# Chapter 12
# Dermal Chemical Hazards

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## Cross-References

*The Occupational Environment—Its Evaluation and Control*

- Chapter 13, Biological Monitoring, by Shane S. Que Hee.
- Chapter 14, Dermal Exposure and Occupational Dermatoses, by J. Thomas Pierce, M. Cathy Fehrenbacher, and Lutz W. Weber.
- Chapter 35, Personal Protective Clothing, by S. Zack Mansdorf.

*Essential Resources for Industrial Hygiene: A Compendium of Practice Standards and Guidelines*

- Chapter 6, Design of Strategies for Assessing and Managing Occupational Exposures, by Paul Hewett.
- Chapter 11, Biological Monitoring, by Stephanie Carter, Mike Morgan, Shane S. Que Hee, and Timothy J. Buckley.
- Chapter 21, Personal Protective Equipment, by S. Zack Mansdorf.

## Scope

The skin is the body's largest organ and is constantly exposed to the outside environment. Although the skin evolved primarily to maintain internal homeostasis and body temperature, and act as a barrier to external pathogens, it is poorly equipped to deal with the chemicals and excessive physical insults that can be present in modern industry. Such exposures and insults to the skin may result in excessive absorption of toxic chemicals, which results in systemic damage, or can directly affect the skin adversely (including mechanical abrasion, corrosion, irritation, and allergic sensitization). Although long neglected, significant recent attention from government and industry to improve the recognition, evaluation, control, and prevention of potential skin hazards is taking place worldwide with the formation of research networks and provision of funding. This compendium will focus on resources and references pertaining to skin hazards and on developing the general understanding needed to prevent dermatitis and toxicity from occurring.

Topics not fully addressed in chapter:

- Quantitative exposure limits for dermal exposures are not available for many industrial chemicals. However, several resources describe approaches for deriving dermal occupational exposure limits (OELs).
- Ultraviolet/sun protection.
- Ocular hazards.
- Heat/cold protection.
- Exposure to microbial hazards, and disinfection agents.

- Bloodborne pathogens.
- Burns and burn treatment (chemical and thermal).
- Personal protective equipment (PPE) is addressed in Chapter 21.

# 1. Regulations

## 1.1 Regulations: United States

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| **General requirements** | **1.1.1** | **General Duty Clause**<br>• The "general duty clause," Section 5(a)(1) of the Occupational Safety and Health Administration (OSHA) Act, requires employers to provide a place of employment free from recognized hazards. |
| **Skin notations** | **1.1.2** | *Toxic and Hazardous Substances,* 29 CFR §1910.1000, Subpart Z. All OSHA Standards are available from the OSHA web page at http://www.osha.gov<br>• Some regulated chemicals have an associated "skin" notation, which alerts the user to the potential for dermal absorption. There are no associated quantitative limits for skin exposure.<br>• This notation is intended for chemicals that are believed capable of causing systemic poisoning and does not include irritants, sensitizers, or other dermatological conditions.<br>• Some chemical-specific carcinogen standards also require that no skin contact occur. |
| **Selection of personal protective clothing** | **1.1.3** | *Personal Protective Equipment for General Industry,* 29 CFR §1910.132 to 1910.139, especially Appendix B to 1910.138(b), Hand Protection Standard.<br>• The revised OSHA Personal Protective Equipment Standard directs that a workplace hazard assessment be performed to evaluate the need for personal protective clothing, including gloves.<br>• Glove selection is to be based "on an evaluation of the performance of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards or potential hazards identified."<br>• Does not specify how to select appropriate chemical protective clothing (CPC). |
| **OSHA chemical specific standard** | **1.1.4** | *29 CFR §1910.1050, 4,4'-Methylenedianiline*<br>• This standard recognizes the skin as a significant route of exposure.<br>• Provides performance requirements to minimize skin exposure, including establishing recommended good work practices and a program for detecting contamination sources.<br>• Does not contain specific quantitative levels for skin exposure. |

**General industry standards for decontamination facilities** 1.1.5

*29 CFR §1910.141, Sanitation General Industry Standards*

- (d)(2)(ii): Each lavatory shall be provided with hot and cold running water, or tepid running water.
- (d)(2)(iii): Hand soap or similar cleaning agents shall be provided.
- (d)(2)(iv): Individual hand 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.

**Decontamination in construction work** 1.1.6

*29 CFR §1926.51(f)(1) Sanitation — Health and Safety Standards Applicable to Construction Work*

- Requires provision of adequate washing facilities for employees engaged in the application of paints, coatings, herbicides, or insecticides, or in other operations where contaminants may be harmful to the employees.
- These facilities shall be in near proximity to the work site and be equipped to enable employees to remove such substances.

**EPA agricultural worker protection** 1.1.7

*40 CFR Part 170, Revised Worker Protection Standard,* **1992 Environmental Protection Agency (EPA)**
This is available at
http://www.epa.gov/pesticides/safety/workers/PART170.htm

- Intended to protect agricultural workers from risks associated with agricultural pesticides.
- Applies to all workers in agriculture performing hand labor in fields, farms, forests, nurseries, and greenhouses.
- Includes pesticide handlers who mix, load, and apply pesticides.
- Requirements include appropriate training, instruction on use of PPE, observance of the established restricted entry intervals after pesticide application, and provision of decontamination supplies that are readily available for use by workers.

**Testing of certain chemicals for percutaneous absorption** 1.1.8

*40 CFR Part 799, Proposed Test Rule for In Vitro Dermal Absorption Rate Testing of Certain Chemicals of Interest to Occupational Safety and Health Administration*
Available on-line at
http://www.epa.gov/fedrgstr/EPA-TOX/1999/June/Day-09/t14640.pdf

- Specifies 47 chemicals for a manufacturer's testing of percutaneous absorption.
- Describes specific in-vitro test protocol for short-term and longer-term exposure.

## 1.2 Regulations: International

**EEC hazardous materials labeling** 1.2.1

**Approximation of Laws, Regulations and Administrative Provisions Related to the Classification, Packaging and Labeling of Dangerous Substances** (Directive 84/449/EEC). *Official J. Euro. Communities, L 251*:1–223 (1984).

Ordering information is available online at http://europa.eu.int/eur-lex/en/index.html.

- Provides guidance on testing and classifying chemical hazards, including corrosivity, irritation and sensitization potential in laboratory animals, and how to translate those results to product labeling.

**EEC PPE selection and use** 1.2.2 **Minimum Health and Safety Requirements for the Use by Workers of Personal Protective Equipment at the Workplace** (Directive 89/656/EEC). *Official J. Euro. Communities L 393/18*:30.12..89. Ordering information is available online at http://europa.eu.int/eur-lex/en/index.html

- Provides general requirements for assessing hazards and for selecting appropriate PPE, including chemically resistant gloves.

**Australian National Occupational Health and Safety Commission** 1.2.3 ***Exposure Standards for Atmospheric Contaminants in the Occupational Environment,*** National Occupational Health and Safety Commission (NOHSC) 1005 (1994), NOHSC: 3008 (1995), and NOHSC: 10005 (1999). Information about this organization is available at http://www.worksafe.gov.au

- Regulations and guidance are modeled on the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs®) and European Economic Community (EEC) guidelines.
- The potential for skin absorption and skin sensitization is included.
- Notations for skin effects follow the EEC notations.

## 2. Consensus Standards

**ASTM mammalian acute percutaneous toxicity test** 2.1 ***Standard Test Method for Mammalian Acute Percutaneous Toxicity*** [E 758–91 (11.05)]. American Society for Testing and Materials (ASTM). Ordering information is available at http://www.astm.org

- Acute percutaneous mammalian toxicity test for pesticides, repellants, biocides, chemicals, and chemical mixtures.
- Assesses lethal and sublethal doses over 4–6 hour of contact for skins clipped free of hair.
- Includes methods for abraded skin.

**ASTM delayed contact hypersensitivity test** 2.2 ***Standard Test Method for Evaluation of Delayed Contact Hypersensitivity*** [E 993–88 (11.05)]. ASTM, reapproved 1992. Ordering information is available at http://www.astm.org

- Evaluation of delayed contact hypersensitivity in guinea pigs for pesticides, repellants, biocides, chemicals, and chemical mixtures.
- Assesses skin sensitization or delayed contact hypersensitivity to the shaved backs of guinea pigs over two 6-hour contact periods that are spaced 2 weeks apart.
- Screening test before conducting tests on human skin.

**ASTM subchronic dermal toxicity test** 2.3

*Standard Test Method for Determining Subchronic Dermal Toxicity* [E 1103–91 (11.05)]. ASTM, 1991. Ordering information is available at http://www.astm.org

- Determination of subchronic dermal toxicity over 90 days of exposure to mammals on their shaved skin, but notably rats, guinea pigs, and rabbits for pesticides, repellants, biocides, chemicals, and chemical mixtures.
- Target organ and bioconcentration effects also can be determined.
- The test may allow selection of doses for chronic studies in the animals studied.

**ASTM handwash test** 2.4

*Standard Test Method for Evaluation of Health Care Personnel Handwash Formulation* [E 1174 –94 (11.05)]. ASTM, 1994. Ordering information is available at http://www.astm.org

- Determination of the ability of an antimicrobial handwashing agent or formulation to protect health care personnel against infection in human volunteer panelists.
- The test organisms used are *Serratia marcescens* and *Escherichia coli.*
- Microbiological skills are necessary.

**ASTM guide for evaluating protective clothing** 2.5

*Standard Guide for Evaluating Chemical Protective Clothing* [F 1296–98 (11.03)]. ASTM, 1998. Ordering information is available at http://www.astm.org

- The protective clothing situations cover protection to potentially hazardous chemicals.
- Clothing items covered include body part protection, for example, fingercots and face, to whole body ensembles.
- Situations in industry, agriculture, government, and academia relative to chemical research, pesticide application, hazardous waste cleanup, and chemical production are applicable.
- Success requires the careful matching of the proper level of protection and performance characteristics of the clothing with the potential hazard and the desired functional requirements of the tasks to be performed while the clothing is worn.

**ASTM standard for chemical protective clothing** 2.6

*Standard Practice for Chemical Protective Clothing Program* [F 1461–93 (11.03)]. ASTM, 1998. Ordering information is available at http://www.astm.org

- Establishes minimum program requirements that include administration; hazard assessment; written program; selection of clothing; clothing use, inspection, maintenance, storage, decontamination, and disposal; and auditing.
- Includes discussions of:
  - Field evaluations
  - Biological monitoring
  - Medical and human factors
  - Training

- Gas, vapor, spill, fume, aerosol, liquid splash, and soiled object exposure situations

- "Nonmandatory" appendices describe exposure situations, toxicity information, PPE coordination, clothing layering, factors that affect the interpretation of permeation resistance test data, and references to other ASTM standards.

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| **Australian Standard on Waterless Hand Cleaners** | 2.7 | *Industrial Hand Cleaners (petroleum solvent type)* (Australian Standard AS 1223–1991). Standards Association of Australia, 1991. ISBN 0–72626–941– 7. Ordering information is available at http://www.standards.com.au/Catalogue<br>• Presents maximum solvent content and minimum labeling requirements along with standard test methods for determination of petroleum solvent content, free alkali content, miscibility with water and pH value, and determination of stability. |

## 3. Guidelines, Position Statements, and Criteria Documents

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| **European Centre for Ecotoxicology and Toxicology of Chemicals (ECE)** | 3.1 | *Examination of a Proposed Skin Notation Strategy* (Special Report No. 15). Brussels, Belgium, 1998. Ordering information is available from ECETOC, Avenue Van Nieuwenhuyse 4, Bte 6, B – I 160 Brussels, Tel. (32) 2- 675 3600.<br>• A tiered strategy for assessing information needed to assign a skin notation is presented along with 36 examples using the approach. |
| **ECE** | 3.2 | *Percutaneous Absorption* (Monograph no. 20). Brussels, Belgium, 1993. Ordering information is available from ECETOC, Avenue Van Nieuwenhuyse 4, Bte 6, B – I 160 Brussels, Tel. (32) 2- 675 3600.<br>• Describes:<br>▪ Factors influencing percutaneous absorption.<br>▪ Methods for measuring percutaneous absorption.<br>▪ Presentation of results.<br>▪ Extrapolating animal data to humans.<br>▪ Performing an exposure assessment.<br>▪ Conducting a hazard and risk analysis of chemically contaminated skin. |
| **U.S. EPA** | 3.3 | *Occupational and Residential Exposure Test Guidelines.* EPA 712–C–99–262, Prevention, Pesticides and Toxic Substances, Washington, D.C. Available on the Federal Bulletin Board, 202–512–1387, telnet and ftp:fedbbs.access.gpo.gov and Internet: http://fedbbs.access.gpo.gov<br>• OPPT 875.1100 Dermal Exposure—Outdoors Guideline.<br>• OPPT 875.1200 Dermal Exposure—Indoors Guideline.<br>• OPPT 875.2300 Indoor Surface Residue Dissipation Guideline.<br>• OPPT 875.2400 Dermal Exposure. |

- Intended to minimize variations among the test procedures performed to meet the data requirements of the U.S. EPA under the Toxic Substances Control Act (15 USC 2601) and the Federal Insecticide, Fungicide and Rodenticide Act (7 USC 136, et seq.)

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U.S. EPA 3.4 **Guidelines for Exposure Assessment,** *Federal Register* (FR) 57, No. 104, May 29, 1992 EPA/600Z–92/001. FR 57:22888–22938 This document is available on-line at http://www.epa.gov/nceawww1/exposure.htm

- Establishes a broad framework for EPA exposure assessments.
- The skin is not the specific focus, but the general principles are relevant to an exposure and risk analysis. These include:
  - Planning and conducting an exposure assessment.
  - Presenting the results.
  - Characterizing uncertainty.
  - Key terms and principles are defined.

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U.S. EPA 3.5 *Risk Assessment Guidance for Superfund Sites,* vol. 1, *Human Health Surveillance Manual, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance* (NCEA–W–0364). Washington, DC: Office of Emergency and Remedial Response, EPA, 1998. This document is available on-line at http://www.epa.gov/oerrpage/superfund/pubs/htm

- Focuses on dermal absorption from water and soil.
- Describes exposure risk parameters using toxicity, surface area, adherence factors, and estimating reasonable maximum exposure.
- Abundant risk estimation formulae and default data.

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NIOSH 3.6 *NIOSH Manual of Analytical Methods,* 4th ed., can be accessed with an Adobe Acrobat® reader at http://www.cdc.gov/niosh/nmam/nmammenu.html

- Methods concerning surface and skin contaminant sampling:
  - NMAM Method 9100 for lead surface wipes.
  - NMAM Method 2017 for surface wipes and skin badges for aromatic amines.
  - NMAM Method 9200, Chlorinated and Organonitrogen Herbicides (Hand Wash) Method.
  - NMAM Method 9201, Chlorinated and Organonitrogen Herbicides (Patch) Method.

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ACGIH 3.7 *TLVs® and BEIs®: Threshold Limit Values for Chemical Substances and Physical Agents; Biological Exposure Indices.* Cincinnati, OH: ACGIH, 1999. Ordering information is available at http://www.acgih.org

- A "skin" notation accompanies those chemicals known to pose a significant hazard of overall exposure by the cutaneous route.
- Biological monitoring is recommended as the primary method of skin exposure evaluation.
- Irritation, sensitization (has its own "SEN" notation), and dermatitis are not considered.
- The SEN notation refers to the confirmed potential for worker sensitization as a result of dermal contact and/or inhalation exposure, based on the weight of scientific evidence.

- Lack of a SEN notation does not necessarily mean that the substance is not a sensitizer.

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| ACGIH | 3.8 | *Documentation of the Threshold Limit Values and Biological Exposure Indices.* Cincinnati, OH: ACGIH, 1991. Updates appear regularly in the ACGIH journal Applied Occupational and Environmental Hygiene.<br>• These documents provide the justification for skin or SEN notations for chemical agents in the TLVs® and BEIs®.<br>• Contains a brief summary of the physical, chemical, and toxicological properties.<br>• The preface to the documentation of the BEIs® is a useful introduction to dermal exposure and how biological monitoring can be used to assess exposure. This information is also available as a separate publication titled Topics in Biological Monitoring, published by ACGIH in 1995. |

## 4. Handbooks, Textbooks, and Review Articles

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| **Introductory text: Biological monitoring to assess skin exposures** | 4.1 | *Biological Monitoring: An Introduction,* S.S. Que Hee (ed.). New York: Van Nostrand Reinhold, 1993.<br>• Intended as an introductory textbook for biological monitoring, which reviews basic chemistry, biochemistry, and immunology.<br>• Discussion of exposure with emphasis on skin route, metabolism, and excretion.<br>• Discusses biomarkers of effect including traditional medical testing for diagnosis of disease.<br>• Provides an extensive list of reference ranges for a variety of markers in Appendix I.<br>• Does not include actual monitoring methods. |
| **Introductory text: Sampling methods** | 4.2 | *Surface and Dermal Monitoring for Toxic Exposures,* S.A. Ness (ed.). New York: John Wiley & Sons, 1994. ISBN 0–47128–564–1. Ordering information is available on-line at http://www.wiley.com<br>• Includes a review of basic physiology of the skin, sampling methods, and regulatory applications.<br>• Discussion of CPC and selection.<br>• Provides extensive lists of references.<br>• Special issues related to surface sampling of amines (Appendix A), metals (Appendix B), PCBs/TCDDs (Appendix C), and pesticides (Appendix D). |
| **Advanced text: Sampling methods** | 4.3 | *Critical Review of Field Sampling Methods for Assessing Potential Skin Exposure, In: Dermal Contamination and Health Risks,* by M. Boeniger and D. Brouwer. London: Imperial College Press. [Late 2000.] The publisher's web page is http://www.icpress.co.uk |

- Detailed review of direct and indirect sampling methods for measuring surface and skin exposures.
- Provides method performance testing data and comparisons between methods.
- Recommendations for additional method performance testing.

**Chemical-specific reviews** 4.4

*Skin Penetration: Hazardous Chemicals at Work*, by P. Grandjean. Bristol, PA: Taylor and Francis, 1990. pp. 18–29. ISBN 0–85066–833–4

- Covers percutaneous absorption, test methods, potential for classification, confounding variables, the skin notation and preventive approaches.
- Provides chemical specific reviews of significant literature on over 60 chemicals or groups of chemicals.

**Sampling methods: A review** 4.5

*Occupational Dermal Exposure Assessment—A Review of Methodologies and Field Data.* Washington, DC: Chemical Engineering Branch, Economic, Exposure and Technology Division, Office of Pollution Prevention and Toxic Substances, EPA, 1996.

- Comprehensive description of surface and skin sampling methods used for risk assessment of chemical exposures.
- Provides empirical exposure data that could be used as default values in other risk estimates.

**Absorption and modeling** 4.6

*Dermal Exposure Assessment—A Literature Review.* Las Vegas, NV: Environmental Monitoring Systems Laboratory, EPA, 1992.

- Review of dermal exposure pathways from soils and dust, solids, water, and nonaqueous liquids.
- *In vivo* and *in vitro* models.
- Noninvasive measures of human exposure.
- Models for predicting absorption following dermal exposures.

**Biological aspects reference** 4.7

*Dermal Exposure Assessment: Principles and Applications* (Interim report; EPA/600/8–91/011B). Washington, DC: Office of Research and Development, 1992. This document is available on-line at http://www.epa.gov/nceawwwl/dermal.html

- Review of mechanisms of dermal absorption and factors influencing percutaneous absorption.
- Includes:
  - Techniques for measuring dermal absorption.
  - Mathematical description of dermal absorption.
  - Dermal absorption of compounds from soil.
  - Dermal absorption of chemical vapors.
  - Applications of dermal exposure, characterizing dermal exposure scenarios, estimating relative contribution of dermal exposure to total absorbed dose.
  - Many tables summarizing available data.

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| Biological aspects of skin | 4.8 | **Occupational Dermatoxicology,** by M. Boeniger. In *Modern Industrial Hygiene,* vol. 5, *Biological Aspects.* Cincinnati, OH: ACGIH, 2000.<br>• Discusses all aspects of dermatoxicology pertaining to occupational exposures, including significance, costs, biology, percutaneous absorption variables, dermatitis, clinical and laboratory testing methods, and assessing barrier function. |
| Skin function and CPC | 4.9 | *Chemical Protective Clothing,* vol. 1, J. Johnston and K. Anderson (eds.). Fairfax, VA: AIHA, 1990. Ordering information is available on-line at http://www.aiha.org<br>• Chapter 2 reviews skin structure, function, and toxicology at the level of a field industrial hygienist. |
| Skin permeation calculations | 4.10 | *Applications and Computational Elements of Industrial Hygiene,* M. Stern and Z. Mansdorf (eds.). Boca Raton, FL: Lewis Publishers, 1999. Ordering information is available at http://www.crcpress.com<br>• Contains chapters on skin toxicology and PPE at the level of a field industrial hygienist. |
| Skin toxicology | 4.11 | **Toxic Responses of the Skin,** by R.H. Rice and D.E. Cohen. In *Casarett and Doull's Toxicology: The Basic Science of Poisons,* 5th ed., C. Klaassen, M. Amdur, and J. Doull (eds.). New York: McGraw-Hill, 1996.<br>• The standard textbook for toxicology, which includes an excellent introduction to skin toxicology. |
| Toxic effects to skin | 4.12 | *Occupational Skin Disease,* 3rd ed., R.M. Adams and J. Fletcher (eds.). Philadelphia: W.B. Saunders, 1999.<br>• The standard textbook for occupational skin diseases, which describes occupational skin diseases by mechanisms of action and chemical agent.<br>• Discusses the occupations for which dermatitis is most observed and practical remedies. |
| Skin care program recommendations | 4.13 | *Essentials of Occupational Skin Management: A Practical guide to the Creation and Maintenance of an Effective Skin Management System,* by C.L. Packham. Southport, UK: Limited Edition Press, 1998. Ordering information is available on-line at http://www.small-print.org.uk<br>• Provides recommendations to create a skin-friendly work environment using engineering, personal protection, skin care products, and management tools. |
| Toxic effects to skin: Strategy for OELs | 4.14 | *Dermatotoxicology,* 5th ed., F. Marzuli and H.I. Maibach (eds.). New York: Taylor and Francis, 1996.<br>• Several chapters on skin structure, function, and biochemistry; toxic and allergic effects; decontamination; and a strategy for exposure limits.<br>• In each of the previous four editions, other topics were addressed that are not necessarily included in the latest edition. The latest edition includes those tables of contents. |

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| **Dermal and ocular toxicology** | 4.15. | *Dermal and Ocular Toxicology: Fundamentals and Methods,* D.W. Hobson (ed.). Boca Raton, FL: CRC Press, 1991. Ordering information is available at http://www.crcpress.com<br>• Emphasis on testing and biological aspects and includes ocular effects. |
| **Risk assessment** | 4.16 | *A Strategy for Assessing and Managing Occupational Exposures,* J.R. Mulhausen and J. Damiano (eds.). Fairfax, VA: AIHA, 1998. Appendix II, pp. 211–226.<br>• Provides detailed guidance on performing skin exposure risk assessments using simple formulas |
| **Pesticide exposure assessment** | 4.17 | **Field Studies: Methods Overview.** In *Dermal Exposure Related to Pesticide Use, Discussion and Risk Assessment,* by H.N. Nigg and J.H. Stamper. Washington, DC: American Chemical Society, 1985. Ordering information is available on-line at http://www.acs.org<br>• Describes:<br>▪ Pesticide exposure assessments.<br>▪ Use of pad dosimetry and dislodgeable foliar residue techniques.<br>▪ Air and biological sampling in agricultural surveys. |
| **Review article: Identifies skin absorption chemicals** | 4.18 | **Preventing Percutaneous Absorption of Industrial Chemicals: The "Skin" Denotation.** P. Grandjean, A. Berlin, M. Gilbert, et al. *Am. J. Ind. Med. 14*:97–107 (1988).<br>• Lists 275 skin notations from countries worldwide. |
| **Review article: Concepts of skin exposure** | 4.19 | **A Quantitative Definition of Exposure and Related Concepts.** V.G. Zartarian, W.R. Ott, and N. Duan. *J. Exposure Anal. Environ. Epidemiol. 7*:411–437 (1997).<br>• Review of skin surface-chemical interactions leading to percutaneous absorption. |
| **Review article: Selection of sampling methods** | 4.20 | **Assessment of Dermal Exposure to Chemicals.** J.J. Van Hemmen and D.H. Brouwer. *Sci. Total Environ. 168*:131–141 (1995).<br>• Overview of methods for assessing skin exposure<br>• Discusses sampling strategy considerations. |
| **Review article: Selection of sampling methods** | 4.21 | **Dermal Exposure Assessment Techniques.** R.A. Fenske. *Ann. Occup. Hyg. 37*:687–706 (1993).<br>• An overview of methods used to measure skin exposures. |
| **Review article: Description of sampling methods** | 4.22 | **Dermal Measurement and Wipe Sampling Methods: A Review.** B. McArthur. *Appl. Occup. Environ. Hyg. 7*:599–606 (1992).<br>• More descriptive of methods than previously cited articles, with emphasis on wipe methods. |

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| **Review article: Pesticide exposure assessment** | 4.23 | **Evaluation of Agricultural Worker Exposure to and Aabsorption of Pesticides.** G. Chester. *Ann. Occup. Hyg. 37*:509–523 (1993).<br>• Practical advice on performing field exposure assessments using techniques needed to satisfy regulatory requirements from a European perspective. |
| **Review article: Skin notations in Germany** | 4.24 | **Assignment of Skin Notation for MAK Values and Its Legal Consequences in Germany.** H. Drexler. *Int. Arch. Occup. Environ. Health 71*:503–505 (1998).<br>• Explains German requirements for biological monitoring when there is a skin notation assignment and other legal statutes. |
| **Review article: Conceptual introduction to dermal exposure limit** | 4.25 | Proposal for the assignment of quantitative dermal exposure limits in occupational environments: Part 1. **Development of a Concept to Derive a Quantitative Dermal Occupational Exposure Limit.** P.M.J. Bos, D.H. Brouwer, H. Stevenson, et al. *Occup. Environ. Med. 55*:795–804 (1998). |
| **Review article: Application of approach for setting dermal exposure limits** | 4.26 | Proposal for the assessment to quantitative dermal exposure limits in occupational environments: Part 2. **Feasibility Study for Application in an Exposure Scenario for MDA by Two Different Dermal Exposure Sampling Methods.** D.H. Brouwer, L. Hoogendoorn, P.M. Bos, P.J. Boogaard, and J.J. van Hemmen. *Occup. Environ. Med. 55*:805–811 (1998).<br>• Describes an approach and data obtained from skin wipe and wash methods to arrive at a quantitative maximum exposure limit. |
| **Review article: Skin absorption** | 4.27 | **Biological Monitoring.** V. Dermal Absorption. V. Fiserova-Bergerova and J.T. Pierce. *Appl. Ind. Hyg. 8*:F14–21 (1989).<br>• Good review of skin exposure, significance, and factors affecting skin absorption.<br>• Provides predictive model for calculating flux through the skin. |
| **Review article: Risk assessment** | 4.28 | **Techniques for Estimating the Percutaneous Absorption of Chemicals Due to Ooccupational and Environmental Exposure.** H. Leung and D.J. Paustenbach. *Appl. Occup. Environ. Hyg. 9*:187–197 (1994).<br>• Review of methods with several formulae for performing a skin exposure risk assessment. |
| **Review article: Preventing exposure** | 4.29 | **OSHA Work-Practice Guidelines for Personnel Dealing with Cytotoxic (Antineoplastic) Drugs.** R.E. Yodaiken and D. Bennett. *Am. J. Hosp. Pharm. 43*:1193–1204 (1986).<br>• Work-practice guidelines to limit the exposure of workers to cytotoxic drugs and the equipment necessary to carry out these practices. |
| **Review article: Preventing dermatitis** | 4.30 | **Allergic Contact Dermatitis: Preventive Measures in the Building and Construction Industry.** N. Holmes. *J. Occup. Health Safety: Aus. New Zealand 7*:409–416 (1991).<br>• Provides practical insights to typical deficiencies in the safe use of industrial coatings used in the construction industry.<br>• Includes suggestions to improve prevention of occupational dermatitis. |

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| **Review article: Preventing dermatitis** | 4.31 | **Occupational Dermatology: The Last Ten Years, The Next Ten Years.** R.J.G. Rycroft. *J. Occup. Health Safety: Aus. New Zealand* 3:255–262 (1987).<br>• Discusses contributing factors in occupational dermatitis due to irritant and sensitizing chemicals. |
| **Review article: Preventing dermatitis** | 4.32 | **The Importance of Skin Barrier Function.** M.J.J. Cork. *Dermatol. Treatment* 8:S7–S13 (1997).<br>• Describes how physical damage to the skin facilitates further risk of dermatitis and methods to improve skin condition. |

## 5. Professional Organizations and Web Sites

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| **ACGIH BEI® Committee** | 5.1 | **ACGIH Biological Exposure Indices Committee**<br>http://www.acgih.org |
| **OSHA guidance** | 5.2 | OSHA guidance on how to recognize, evaluate and control skin exposure hazards in the workplace.<br>http://www.osha-slc.gov/SLTC/dermalexposure |
| **OSHA guidance** | 5.3 | OSHA Guidance on assessing surface contamination, references, and includes links to relevant OSHA standards and methods.<br>http://www.osha-slc.gov/SLTC/surfacecontamination |
| **NIOSH** | 5.4 | The NIOSH Allergic and Irritant Dermatitis (AID) web site provides background information on the National Occupational Research Agenda goals for stimulating research on skin hazards and prevention. Provides many links to relevant information.<br>http://www.cdc.gov/niosh/nrderm.html |
| **AIHCE 1998 abstracts** | 5.5 | AIHCE 1998 Abstracts on Skin Exposures in the Workplace. In 2000 another session on skin exposures will occur.<br>http://www.aiha.org/abs99/abindx.html |
| **NIOSH photo library** | 5.6 | NIOSH photo library on dermatitis.<br>http://www.cdc.gov/niosh/photolib.html<br>• Created primarily for medical educators in occupational dermatology, it offers a large number of pictures, some which could be used for employee training purposes. |
| **AIHA Biological Monitoring Committee** | 5.7 | AIHA Biological Monitoring Committee offers professional advice and contacts on skin exposures as well as biological monitoring.<br>http://www.aiha.org |

## 6. Other Resources

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| **Companies providing CPC and skin care products (noninclusive)** | 6.1 | *Industrial Hygiene News* annual buyer's guide.<br>*Best Safety Directory*<br>Occupational Hazards annual directory.<br>Occupational Health and Safety annual purchasing source book. |

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| **Electronic mail list** | 6.2 | NIOSH OCCSKIN-L: Occupational and environmental skin exposure and dermatitis e-mail discussion group with exchange of information encouraged. Subscribe by sending e-mail message to: LISTSERVE@LISTSERV.CDC.GOV. In the message area type SUBSCRIBE OCCSKIN-L Your last name, Your first name. You will receive a message back in about 1 minute to which you must respond by typing "ok" in the message section. You will receive back a WELCOME message with further information about the list. |
| **Commercial presentation on choosing clothing PPE** | 6.3 | *Chemical Protective Clothing: The Last Line of Defense,* DuPont TYCHEM, Protective apparel, DuPont Nonwoven, 1996.<br>• A multimedia program on selection and use of CPC. |