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Cora R. Roelofs & Michael J. Ellenbecker

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Results of the Massachusetts Methylene Chloride End-Users Survey

Cora R. Roelofs[1] and Michael J. Ellenbecker[2]

[1]Department of Adult Oncology, Dana Farber Cancer Institute and Department of Health and Social Behavior, Harvard School of Public Health, Boston, Massachusetts; [2]Department of Work Environment, University of Massachusetts, Lowell, Massachusetts

A survey of Massachusetts companies reporting use of methylene chloride between 1995 and 1999 was conducted to assess the status of industrial use of the chemical in 2000. Methylene chloride has had wide use in industry although it has been identified as potentially hazardous to exposed workers and the environment. New and tightened occupational and environmental regulations taking effect in the 1990s were hypothesized to have reduced use of the chemical in Massachusetts. Substitute technologies, especially aqueous cleaning, were expected to have replaced methylene chloride in many industries. Seventeen of the 21 Massachusetts manufacturing companies reporting use of over 10,000 lb/y of methylene chloride between 1995 and 1999 were surveyed by telephone regarding their experiences of methylene chloride use and elimination and/or replacement. Fifteen of the 17 companies had either eliminated (10) or reduced to below 10,000 lbs/yr (5) their use of methylene chloride at the time of the survey in 2000. Many of the surveyed companies moved to aqueous cleaning from methylene chloride degreasing operations. Environmental concerns were the most popular reason given for eliminating or reducing use of methylene chloride. Worker health and safety concerns, especially concern about compliance with the 1997 Occupational Safety and Health Administration methylene chloride standard, were also a motivation. In general, the companies associated many benefits and few problems with eliminating or reducing use of methylene chloride. Exposure reduction strategies based on toxics use reduction techniques appear to be feasible for many manufacturing companies. However, research should be conducted to assess the introduction of new hazards as a result of tightened regulations on methylene chloride.

Keywords Methylene Chloride, Engineering Controls, Toxics Use Reduction, Massachusetts

To gain information about use of methylene chloride, also known as dichloromethane (DCM), in light of recent environmental and occupational regulations, Massachusetts manufacturing companies reporting use of the chemical between 1995 and 1999 were surveyed via an open-ended survey instrument. The survey sought information about how these companies used DCM and their recent experiences of its use, elimination, and/or replacement. The information collected from these companies was expected to shed light on the feasibility and effectiveness of toxics use reduction strategies for hazard prevention.

In a compliance guide for employers operating vapor degreasers, the U.S. Occupational Safety and Health Administration (OSHA) advises that "local exhaust ventilation is often the best way to reduce methylene chloride exposures to acceptable levels."[(1)] However, the Clean Air Act's Maximum Available Control Technology (MACT) standard for vapor degreasers using DCM discourages the use of local exhaust ventilation, citing increased consumption of the chemical, costs, and potential for environmental contamination.[(2)] Toxics use reduction strategies—changes in production processes or raw materials that reduce, avoid, or eliminate the use of toxic or hazardous substances—have the potential to avoid conflicts between environmental and worker protection.[(3)] Based on data showing reduction in total use of DCM in Massachusetts from 1990 to 1999, it was hypothesized that surveyed companies would have reduced their use of the chemical, and that they would have done so by utilizing toxics use reduction techniques, especially substituting aqueous cleaning for DCM degreasing.

DCM was selected as the subject of this research because of its toxicity, recent increased regulation, and extensive use in industry. DCM has been determined to be a potential occupational

carcinogen by OSHA, the U.S. Environmental Protection Agency's National Toxicology Program, the International Agency for Research on Cancer, and the National Institute for Occupational Safety and Health.[4–7] Additionally, DCM can cause systemic toxic effects on the central nervous system and heart (resulting from DCM metabolism to carbon monoxide), and eye, skin, and mucous membrane irritation.

In 1997, a new comprehensive OSHA regulation lowered the permissible exposure limit for DCM from 500 ppm to 25 ppm (8-h TWA), and required that employers conduct exposure monitoring, training, and medical surveillance, and utilize engineering controls to control exposure.[8] DCM is also regulated as a Hazardous Air Pollutant under the Clean Air Act and it is a reportable chemical under the 1989 Massachusetts Toxics Use Reduction Act (TURA).[2,3] TURA was established to facilitate the reduction of toxic waste in Massachusetts by 50 percent using toxics use reduction techniques—a goal that was met by 1998.[9] TURA does not require companies to reduce toxic chemical use, but it does require that they report their use of over 10,000 lbs/yr of federally listed chemicals and that they utilize the services of a certified Toxics Use Reduction Planner (who may be a company employee) to create Toxics Use Reduction Plans. The reporting and planning requirements apply to companies in covered Standard Industrial Classifications (manufacturing, mining, transportation, wholesale, and some services are included—agriculture, construction, health, education, and government are excluded) that employ more than 10 full-time workers.

DCM is a high vapor pressure solvent used in many industries for many purposes. In the preamble to the 1997 OSHA standard, OSHA estimated that 237,500 workers were potentially exposed to DCM in over 92,000 establishments. DCM is used to clean metal, strip paint from metal and wood surfaces, blow foam, coat pharmaceutical tablets, formulate aerosols, cast film, carry adhesives, and dissolve plastic in a process called solvent welding. The greatest uses of the chemical are in paint strippers and adhesives. DCM is considered desirable in many operations because it is not flammable, has good organic solubility, is inexpensive, and lacks photoreactivity and ozone-depleting power.

Overall consumption of DCM in the United States declined throughout the 1990s and is projected to continue to decline.[10] However, following the ban of ozone-depleting substances such as chlorofluorocarbons, and restrictions on global-warming volatile organic compounds, some companies have substituted DCM for these more tightly regulated substances. For example, DCM has substituted for other organic solvents in adhesive formulations and in metal degreasing operations.[11–13]

METHODS

The Massachusetts TURA data were searched for companies reporting use of DCM between 1995 and 1999 (the last year of available data).[14] Forty-nine companies fit this initial criterion. From this group, companies were selected that appeared to be "end-users" of DCM, rather than shippers, waste handlers, formulators, or distributors of products containing DCM as an ingredient. A company was excluded as a nominal "chemical" company if its reported use data showed a close match between amounts "processed" and amounts "shipped." This segregation resulted in a group of 21 "using" companies.

Contact information could not be obtained for 2 companies; the 19 remaining companies were contacted by fax and phone for participation in the survey. The surveyor asked company receptionists for the person at the company who could answer questions about use of DCM. After determining appropriate contact personnel at each company, a cover letter and copy of the survey questions were faxed to the identified individual at each company. Within one week of the fax, the investigator contacted each individual by phone. Two refused participation and seventeen surveys were collected, primarily by 20–30 minute phone interview (two faxed their responses) during June and July 2000.

The survey asked respondents (primarily environmental health and safety managers) about the primary operations of the facility and the number of full-time employees. It asked about 1) current and past DCM use including the purpose of its use; 2) why DCM had been selected; 3) plans, if any, for reduction or elimination of use; 4) when and why its use was ended and what it had been replaced with; and 5) any problems or benefits resulting from such changes. The survey questions were open-ended to minimize bias inherent in self-reported data and to promote a richer understanding of company behavior and attitudes than is possible in a closed-ended survey.

In an open-ended format, company representatives use their own language to describe their company's experience, instead of picking from pre-determined responses that might betray the researchers' preferences.[15] Responses were hand-recorded on forms by the surveyor who attempted to capture as much of the responders' language as possible. In addition to the survey data, data on these companies' DCM use from 1990 to 1999 were compiled from publicly available TURA data.

RESULTS

DCM use by all companies reporting in Massachusetts declined from 7.8 to 5.9 million lbs from 1990 to 1999.[15] The TURA data show that of the 49 companies reporting DCM use after 1994, only 23 (49%) were still reporting use in 1999. Use also declined for the 21 companies designated as end-users in this study. These companies' reported use went from 1.8 million lbs in 1990 to 0.8 million lbs in 1999—a decline of 58 percent. As shown in Figure 1, total use in these companies rose in the mid-1990s and then steadily declined after 1995. Use of DCM peaked in 1995 with 17 of the 21 companies reporting a total of 1.9 million lbs that year. Reported "releases" of DCM—defined as either stack or fugitive emissions—declined in the using companies by 94 percent from 1990 levels, from 0.6 to 0.04 million lb/y (see Figure 1).

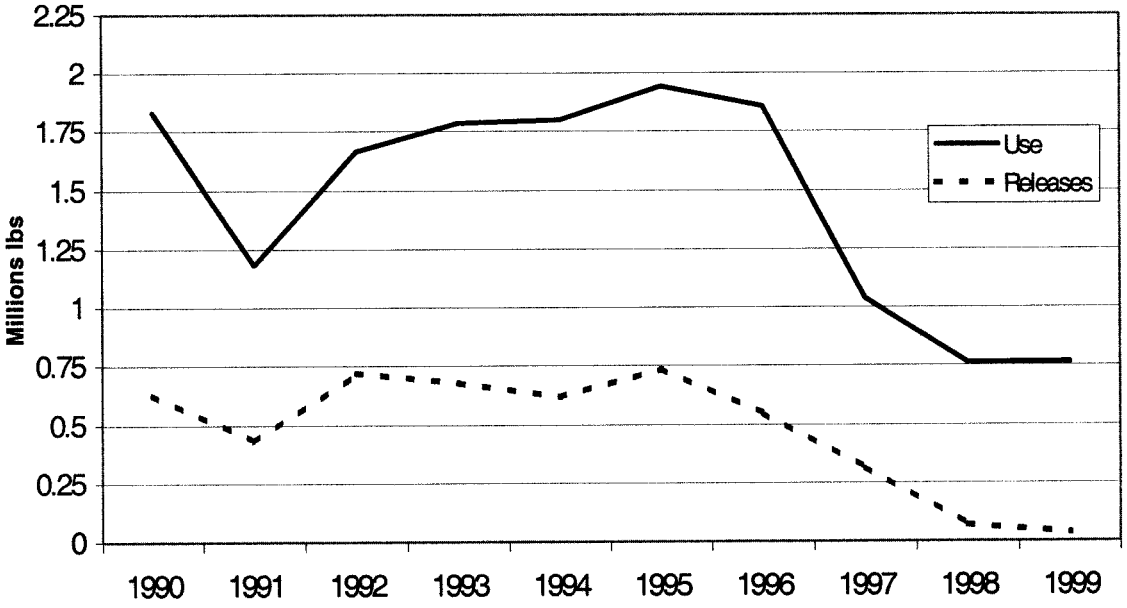

FIGURE 1
Massachusetts end-users' reported use and release of methylene chloride.

The 17 companies that responded to this survey manufacture a variety of products including guns, foam mattresses, and pharmaceuticals (see Table I). The surveyed companies ranged in size from 30 to over 2000 full-time employees. The median size was 160; however, 8 employed 100 or fewer workers.

Only 2 of the 21 companies classified in this study as end-users based on their use of DCM after 1994 were still reporting use of DCM over 10,000 lb/yr in 1999. However, as discussed above, a company is no longer required to report *any use* if their use drops below 10,000 lb/yr. The survey found that 7 of the 17 (41%) surveyed companies were still using DCM at the time of the survey (mid-2000) and, of these, 5 (29%) were using less than 10,000 lb/y of the chemical. In other words, 10 (59%) of the 17 companies reporting DCM use between 1995 and 1999 had stopped using the chemical altogether, and another 5 had reduced their DCM use to below 10,000 lb/yr.

Table I details the former and current uses of DCM by the surveyed companies. In 11 cases (65%), DCM was used for degreasing and cleaning parts, equipment, and products in vapor degreasers or by manual cleaning processes. DCM was used as a thinner or solvent in three applications. Other uses, including as a process chemical, were particular to a company's manufacturing operations. Of the ten companies that ceased using DCM, eight had been using it for either cleaning or thinning—two applications with readily available substitute materials and processes.

The seven companies still using DCM were asked why they continue to use it. The most common response was, "It works," and/or that they had not yet found acceptable substitutes. Other responses included that customers required DCM, it was nonflammable, and it was selected years ago. All of the companies still using DCM reported plans to reduce or eliminate their use of the chemical. Examples of their strategies to reduce or eliminate use included trying to convince customers to not require it; ongoing operations and maintenance improvements; phasing it out with declining customer demand; and tight degreaser controls required by the MACT standard.

Fourteen companies that had reduced their use or stopped using DCM provided the reasons why their DCM use declined or was eliminated. The 1997 OSHA standard was cited as the specific reason in three cases. One of these companies reported that they had eliminated use because they could not meet the OSHA standard while using the chemical. Two others mentioned medical surveillance and respirator requirements as burdens they wished to avoid. General worker health and safety concerns related to DCM as a hazardous material—"a bad actor," as one company put it—were cited as a reason in part or in full for reduction or elimination of DCM use in six cases. Eight companies mentioned environmental goals or compliance with environmental regulation as a reason for their reduction in use. Environmental motivations cited included compliance with a required toxics use reduction project as a supplemental environmental project for a Clean Air Act violation; fear of a ban; and the "regulatory climate."

Most of the companies that had reduced or eliminated their use of DCM did so by utilizing chemical, process, and/or equipment substitution. Hydrocarbon solvents, including toluene, trichloroethylene, acetone, n-methyl pyrrolidone, ethyl acetate, and methanol, took DCM's place in eight cases. Aqueous cleaning and thinning were popular substitutes; seven companies reported moving to aqueous processes. Substitute aqueous cleaning processes utilized alkaline cleaners in either immersion tanks

TABLE I
Surveyed companies DCM use status in 2000

DCM use	Industrial activity	Using less than 10,000 lbs	Using more than 10,000 lbs	Not using	Year stopped
Cleaning/degreasing					
Degreasing metal machined parts	Instruments mfg.			√	1997
Vapor degreaser; surface prep for painting	Materials testing systems mfg.			√	1997
Degreaser	Anti-theft equipment mfg.			√	1997
Vapor degreaser	Gun maker			√	1996
Vapor degreaser	Gun maker			√	1998
Degreasing, clean resin injection molds	Plastic foam products			√	1997
Solvent washing and treating of membranes	Specialty plastics			√	1998
Clean equipment of epoxy resin coating	Filtration supplies	√			n/a
Vapor degreaser	Electroplating	√			n/a
Clean parts before painting	Sheet metal fabricator	√			n/a
Thinner (and cleaner)					
Spray paint thinner and cleanup solvent	Grinding wheel mfg.			√	1998
Epoxy cleaner and silicone sealant thinner	Capacitors mfg.			√	1999
Solvent in adhesive	Fabric coatings mfg. and service	√			n/a
Other					
Blowing agent in foam	Foam mfg.			√	1996
Reaction catalyst and process solvent	Pharmaceutical mfg.	√			n/a
Process solvent: purification/catalyst	Pharmaceutical mfg.		√		n/a
Process solvent in assembly of devices	Filtration supplies		√		n/a

or immersion plus ultrasonic action in manual or automated systems. Some companies used several strategies including combining process changes to reduce the need for the solvent with the use of substitutes. These included new adhesive application equipment that eliminated the need for thinner; process modification and product composition change permitting a water wash; new customers not requiring it coupled with declining orders requiring DCM; water-based spray paint booths; and efficiency improvements that reduced solvent use. Liquified CO_2 and thermal heat cleaning were two newer technologies mentioned by companies.

Companies were asked if they had experienced any problems with these substitute chemicals, processes, and equipment. Eight reported that they had not experienced any problems. Problems reported by the others related to initial start-up adjustments, increased cycle time for rinsing and drying, less effective cleaning, new fire hazards, and customers still demanding use of DCM.

Fourteen companies reported a variety of benefits including elimination or reduction of DCM exposure to workers and the environment (7), hazardous waste and other costs (6), reporting and other compliance requirements (8), and the use of other chemicals (2). Cost savings were attributed to reduced hazardous waste costs, reduced chemical costs as less DCM was purchased, and reduced production time devoted to pre-cleaning. Compliance benefits mentioned by companies included compliance with the OSHA standard, not having to report under TURA or federal environmental protection laws, and greater ease in meeting air permit requirements. Two companies reported production efficiency improvements from the change, one reported that their "operators were thrilled," and another said that it had gotten new business as a result of being able to provide environmentally friendly formulations. Three companies did not report any benefits of the new processes or the reduced use of DCM.

DISCUSSION

The decline in use and releases of DCM in Massachusetts represents an impressive effort on the part of companies and regulators to eliminate DCM pollution. The TURA data for the surveyed companies show an especially dramatic decline from the peak 1995 levels. However, the actual decline in use is less than is apparent from TURA data because the reporting amounts drop to 0 for companies that continue to use DCM, but at levels under the 10,000 lb/yr threshold. Indeed, the survey showed that while only 2 companies were still reporting use of DCM under TURA in 1999, an additional 5 continued to use it at levels below the reporting threshold. However, the survey also found that 10 of the 17 companies had actually eliminated use

of DCM completely as they stopped reporting. The decline in use of DCM in Massachusetts is likely to continue; companies in this survey currently using DCM stated their commitment to further reduce or eliminate their use of the chemical and chemical industry economic forecasters have also predicted a decline in consumption for the United States as a whole.[10]

Of central importance for the purpose of this research, the survey results show that DCM end-users have accomplished the DCM reduction and elimination by toxics use reduction strategies including substitution and operations and maintenance improvements. The majority of companies using DCM to clean parts, equipment, or products, or using DCM as a thinning solvent, had switched to aqueous substitutes. This substitution, and in the cases where companies had switched to other hydrocarbon solvents, most likely represents a reduction in worker health hazard associated with these processes. Of course, caution is required in making this assumption given the absence of toxicity information about most "unlisted" chemicals, such as those in substitute chemistries. Additionally, at least one company switched from DCM to trichloroethylene, also a suspected human carcinogen. Further study is needed to measure the total worker health and safety impact of DCM substitution strategies.

Both worker health and safety and environmental concerns motivated companies to eliminate or reduce use of DCM, but environmental issues, particularly reporting requirements, figured more prominently as motivation. It is significant that TURA was cited by several companies as their motivation for undertaking such activities, given that TURA requires only reporting and planning—actual toxics use reductions activities are voluntary. This research also suggests that comprehensive OSHA air contaminant standards may motivate companies to reduce or eliminate their use of chemicals rather than implement traditional engineering controls.

The survey found an apparent lack of serious and persistent problems associated with new processes and chemistries. While not all companies reported benefits of the change, the majority reported multiple benefits, including cost savings, improved processes, and a safer work environment. This finding points not only to the feasibility of toxics use reduction strategies, but to potential positive impacts of toxics use reduction in addition to compliance with standards. A 1995 Office of Technology Assessment report found that companies frequently comply with aggressive new OSHA standards—not by traditional industrial hygiene control approaches such as those recommended in the compliance guides, but by innovating processes, equipment, and materials to reduce or eliminate their use of the regulated substance.[16] The survey results reinforce this finding and suggest that it is possible for some companies to use the "crisis" of increased regulatory pressures to modernize and innovate processes and products.

Limitations of this study include the small survey size of just 17 companies. However, this group represented over 80 percent of the universe of DCM end-users reporting in Massachusetts after 1994 and 89 percent of the contacted sample. Another limitation was the exclusion of chemical supply companies who may find it more difficult to adopt toxics use reduction strategies in the face of increased regulatory pressures. Underreporting or failure to report under TURA may have reduced the sample size or the amount of DCM used and released in Massachusetts. Additionally, companies that have never reported use of DCM were not included in this study. For example, furniture-stripping companies are significant end-users of DCM, but are not included in this survey because they do not report their use of the chemical, either because they use it at less than 10,000 lb/yr, they employ fewer than 10 workers, or they are not complying with TURA. Further research is required to understand the applicability of toxic-use reduction strategies to chemical supply companies and small companies using DCM.

CONCLUSION AND RECOMMENDATIONS

This survey of DCM users in Massachusetts found that due to environmental and worker health concerns and regulatory pressures, companies of a variety of sizes and industrial sectors have made significant efforts to reduce or eliminate their use of the chemical. The results of this survey and the aggregate data from all DCM reporters in Massachusetts from 1990 to 1999 suggest a likely reduction in worker health hazard related to exposure to DCM as a result of implementation of toxics use reduction projects. Toxics use reduction appears to be a feasible strategy for the reduction of potential exposure to DCM, especially for uses related to cleaning and thinning.

Faced with both environmental and occupational health regulation for the same contaminant, the majority of DCM end-users in Massachusetts sought out ways of innovating their processes to reduce the need for DCM rather than relying on traditional engineering controls. They have found few problems and several benefits due to their efforts. Further study is needed to clarify the full range of potential impacts of toxics use reduction as a hazard control strategy including introduction of new hazards and the feasibility of these strategies for small end-users and chemical supply companies. Recommendations related to these findings include:

- Efforts by state and federal worker health and environmental agencies to coordinate regulation and compliance activities should be increased. Toxics use reduction should be promoted by these agencies in their compliance guidance because it may be the most feasible, efficient, and beneficial strategy for both environmental and worker health protection.
- Comprehensive change analyses should be encouraged to avoid risk-shifting.[17] Substitutes for contaminants facing regulatory scrutiny should be investigated for their potential hazards to workers and the environment in advance of regulation.
- Approaches based on the elimination or reduction of hazardous chemical use through use of new, safer chemistries, equipment, and processes should be

included as feasible methods of compliance in the justification of new health standards.
- Research should be conducted to determine the limitations and applicability of toxics use reduction as a hazard reduction strategy across sectors and substances.

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REFERENCES

1. Occupational Safety and Health Administration: Methylene Chloride Factsheets. (on-line) http://www.osha-slc.gov/SLTC/methylenechloride/factsheets/mcfsno10.html (Accessed May 5, 1998) (1997).
2. U.S. Code of Federal Regulations: 40 Chapter Parts 9 and 63 National Emission Standards for Hazardous Air Pollutants: Halogenated Solvent Cleaning. (on-line) http://www.epa.gov/docs/fedrgstr/EPA-AIR/1994/December/Day-02/pr-184.html (Accessed December 10, 2001) (1994).
3. Massachusetts General Law: Toxics Use Reduction Act Ch. 21I. (1989).
4. Occupational Safety and Health Administration: OSHA Preambles: Methylene Chloride v. Health Effects (on-line) http://www.osha-slc.gov/Preamble/methylch_data/METHYLENE_CL5.html (Accessed Dec. 12, 2001) (1997).
5. Environmental Protection Agency National Toxicology Program: 9th Report on Carcinogens. (on-line) http://ehis.niehs.nih.gov/roc/ninth/rahc/dichloromethane.pdf (Accessed Dec. 12, 2001) (2001).
6. International Agency for Research on Cancer: Dichloromethane (Group 2B) vol. 71, p. 251. (on-line) http://193.51.164.11/htdocs/monographs/Vol71/004-dichloromethane.html (Accessed Dec. 12, 2001) (1999).
7. National Institute for Occupational Safety and Health: NIOSH Carcinogens List. (on-line) http://www.cdc.gov/niosh/npotocca.html (Accessed Dec. 12, 2001) (2001).
8. U.S. Code of Federal Regulations: 29 Chapter 1910.1052: Methylene Chloride (1997).
9. Commonwealth of Massachusetts, Department of Environmental Protection: 1999 Toxics Use Reduction Information Release. Boston. Available at http://www.state.ma.us/dep/bwp/dhm/tura/files/99rel.doc (2001).
10. Linak, E.; Toki, G.: Chlorinated Methanes. In: Chemical Economics Handbook. SRI Consulting, Menlo Park, CA (2001).
11. Institute for Research and Technical Assistance: Case Study: Foam Fabricator Serves as Example for Industry. (on-line) http://home.earthlink.net/∼irta/csadh001.htm (Accessed December 10, 2001) (1997).
12. Environmental Protection Agency, National Risk Management Research Laboratory: Evaluation of Alternatives to Chlorinated Solvents for Metal Cleaning. NTIS PB97-147946. NTIS, Springfield, VA. Summary on-line at http://www.epa.gov/ORD/WebPubs/projsum/600sr97032.pdf (Accessed Dec. 12, 2001) (1997).
13. Riklik, L.: Providing Technical Support to Joint Committees Investigating Hazardous Product Substitution. Community and Social Issues Paper 215, American Industrial Hygiene Conference and Exhibition Abstracts. (on-line) http://www.aiha.org/abs99/9comm.html (Accessed Dec. 12, 2001) (1999).
14. Toxics Use Reduction Institute: TURA Data. (on-line) http://www.turi.org/turadata/index.html (Accessed Dec. 12, 2001) (2001).
15. Patton, M.Q.: Qualitative Evaluation and Research Methods, p. 41. Sage Publishers, Thousand Oaks, CA (1990).
16. Office of Technology Assessment: Gauging Control Technology and Regulatory Impacts in Occupational Safety and Health: An Appraisal of OSHA's Analytic Approach. OTA-ENV-635, GPO #052-003-01445-9. U.S. Congress, Washington, DC (Available on-line at http://www.wws.princeton.edu/cgi-bin/byteserv.prl/∼ota/disk1/1995/9531/9531.PDF) (1995).
17. Rosenberg, B.J.; Barbeau, E.M.; Moure-Eraso, R.; et al.: The Work Environment Impact Assessment: A Methodological Framework for Evaluating Health-Based Interventions. Am J Indus Med 39:218–226 (2001).