

WORKER RISK AS A FACTOR IN TECHNOLOGY SELECTION

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ABSTRACT

The DOE remediation program is the largest and most technically challenging cleanup in history. Given the complex and unprecedented nature of the task, it is certain that, without proper foresight, there will be an unintended transfer of risk to workers. In addition, the innovative nature of many of the new technologies will pose challenges with regard to worker education and training. Thus, early consideration of the potential impact of new technologies on worker health and safety is a major need of the EM technology development program.

Safety and health considerations should be factored into the technology development process as early as possible. Major focal points for technology safety improvement are the technology developer, who is in the best position to systematically identify and address safety hazards early in the development process, and the OST internal and external technical review process that occurs at major funding decision points. The earlier in the development process that potential hazards are identified and controlled, the greater the protection afforded to workers and the greater the cost savings for developers. The focus should be on elimination or substitution of hazardous processes associated with the technology rather than building barriers between workers and hazards.

INTRODUCTION

The science and technology challenges of the EM program are major and are driven by the need to reduce the large projected, and highly uncertain, life-cycle costs (currently \$147 billion), to find technical solutions to cleanup and storage problems that currently do not have technical solutions, and to protect workers during cleanup activities (1,2,3). In an attempt to address these issues, EM has established a \$1.2 billion science and technology strategy for the next five years (4% of EM total budget).

However, this massive technology development effort raises questions regarding the impact of new environmental technologies on worker health and safety. It is widely recognized that proactive analysis of health and safety hazards early in the technology development process can ensure that new environmental technologies are significantly safer for workers to operate and maintain. However, what tools, methodologies and guidance are necessary to accomplish this aim? Should reduction in worker safety and

health risk be a measure used to evaluate which technologies receive funding? Where in the technology review process should worker health and safety be considered?

The Environmental Management Advisory Board, in a recent review of EM technology development efforts (4), recognized that increased emphasis on occupational safety and health early in the environmental technology development process is needed. They recommended that EM develop:

- A safety and health checklist for technology developers
- Guidance for safety and health evaluation during Stage-Gate procedure
- Guidance for safety and health evaluation during the ASME peer review process
- Technology Safety Data Sheets for every technology
- A Heat Stress Management program

The purpose of this paper is to provide an overview of some issues surrounding worker risk and its relationship to technology development.

RISKS TO REMEDIATION WORKERS

There are three major components to the worker safety picture (see figure 1).

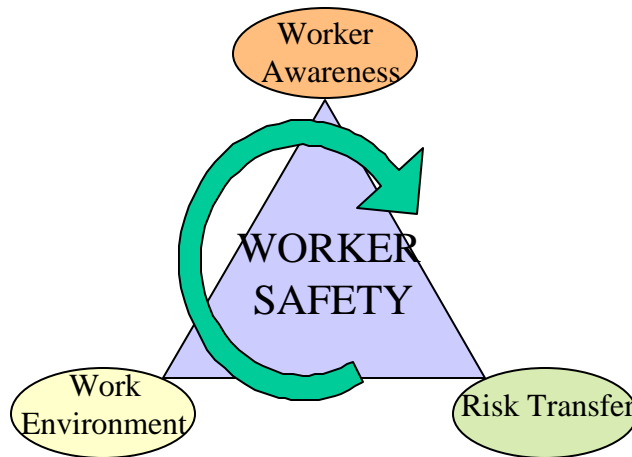


Fig. 1

The work environment (both the task at hand and the technologies employed) is a major factor controlling the magnitude of risks to which workers are exposed. This is particularly true in environmental restoration where the technical challenges are unprecedented and the use of new and innovative technologies is the rule. Worker awareness of safety issues is another important component of worker safety programs. An additional, and often overlooked, issue in the worker safety equation is that the choice

of remediation option can have a big impact on worker safety. The desire to reduce offsite public risk frequently results in an increase in worker risk.

We look at each of these issues in turn.

- **Technology.** The DOE remediation program is the largest and most technically challenging cleanup in history. The sheer size of the problem is monumental: leaking high-level waste tanks, stored nuclear materials, highly-contaminated concrete processing buildings, and contaminated soil and ground water. Many of the problems are inadequately understood and currently do not have technical solutions. The exact nature of most problems remains to be characterized. Given the complex and unprecedented nature of the task, it is certain that, without proper foresight, worker risk will be high. In addition, the innovative nature of many of the new technologies will pose challenges with regard to worker education and training. Thus, early consideration of the potential impact of new technologies on worker health and safety is a major need of the EM technology development program.
- **Behavior-Based Safety.** Advocates of behavior-based safety believe that achieving safety excellence requires going beyond the traditional focus on engineering and barriers. Because human behavior is the primary cause of most incidents and injuries, safety excellence can only be achieved by addressing the human dimensions of safety. Actively engaging workers in identifying unsafe behavior in themselves and others identifies relevant intervention strategies, enhances worker awareness of safety, and creates a positive work culture.

Critics of behavior-based safety believe such systems start at the bottom of the safety hierarchy by implementing the least effective controls first rather than controlling the hazard at the source. They believe such programs are completely reactive, recommending ineffective methods of control, such as safety procedures and personal protective equipment, while placing blame on the workers and their actions rather than focusing on the source of the problem: faulty technology. The truth lies between these two extremes. To improve EM worker safety, increased focus must be placed both on improving the inherent safety of technology and increasing worker awareness of routine hazards. It is important that technologies are designed to minimize worker accidents and that training be given to workers concerning the proper operation of the technologies. It is also important for workers to take an active part in identifying and minimizing unsafe behavior.

- **Unacknowledged Transfer of Risk.** There is an inverse relationship between cleanup levels and worker risk. Strict cleanup levels result in increased manpower requirements and, as a consequence, increased worker construction injuries and fatalities. Thus, the desire to reduce offsite public risk inadvertently results in an increase in worker risk. The pressure to return sites to unrestricted use aggravates this situation. In selecting remediation cleanup goals, attention must be paid to the tradeoff between reduction in public risk and increased worker risk incurred

during cleanup. The largest risk of the DOE cleanup will be the occupational fatalities that occur with statistical certainty on any large construction job. The cleanup will require hundreds of thousands of labor-hours with the unavoidable consequence that construction accidents will occur.

Many have questioned whether worker risk should be considered in selecting cleanup levels since workers voluntarily assume these risks and are compensated for them. On the other hand, John Moran, of the EMAB Safety and Health Subcommittee, has said "Workers are paid to work, not to expose themselves to hazards". While increased attention must definitely be paid to making technologies safer, the biggest risk to workers comes not from the technology itself, but from the increase in accidents associated with increases in manpower requirements. The largest risk of the DOE cleanup will be the occupational fatalities that occur with statistical certainty on any large construction job. The cleanup will require hundreds of thousands of labor-hours with the unavoidable consequence that construction accidents will occur. Even such low-tech operations as soil excavation result in increased worker deaths.

INTEGRATION OF WORKER SAFETY AND HEALTH INTO TECHNOLOGY DEVELOPMENT

Safety and health considerations should be factored into the technology development process as early as possible. The earlier in the development process that potential hazards are identified and controlled, the greater the protection afforded to workers and the greater the cost savings for developers. The focus should be on elimination or substitution of hazardous processes associated with the technology rather than building barriers between workers and hazards.

The hazard assessment should start early in the development process with a check of the inherent safety of the entire process. A process is considered inherently safer if it reduces or eliminates hazards associated with materials and operations used in the process, and this reduction or elimination is a permanent and inseparable part of the process technology.

- **Hierarchy of Health and Safety Controls.** The most effective defense against worker accidents is technology that is inherently safe. It is widely recognized that a hierarchy in the effectiveness of controls exists that follows the preference of elimination of hazards, engineering controls, training and procedures, administrative controls, and finally personal protective equipment. This hierarchy recognizes that elimination and control of hazards is more effective than training, procedures and personal protective equipment. Elimination or substitution of hazardous processes is always the first priority. This is why it is important to identify and eliminate risks early in the technology development process when design chances are easiest to make. If engineering controls do not fully protect the worker, administrative controls such as job rotation can be considered. Only when

all other options are not sufficiently protective, should personal protective equipment, such as protective clothing and respirators, be used.

- **Involvement of the Technology Developer** Developers of EM technologies must play a major role in development of safer environmental technologies. They are in the best position to systematically identify and address safety and health hazards early in the development process. A complicating factor is that ownership of remediation technologies frequently changes during different stage of development. It is important that EM develop a checklist that a technology developer should follow to sufficiently address safety and health issues. OSHA's Process Safety Management standard and the Operating Engineers National HAZMAT Program (5) provide examples of such checklists. OST has been working with the IUOE to incorporate this guidance into the EM technology development process. Such guidance should encourage comprehensive analysis of potential hazards of new technologies and promote training of workers to safely operate and maintain equipment used by the technology
- **Technology Hazard Analysis.** Before technologies can be made safer, hazards associated with their use must be identified. The classic engineering process of hazard analysis can be successfully applied to identify safety issues with emerging technologies. One of the most basic analytical tools that can be used in evaluating a new technology is the Technology Safety Analysis, which consists of three steps. First, list each step thought to be associated with application of the technology to a particular situation. Second, examine each step in the technology application to identify hazards and their causes. Finally, identify modifications in the design of the technology or its use that could avoid the hazard.
- **Emergency Preparedness.** The developer should identify and communicate the technology-specific information needed by the user to meet emergency preparedness requirements. Emergency preparedness has three components: emergency prevention, emergency planning, and emergency response. Emergency prevention involves designing potential hazards out of the technology in the design phase. Emergency prevention involves training workers to take action to prevent an unfolding emergency (emergency shut down procedures, fire prevention, etc.) and designing safety into the technology. Emergency planning involves understanding the spectrum of potential worst-case scenarios, identifying appropriate response procedures, and training personnel who will be expected to respond.
- **Technology Safety Data Sheets** There is a need for a uniform tool to collect and report hazard information about new environmental technologies in a form that is useful to the workers. The development of Technology Safety Data Sheets (TSDS) has been proposed for this purpose. The Technology Safety Data Sheets should contain information accumulated throughout the process of development and should (1) identify the technology and how it functions, (2) identify and rank the safety and health hazards associated with the technology, and (3) identify

unique hazards associated with different phases (characterization, remediation, closure, maintenance, emergency repairs, etc.) of the use of the technology.

- **Heat Stress** Maintaining an adequate state of hydration is important for the maintenance of high levels of physical performance (6). At a 3% decrease in body weight due to dehydration, there is a substantial decrease in physical working capacity. Heavy physical activity, especially in hot environments and wearing of protective clothing leads to heat stress. Workers need information on the types of heat stress, factors influencing the frequency of heat stress, and treatment and prevention of heat stress.
- **Technology Cost** One reason that safety and health considerations do not achieve the recognition they deserve is that safety and health compliance costs are not considered as part of total costs when evaluating emerging technologies. In comparing technologies, life-cycle safety costs must be considered. This includes both increased compliance costs associated with riskier technologies and increased labor costs associated with worker compensation and increased down time resulting from more accidents and injuries. OST has been working with the IUOE to develop approaches to including occupational safety and health compliance costs in technology cost-performance data. The first step in identifying these costs is to assess the hazards of these technologies. To improve the hazard assessment practices of technology developers, the DOE-IUOE partnership has generated a series of checklists that will be made available to the entire technology development community.
- **Technology Peer Review** The American Society of Mechanical Engineers (ASME) conducts technical peer reviews for OST at the request of the Focus Areas. OST requires technical peer reviews for all ongoing projects at least every three years, and at the decision points for transition from research to development or development to demonstration. While the main focus of the technical review is technical validity of the project, one element of the review criteria is "Have occupational health and safety issues been adequately addressed?" However, guidance is needed as to what health and safety issues should be considered in the ASME peer review process and how they might be evaluated.
- **Stakeholder Participation is Important.** Raising the visibility of worker risk as an issue in environmental restoration will require the active participation of workers and their representatives. It will also require participation of representatives of State and Federal governments. Many of the issues associated with technology risk are political as well as technical. They cannot be solved in isolation.

RECOMMENDATIONS

The OST is in a unique position to facilitate the integration of worker safety and health considerations into the technology development process. It is recommended that OST develop guidance on the following issues.

- **Guidance for the Technology Developer** Developers of EM technologies are in the best position to systematically identify and address safety and health hazards early in the development process. It is important that EM develop a checklist of Good Engineering Practices that a technology developer should follow to sufficiently address safety and health issues.
- **Technology Safety Data Sheets** Technology users must be provided with hazard information about new environmental technologies in a form that is useful to workers. OST has been working with the IUOE to develop Technology Safety Data Sheets (TSDS) for application to EM technologies. It is important that the use of TSDS be extended to the entire OST program and that OST require a TSDS for every technology at mid-stage review.
- **Guidance for Peer Review** The peer review process is an important part of the OST technology development program. However, while one element of the review criteria is "Have occupational health and safety issues been adequately addressed?", this element is not sufficiently well defined. EM should develop guidance for consideration of safety and health issues during the ASME peer review process.
- **Heat Stress Management Program** As pointed out by the Environmental Management Advisory Board, heat stress is a significant safety and health factor in much environmental remediation activity. EM should develop a Heat Stress Management Program.
- **Technology Cost** One reason that safety and health considerations do not achieve the recognition they deserve is that safety and health compliance costs are not considered as part of total costs when evaluating emerging technologies. OST has been working with the IUOE to develop approaches to including occupational safety and health compliance costs in technology cost-performance data. The first step in identifying these costs is to assess the hazards of these technologies. To improve the hazard assessment practices of technology developers, the DOE-IUOE partnership has generated a series of checklists that will be made available to the entire technology development community.

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