance assessment criteria, decontamination and re-use guidelines, and many other related issues, need to be researched. Although there are clear guidelines on how to select and assess the performance of respiratory protection for preventing inhalation hazards, there is no similar guidance on what defines ''appropriate'' or ''effective'' CPC. This observation is supported by the OSHA citation record during the period 1 January 1998 to 31 July 2000 for 29 CFR 1910.138, as depicted in Table 2. Citations were given out ten-times more often for failure of the employer to select and require employees to use appropriate hand protection [i.e., Sect. 138(a)], than for failure of the employer to select gloves based on an assessment of the performance characteristics of the hand protection relative to the task(s) performed [i.e., Sect. 138(b)]. Initial penalties for 138(a) were $422,000, again approximately ten-times that for citations that used 138(b).

Although the OSHA sanitation standards that provide for washing facilities encourage that such facilities are available and clean, guidance is not provided for the selection of cleansing products that are used in those facilities. Cleanser products should be selected that are effective for the removal of workplace chemicals, while at the same time are not damaging to the skin. Often these two features may not occur simultaneously. For instance, water-insoluble chemicals may not be effectively removed from the skin with soap and water. To be effective, a non-aqueous solvent might better solubilize and visibly remove hydrophobic contaminants; however, these solvents may also de-fat the skin, which can lead to skin damage. Also, if used to decontaminate the skin, some non-aqueous solvents may actually enhance percutaneous absorption. The growing use of waterless cleansers that contain petrochemicals, as well as citrus-based cleansers that use d-limonene, warrants concern. An informal survey of several dominant manufacturers of occupational skin cleansers indicates that none has tested its products for enhanced absorption at this time.

Even common soap-and-water-type skin cleansers may irritate the skin or promote percutaneous absorption of skin contaminants (Adams 1999). A well-known cleanser ingredient, sodium lauryl sulfate, is well recognized for its irritation of the skin and is frequently used as a positive reference chemical in irritation experiments. There are numerous reports of surfactant enhancement of permeation of both lipophilic and hydrophilic penetrants (Ashton et al. 1992; Kushla and Zatz, 1991; Tan et al. 1993). Other components of skin cleansers, such as propylene glycol, isopropyl myristate, and glycerol, are readily absorbed into the skin and may enhance percutaneous absorption (Bronaugh et al. 1981; Zesch 1983; Cornwell et al. 1994; Bettinger et al. 1998). Fortunately, there are surfactants that will cause minimal irritation and high-molecular-weight solvents that will not enhance percutaneous absorption (Navarro et al. 1982; Effendy and Maibach 1995, 1996; Smyth et al. 1950; Krogsrud and Larsen 1992). Manufacturers and consumers need to be educated about the preference of using these products and the possible benefit to workers. Laboratory tests are needed that can be used to assess decontamination effectiveness, adverse dermal effects, and percutaneous absorption enhancement by skin cleansing products, and provide a better understanding of the impact of individual components of skin cleansers. Presently, there are no standard guidelines available through the FDA or others that either voluntarily or statutorily require manufacturers to prove efficacy or safety of skin cleansers.

There are numerous skin-care products presently on the market that make claims of protecting the skin or restoring the skin to a healthful state. According to the FD&C Act, these products could be considered to be new drugs, and thus their efficacy and safety need to be proven before they are marketed. Historically, there has not been an aggressive policing of such product claims in the past. There are indications that this may be changing for skin-care products used by workers.

OSHA's Hazard Communication Standard has encouraged a uniform approach to material-hazard labeling and hazard-information reporting and communication. However, there is the question as to what extent the information generated and reported in MSDSs may be expected to be accurate or complete (Kolp et al. 1995; Lerman and Kiping 1990). One assessment commissioned by OSHA in 1990 evaluated a random sample of 150 MSDSs and found identifiable chemical names in 89% and accurate health effects data

Table 3 Number of federal OSHA citations issues for a recent 31 month period: 1910.1200 g (5)

Total violations	Serious violations	Willful violations	Repeat violations	Other, non-serious
8	4	1	0	3

in 37%, and less than half were judged to have accurate ratings for personal protective equipment or correct listings for applicable occupational-exposure limits (Kolp et al. 1995). A possible contributing cause of inaccuracies in MSDSs may be from lack of compliance enforcement. A search of the federal citation record reveals that there have been very few instances of citations relative to the accuracy of the information in the MSDSs. Table 3 provides the citation compilation during 1 Jan 1998 to 31 July 2000 for 1910.1200 g(5) concerning the accuracy of MSDSs. Initial citations amounted to $8,900, whereas the final adjusted penalties were $3,085. A possible explanation for the small number of citations issued may be due to the lengthy process of performing a complete hazard review, especially of complex mixtures, that is simply not feasible for OSHA compliance staff to perform.

Another requirement is that all hazardous substances in mixtures be identified. Often, formulators do not fully know some of the minor constituents of a final formulation because a complete chemical analysis has not been performed. Rather, formulators legally rely on upstream chemical manufacturers for ingredient identification and hazard reviews. If this information is incomplete or inaccurate, the product formulation may also contain incomplete or inaccurate information. This is especially true if in situ chemical interactions occur during and after formulation. This is of concern because allergic contact dermatitis reactions may be triggered by even trace quantities of some chemicals. The existence of such components may frequently be overlooked by the manufacturer (Flyvholm and Menné 1992).

Unfortunately, regulatory requirements relevant to occupational skin exposures in the USA are lacking in clearly defining the performance criteria to be met. Most employer and compliance-officer decisions of appropriate skin protection are apparently made based on a personal judgment of what constitutes good practice. Fortunately, the amount of available non-mandatory guidance information on testing methods for meeting regulatory requirements is improving and being posted on the internet by both OSHA (http://www.osha-slc.gov/SLTC/) and EPA (http://www.epa.gov/opptsfrs/home/testmeth.htm).

One rule currently in development by OSHA could have a significant impact on, and prevent, occupational skin exposures in the USA. The draft OSHA Safety and Health Program Rule has the requirement that a hazard identification and assessment be performed, and hazard prevention and control be provided, which could certainly include skin exposure. Core elements of a proposed company program should include (a) management leadership and employee participation, (b) hazard identification and assessment, (c) hazard prevention and control, (d) information and training, and (e) assessment of program effectiveness. If all these elements were appropriately applied to skin-exposure hazards, significant improvement might be expected. If consensus standards concerning good practice for the control of skin exposures were available, OSHA could use these nationally acceptable criteria as a standard for industry performance.

A variety of potentially valuable exposure measurement tools, including the use of biological specimens for the measurement of exposure to organic compounds that are appreciably absorbed through the skin, is presently not utilized by OSHA. Other federal organizations, such as the Agency for Toxic Substances and Disease Registries, in collaboration with the National Center for Environmental Health, have supported the development of over 100 biological markers of exposure on the most hazardous substances that are related to chemical waste sites (Superfund) and a number of reference range determinations. Biological monitoring can be very effective in the assessment of whether skin absorption is a significant route of exposure, but there is little regulatory stimulus for its widespread use by industry. OSHA does specifically require biological monitoring for lead and cadmium, but not because these are significantly absorbed through the skin. More generally, OSHA directs its field compliance officers to evaluate an employer's biological monitoring results if this has been conducted for any chemical. The results may be used to assist in the determination of whether a significant quantity of toxic material is being ingested or absorbed through the skin (OSHA 2000b). Unfortunately, few of these officers may be adequately trained or experienced to utilize these types of data appropriately. OSHA could produce additional guidance, similar to that produced by the EPA, on the types of measurement data that industry could collect in order to meet the legal requirements of the regulations. This could apply to biological measures of exposure as well as to other more direct assessment approaches for the measurement of skin exposure. Use of these assessment tools and provision of performance criteria to compare sampling results could significantly stimulate measurement and control of occupational skin exposures.

Much research still needs to be conducted with regard to the understanding and prevention of occupational skin exposure. NIOSH has recently received major funding for a broad-based research program that will emphasize findings that can be used to support policy recommendations to prevent occupational skin exposures and the adverse outcomes that may occur. Similar efforts in Europe should also improve our knowledge in the future. Hopefully, several significant informational gaps can be quickly filled, so that workers will be better protected against skin-exposure hazards where they work.

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