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The Case for Integrating Safety and Health into the Design of Innovative Environmental Remediation Technology

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INTRODUCTION

Through the Manhattan Project, the U.S. was able to design and build an atomic bomb in less than 4 years at a cost of approximately $2 billion dollars (OTA 1993). The nuclear weapons complex grew over the years into a complex of more than 120 million ft^2 (11 Mm^2) of buildings and 2.3 million acres (92 000 km^2) of land - an area larger than Delaware, Rhode Island, and the District of Columbia combined. The Department of Energy (DOE) is the agency responsible for this enormous complex and for cleaning up the environmental contamination that occurred during our arms race with the Soviets - what the agency refers to as the "Cold War Mortgage." DOE has recently estimated the mortgage costs to be $230 billion over the next 75 years. This estimate could increase to $350 billion if the country decides that more pristine standards of cleanup are required (DOE 1995).

This cost is only for the sites controlled by the DOE; the Department of Defense (DOD) has identified 10 000 contaminated sites at over 800 bases nationwide and spends $2.1 billion annually for environmental restoration. The DOD spends another $2 billion annually on operations and maintenance related to pollution prevention and $170 million on environmental research and development each year (SSEB 1997).

THE IMPORTANCE OF INNOVATIVE REMEDIATION TECHNOLOGIES

The Comprehensive Environmental Restoration Compensation and Liability Act (CERCLA), also known as Superfund, set an important precedent by requiring a formal Record of Decision (ROD) for each remediation project, including a systematic evaluation of the technologies available for accomplishing the cleanup and a written explanation of the final choice. U.S. Environmental Protection Agency (EPA) required that innovative technologies be considered as part of this formal evaluation and provided funding through its Superfund Innovative Technology Evaluation (SITE) program to test the efficacy of these technologies at cleaning up soils, ground water, and contaminated equipment. New environmental technologies hold great promise for cleaning up our hazardous wastes sites more quickly, at lower costs, and with less exposure to the workers.

The DOE recently screened more than 100 potential technologies scheduled to be implemented by the year 2000 for applicability to high-cost remediation projects. The

DOE found that the 15 technologies with the greatest impact could result in cost savings from $9 to $80 billion, depending on future land use strategies and assuming the technologies could be implemented by 2010 (DOE 1995). New technologies can make a real difference. Unfortunately, their impact will be zero if they aren't deployed. A preliminary evaluation of 39 RODs by the DOE indicated that innovative technologies were incorporated into only 9 (23%), despite a directive to consider innovative and emerging technologies in primary documents (DOE 1994).

There are serious impediments to the use of innovative technologies. State environmental regulators continue to rely on conventional solutions for many reasons including governmental inertia toward change and because their technical training budgets are always underfunded, limiting comfort with new technologies. They fear the liability, too, of innovative technologies that don't do the job. Remediators have been slow to propose innovative technologies because of the costly and onerous demonstration projects each state requires, regardless of the successes in other states (Unger 1998).

Although Superfund has required consideration of innovative technologies, it has also been one of the impediments because of the rigidity of its requirements. Too often the ROD for a cleanup project reflects the choice of one of the standard technologies, generally requiring active engineering solutions, often with questionable results. This is changing, however. As William Reilly, Former EPA Administrator, said in October 1996, "Going into the year 2000, a great many Records of Decision will be renegotiated due to advances in technology, new understandings about site and contaminant risk and legislative changes. This will involve billions of dollars" (Paterson 1998). Another important consideration - the theme of the EPA's Brownfields Conference in September 1996 - is that the greatest impact from accelerating site remediation is not just the cost savings, but more so the economic gain from placing a property or facility back into productive use.

DYNAMIC CHANGES IN THE TECHNOLOGY APPROVAL PROCESS

The last decade of site investigations and remediation has afforded a much clearer understanding of the mechanics of cleanup. More realistic models are available to predict the extent of contamination and the most effective cleanup methods (Unger 1998). Coupled with this improved technical understanding are major political shifts in the approach to regulating the use of new remediation technologies. One of the most important causes is an increased acceptability of the EPA proposed Risk-Based Corrective Actions (RBCA). Using risk rather than a legal prescription to determine the scope of the response has been advocated by many groups previously, including the Institute for Regulatory Science and the National Research Council. The American Society for Testing and Materials (ASTM) has developed a procedure for setting cleanup requirements based on reducing risk rather than meeting a generic standard (ASTM 1994).

Of even greater significance is the trend towards multi-state alliances. More than half of the states have joined in various working groups to establish minimum technical requirements, demonstration protocols, permit protocols, and technology-specific resource documents to streamline the technology acceptance process. Six states, that include nearly a third of the environmental market, are attempting to establish reciprocity for environmental permits, using twelve technologies to pilot their studies (Unger 1998). They have divided the conventional permitting process into four key segments: 1) technology demonstration; 2) technology acceptance; 3) developing permit operating conditions; and 4) administrative procedures for making a decision.

A critical finding of this group was that the first two categories require approximately 90% of the time for the entire permitting process. When the regulators are comfortable with the technology, defining the local operating conditions for the permit is a relatively simple task. Consequently, the multi-state efforts are particularly critical.

Regulators from 27 states have been voluntarily cooperating since 1995 in the Interstate Technology and Regulatory Committee, which has been working to share information and streamline the technology approval process. Similarly, the Southern States Energy Board has created the Permitting Leadership in the United States (PLUS) initiative as a means to overcome regulatory barriers to expedite technology deployment on a state and regional basis. On September 1996, the Southern States Energy Board unanimously approved a policy position on the "Expedited Multi-Site Deployment of Environmental Technologies", which serves as a template for states to assess change to legislative policy and regulatory programs (Nemeth 1998).

THE MISSING ELEMENT: WORKER PROTECTION

Amidst the change, one thing has remained constant: insufficient consideration has been given to the safety of the workers who must operate and maintain these new technologies. This is a trend with a long historical precedent. Superfund was promulgated in 1980 but Occupational Safety and Health Administration (OSHA 1989) did not create a standard for the protection of the workers who were handling the toxic wastes until 1989 (Herr 1998). This is not coincidence but reflects the setting of national priorities. The EPA's annual budget has averaged over 22 times OSHA's annual budget. For the present fiscal year, OSHA's budget is for $336 million while the EPA budget is for $7.36 billion (Herr 1998).

A recent study of occupational injury and illness looked carefully at 1992 data and estimated that there were 6529 workplace fatalities, over 6 million disabling injuries, and 862 000 new cases of occupational disease. The direct and indirect costs of the injuries and fatalities totaled $145.4 billion, while the estimated costs of the occupational diseases came to $25.5 billion. The researchers indicated this is undoubtedly an underestimation and concluded that the medical costs of occupational injuries and illnesses were much larger than the costs for AIDS or for Alzheimer's disease and are of the same magnitude as the costs for cancer or all circulatory diseases (Leigh et al. 1997). While this carnage continues in our workplaces year after year, only one person has been jailed for violating the Occupational Safety and Health Act since its creation in 1970 and the sentence was for six months. In contrast, hundreds of people have been jailed for violating EPA standards –

seven people have received 1-year jail sentences for harassing a wild burro on federal land (Herr 1998).

The choice of cleanup technologies has always been driven by efficacy considerations. The choice of technologies directly affects risk to workers, however. The National Safety Council found the total estimated death rate for occupations involved in the “excavation and landfill” remediation method could be 19 % higher than for the “capping” method (Hoskins et al. 1994). New technologies have claimed the life of at least one worker. The individual died of severe burns after a drum exploded in the feed chamber of a plasma hearth furnace. There have been several other accidents, as well.

There have been well over 150 different technologies evaluated through the EPA SITE program and many more are listed in the Remediation Technologies Screening Matrix and Reference Guide published through a collaboration between the EPA and Air Force. Databases including the Hazardous Waste Superfund Database, the Vendor Information System for Innovative Treatment Technologies (VISITT), and the Risk Reduction Engineering Laboratory (RREL) treatability database are available to help decision makers choose the appropriate technology. None of the aforementioned databases contain substantive information about the health and safety risks of the technologies.

Even an organization as prestigious as the National Research Council (NRC, 1997) has recommended to the DOE's Office of Science and Technology that worker health and safety should not be considered as part of a formal peer review of remediation technologies:

> "OST’s general list of review criteria includes broad issues such as cost effectiveness, reduced risk**,** regulatory acceptability and public acceptance, which include many nontechnical considerations… The committee therefore recommends that OST revise these general nontechnical criteria to focus on technical aspect of these issues, or to remove them from the list of review criteria."

Ironically, the OSHA Hazardous Waste standard has been a source of problems with new technologies. Section (o) *New technology programs* requires the employer “to develop and implement procedures for the introduction of effective new technologies and equipment developed for the improved protection of employees working with hazardous waste clean-up operations.” This is undoubtedly the most ignored section of this highly publicized standard. OSHA has never cited any employer for not introducing new technologies. Rather than fostering proactive approaches, the standard has resulted in safety being considered at the very end of the development continuum. The safety and health officer required to be onsite at a hazardous waste site by OSHA has become the de facto source of safety considerations for new technologies. Developers and government agencies, when pressed about the safety precautions taken with new technologies, have repeatedly stressed that there is a site safety professional who will oversee the operation and train the workers when the technology arrives at the site.

The OSHA standard puts such strong emphasis on the writing of a Health and Safety Plan that this effort has eclipsed the far more appropriate action of performing a system safety analysis of new technologies, a keystone to the Process Safety Management standard. Consequently, by the time the technologies reach the field, serious design flaws that should have been caught early are passed on to the site safety officer who must do the best he or she can to keep the flaw from hurting or killing workers. Often, this requires encumbering workers with additional personal protective equipment such as hearing protectors or respirators.

New technologies can benefit from old approaches. Developers should be using time-proven tools of system safety analysis, such as Hazard and Operability studies (HAZOP) and Failure Mode and Effects Analysis (FMEA) to identify and correct the safety problems with their technologies - as early as possible in the development timeline. It saves lives but it also saves money. One study showed that every dollar spent on design review saved $20 (Ferry 1990).

EFFORTS OF THE INTERNATIONAL ENVIRONMENTAL TECHNOLOGY AND TRAINING CENTER

The Operating Engineers National Hazmat Program, through a cooperative agreement with the DOE's Federal Technology Center, has created a center to fill in this missing information on innovative environmental remediation technologies. The Center is located beside the National Mine Health and Safety Academy in Beckley, WV.

The Center's main mission is to conduct formal safety and health evaluations of technologies chosen by DOE as sufficiently effective and robust to provide real service to DOE and, potentially, the commercial market. These formal evaluations are conducted working with the developer using a team of experts chosen specifically for the technology. Industrial hygiene and ergonomic measurements are routinely made. The Center classifies technologies into three types to better frame the evaluations:

1. Type I technologies are innovations in worker protection such like a liquid-air breathing apparatus that provides cooling as well as breathing air.
2. Type II are the environmental remediation technologies, ranging from floor blasting devices to entire plants built to vitrify radioactive wastes.
3. Type III are robotic technologies, such as the robot that crawls down a pipe removing asbestos. Robotic units pose unique hazards. Most have computer software that replaces mechanical interlocks found in standard industrial equipment.

A comprehensive protocol has been created by the Center for evaluating each type of technology. The Type II protocol, for instance, contains 20 checklists for use on a broad range of environmental remediation technologies (IETTC 1997a). To date 27 technologies have been evaluated. Some of the findings are:

1. The innovative liquid air breathing apparatus was significantly better than a conventional self-contained breathing apparatus for lower back stress, as determined with digitized videotape used in a computer model called Watbak.
2. The noise levels were extremely high for nearly all of the technologies that remove the upper surface of contaminated floors and painted metal structures, with an average level of 182% of OSHA's allowable dose for an 8-h day for a sampling period of less than half of a workday. The results of measurements taken outdoors varied widely, with a coefficient of variation of 152.5% for 37 readings. When the technologies were used to remove surfaces from metal, the values were usually in excess of 10 fold of OSHA's allowable dose, again measured outdoors.
3. From 37 nuisance dust samples collected during concrete surface removal tests of 12 technologies, the average result was 375 mg/m3, compared against the OSHA standard of 15 mg/m3 (OSHA 1997). The results varied widely depending on the technology producing a coefficient of variation of 206 %. These tests were conducted on surfaces that were not contaminated but the technologies are designed to cleanup concrete contaminated with toxic chemicals and radioactive materials.

Recognizing the need to provide guidance for operators of robots, in cooperation with the National Institute of Standards and Technology and the Association for Robotics in Hazardous Environments, a workshop was held to draft guidelines for minimum personnel qualifications for operating robotic systems in hazardous environments. The guidance document, (IETTC 1997b) provides information on appropriate qualifications and training for operators of robots.

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