

Recommendations for Chemical Protective Clothing: A Companion to the NIOSH Pocket Guide to Chemical Hazards

The *Recommendations for Chemical Protective Clothing* database:
<http://www.cdc.gov/niosh/ncpc/ncpc1.html>

NIOSH Pocket Guide to Chemical Hazards : <http://www.cdc.gov/niosh/npg/>

The *Recommendations for Chemical Protective Clothing* database is a contractor's product procured by the National Institute for Occupational Safety and Health (NIOSH). Thus, the recommendations contained in this database do not necessarily reflect NIOSH policy.

This companion provides additional information believed to be critical for properly using the provided recommendations for selecting barrier materials used in chemical protective clothing (CPC). As required by the Occupational Safety and Health Administration (OSHA) Personal Protective Equipment Standard [OSHA 1994], selection of CPC must be provided after a hazard assessment is performed and a need for CPC is determined. A non-mandatory appendix (Appendix B) in the standard provides some general suggestions on what should be included in a hazard assessment: conducting a survey of each operation, identifying specific potential hazards, organizing the data, and analyzing the information. The analysis should include a determination of the level of risk and seriousness of the potential injury from each hazard found in the area. OSHA does not present specific recommendations on how these elements are to be accomplished or how the information is to be interpreted for protection against specific chemicals and against mixtures of chemicals as they are used under a variety of conditions in industry. In reference to gloves, the appendix also states that OSHA is unaware of any gloves that provide protection against all potential hand hazards and that commonly available glove materials provide only limited protection against many chemicals. Therefore, it is important 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. The OSHA website provides the most recent guidance on performing a hazard assessment of skin exposures.

Before discussing the technical issues regarding selection of CPC, it is appropriate to introduce this subject with the understanding that NIOSH does not recommend using CPC as a first choice for preventing skin contact [Roder 1990]. NIOSH believes that CPC should be considered as the last line of defense to protect against accidental contact (e.g., spills, splashes). This is in conformance with the generally accepted industrial hygiene strategy for controlling workplace exposures to chemical hazards, which recommends, beginning with the highest preference, the following hierarchy of primary controls: (1) substitution or elimination, (2) process change, (3) isolation/enclosure, (4) ventilation, (5) good housekeeping, and (6) personal protection [Birmingham 1991]. This hierarchy of controls is similarly expressed by OSHA [1997]. In addition, three secondary means of preventing exposure and occupational illness include: (1) education and training of management, first-line supervisors, and employees, (2) medical surveillance programs, and (3) environmental monitoring. With this strategy, all chemical hazards, including those that primarily involve potential contact with the skin because of aerosol impingement or direct contact, may be effectively controlled. Experience indicates that choosing CPC as a first choice of protection is not prudent as it is likely to be the least reliable in providing consistent, dependable protection.

The **Recommendations for Chemical Protective Clothing** database is intended to provide assistance for identifying potentially appropriate types of chemical barrier material for protection against skin contact with the chemicals listed in the **NIOSH Pocket Guide to Chemical Hazards**. In the Pocket Guide, a broadly applicable phrase, **Prevent skin contact**, is used. In the **Recommendations for Chemical Protective Clothing** database, the author defines possible circumstances under which this phrase might be applied. These scenarios include damaging the skin directly, absorption through the skin and into the body, or concern for hand-to-mouth transfer. However, the Pocket Guide does not indicate in such detail the specific concern involved for each substance.

For the approximately 450 organic substances where it is recommended in the Pocket Guide to protect the skin, a recommendation for specific glove material could be provided for only 39%. For those substances where a glove type was recommended, 47% of the recommendations for glove material were for PE/EVAL co-laminate, Teflon® or Viton® polymers. Unfortunately, these latter materials are either uncomfortable to wear, lack good tactility, are fragile and expensive, or (as in the case of Teflon®) are presently difficult to purchase. Polyvinyl alcohol (PVA) polymer offers excellent resistance against many organic substances but is highly sensitive to degradation by water and may be ineffective for extended use where perspiration occurs. Thus, a glove material such as natural rubber, polyvinyl chloride, butyl rubber, nitrile, or neoprene is suggested for less than 21% of the organic substances listed in the Pocket Guide where preventing skin contact is recommended. For many organic substances that may be potential skin exposure hazards, no recommended barrier for hand protection can be presently provided. The principal reason why a specific glove material type is not provided for over 60% of the chemicals for which skin protection is recommended is because of the limitations of the American Society for Testing and Materials (ASTM) Method F739. In its most common applications, Method F739 is limited to chemicals with vapor pressures of at least 0.1 mm Hg and up to 10 mm Hg, depending on modifications to the method, or to chemicals that are water soluble so that the permeant can be collected in a gaseous or aqueous receptor stream, respectively [ASTM 1999]. However, modifications to optimize the method have suggested that toxic chemicals with very low vapor pressures will permeate most CPC materials within a short time, albeit perhaps not at the same mass flux rate as more volatile substances [Fricker and Hardy 1992]. Chemicals with low volatility may readily penetrate the skin barrier, may be highly toxic, and may tend to bio-accumulate within exposed persons over time. Thus, even small amounts of CPC breakthrough could carry a health concern.

For chemicals that exist as a powder, flake, or solid at room temperature, guidance for selecting appropriate CPC materials is generally not available because of the technical difficulties of testing membranes against such substances. It may not be prudent to assume that the chemical cannot substantially solubilize into a CPC polymer membrane or that the dry chemical will never become moistened, both potentially resulting in enhanced permeation through the barrier. If the chemical is capable of affecting the skin or causing systemic effects, a good chemical protective barrier should be worn, regardless of its physical state. A review of the literature and possible approaches to testing gloves using solid sorbents as collection media has been recently proposed to objectively determine the adequacy of CPC performance [Boeniger and Klingner forthcoming]. Additional testing results are needed regarding the effectiveness of CPC membranes against substances not previously tested.

Another problem with the published permeation data is that great inconsistencies in glove performance are sometimes reported for substances with similar chemical properties (e.g., dimethylamine, diethylamine), and a wide range of test values may be reported by different laboratories for similar glove materials. This is likely to be explained in part by the apparent inconsistent composition of manufactured gloves [Mickelsen and Hall 1987; Perkins and Pool 1997; Oppl 2001a]. Thus, kinetic testing data reported on a specific barrier membrane from one manufacturer, and even from different lot batches, may differ substantially and may not be representative of all such membranes from different sources. Imperfections during manufacturing, resulting in thin areas and even small holes that can allow penetration through

the membrane have been found in gloves meant to be used for both single use and longer term chemically resistant use [Canning et al. 1998; Dashner and Habel 1988; Sansone and Tewari 1978]. Imprecision in laboratory testing has also been cited to contribute to some of the variance in reported permeation results, which may vary up to 50% between laboratories [Oppl 2001b].

In selecting CPC materials, the user is also confronted with the fact that the actual use conditions of the CPC is likely to be different than the testing conditions used in the laboratory. Multiple variables present in actual use that are dissimilar to typical laboratory testing conditions might include higher working temperatures, mechanical stresses, and exposure to chemical mixtures. Cost and human factors, such as the need for tactility when performing a job, are also important considerations. In many cases, a glove with the longest breakthrough time may not necessarily be the most practical choice. More frequent changes but better usability may be an acceptable trade-off for choosing a glove with a shorter breakthrough time [Klingner and Boeniger forthcoming]. Over extended periods of use, gloves will likely become contaminated on the inside by repeated doffing and donning [Garrod et al. 1999; Garrod et al. 2001; Kusters 1992; Sanderson et al. 1995].

In summary, the ***Recommendations for Chemical Protective Clothing*** database should be used as a starting point for considering which barrier materials might provide resistance to chemical permeation as shown under laboratory testing conditions. When such laboratory testing data are available, it should not be assumed, that based on this information alone, selection of this material for use in the workplace will always provide adequate protection. For chemicals for which no recommended barrier material is provided, additional testing would be necessary to support any determination of adequacy after selecting a specific barrier material. Other factors, such as cost, practicality of use, workplace exposure conditions, and toxicity must be considered when choosing CPC. Finally, CPC should ideally be used only after other options to control skin exposures are investigated, and if CPC is deemed necessary, it should be used by workers with an appropriate level of understanding of its proper use.

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