

CHAPTER 5. DECONTAMINATION PROCEDURES

CHAPTER SUMMARY

In this Chapter studies relevant to decontamination of clothing, homes and equipment are reviewed. Decontamination procedures include: air showers; laundering; dry cleaning; dispersal into the air; vacuuming; shampooing; washing; and chemical or physical destruction of contaminated items. The effectiveness of decontamination procedures depends upon the physical and chemical characteristics of the contaminant, the level of contamination, and the physical characteristics of the contaminated material or item.

Clothing and carpets are perhaps the most difficult items to decontaminate. Most studies on decontamination of clothing have been on laundry procedures for pesticides, although some clothing decontamination information exists for: fibrous materials, including asbestos; beryllium; PCBs; lead; 3,4-benzo(a)pyrene; and infectious agents.

Reports on decontamination of homes that were contaminated by workers' take-home activities are limited to lead, mercury, and 4,4'-methylene-bis-(2-chloroaniline) (MOCA). Information on decontamination of buildings contaminated by dioxin and polychlorinated biphenyl (PCB) from sources other than workers' take-home activities provides additional information on the effectiveness of decontamination procedures. For asbestos, only laboratory studies are available.

Decontamination is the last resort in protecting workers' family members, a step that must be taken when preventive measures have not been used or were inadequate. The decontamination process can be hazardous to persons involved in the process. Hazardous concentrations of contaminants can be generated when handling contaminated clothing, vacuuming and mopping floors. Contaminants can be transferred to other clothing during laundry and dry cleaning. Laundry and dry cleaning equipment can become contaminated with subsequent contamination of other clothing.

Normal house cleaning and laundry practices are usually not effective. To achieve acceptable levels of decontamination, special procedures are required. These procedures include specially designed vacuum cleaners, special cleaning compounds, and use of appropriate laundry procedures, including decontamination of laundry equipment after each use. Destroying highly contaminated items such as carpets, furniture, and clothing may be the most effective and practical decontamination procedure.

DECONTAMINATION GUIDELINES

While the studies cited in this section provide information on decontamination procedures and effectiveness for several contaminants, guidelines on levels of contamination that are acceptable were found only for lead, mercury, and PCBs.

For lead loading, the Department of Housing and Urban Development (HUD) has guidelines for floors of $200 \mu\text{g}/\text{ft}^2$ ($2,152 \mu\text{g}/\text{m}^2$) and for window sills of $500 \mu\text{g}/\text{ft}^2$ ($5,380 \mu\text{g}/\text{m}^2$) [Jacobs 1994]. The HUD guidelines are not based on health considerations, they are based on levels that can be practically achieved following lead-paint abatement. These values were used by the State of Alabama [1992] and Pollock [1994]. Matte and Burr [1989] cited $1,500 \mu\text{g}/\text{m}^2$ as a level of concern for children's health. CH₂M Hill [1991] used a concentration of lead in dust of 500 ppm as an action level for cleaning residences.

Mercury concentrations in air of workers' homes of $0.5 \mu\text{g}/\text{m}^3$ and $1.0 \mu\text{g}/\text{m}^3$ were used as decontamination goals in the reports by ATSDR [1990a] and Zirschky and Witherell [1987] respectively. In a recent report on decontamination of homes in Florida, $0.3 \mu\text{g}/\text{m}^3$ was the level at which families were allowed to return to their homes following decontamination [CDC 1995].

For PCBs, EPA guidelines for indoor solid surfaces and high contact outdoor solid surfaces state that post clean-up levels should not exceed $10 \mu\text{g}/100 \text{ cm}^2$ (40 CFR 761.125). Based on PCB levels found in non-manufacturing buildings, $0.11 \mu\text{g}/100 \text{ cm}^2$ was used as a guideline for decontaminating a school building [Orris and Kominsky 1984]. Other guidelines cited by Hartle et al. [1987] were $0.5 \mu\text{g}/100 \text{ cm}^2$ for office buildings; for an aircraft plant, $2.50 \mu\text{g}/100 \text{ cm}^2$ was cited for low contact surfaces, and $1 \mu\text{g}/100 \text{ cm}^2$ for high contact surfaces.

REVIEW OF DECONTAMINATION PROCEDURES

BERYLLIUM

Shirts worn for one day in a beryllium plant were studied by Cohen and Positano [1986]. Three shirts were classified as "nearly new" and three were classified as "old." One "nearly new" and one "old" shirt was laundered at the workplace. Beryllium was present at $22 \text{ mg}/\text{m}^3$ and $30 \text{ mg}/\text{m}^3$ in the "old" washed shirt. Beryllium was present at $12 \text{ mg}/\text{m}^3$ and $20 \text{ mg}/\text{m}^3$ in the "nearly new" unwashed shirts and at $0.2 \text{ mg}/\text{m}^3$ in the "nearly new" washed shirt. Although this was a pilot study, it is the only study found that provides information on laundering clothing contaminated with beryllium or similar particulate material. The study indicates that the beryllium was laundered from the "nearly new" shirts, but that beryllium had accumulated and was well entrenched in the "old" shirts. Substantial levels of beryllium dust in air were generated during laundry procedures. The concentrations were up to $1.2 \text{ mg}/\text{m}^3$ [Eisenbud et al. 1949] compared to the occupational exposure limit of $2 \mu\text{g}/\text{m}^3$ as an 8-hr. time-weighted average [29 CFR 1910.1000].

ASBESTOS

There were no studies on the effectiveness of any methods for removal of asbestos from clothing contaminated in the workplace. One study conducted on dry cleaning a coat which contained 8% asbestos in its fabric, indicated that some of the loose fibers were removed [NIOSH 1971]. Concentrations in the air of asbestos fibers

longer than 5μ that were generated by wearing the coat before cleaning were around 2/cc whereas after cleaning the concentrations were about 0.5/cc. Since the fibers were part of the fabric, the study may underestimate the ability of laundry procedures to remove asbestos from contaminated clothing. Asbestos fibers were transferred to sport coats dry cleaned with the coat containing asbestos.

In a laboratory study, asbestos-contaminated carpets were cleaned for about 65 minutes by either dry vacuuming or hot water extraction, using vacuum cleaners equipped with high efficiency particulate air (HEPA) filters [Kominsky et al. 1990]. The carpets were artificially contaminated with 9.3×10^4 and 9.3×10^7 asbestos structures per meter squared (s/m^2), based on levels found in carpets from an asbestos-containing building. Dry vacuuming removed little or no asbestos from the carpets whereas hot water extraction removed about 70%. An important aspect of this study was the effect of the cleaning procedures on airborne asbestos concentrations. During carpet cleaning, by either method and at either level of carpet contamination, average asbestos concentrations in room air of 0.15-0.25 s/cm^3 were generated. The OSHA permissible exposure limit for asbestos is 0.1 fiber/ cm^3 as an 8-hr. time-weighted average [29 CFR 1910.1001; 29 CFR 1915.1001; 29 CFR 1926.1101].

Resuspension of asbestos fibers was observed with a fiber aerosol monitor during a daily cleaning period of a classroom by Litzistorf et al. [1985]. Resuspension of dust by cleaning activities is an important consideration not only for the decontamination process, but also for persons living in the home and performing routine cleaning operations.

LEAD

No studies on laundering of clothes contaminated with lead were found. However, Simonson and Mecham [1983] showed that a workplace airshower removed from 5% to 72% of lead oxide dust from clothing samples contaminated with about 1 mg/cm^2 , and from 23% to 69% from samples contaminated with about 0.6 - 2.5 mg/cm^2 in laboratory studies. A small amount of lead was blown through the clothing to the underclothing and body of the workers (up to 1% of the dust loading).

Ewers et al. [1994b] studied the effectiveness of dry vacuuming for removal of lead from carpets taken from homes of children who had high BLLs. These carpets were highly contaminated with surface lead loadings of 114,000 $\mu g/m^2$ to 5,650,000 $\mu g/m^2$. The carpets were vacuumed with commercially available vacuum cleaners intended for industrial use. The vacuum cleaners were equipped with HEPA filters and fitted with a commercial beater bar nozzle. The carpets were vacuumed 10 times for 1 min/ m^2 each time. Surface loadings and amount of lead removed were measured after each vacuuming. After some of the earlier vacuumings, lead loading on the surface increased by up to four times, but by the tenth vacuuming the surface lead loading was reduced to 6%-61% (average 20%) of the initial loading. The

investigators concluded that it may be more practical to replace than clean contaminated carpets.

In a study of contaminated homes near a lead smelter, the carpets were first vacuumed with a high efficiency particulate vacuum cleaner equipped with a beater bar attachment, then shampooed three times with an industrial grade shampooer [CH₂M Hill 1991]. The carpets in this study had lead loadings of 130,000 $\mu\text{g}/\text{m}^2$ to 2,500,000 $\mu\text{g}/\text{m}^2$. The cleaning procedures reduced the loadings by only 0.9%-13.5%. The authors estimated that 74 separate shampoos would be needed to remove all lead from the carpets.

Vacuuming of lead-containing carpets with a power carpet beater followed by steam cleaning with a commercial carpet cleaner containing a water-detergent mixture was also found by Milar and Mushak [1982] to have little effect on the level of lead contamination. Two steam cleanings 24 hours apart using detergent in the vacuum cleaner reduced the concentration of lead in dust by 12% and the lead loading by 38%. When a Calgon® (sodium hexametaphosphate) solution (1 lb/5 gal water) was used for the initial steam cleaning followed a day later by steam cleaning with detergent, lead concentration in the carpet dust was reduced by 61% and the lead loading by up to 91%. The authors suggested that Calgon® coats the particulate surface with phosphate or polyphosphate groups, reducing electrostatic interaction with carpet fiber and allowing easier removal by detergent. When this method was applied to decontaminating a home where a worker took home battery casings to use for fuel in the family stove, a surface lead loading of 4,125 $\mu\text{g}/\text{m}^2$ was reduced to 1,961 $\mu\text{g}/\text{m}^2$ [Dolcourt et al. 1981].

Decontamination of other surfaces is generally more effective than cleaning carpets. Farfel and Chisolm [1990] reported that the ability to reduce lead dust levels on household surfaces after lead-paint abatement activities depended on their condition. Smooth floor surfaces such as vinyl tile and linoleum tended to have lower dust levels than wooden floors which tended to be pitted, splintered and worn.

HEPA vacuuming of bare wooden floors for 1 min/ m^2 , removed from 14% to 62% of the total lead removable (95% of that present) by vacuuming for 5 min/ m^2 followed by washing with tap water [Ewers et al. 1994b]; the condition of the floors was not described. For linoleum floors, most of the lead dust that could be removed by vacuuming for 5 min/ m^2 (75% of total dust present) was removed in the first two minutes. With linoleum floors, about 20% of lead dust was removed by the post-vacuuming washing, whereas less than 5% was removed by the post-vacuuming washing of bare wooden floors.

PESTICIDES

Twenty-eight studies on decontaminating clothing contaminated with pesticides are summarized in Table 16. Many of these studies were included in a review article by Laughlin and Gold [1988]. The studies involve 33 pesticides with a wide range of

chemical and physical properties including: 14 acetylcholinesterase inhibiting insecticides (9 organophosphates and 5 carbamates); 5 organochlorine insecticides; 4 pyrethroid insecticides; 9 herbicides; and 1 fungicide. The studies were conducted with various formulations including liquids, emulsifiable concentrates, encapsulated, wettable powders, and water dispersible granules. Various fabrics were contaminated, usually by laboratory procedures, to determine the effectiveness of different laundry procedures. Fabrics of different weights and weaves (e.g., twill denim, poplin) were chosen to represent clothing worn by exposed workers; they included 100% cotton, various cotton polyester blends, and fabrics treated with soil repellents. Most of the studies were conducted using an accelerated laundering apparatus (Atlas Launder-Ometer), usually using 150 mL water. Laundry variables studied included water temperature, detergent, and pre-wash treatment.

The various laundry procedures applied to pesticides removed from about 20% to over 99% of the contaminant from the cloth, depending on pesticide characteristics, clothing characteristics, and laundry variables.

Pesticide characteristics that make cleaning difficult include: (1) formulation as an emulsifiable concentrate [Easley et al. 1981b; Kim et al. 1993; Laughlin and Gold [1989a,b; Nelson et al. 1992; Laughlin et al. 1985; Easter 1983]; (2) high concentration of pesticide [Easley et al. 1982a; Laughlin and Gold 1989a; Laughlin et al. 1985]; and (3) low solubility in water (e.g., 1 mg/L) [Easley et al. 1983]. Repeated contamination without laundering after each use also makes it more difficult to remove pesticides from clothing [Goodman et al. 1988].

Clothing characteristics that may influence the effectiveness of laundering include: weight of the fabric, chemical composition of the fiber (e.g., cotton, wool, nylon, polyester), and functional finishes (durable press, soil-release, and soil repellent). Heavier fabrics, such as denim pants, may be more difficult to clean than lighter ones, such as shirts [Kim et al. 1982].

Most studies on the effect of chemical composition of the fibers have been with various blends of cotton and polyester, ranging from 100% cotton to 65%/35% polyester-cotton. The results of these studies are variable, and most of them have found no effect with methyl parathion [Easley et al. 1981b; Easley et al. 1982b; Finley et al. 1974; Goodman et al. 1988; Laughlin et al. 1985; Laughlin and Gold 1989a]. Finley and Rogillo [1969] studied fabrics worn in cotton fields the day after spraying with a mixture of DDT and methyl parathion. They found that after-washing residues of DDT were greater for 100% cotton and 65%/35% cotton-polyester fabrics than for 50%/50% and 35%/65% cotton-polyester fabrics. The same was found for methyl parathion but to a lesser extent. By contrast, Nelson et al. [1992] found greater after-washing residues on 50%/50% cotton-polyester fabrics than on 100% cotton fabrics when organophosphates (methyl parathion, fonofos, and terbufos) were the contaminants. In the same study, Nelson et al. [1992] found residues greater on the 100% cotton fabric when carbaryl and atrazine were the

contaminants. Lillie et al. [1981] found no differences in after-washing residues between 100% cotton and 100% polyester fabrics when diazinon, propoxur, carbaryl and prometon were the contaminants.

Functional finishes generally make laundering less effective [Laughlin and Gold 1988]. Keaschall et al. [1986] found that fluorocarbon finishes reduced absorption of pesticides, but did not facilitate removal by laundering. Laughlin and Gold [1989a,b] found that while contamination of 100% cotton and 50%/50% cotton-polyester fabrics was decreased by finishing the fabrics with a fluoroaliphatic soil repellent, residual methyl parathion after washing was greater in the finished fabrics. Similar results were reported by Hild et al. [1989] for 50%/50% cotton-polyester fabric.

Laundry variables that have been studied include: water temperature, detergents, pre-wash treatment, water level, drying method (air/machine), repeated washing, and other laundry additives (bleach, ammonia).

Hot water (60°C), in general, removes more pesticides than warm (49°C) or cold (30°C) water [Lillie et al. 1981; Kim et al. 1982; Kim et al. 1986; Lillie et al. 1982; Kim and Wang 1992; Easter 1983; Easter and DeJange 1985; Laughlin et al. 1985]. With 2,4-D ester which is classified as insoluble, Easter et al. [1983] found 26% removal from contaminated fabrics washed at 30°C and 45% removal when washed at 60°C. With the 2,4-D amine (solubility 4,400-18,000 mg/L at 30°C), more than 99% was removed when washed either at 30°C or 60°C. Similarly, Chiao-Cheng et al. [1988] found that more than 99% of carbofuran (solubility 700 mg/L) and methomyl (solubility 60,000 mg/L) were removed by washing at either 49°C or 60°C.

Detergents that have been studied include heavy-duty liquid detergents without phosphates, detergents with phosphates, and those with carbonates. Easley et al. [1982b] and Laughlin et al. [1985] found that a heavy duty liquid detergent resulted in lower residual methyl parathion in fabrics after washing than when commercially available detergents containing phosphates or carbonates were used. A heavy-duty liquid detergent without phosphate was also found to be superior to a 12% phosphate detergent for laundering clothes contaminated with 2,4-D ester. By contrast, Kim et al. [1986] found that detergents containing phosphate were superior to a heavy-duty liquid detergent for removing alachlor from contaminated fabrics. Hild et al. [1989] found that a heavy-duty nonionic liquid detergent and an anionic phosphate detergent were equally effective in removing parathion from contaminated fabrics.

Pre-wash treatments have generally been found to contribute substantially to removal of pesticides from fabrics. Nelson et al. [1992] found that a commercial pre-wash product lowered the amount of contaminants remaining in fabrics after washing for 11 pesticides, and Keaschall et al. [1986] found that a pre-wash spray and a degreaser were both beneficial for removing another group of 11 pesticides from contaminated fabrics. Rigakis et al. [1987] confirmed the effectiveness of a pre-wash treatment to enhance removal of three of the pesticides studied by Nelson et al. [1992]. Kim et al.

[1986] found perchloroethylene to be a more effective pre-wash treatment than ethyl alcohol for removing alachlor from fabrics.

Water level was shown by Hild et al. [1989] to result in lower levels of methyl parathion in laundered fabrics.

Kim et al. [1986] found that machine drying of fabrics that had been contaminated with alachlor resulted in lower residual contaminant than air drying. On the other hand, Kim and Wang [1992] found no difference in residual atrazine between machine and air drying.

Repeated washing has been studied with parathion, 2,4-D ester, pyrazophos, triallate, trifluralin, and deltamethrin. Satoh [1979] found that a single washing removed 75%-95% of parathion from clothing contaminated from one day of work in a cotton field; the second washing removed a smaller percentage of the remaining contaminant. It was noted that the more contaminated the clothing the harder it was to clean.

The effect of concentration of methyl parathion on laundry effectiveness was reported by Easley et al. [1982a] and Laughlin et al. [1985]. When an emulsifiable concentrate was applied to fabrics at a concentration of 1.25%, 18% of that applied remained after the first wash, 4% after the second wash, and 0.37% after the tenth wash. When the emulsifiable concentrate was applied at a concentration of 54%, 84% of that applied remained after the first wash, 65% after the second wash, and 33% remained after the tenth wash.

Pyrazophos was applied to fabrics to simulate contamination in greenhouses by spraying or spilling [Braun et al. 1989]. When applied by spraying, the first wash removed 78% of the contaminant and the second wash removed an additional 14%. When applied by spilling, the first wash removed 92% of the contaminant but the second wash removed only an additional 2%.

Easley et al. [1983] found that a single washing of fabrics contaminated with 2,4-D ester removed about 30% of that applied and that two washings removed about 41%.

Fifty-two percent of triallate was removed by the first washing and an additional 30% by the second washing in a study by Rigakis et al. [1987]. In this same report, the first washing removed 77% of trifluralin and 84% deltamethrin; the second washings removed an additional 14% of trifluralin, and 15% of deltamethrin.

Other laundry additives such as bleach and ammonia have been found to have little effect on the effectiveness of laundering fabrics contaminated with methyl parathion [Easley et al. 1981b; Laughlin et al. 1985], or with chlorpyrifos, diazinon, and chlordane [Lillie et al. 1982].

Other clothing decontamination methods that have been studied include storage with and without air flow, and chemical decomposition by heat. Laughlin and Gold [1989a] found that residues of methyl parathion remaining in fabrics after a single wash decreased when stored in moving air up to six months. Alachor was found to degrade rapidly in contaminated fabrics heated in a convection oven at 200°C and after 30 minutes when heated at 150°C; at 150°C for 60 minutes, the residue was 0.005% of the contamination level [Kim 1989]. Microwaves of 2,450 MHz at 50W, 250W, and 500W for up to 200 seconds were not very effective.

CHLORINATED HYDROCARBONS

Kominsky [1984b, 1987a] reported on decontamination of clothing contaminated by PCBs during a fire at an electric transformer oil reclamation facility. In one setting, the Nomex® protective clothing was dipped into a tub containing detergent followed by a water rinse in a second tub. The procedure reduced the PCB surface contamination (from 15.8 µg/cm² to 0.35 - 7.2 µg/cm²), but may have increased the concentration of PCBs in the fabric (0.76 - 601 µg/gm fabric before washing; 14-1050 µg/gm fabric after washing).

Subsequently, Kominsky [1987a] conducted a dry-cleaning experiment on Nomex® clothing that was contaminated during the same fire. The clothing contained PCBs at 5.3-480 µg/g fabric. Laboratory-contaminated Nomex® clothing containing PCBs at 10,000-1,000,000 µg/g fabric were also included in the study. A trichlorotrifluoroethane (Freon® 113)-based dry cleaning machine with a revolving chamber system was used. This process reduced site-contaminated garment PCB levels by an average of 88%, and of laboratory-contaminated garments by 99%. Since safe levels of surface contamination are not known, it could not be stated if this would protect workers or prevent home contamination.

Homes were contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin) when contaminated waste oil was used for dust suppression in two neighborhoods [Hess 1988; Doherty 1984]. Hess [1988] reported on decontamination of eight residences and three commercial buildings in one of the areas. After vacuuming with a high efficiency electric vacuum equipped with a HEPA filter, every surface was wiped with a damp cloth and detergent wash. The procedure resulted in non-detectable levels of dioxin in the eight residences and two commercial buildings, and reduced the level in the most contaminated building from 36.6 ppb to 13 ppb. In the other area, Doherty [1984] removed the contaminated carpet, then thoroughly vacuumed and washed the residence with a detergent solution. A post-clean-up vacuum dust sample was negative for dioxin.

Homes contaminated with MOCA, including homes of exposed workers, were cleaned by a commercial carpet cleaner [Hesse 1991]. In the more contaminated homes, the amount of MOCA removed by vacuuming carpets before commercial cleaning was 30-300 times that collected after commercial cleaning. However, in a laboratory study, a single commercial cleaning technique removed only 31% of the

MOCA contained in a carpet from a worker's home. In this study, it was found that dry vacuuming with a good household style vacuum was equal to or better than the wet commercial method for removing MOCA from carpet.

When a transformer in a school building malfunctioned, dielectric fluid was vented into the transformer vault [Orris and Kominsky 1984]. Contamination by PCBs, trichlorobenzene, and tetrachlorobenzene occurred to varying degrees throughout the building. All vertical and horizontal surfaces in the building were washed with liquid alkaline synthetic detergent formulated for penetration and removal of PCBs. The cleaning procedure reduced PCB surface concentration in the most contaminated area by 98%, from 2,620 $\mu\text{g}/100\text{ cm}^2$ to 46 $\mu\text{g}/100\text{ cm}^2$. The cleaning procedure was also effective in reducing concentrations of PCBs, trichlorobenzene, and tetrachlorobenzene in air by 90-98%.

MERCURY

No information was found on decontamination of clothing contaminated with mercury; however contamination of washing machines after laundering contaminated clothing has been found [ATSDR 1990a; Hudson et al. 1985, 1988; Zalesak 1994].

Workers' homes contaminated with mercury have been successfully decontaminated [Zirschky and Witherell 1987; ATSDR 1990a; CDC 1995]. However, unless special techniques are used, mercury vapor can be generated in the cleanup process [Votaw and Zey 1991; Zey 1988] and vacuum cleaners can become contaminated [Tubbs and Galson 1989; Zey 1984; Zey 1988]. An employee's exposure to mercury while vacuuming in a dental office was at 69 $\mu\text{g}/\text{m}^3$ compared to 8.5 $\mu\text{g}/\text{m}^3$ when not vacuuming [Votaw and Zey 1991; Zey 1988]. Workers' family members who vacuumed and mopped floors in workers' contaminated homes were found to be at increased risk for elevated levels of mercury in urine [ATSDR 1990a].

Methodology used to successfully decontaminate workers' homes includes vacuum cleaners specially designed for mercury and use of mercury suppressants for cleaning surfaces [Zirsky and Witherell 1987; ERM Southeast, Inc. 1989; ATSDR 1990a, CDC 1995].

Vacuum cleaners for mercury are equipped with a suction hose, vacuum pump, inline mercury trap, charcoal filters to remove mercury vapor and HEPA filters to remove mercury droplets [Reisdorf and D'Orlando 1984]. Mercury suppressants chemically combine with mercury, enhancing the ability to remove it from contaminated surfaces [Murphy 1978]. Using these procedures, 25 workers' homes in Tennessee were decontaminated to mercury concentrations that were less than 0.5 $\mu\text{g}/\text{m}^3$ from decontamination levels that were up to 5.0 $\mu\text{g}/\text{m}^3$ [ATSDR 1990a]. The homes of thermometer plant workers were decontaminated to levels below 1 $\mu\text{g}/\text{m}^3$ [Zirschky and Witherell 1987]; the contaminant levels were not well described, but one report indicated the levels may have been as high as "4 times the levels allowed at work" [Trost 1985]. In a recent report of homes contaminated by children playing with

abandoned mercury, the homes were decontaminated by a combination of techniques including destruction of contaminated items, vacuuming, and ventilation [CDC 1995].

OTHER SUBSTANCES

Commercial laundering of clothing contaminated in the workplace with ceramic fibers at 50 to 500 fibers/mm² reduced the contamination by 86%-100%, resulting in levels that ranged up to 7 fibers/mm² [Weller 1994].

One article discusses the effectiveness of removing 3,4 Benzo(a)pyrene by washing work clothes worn by workers at a pitch coking plant [Masek et al. 1972]. The author states that "the present procedure of washing working underwear and clothes by no means ensures an efficient removal of the carcinogenic 3,4-benzo(a)pyrene from the fabric . . ." It is assumed that the "present procedure" was normal detergent and rinse.

Perkins et al. [1987] found that Freon® decontamination reduced toluene to 0.8% of the original exposure on a butyl rubber test material. A soap and water decontamination reduced the level to 1.1 percent. However, air drying the test material at 50°C for 24 hours reduced the level to 0.25%. This research also showed that air drying at 50°C reduced seven other solvent contaminants to limits of detection. Finding no evidence of damage to the material with this process, the authors recommended it as the preferred means of decontaminating chemical protective clothing against solvents. They noted that with small amounts of contamination from solvents with "substantially different solubility properties from the protective clothing," air drying at room temperature for 24 hours should be adequate to remove the solvent.

INFECTIOUS AGENTS

Several articles, and general recommendations [Joint Committee on Health Care Laundry Guidelines 1983] exist regarding laundering to remove biologic agents, such as anthrax, which can be transmitted to laundry personnel via work clothes [Hardy 1965], or fungal spores which can be brought into farmers' homes on work clothes [Pasanen et al. 1989].

In the medical facility setting, laundering is universally recommended, and is believed to be effective in killing or markedly reducing biological contamination of clothing and linens [Garner and Favero 1987]. Although a major emphasis of laundering in this setting is to prevent contagion spread in the medical facility, effective laundering and other decontamination practices also help to protect employees from bringing infectious diseases into their homes. A number of mechanisms are probably active in this process, including dilution and inactivation or the microbicidal properties of heat, detergents, pH changes, chlorine, and drying. Studies of bacterial survival after various types of hospital laundering have shown marked reduction of viable bacteria [Walter and Schillinger 1975], [Christian et al. 1983], [Blaser et al. 1984]. Careful procedures and appropriate equipment are needed to ensure that the laundry staff

themselves are not contaminated with the hazardous biological materials [Garner and Favero 1987; McKay-Ferguson and Mortimer 1977].

CHAPTER 6. REVIEW OF EXISTING FEDERAL AND STATES LAWS

CHAPTER SUMMARY

FEDERAL LAWS

Statutes and rules are reviewed that provide Federal agencies with relatively limited authority to prevent or remediate workers' home contamination. Table 17 displays, in summary form, the text of those statutes most relevant to this topic, while Table 18 provides a brief explanation of the relevant regulations. Examples of workers' home contamination in which Federal agencies exercised their statutory and regulatory authority are presented in the following chapter, as well as Table 19. Seven statutes were identified in the United States Code (U.S.C.), and 20 regulations were found in the Code of Federal Regulations (CFR), that addressed workers' home contamination. Below are summaries of Federal and State laws that are relevant to the issue of workers' home contamination.

Under the Occupational Safety and Health Act of 1970 (OSH Act), the Occupational Safety and Health Administration (OSHA) has limited authority to develop and promulgate standards for protecting workers' families directly; under this authority, OSHA can protect workers' families from workplace contaminants if workers are required to reside in employer-provided housing as a condition of employment. OSHA has extensive authority, however, to require that workers not carry home workplace contaminants on their clothing, in their automobiles, or by other means (i.e., by promulgating standards that require workers to remove contaminants from their skin and clothing prior to leaving the workplace). OSHA consultations conducted pursuant to 29 U.S.C. 670 also may promote, indirectly, prevention of take-home contamination.

The OSH Act does not provide specific authority to the National Institute for Occupational Safety and Health (NIOSH) to conduct studies on family protection from workers' home contamination. To the same extent that OSHA regulations and actions intended to protect workers also help assure that families are protected, however, NIOSH research assessing work hazards enables the agency to identify the potential for home contamination and make preventive recommendations. While NIOSH has no specific legal authority to evaluate conditions in workers' homes, the agency can conduct such studies with the cooperation of workers and their families.

The Federal Mine Safety and Health Act of 1977 (Mine Act) provides the Mine Safety and Health Administration (MSHA) with authority comparable to OSHA's. The Mine Act also authorizes MSHA to regulate home contamination if the mine is solely owned and operated by the miner.

The Environmental Protection Agency (EPA) has general authority under the Toxic Substances Control Act to regulate chemicals and to obtain information on the adverse effects of chemicals, thereby permitting EPA, at least indirectly, to prevent workers' home contamination. EPA has specific authority to prevent workers' home contamination under the Asbestos Hazard Emergency Response Act of 1986 and the Residential Lead-Based Paint Hazard Reduction Act of 1992.

Under the Federal Insecticide, Fungicide, and Rodenticide Act, EPA has broad authority to regulate the application and disposal of pesticides; EPA has used this authority, at least to a limited extent, to promulgate standards that prevent workers and farm owners from contaminating their homes with pesticides.

The Comprehensive Environmental Responses, Compensation, and Liability Act, and the Superfund Amendments and Reauthorization Act, authorize EPA and the Agency for Toxic Substances and Disease Registry to regard workers' contaminated homes as hazardous-waste-release sites, thereby allowing these agencies to take those measures necessary to decontaminate workers' homes and to control the sources of home contamination.

STATE LAWS

Thirty States, and Puerto Rico, responded to requests from NIOSH for information regarding State laws on this topic. These respondents indicated they had no laws currently in force relating directly to the protection of workers' families. Some of these States identified laws requiring that cases of elevated blood lead and pesticide poisoning be reported to a State agency, as well as laws addressing work practices at hazardous-waste sites and during emergency responses to the release of hazardous substances. Examination of occupational safety and health laws of States with OSHA-approved occupational safety and health programs did not find any laws that were more stringent than the commensurate Federal laws. Extension of occupational safety and health laws to State and local government employees in these States, however, provides added protection to their family members that is not available in States without OSHA-approved programs.

BACKGROUND

The first laws addressing workers' home contamination were enacted in England between 1903 and 1911 [Oliver 1914]. The purpose of these laws was to prevent workers from exposing their families to lead dust that was deposited on the workers' clothing during the work process. Enactment of these laws occurred after Oliver observed lead poisoning among workers' wives, and attributed this poisoning to the wives being exposed to lead while washing their husbands' work clothes. The following industries or work activities were subject to these laws: manual file cutting; manufacturing batteries, paints and colors, decorative pottery, and lead-containing compounds; heading lead-dyed yarn; and smelting lead-containing materials. The laws required employers to provide their

workers with clean work clothes (that employees were mandated to wear), rooms for donning and removing work clothes, and facilities for storing work clothes; employers also had to communicate and enforce prohibitions against removing work clothes from the workplace.

In the United States, a variety of statutes and rules currently provide some protection against workers' home contamination. This review found only two statutes that specifically addressed protection of workers' families. These two statutes are the:

- Asbestos Hazard Emergency Response Act of 1986, Public Law 99-519, [15 U.S.C. 2641 et seq.]; and
- Residential Lead-Based Paint Hazard Reduction Act of 1992, Public Law 102-550, Title X, Subtitle B [15 U.S.C. 2681 et seq.].

Details of these statutes are discussed below under the appropriate statute headings.

The remaining federal statutes that permit agencies to promulgate requirements addressing prevention of workers' home contamination, as well as remedial actions to be taken should such contamination occur, include the:

- Occupational Safety and Health Act of 1970, Public Law 91- 596 [29 U.S.C. 651 et seq.];
- Federal Mine Safety and Health Act of 1977, Public Law 95-164 [30 U.S.C. 801 et seq.];
- Toxic Substances Control Act, Public Law 94-469 [15 U.S.C. 2601 et seq.];
- Federal Insecticide, Fungicide, and Rodenticide Act, Public Law 92-516 [7 U.S.C. 136 et seq.];
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Public Law 96-510, [42 U.S.C. 9601 et seq.]; and
- Superfund Amendments and Reauthorization Act of 1986, Public Law 99-499 [42 U.S.C. 9601 et seq.].

The sections of these statutes related to workers' home contamination are presented in Table 17; this table also lists citations to the case law associated with these sections.³ The following discussion provides a summary of the manner in which each statute has been used to promulgate rules that address workers' home contamination.

³Note that this case law will not be discussed extensively in this review.

REVIEW OF RELEVANT FEDERAL STATUTES AND RULES

Occupational Safety and Health Act of 1970 (OSH Act)

The purpose of the OSH Act is to protect workers while they are at their place of employment. Workers' home contamination has been addressed only in a limited fashion by the two principle agencies established under the OSH Act, the Occupational Safety and Health Administration (OSHA, responsible for the promulgation and enforcement of occupational safety and health standards) and the National Institute for Occupational Safety and Health (NIOSH, responsible for research needed to identify and prevent occupational safety and health problems).⁴

OSHA. In general, OSHA appears to have limited authority under the OSH Act to develop and promulgate standards for protecting workers' families directly; under this authority, OSHA can protect workers' families from workplace contaminants if workers are required to reside in employer-provided housing as a condition of employment. This determination was made by a federal appellate court in Frank Diehl Farms v. Secretary of Labor. In this case, the employer (i.e., Frank Diehl Farms) provided employees, who were seasonal workers, with temporary housing while they were harvesting vegetables; employee use of this housing was voluntary. The housing was readily available, and little or no rent was paid by the employees for the housing; nevertheless, some employees chose to stay elsewhere. On inspecting this housing, OSHA cited the employer under the standard that regulated temporary labor camps; this standard is codified at 29 CFR 1910.142. This enforcement action was based on an OSHA instruction interpreting the standard to apply to any housing provided by employers to employees, whether or not employee use of the housing was voluntary. The federal appellate court that reviewed this case, however, interpreted OSHA's authority differently. Finding that the term "workplace" is commonly and ordinarily defined as "the place where one must be in order to do his job," the court held that OSHA could enforce this standard "[o]nly if company policy or practical necessity force workers to live in employer provided housing" This decision, therefore, implies that OSHA could cite an employer for contamination of workers' homes only if these workers were forced to reside in the housing as a condition of employment or because no reasonable alternative housing was available.⁵

⁴Section 20(a)(6) of the OSH Act authorizes NIOSH to conduct health hazard evaluations. This section requires that HHEs be performed after NIOSH receives "a written request by any employer or authorized representative of employees...." Requests submitted by individual employees, members of their families, or other parties do not satisfy this requirement.

⁵While injury or death to employees resulting from workplace hazards usually are addressed under state or federal workers' compensation systems, family members who suffer health effects associated with workers' home contamination may, under some circumstances, bring tort actions against culpable employers through the appropriate state or federal courts. Even children who have been injured in utero as a result of their parents' exposure to workplace hazards have brought negligence claims against the responsible employers (see, for example, Widera v. Ettco Wire & Cable Corp. [1994] and Agnew-Watson v. County of Alameda [1994]); the outcome of these cases, however, has been mixed, and appears to depend in large part of the

Despite the enforcement limitations implied by the decision in Diehl, OSHA has been successful in promulgating several standards that serve, indirectly, to protect workers' families from take-home contamination. These rules include the substance-specific standards for asbestos, lead, arsenic, and cadmium. While these standards contain provisions that reduce workers' home contamination, the specific purpose of these provisions is to prevent excessive worker exposure to these contaminants (i.e., employers need not comply with these provisions unless workplace contamination exceeds permissible exposure limits). These standards require, in part, that employers clean or replace contaminated work clothes periodically, train workers to handle and store contaminated work clothes properly, and provide shower and washing facilities for employee use after each work shift. (See Table 18 for a detailed listing of these requirements. Note, however, that these decontamination requirements do not apply to the hundreds of hazardous substances regulated by OSHA under 29 CFR 1910.1000.)

Several of these standards recognize the importance of preventing workers' home contamination. For example, a statement in the preamble to the cadmium standard [57 Federal Register 42349 (1992)] notes that "wearing contaminated street clothing outside the worksite would lengthen the duration of the employee's exposure and could cause cadmium to accumulate in employees' cars and homes, exposing other individuals to the hazard." Later, at 57 Federal Register 42350, the preamble mentions that, to prevent this contamination, the cadmium standard requires employees "to change out of work clothes, which are then segregated from their street clothes, to shower before leaving the plant, and to leave work clothing at the workplace, [which] significantly reduces the movement of cadmium from the workplace." The purpose of this provision is to limit additional worker exposure to cadmium and to "provide added protection to employees and their families."

Statements in the preamble to OSHA's asbestos standards [59 Federal Register 49964 and 41012 (1994)] recognize the hazard of asbestos to workers' family members, noting that "studies have documented that in the past workers have brought asbestos contaminated clothing home with them and thereby caused exposure and asbestos-related disease among family members." OSHA found that this situation warranted "special consideration"; therefore, the asbestos standards for construction and shipyards [29 CFR 1926.1101 and 29 CFR 1915.1001, respectively] require that employers control the release of asbestos particles from contaminated work clothing using several different procedures depending on the type (or class) of work being performed by the employees.

OSHA's lead standards [29 CFR 1910.1025, 29 CFR 1915.1025, and 29 CFR 1926.62] have similar hygiene requirements. Appendix B of these standards, entitled "Employee Standard Summary," advises that "contaminated work clothing or equipment must be

willingness of a court to recognize a child's claims as independent from any cause of action that could be asserted by a parent.

removed in change rooms and not worn home or you will extend your exposure and expose your family since lead from your clothing can accumulate in your house, car, etc."

The OSHA standards addressing hazardous-waste operations and emergency response [29 CFR 1910.120, and 29 CFR 1926.65] have requirements for wearing protective clothing, decontaminating employees, and decontaminating or disposing of contaminated clothing and equipment before leaving the worksite. These standards, however, contain no specific advisory information regarding contamination of workers' automobiles and homes.

OSHA's hazard-communication standards [29 CFR 1910.1200, 29 CFR 1915.1200, and 29 CFR 1926.59] require that employees be advised about hazards with which they work. While not required by OSHA under these standards, information on workers' home contamination could be included in Material Safety Data Sheets that accompany hazardous chemicals, and could be incorporated as well into employee training.

NIOSH. NIOSH's research authority to study occupational safety and health hazards [29 U.S.C. 669] enables the agency to identify instances for which the potential for home contamination exists, and to make preventive recommendations regarding this problem. NIOSH also is authorized to recommend safety and health standards to OSHA [29 U.S.C. 671(c)]. Operating under the same limitations as OSHA, the basis of NIOSH-recommended standards must relate directly to the protection of workers, but the recommendations may be equally effective in protecting the workers' families. Under this authority, the agency compiled information regarding workers' home contamination in NIOSH criteria documents for asbestos [NIOSH 1972a, 1977], beryllium [NIOSH 1972b], and mercury [NIOSH 1973]). In a recommended standard on the manufacture and formulation of pesticides, NIOSH recommended that work clothing not be worn or taken home to be laundered, and that the clothing be laundered by the employer [NIOSH 1978].

Federal Mine Safety and Health Act of 1977 (Mine Act)

The Mine Act at 30 U.S.C. 802 and 803 provides indirect authority for preventing workers' home contamination. These sections require that an employer who also is an employee in his/her workplace (i.e., an owner-miner of a mining operation) must comply with applicable safety and health rules developed under the statute by the Mine Safety and Health Administration (MSHA). If a mine, for example, is located on the owner's home/family property, and the owner is the only miner involved in extracting minerals from the mine, the owner must provide himself/herself with the safety and health measures prescribed by the appropriate MSHA rules. Under these circumstances, compliance with the MSHA rules will reduce exposure of the owner-miner's family to mineral dusts and other mining contaminants.

Having more general implications for the protection of miners' families, § 811 of the Mine Act grants MSHA authority to establish rules to protect miners from exposure to

toxic substances, and specifically grants MSHA the authority to establish rules addressing suitable protective equipment. As with OSHA standards, these rules can ultimately protect both miners and their families.

Additional protection against home contamination by miners is provided implicitly in § 877 of the Mine Act. This section authorizes MSHA to require that employers make sanitary and bathing facilities available at the worksite for use by miners in removing mining-related contaminants; also, these facilities must be adequate for miners to change and store their work clothes between work shifts. These requirements have been incorporated into regulations for coal mines [30 CFR 71.400-404 and 30 CFR 75.1712].

NIOSH has authority under § 951 of the Mine Act to conduct research on the health effects of exposure to mining operations, and to make preventive recommendations.

Toxic Substances Control Act (TSCA)

The Environmental Protection Agency (EPA) has extensive authority under TSCA to regulate chemical hazards. Under 15 U.S.C. 2604 and 2605, EPA can regulate the manufacturing, processing, use, distribution in commerce, and disposal of new and existing chemicals, respectively. While another section, 15 U.S.C. 2682, does not refer explicitly to the hazard of take-home lead to workers' families, paragraph (a)(1) of this section directs EPA to "promulgate final regulations governing lead-based paint activities to ensure that individuals engaged in such activities are properly trained, that training programs are accredited, and that contractors engaged in such activities are certified." This provision states further that "[s]uch regulations shall contain standards for performing lead-based paint activities, taking into account reliability, effectiveness, and safety." A later provision of this section requires a "Study of Certification," and states that "[t]he Administrator [of EPA] shall conduct a study of the extent to which persons engaged in various types of renovation and remodeling activities in target housing...are exposed to lead and create a lead-based-paint hazard on a regular or occasional basis." A subsequent paragraph of this section requires that regulations promulgated under paragraph (a)(1) of this section be amended as appropriate using the results of such a study. Should such a study find hazards to the health of workers' families resulting from the workers' lead-based paint activities, EPA is obligated to establish training and certification requirements to reduce or eliminate the risk of injury to these families.

The following provisions of the TSCA also are useful in reducing the risk of workers' home contamination: 15 U.S.C. 2604 (requiring an evaluation by EPA of the health and environmental effects of new chemicals, and of significant new uses of existing chemicals, prior to the manufacture, or new use, of these chemicals); 15 U.S.C. 2605(a) (mandating that chemical manufacturers and processors provide notice of unreasonable risk of injury resulting from their chemicals); 15 U.S.C. 2607(c) (providing that chemical manufacturers, processors, and distributors maintain records of significant, adverse health effects resulting from chemicals for which they are responsible); and 15 U.S.C. 2607(e) (imposing on chemical manufacturers, processors, and distributors a duty to report

immediately information that a substance or mixture for which they are responsible presents substantial risk of injury to health).

Under 15 U.S.C. 2605(a) (i.e., the provision of the TSCA granting EPA authority to regulate hazardous-chemical substances and mixtures), EPA promulgated a standard [40 CFR 763.121] that prescribes full-scale decontamination procedures following asbestos-abatement actions performed by state and local government workers; these asbestos-decontamination procedures are somewhat abbreviated for workers involved in small-scale, short-duration asbestos-abatement actions. Among the asbestos-decontamination procedures specified under this standard is a requirement that workers wear protective clothing, and that this protective clothing be handled appropriately to avoid release of asbestos fibers; this standard, therefore, indirectly prevents asbestos contamination of workers' homes.

Asbestos Hazard Emergency Response Act of 1986

This act contains a provision [15 U.S.C. 2646(b)(1)(B)(xi)] that addresses, explicitly, workers' home contamination. This provision requires implementation of "[h]ousekeeping and personal hygiene practices, including the necessity of showers, and procedures to prevent asbestos exposure to the employee's family." Additionally, this act specifically requires that state plans for accrediting asbestos-removal contractors contain procedures to prevent asbestos contamination, including contamination of an employee's family. This requirement was implemented by EPA under Appendix C to 40 CFR part 763, subpart E.

Residential Lead-Based Paint Hazard Reduction Act of 1992

This Act has several provisions that indirectly protect workers' families from lead-contaminated dust in their homes. These provisions include the development of a health-based standard for lead-contaminated household dust, development of a comprehensive, lead-exposure abatement program, and studies of the sources of lead exposure among children, including the occupational contribution to this exposure. In addition to the sections of this act presented in Table 17, the following sections may be considered relevant to preventing workers' home contamination: 15 U.S.C. 2682(a); 15 U.S.C. 2682(c)(2); and 15 U.S.C. 2682(c)(3).

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Under 7 U.S.C. 136(w), EPA has broad regulatory authority to establish standards that prevent, indirectly, contamination of workers' homes. This section authorizes the promulgation of standards "with respect to the package, container, or wrapping in which a pesticide or device is enclosed for use or consumption, in order to protect children and adults from serious injury or illness resulting from accidental ingestion or contact with pesticides or devices regulated by this subchapter, as well as to accomplish the other purposes of this subchapter." Using this authority, EPA has promulgated a number of

rules that protect workers' families. These standards include: Child Resistant Packaging [40 CFR 157]; Certification of Pesticide Applications [40 CFR 171]; Labeling Requirements for Pesticides and Devices [40 CFR 156]; and the Worker Protection Standard [40 CFR 170].

The provisions of the Worker Protection Standard contain requirements that, at least indirectly, prevent workers' home contamination. The principal purpose of this standard is to protect workers from exposure to pesticides that are used during normal pesticide operations by the agricultural, nursery, greenhouse, and forestry sectors; with regard to the agricultural sector, this standard also requires prevention of accidental exposure of workers and other persons to pesticides. The phrase "other persons" would include family members (of both workers and the owners of agricultural establishments) who may be in the vicinity of pesticide operations. Another provision of this standard [40 CFR 170.112] requires owners of agricultural establishments to prevent workers from entering pesticide-treated areas until the pesticides have dissipated from these areas. This provision also requires that protective clothing be: worn by workers while applying pesticides; cleaned daily after use according to clothing manufacturers' instructions and instructions provided on pesticide-product labels;⁶ cleaned separately from other clothing; and stored, after cleaning, away from contaminated areas and separately from other clothing. In addition, those who launder protective clothing must be informed of the: pesticide-contamination problem; harmful effects of pesticide contamination; correct methods of handling and cleaning protective clothing; and procedures to use in protecting themselves from contamination. While the requirements of this provision could, indirectly, do much to prevent workers' home contamination, prevention is incomplete because the owners of agricultural establishments are not required to provide this protection for themselves or members of their immediate families; the standard does, however, encourage them to do so.

The Certification of Pesticide Applications standard [40 CFR 171] requires certification of pesticide applicators, including farm owners and farm workers, who apply restricted-use pesticides; these applicators must be certified for each restricted-use pesticide they apply. To be certified, these applicators must be able to read and understand the pesticide-product label, and have practical knowledge of the correct use, storage, handling, and disposal of pesticides and pesticide containers. Full compliance with these certification requirements would do much to prevent workers' home contamination.

The provisions of 40 CFR part 165, authorized under FIFRA at 7 U.S.C. 136(q), address specifically the storage and disposal of pesticide containers. If these provisions were properly implemented, the incidence of child poisoning resulting from improper disposal

⁶The Labeling Requirements for Pesticides and Devices standard requires that labels on pesticide containers provide information regarding worker protection. These labels, however, are not required to prescribe the decontamination procedures to be used on protective clothing. Shirts, short pants, shoes, and other items of ordinary work clothing are not considered protective clothing and, therefore, are not subject to these requirements.

of pesticide containers, a serious problem in the agriculture sector, would be substantially reduced.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)

CERCLA was enacted in 1980 in response to concerns by Congress regarding hazardous-waste disposal problems [Ways and Means Committee 1980]. These concerns involved sites that contained large quantities of hazardous wastes, unsafe hazardous-waste disposal practices, and the substantial dangers to health and the environment resulting from improper hazardous-waste disposal. A primary purpose of SARA, the 1986 Superfund Amendments, was to decontaminate abandoned hazardous-waste sites and leaking, underground-storage tanks that present the most serious public health and/or environmental hazards [Energy and Commerce Committee 1986].

The primary purpose of CERCLA is to address major hazardous-waste issues and to protect the public from emergency releases of hazardous substances; however, as discussed by Zirschky et al. [1987] and Zirschky [1990], several sections of CERCLA and SARA provide, at least indirectly, protections against workers' home contamination (Table 17). These protections are inferred from the: broad definitions of "facility," "hazardous substance," "release," and "pollutant or contaminant"; and the authority assigned to EPA and to the Agency for Toxic Substances and Disease Registry (ATSDR) to designate hazardous substances, respond to releases of hazardous substances, and perform health assessments near hazardous-waste sites.

Under the CERCLA provisions, two occupational groups have been identified that are at enhanced risk of workers' home contamination. The first occupational group consists of workers who remediate (i.e., "clean up") hazardous-waste sites; this workforce is both large and highly mobile. Remediation work involves exposure of workers' protective clothing to chemical contaminants, and these contaminants can be carried to workers' homes unless adequate workplace safeguards are in place. The second occupational group is composed of chemical-emergency responders. ATSDR data indicate that chemical emergencies are frequent, and often result from industrial-plant mishaps, transportation accidents, and improper disposal of chemicals. Emergency responders can transport chemical contaminants into the home unless clothing changes and other safeguards are effected.

The worker protection standards [29 CFR 1910.120 and 40 CFR 311] required under § 126 of SARA have provisions for changing and decontaminating work clothing, providing change rooms, and showering before leaving a hazardous-waste site. Adherence to these requirements should prevent home contamination by hazardous-waste workers.

Constraints incorporated into CERCLA reduce the likelihood that incidents of workers' home contamination will be addressed extensively by either EPA or ATSDR. These constraints include: in responding to hazard-waste releases, the highest priorities must be

assigned to releases that present the largest public health threat [42 U.S.C. 9604]; and specification of strict criteria for determining these priorities [42 U.S.C. 9605]. Criteria to be considered in determining these priorities are the: population at risk; harmful effects of toxic substances located at hazardous-waste sites; likelihood that these substances have contaminated, or will contaminate, drinking water; and the potential for direct human contact with these substances.

Under these provisions, the following rules have been promulgated: 40 CFR 300, which resulted in the National Priorities List consisting of high-priority, hazardous-waste sites; and 40 CFR 302, which specifies hazardous substances and the reportable-release quantities of these substances (i.e., quantities of hazardous substances that, if released, may be harmful to public health and/or the environment and must, therefore, be reported to the National Response Center). While these constraints may limit EPA and ATSDR in prevention and control of workers' home contamination, recent case law indicates that State and Federal courts may provide an alternate vehicle for addressing this issue under CERCLA and SARA.⁷

Although decontamination of workers' homes is not addressed directly under any of the above-mentioned rules, some hazardous-waste sites (Alaska Battery Enterprises, Anderson Development Company, and Borfos Nobel, Inc.) designated on the National Priorities List have been identified as sources of workers' home contamination. As EPA and ATSDR conduct studies at other sites on the National Priorities List, additional cases of workers' home contamination may be found. Many of the chemicals noted in previous chapters as being involved in workers' home contamination are on the priority list of hazardous substances [40 CFR 302], and these chemicals typically have low reportable-release quantities (i.e., 1-10 pounds).

REVIEW OF STATE LAWS

NIOSH requested information (Appendices 2 and 3) on State and local laws that were relevant to preventing workers' home contamination. The responses from State agencies to these requests are summarized in Tables 20 and 21. Agencies from 30 States and Puerto Rico responded to this request; these responses also are summarized in Tables 20 and 21. Eleven States and Puerto Rico replied that no statutes or rules related to workers' home contamination currently are in force. Arizona, California, and Idaho reported that laws existed for reporting elevated blood-lead levels and/or pesticide poisonings. Michigan, Maine, and Pennsylvania reported on laws, similar to CERCLA, that regulated hazardous-waste sites and the emergency response to hazardous-chemical releases. Oregon wrote that, while no laws or regulations dealing directly with workers'

⁷In *Vermont v. Staco, Inc.* [1988], the court awarded the plaintiffs (the state of Vermont and the village of Poultney) nearly \$74,000 in damages for decontamination costs incurred by the plaintiffs in responding to a release of mercury from the defendants' thermometer-manufacturing facility into Poultney's sewer system. In finding the defendants liable, the court stated that "the defendants released mercury to the environment through the movement of workers to and from the...facility in [the village of] Poultney."

home contamination had been enacted, many occupational safety and health regulations had been promulgated that help, indirectly, to prevent this problem.

About half of the respondents have occupational safety and health programs approved by OSHA. To be approved, a State's occupational safety and health laws have to be at least as protective of workers as the Federal laws. To determine whether any of these laws had requirements that are more stringent than the commensurate Federal OSHA regulations, the occupational safety and health laws of States with OSHA-approved programs were obtained and evaluated. Most of the State laws were identical to the Federal OSHA regulations with regard to workers' family protection; unlike the Federal OSHA regulations, however, the State laws apply to State and local government employees. Thus, in States that have OSHA-approved programs, the families of government employees have benefitted indirectly from provisions of the arsenic, asbestos, cadmium, and lead standards requiring that workers shower and change clothes before leaving the workplace; in contrast, the families of State and local government employees in the remaining States may not have benefitted from these requirements because compliance by these State and local governments is voluntary.