Commentary

The Concordance of Pollution Prevention and Occupational Health and Safety: A Perspective on U.S. Policy

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Background *Occupational health and pollution prevention, although conceptually linked by the common goals of preventing exposure to toxic materials and lowering risk functions, have been largely confined to separate patterns of practice and professional development. Some analysts see this as a missed opportunity for synergy and raising the level of protection afforded to both the worker and the ambient environment. By using current specific examples we show how strategies that integrate pollution prevention and occupational health practices can be effective at reducing chemical exposures and environmental releases beyond the levels normally achieved using traditional methods alone.*

Methods *Similarities in approaches to addressing chemical hazards at the source, are analyzed in the context of U.S. policy and recent state and federal initiatives. Results obtained from the analysis of multi-pathway risks found within the automotive refinishing sector serve as examples of how best to select engineering and control strategies.*

Results *Industry survey, metal speciation, and methylene chloride usage data from studies conducted in Rhode Island, coupled with case reports from other settings, demonstrate that opportunities exist to concurrently mitigate multiple environmental and occupational health hazards.*

Conclusions *The collaborative initiatives undertaken in the automotive refinishing industry sector demonstrate that an integrated environmental and occupational health approach can more effectively address multiple chemical releases and workplace exposures. Such synergy should be advanced in the future by similar integrative and collaborative strategies.* Am. J. Ind. Med. 44:312–320, 2003. *© 2003 Wiley-Liss, Inc.*

KEY WORDS: pollution prevention; occupational health; environmental policy; automotive refinishing; risk reduction

We have a policy in the United States, when something is found to cause disease, we almost never ban it. We say it will be subject to control. We opt for control but we fail to put in place effective measures for control.

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INTRODUCTION

Within the United States [United States Department of Labor (DOL), 2000a; United States Environmental Protection Agency (EPA), 2000a], Europe [European Union (EU), 1998, 2000], and in the international community [Rantanen, 1994] there is growing interest in the benefits of integrating occupational and environmental health protection practices. While traditional regulatory programs have been successful at addressing some of the more obvious risks, such as the pollution induced fires ‘‘erupting’’ on Cleveland’s Cuyahoga River between 1936 and 1969 [United States Environmental Protection Agency (EPA), 2003a], alternate strategies are being sought to protect human health ‘‘beyond [our] current capabilities’’ [United States Environmental Protection Agency (EPA), 2000a].

The potential benefits of such integration are noted in international policy initiatives arising from both an occupational framework as well as from a predominately environmental perspective where ‘‘health and safety’’ have been incorporated under the banner of integrated pollution prevention and control—as defined by the European Union Network for the Implementation and Enforcement of Environmental Law [Rantanen, 1994; European Union (EU), 1998]. Although the benefits have been recognized by some, implementation has fallen short and the need for a more aggressive, fully integrated approach remains compelling.

In the U.S. workplace, for example, even though injury and illness reports declined 21% between 1993 and 1998, an estimated 137 workers continue to die each day from diseases caused by occupational exposures. Families in 36 states have also been affected by hazardous substances brought home on ‘‘worker’s clothing, tools, or [in] vehicles’’ [United States Department of Health and Human Services (DHHS), 1995; United States Department of Health and Human Services (DHHS), 2003b; United States Department of Labor (DOL), 2000a; Jeffress, 2003]. At the same time, approximately 2,000 new chemicals are introduced into commerce annually (80,000 currently exist), while an estimated 2 billion pounds of toxic chemicals are released each year from more than 21,000 facilities to our nation’s air, land, and waterways [United States Environmental Protection Agency (EPA), 2000b; United States Department of Health and Human Services (DHHS), 2003a].

We will describe industry practices and review government programs that demonstrate the benefits of an integrated, pollution prevention-occupational health model for reducing workplace exposures and environmental releases—as exemplified within the automotive refinishing industry sector. Defined as the use of materials, processes, and practices that eliminate or reduce the creation of pollutants at their source, pollution prevention has become ‘‘the environmental policy of the United States’’ [United States Environmental Protection Agency (EPA), 1992a, 2000c]. Similar to occupational health protection, pollution prevention has the potential to address human health hazards at their source—often resulting in decreased reliance on costly control measures. As the hierarchical approach to chemical hazards in the workplace is similar—in that each begins with product, process, or material substitution—pollution prevention and occupational health protection efforts are theoretically quite compatible. But unlike traditional occupational health and safety, it can be argued that pollution prevention has enjoyed higher acceptance and adoption by both the private and public sectors. It is the thesis of this paper that when both practices are integrated, previously unrealized advancements in ‘‘disease prevention’’ are possible, for both workers and communities alike.

POLLUTION PREVENTION AND ENGINEERING CONTROLS

Workplace and environmental health protection standards have historically focused on limiting hazardous material exposures to some ‘‘acceptable’’ or ‘‘permissible’’ risk level; 10^{-3}–10^{-6} individual excess lifetime cancer risk, for example. These standards evolved from an early recognition that adverse health effects associated with exposure to environmental agents are a function of toxicity, dose, and host variation in susceptibility. To reduce unacceptable risks, the prevailing approach has focused on controlling media-specific chemical concentrations and the potential for human exposure. The primary emphasis of this strategy has been to ‘‘permit’’ pollution or establish regulatory thresholds for the acceptable release of chemical contaminants once they have been generated. Today, ‘‘prevention’’ has emerged as the preferred method for reducing occupational and environmental health risks and is now widely accepted as the most logical and effective approach for safeguarding human health.

Within the work environment, methods to prevent the creation of pollutants at their source include the substitution of raw materials, product reformulation, process and technology modifications, improved operating practices (such as improved maintenance, material handling, training, and inventory control), and in-process recycling for the purpose of material recovery and reuse [United States Environmental Protection Agency (EPA), 1992a, 2000d; United States Congress, 2003]. Although a range of pollution prevention techniques appropriate to a specific problem may exist, the selection and application of any one or combination of options is dependent upon a number of criteria including applicable regulatory requirements, production impacts, cost effectiveness, and ‘‘the level of risk reduction that can be achieved’’ [United States Environmental Protection Agency, 1992b]. Since the application of pollution prevention measures can ‘‘directly’’ affect workplace risks, occupational health and safety considerations need to be at the forefront of the decision-making process. This is especially important as pollution prevention alternatives can sometimes introduce new hazards into the workplace or change the conditions of potential worker exposure—such as the replacement of an ozone-depleting organic solvent with a caustic solution—requiring modifications in material handling, personal protection requirements, or hazard communication, for example.

Recognizing an underlying similarity in approach, the American Industrial Hygiene Association (AIHA) issued a ‘‘Position Statement on Pollution Prevention and Toxic Use Reduction’’ in November 1993 [American Industrial Hygiene Association, 2003]. This statement holds that:

> Pollution prevention and toxic use reduction (a group of activities under pollution prevention) are examples of fundamental industrial hygiene professional practices. . .[and]. . .if workers and the community can be protected from harm through prevention, this is preferred over other control measures.

The AIHA language supports the notion that pollution prevention and industrial hygiene practice are not only compatible, but that the fundamental approach for reducing chemical hazards in the work environment is similar. Where chemical hazards cannot be reduced or eliminated, the AIHA promotes the safe use of chemicals in accordance with the ‘‘industrial hygiene hierarchy of controls and good practices’’ [American Industrial Hygiene Association, 2003].

An integrated hierarchy that gives primacy to substitution as an engineering control and pollution prevention is shown in Figure 1. In this illustration, occupational and environmental health protection efforts are shown to intersect and begin with the investigation of potential hazard ‘‘elimination’’ or ‘‘substitution’’ alternatives such as changes in raw materials, processes, and equipment. As articulated by the U.S. Occupational Safety and Health Administration (OSHA) in 1978, the rationale behind the hierarchy of industrial hygiene practice is based on the familiar pollution prevention concept that worker protection is ‘‘most effectively attained by elimination or minimization of the hazard at its source’’ [United States Department of Labor (DOL), 2000b]. Where hazards cannot be entirely eliminated through substitution or pollution prevention (in-process chemical recycling is often recommended, for example), process isolation or enclosure, ventilation, work practice controls, or personal protective equipment and sound environmental management practices may be needed.

AUTOMOTIVE REFINISHING CASE STUDY

Occupational Health and Environmental Overview

Automotive refinishing—that is, the process of coating automobiles or their parts subsequent to the original coating applied at a manufacturing plant—presents a range of occupational health and safety and environmental management challenges [United States Environmental Protection Agency (EPA), 1998a]. In 1988 and 1996, for example, car painters died from occupational asthma induced by chemical exposure while working in an auto body shop [United States Department of Health and Human Services (DHHS), 1996; United States Department of Labor (DOL), 1998]. Prior to his death, one of the painters complained about ‘‘clogged filters

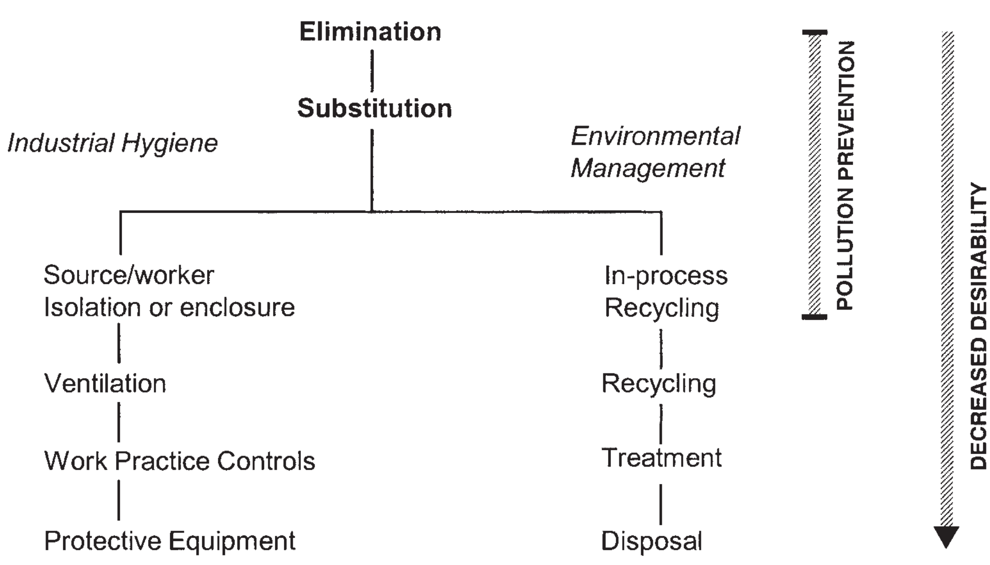

FIGURE 1. Concordance of industrial hygiene and environmental management practice. Note: Environmental management hierarchy adapted from United States Environmental Protection Agency (EPA), 1992a.

in the spray booth, the lack of chemical training, and lack of respirator training.'' The autopsy report for this 44-year-old male indicated that the painter had experienced a fatal attack of acute bronchial asthma ''precipitated by exposure to fumes and chemicals in an automobile paint shop'' [United States Department of Labor (DOL), 1998]. Research conducted by the authors has also shown that automotive body repair technicians who sand on painted surfaces for extended periods of time can have elevated blood lead levels (PbB), endure exposure to a myriad of additional physical/chemical hazards, and carry home toxic metals on their work clothes [Enander et al., 2002, 2004].

Environmental burdens created by this industry sector are diffuse and remarkable. In 1996, the U.S. Environmental Protection Agency (EPA) estimated that 80,000–286,000 tons of volatile organic compounds (VOCs) are released each year from more than 60,000 automotive refinishing facilities located throughout the United States [United States Environmental Protection Agency (EPA), 1996; Enander et al., 1998]. Communities with refinishing facilities have filed formal complaints with state health and environmental protection agencies regarding solvent odors, incidents of property contamination (involving metal-bearing sanding dust), and a variety of health related problems [Gazzette, 1999; Lord, 1999; Rhode Island Department of Environmental Management (DEM), 2000; Enander et al., 2002].

Potential occupational and environmental health risks associated with automotive refinishing are shown in Table I. As environmental health risks often arise from workplace hazards (Table I), intervention strategies that focus on ''prevention'' and substitution controls within a facility will have the combined effect of reducing or eliminating risks both within and outside the work environment. At the facility level, those at greatest risk of exposure are repair technicians, who engage in structural damage repair and surface preparation operations, and spray painters. For surrounding communities, environmental releases are determined by the facility and subject to compliance of individual work practices regarding methods and materials used; neighborhood impacts are also dependent upon facility throughput and proximity to residential areas. This sector, as previously reported [Enander et al., 2004], is characterized by a small facility size and a relative inability to enjoy sufficient access to capital to engage in major technological enhancements to further ensure the safety of work processes. These two factors are traditionally major impediments to progress in either of the realms of importance to this discussion—occupational health and safety, and environmental health [Jones, 1999].

TABLE I. Occupational and Environmental Health Risks Posed by Automotive Refinishing

Occupational health
Body repair technician exposures
Lead and other sanding dust metals
Isocyanates, solvents, and metals (priming)
Methylene chloride vapors (paint stripping)
Silica dust from sand blasting
Welding fumes
Solvents in surface cleaners/body fillers
Spray painter exposures
Isocyanates and paint solvents
Gun wash cleaner chemicals
Metal pigments in paint
Other shop workers
Incidental exposure from repair technician (Pb, for example) and spray painting operations
Environmental health
Nearby communities
Aliphatic and aromatic solvent emissions
Fugitive dust emissions
Isocyanate emissions
Fugitive emissions of methylene chloride
Workers' families
"Take-home toxics" on shoes, skin, work clothes, in vehicles
Potential adverse reproductive effects (technician exposure to lead in sanding dust)
Environment
Improper disposal of solid and hazardous waste
Heavy metal, priority pollutant discharge to wastewater systems, storm drains, etc.

Does not include physical hazards such as noise or those that arise from material handling (ergonomic hazards) and the use of mechanical and electrical equipment—for example, cuts, abrasions, and potential eye injury from exposure to electromagnetic radiation during welding [Enander et al., 1998]. Also not included are potential explosion hazards from the use of flammable solvents both within the workplace and in sewer conveyance systems where flammable liquids may be illegally discharged.

Organic Solvents and Isocyanates

Automotive refinishing workers use a range of organic solvents, most of which are associated with spray painting. Once released, the VOCs present in paints react with nitrogen oxides in sunlight to form ground-level ozone. According to the EPA, automotive coatings contain ''higher concentrations of the more reactive VOC than do other types of paints'' [United States Environmental Protection Agency (EPA), 1996]. In addition, nonhalogenated organic solvents are also used to clean spray guns, equipment, and vehicle surfaces prior to painting, while solvent-based body filler compounds are used in damage repair. Methylene chloride, an OSHA and EPA regulated carcinogen, is also released to the air from facilities that engage in chemical paint stripping operations.

One of the more successful strategies for reducing environmental health risks associated with spray painting was the passage of EPAs ''National Volatile Organic Compound Emission Standards for Automobile Refinish

Coatings'' in September of 1998. This national pollution prevention rule, estimated to reduce VOC emissions by 31,900 tons per year, required all U.S. manufacturers and importers to limit the VOC content of their coatings [United States Environmental Protection Agency (EPA), 1998a]. At about the same time, several state environmental protection agencies had also adopted regulations limiting the VOC content of paints/cleaners, as well as, requiring the use of other technological controls designed to reduce pollutants at their source—high volume low pressure (HVLP) spray guns and enclosed spray gun cleaners, for example. Collectively, these ''regulatory'' initiatives not only served to reduce facility emissions, but also helped to improve workplace conditions while maintaining business profitability.

Though state and federal pollution prevention regulatory initiatives can produce measurable reductions in chemical releases, they are not always effective at reducing residual risks to acceptable levels. While HVLP spray gun technology coupled with high solids, low solvent paints can reduce coating usage (and chemical emissions) by increasing paint-to-substrate transfer efficiencies, for example, occupational health protection measures are still needed to control potential solvent and isocyanate exposures in the workplace. Similarly, although enclosed spray gun cleaners and solvent recycling units are effective as assessed by resource conservation (pollution prevention) measures, an unanticipated hazard may result from the build up of isocyanates over time in the recovered solvent mixture; that is, in-process recycling may actually serve to increase the potential for isocyanate contact.

In the case of chemical paint stripping, research conducted by the authors suggests that the use of methylene chloride in refinishing operations can be eliminated and replaced with conventional mechanical sanding [Enander et al., 2003]. It appears that chemical paint stripping became popular because it is a relatively quick method for removing multiple layers of paint in a short period of time. Switching to a purely mechanical operation, however, still requires the use of appropriate industrial hygiene controls to protect against potential lead dust exposures and environmental releases [Enander et al., 2004].

Other examples that underscore the need for an integrated pollution prevention-occupational health approach to risk reduction include the recommendation and use of computerized paint mixing scales (to more accurately measure quantities of paint) and solvent distillation units. While each serve to reduce the amount of raw material used, commercial units that are purchased and used within refinishing facilities must be designed to prevent the ''accidental ignition of flammable vapors'' [Rhode Island Department of Health (DOH), 1999]. During a recent Occupational Safety and Health Consultation conducted by the Rhode Island Department of Health, for example, one company was cited for using an electronic paint mixing scale (not approved for hazardous locations) in a flammable storage room—the scale was also ''electrically connected through an ordinary extension cord'' [Rhode Island Department of Health (DOH), 1999].

Metal Particulates

Air-assisted orbital sanding, conducted during surface preparation operations, results in the generation of a fine, heavy metal-bearing dust. Analysis of 15 composite samples representing more than 200 vehicles, showed a range of metals—including lead—to be present in virtually every sample of sanding dust tested [Enander et al., 2002]. Among three types of facilities that participated in the study, lead was found in the highest mean concentrations at a vocational technical high school and complete vehicle repainting facility (Table II). Lead was also present at a concentration of 1,800 ppm in one of seven collision repair shop samples.

Additional studies conducted by the authors demonstrated that the lead contained in sanding dust is biologically available and results in blood lead (PbB) concentrations at or above OSHA's maximum permissible level (30 μg/dl) for adverse reproductive effects [Enander et al., 2004]. At the same time, technicians were found to carry lead dust home on their work clothes, while environmental releases to residential properties have been reported in several cities including Philadelphia and Honolulu [Enander et al., 2002]. Metal dust may also be illegally discharged to off-site wastewater treatment systems or storm drains, potentially resulting in the contamination of groundwater, soils, biological solids, and waterways (Table I).

Through the application of occupational and environmental control hierarchies, reductions in risk for the automotive refinishing sector are best accomplished through the elimination of toxics in coatings and other widely used products. Although lead concentrations in paints have decreased over time, for example, lead is still present in E (electrolytic)-coats applied by original equipment

TABLE II. Facility Comparisons: Original Equipment Manufacturer Sanding Dust (mg/kg)

Facility type	fd	AM	Min	Max
Collision repair				
Lead	7/7	521	180	1,800
Complete repainting				
Lead	3/3	869	770	1,000
Vocational school				
Lead	3/3	4,367	1,400	7,300
Hex chrome	2/3		54	710

fd, frequency of detection indicates the number of samples in which the metal was detected over the number of samples analyzed for that element; AM, arithmetic mean.

manufacturers (OEMs), and in tints used to color some base coats (lead chromate and lead chromate molybdate can be found in yellow and orange tints of some after-market paints). Until OEMs and after-market paint suppliers completely eliminate lead from their product lines, engineering controls and personal protection will be needed to reduce lead exposures and environmental releases.

While raw material substitution (Fig. 1) is one of the most effective pollution prevention/industrial hygiene measures that can be undertaken, reductions in residual risk are often only possible through the application of workplace controls. Even where lead levels can be further reduced and may eventually be eliminated from all OEM and after-market paints, for example, sanding dust was still found to contain a range of other toxicants including arsenic, cadmium, and di-2 ethylhexyl phthalate—an EPA probable human carcinogen [Enander et al., 2004]. In addition, researchers from the National Institute for Occupational Safety and Health found that total dust concentrations on workers who sand on body filler compound can be excessive [Heitbrink et al., 1994]. To fully protect against workplace exposures, ‘‘take-home toxics,’’ and environmental releases of dust generated during sanding, the use of ventilated sanding equipment, dust respirators, and work gloves may be needed [Enander et al., 2004]. Occupational and environmental health risks are effectively reduced in this example through a combination of pollution prevention, engineering controls, and personal protection measures.

STATE AND FEDERAL COLLABORATIVE INITIATIVES

Toxics use reduction and pollution prevention regulatory initiatives are a necessary and effective means for reducing workplace and environmental exposures. Earlier examples, which included paint VOC reformulation efforts and the mandatory use of HVLP spray guns and enclosed spray gun cleaners, underscored the importance of state and federal actions taken to reduce pollutants at their source. Traditional regulatory approaches alone, however, cannot fully anticipate nor entirely address the myriad of multiple chemical hazards encountered in the work environment. Such intervention strategies are also not very effective at promoting voluntary changes in behavior leading to toxics use reduction—such as the voluntary use of laser guided systems to improve overall spray painting technique (concomitantly leading to reductions in VOC emissions). To more fully address chemical hazards, technology performance and product use issues encountered in the workplace, collaborative approaches that integrate pollution prevention and occupational health training and technical assistance are needed.

In Philadelphia, for example, the EPA is conducting the Design for the Environment Automotive Refinishing Project which partners with local refinishing facilities to prevent pollution, ‘‘promote best practices and technologies that reduce toxic emissions, and advocate the use of appropriate control technologies/personal protective equipment to reduce worker and environmental exposure and risk’’ [United States Environmental Protection Agency (EPA), 2003b]. During the pilot phase of this project, each participating facility received an industrial hygiene and environmental survey of its practices and equipment. Safe work practices and pollution prevention opportunities were identified and communicated through reports and conversations with owners and workers; insights concerning barriers and incentives to change, such as regulatory requirements, worker safety, and the quality of completed paint jobs, were also documented [United States Environmental Protection Agency (EPA), 1998b]. Through an integrated approach, the EPA project team was able to recommend sound environmental, health, and safety improvements aimed at reducing worker exposure, improving compliance with environmental regulations, and increasing production efficiency [United States Environmental Protection Agency (EPA), 1999].

At the state level in Rhode Island, a comprehensive interagency pollution prevention-occupational health collaborative began in the mid-1990s and was formalized in 1999 through a ‘‘Memorandum of Understanding Regarding the Automotive Refinishing Industry (MOU).’’ Signatories to the MOU included the Rhode Island Department of Environmental Management (DEM), Rhode Island Department of Health (DOH), and U.S. OSHA. The purpose of the agreement was to provide Rhode Island’s automotive refinishing industry with coordinated assistance to address pollution prevention, environmental compliance, and occupational safety and health issues [Rhode Island Department of Environmental Management (DEM), 1999].

Leading this initiative are the DEM’s Pollution Prevention and DOH’s Occupational Safety and Health Consultation Programs; training, mentoring, and technology demonstration support was also provided by a vocational technical school. During the initial stages of the program, scientists and engineers from each agency performed nonregulatory technical assessments of participating companies. Pollution prevention opportunities such as the elimination of methylene chloride-based paint strippers and the purchase and use of solvent recovery units and computerized paint mixing scales were identified; specific attention was given to safety issues concerning chemical replacement alternatives, personal protection while using HVLP spray gun technology/low VOC coatings, and the proper location and purchase of electronic measurement and distillation equipment. Personal air monitoring, blood lead (PbB) testing, and hazardous waste analyses were performed, and a formal report summarizing conditions, occupational hazards, and multimedia environmental compliance issues was presented at the conclusion of each assessment. At one vehicle repainting facility, for example, a team of pollution prevention and occupational health specialists identified 27 safety, health, and environmental compliance issues in addition to elevated PbB levels among several dedicated automotive sanding technicians.

As a result of these audits and to further integrate the concepts of pollution prevention and worker health protection into everyday practice, the DEM introduced its plan for a statewide ‘‘self-certification’’ program to over 150 automotive refinishing industry representatives at a workshop held in the fall of 1999. The program, formally launched in December 2002, addresses training requirements, pollution prevention, occupational health and safety, hazardous waste management, air pollution control, and wastewater discharge concerns in a question and answer format that allows for the self-evaluation of facility operations. Results of the self-evaluation will be analyzed by DEM in order to determine compliance rates and to assist in identifying program priorities. Patterned after the very successful Environmental Results Program developed by the Massachusetts Department of Environmental Protection, this initiative is being viewed as the first ever regulatory and assistance partnership involving state environmental and health departments, a state university (the University of Rhode Island Center for Pollution Prevention), and a vocational training institution that will result in an environmentally measurable protection program [Gagnon and Enander, 2000]. The involvement of the vocational training institution we believe is of critical importance as a mechanism to influence the ‘‘demand’’ side of technological improvements in this industry sector. Students who benefit from training in the necessity and use of new and safer technologies will advocate for and expect such systems in the jobs they assume in the industry.

The experiences in both Philadelphia and Rhode Island demonstrate that collaborative efforts among environmental and occupational health professionals can be an effective means for addressing multimedia chemical releases and workplace exposures. Such cooperation not only has the advantage of leveraging scarce public resources, but can also address a more complete range of worker exposure, safety hazards, and environmental health risks at their source [Weinberg, 1997]. The rationale for combining pollution prevention and occupational health has been championed in the past particularly as advanced by the discipline of industrial hygiene [Lippman, 1991; Burgess, 1997]. Moreover, the ‘‘philosophical framework’’ of pollution prevention also ‘‘closely parallels public health with a focus on primary prevention, education, technical assistance, and voluntary action’’ [National Association of County and City Health Officials (NACCHO), 1995]. The similarities in approach among pollution prevention and occupational and public health protection, therefore, offer a wide spectrum of opportunities for more effective collaboration in human health protection and disease prevention.

CONCLUSIONS

Pollution prevention and occupational health intervention measures were shown to generally take one of two forms—rulemaking at the state or federal level and voluntary initiatives undertaken by suppliers, facility owners, and employees. While each approach has its relative strengths, experience has shown that human health risks are most effectively reduced through a combination of both regulatory (that is, enforceable standards) and non-regulatory actions. For voluntary initiatives, the integration of pollution prevention and occupational health principles at the facility level offers real promise for future advancements in disease prevention. Decreased reliance on engineering controls, a more comprehensive approach to chemical hazards, and substantial improvements in risk reduction/communication are possible when interdisciplinary, collaborative initiatives—such as joint standards development, on-site assessments of hazardous operations, and industry/technical assistance provider cross training in fundamental pollution prevention and industrial hygiene principles—are undertaken.

The approach demonstrated here, even within an industry sector characterized by traditional barriers to innovation and best practices, demonstrates the real contribution that the integration of occupational health and safety and environmental protection can provide. The central elements of this approach are:

- the identification of effective and economically feasible interventions;
- modifications to products up the supply chain in the case of toxic materials used in the work place;
- improved training of new entrants to the work place who then will expect and advocate for a cleaner, safer, and more environmentally sound work place;
- the involvement of employers and employees in self-certification efforts that will reward self-study and compliance with better familiarity and facility in achieving the expectations of regulatory programs;
- the rising interest in such an approach in the United States and internationally.

We report on a nascent attempt at implementing and delivering this integrated model. Inertia and other obstacles—such as resource limitations at the facility level and broad acceptance of new methods by traditional regulatory agencies—remain significant challenges to faster progress in implementing such innovative models in occupational health and safety and environmental protection. Nevertheless, we recognize the promise that this integrated approach may have in other industry sectors and in other global regions.

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